



**BOLOGNA**  
ITALY

2 • 5  
SEPTEMBER 2019

# PREMUS 2019

10<sup>th</sup> International  
Scientific Conference  
on the Prevention of  
Work-Related  
Musculoskeletal  
Disorders

**From research to evidence  
based sustainable  
interventions and practices**



**PREMUS 2019 is a place where scientists and practitioners from different cultures and backgrounds meet and interact to promote research in this field**

The Medieval atmosphere of the Conference Venue and the traditional hospitality of Bologna, with its Alma Mater Studiorum considered to be the oldest university in the Western world, will assist to make your stay fruitful and comfortable.

Palazzo Re Enzo  
Piazza del Nettuno, 1 - Bologna - Italia





## Welcome to PREMUS 2019, the 10th International Scientific Conference on the Prevention of Work-Related Musculoskeletal Disorders.

Musculoskeletal disorders and injuries are relevant conditions across life-course and the most common work-related diseases. They are the second most common cause of disability worldwide, measured by years lived with disability, with low back pain being the most frequent condition and osteoarthritis the most common joint disorders.

Challenges of managing an increased life expectancy and an ageing workforce put the occupational setting in a unique position to study significant predictors of musculoskeletal disorders and to develop preventive strategies.

A multidisciplinary scientific approach focusing on lifestyle, work-related biomechanical conditions and psychosocial factors is strategic for the development of evidence-based preventive measures.

High quality epidemiological studies, combining new technologies for exposure assessment and high-resolution diagnostic imaging, are desirable to improve our knowledge on the underlying biological mechanisms of musculoskeletal conditions and the dose-response relationship.

PREMUS 2019 is a place where scientists and practitioners from different cultures and backgrounds meet and interact to promote research in this field.

The Medieval atmosphere of the Conference Venue and the traditional hospitality of Bologna, with its Alma Mater Studiorum considered to be the oldest university in the Western world, will assist to make your stay fruitful and comfortable.



## Conference themes

Musculoskeletal diseases evidence based case definition in epidemiology, clinical practice and for evaluating causation in groups and individuals

Ageing, musculoskeletal health and work

Health-related work disability of the musculoskeletal system

Effective interventions to reduce musculoskeletal disorders and work disability

Rehabilitation/supportive conditions at work to improve work ability

Assessing exposure to risk factors for work-related musculoskeletal disorders

Occupational exposure limits to prevent work-related musculoskeletal disorders

Gender and musculoskeletal disorders



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### **VIOLANTE FRANCESCO SAVERIO, ITALY**

Department of Medical and Surgical Sciences, University of Bologna



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Technische Universität Dresden

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Consultant in Orthopaedics, Rehabilitation, Ergonomics, Occupational Safety and Health  
RECOUP Neuromusculoskeletal Rehabilitation Centre, Bengaluru, India

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Department of Biomedical and Dental Sciences and of Morphological and Functional  
Images, University of Messina  
Chair of the Italian Society of Occupational Medicine (SIML)

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Head, Scientific Group on Work-related Musculoskeletal Disorders  
Quebec Institute of Public Health (INSPQ)  
Associate Clinical Professor  
Department of Social & Preventive Medicine  
University of Montreal School of Public Health  
Adjunct Professor  
Department of Epidemiology, Biostatistics & Occupational Health, McGill University

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Finnish Institute of Occupational Health, Cochrane Work

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Department of Medical and Surgical Sciences, University of Bologna,  
ICOH Board Member

**WALKER-BONE, KAREN, UK**

Director Arthritis Research UK/MRC Centre for Musculoskeletal Health and Work,  
MRC Lifecourse Epidemiology Unit, Southampton

**WULFF SVENDSEN, SUSANNE, DENMARK**

Department of Occupational Medicine  
Regional Hospital West Jutland – University Research Clinic, Denmark



## Keynote Speakers

### BONFIGLIOLI ROBERTA, ITALY

Department of Medical and Surgical Sciences, University of Bologna

Roberta Bonfiglioli MD is Associate Professor of Occupational Medicine at the University of Bologna and Staff physician at the Unit of Occupational Medicine, Sant'Orsola Malpighi University Hospital in Bologna. Her research interests include diagnosis and prevention of work-related musculoskeletal disorders and peripheral neuropathy, occupational risk factors in the health care setting. Prof. Bonfiglioli is Chair of the "Scientific Committee on Musculoskeletal Disorders" of the International Commission on Occupational Health (ICOH) for the triennium 2018-2021, Chair of the Emiliano-Romagnola branch of the Italian Society of Occupational Medicine for the triennium 2019-2022 and currently degree program Director - Second Cycle Degree Program in Health Professions of Prevention Sciences at the University of Bologna.

### CARISA HARRIS ADAMSON, USA

Assistant Professor, University of California, Director, UCSF/UCB Ergonomics Graduate Training Program, Richmond CA, USA

Carisa Harris Adamson, PhD, CPE is an Assistant Professor in the Department of Medicine at the University of California at San Francisco, and in the School of Public Health at the University of California at Berkeley. She is also the Director of the UCSF/UCB Ergonomics Research & Graduate Training Program and the Deputy Director of the Northern California Center of Occupational & Environmental Health. Dr. Harris and her team performs research in a variety of areas focused on understanding and preventing work related injuries and improving human performance, productivity and health. Her epidemiological research assesses and adjusts for healthy worker survivor bias in the assessment of physical, personal and work psychosocial factors associated with Carpal Tunnel Syndrome and subsequent work disability. Additionally, her team is developing and testing a variety of exposure assessment devices (wearables) for primary and secondary prevention purposes and performs various intervention studies on occupational tasks with high risk of musculoskeletal injuries, such as the implementation of passive exoskeletons in construction work.

### JUDITH GOLD, SWEDEN

Centre for Musculoskeletal Research, Department of Occupational and Public Health Sciences, University of Gävle, Gävle, Sweden. Gold Standard Research Consulting

Judith E. Gold, ScD is an occupational epidemiologist, ergonomist, and electrical engineer. She is the founder of Gold Standard Research Consulting, providing epidemiology and data science/data analysis expertise to academic, non-profit (NGOs), and business clients. Most recently at the Centre for Musculoskeletal Research (CBF) in Gävle, Sweden, and prior to that at Temple University in Philadelphia, Pennsylvania, USA, her research has focused on the epidemiology of work-related musculoskeletal disorders (MSDs), with particular attention to biomarkers and physiological mechanisms. Dr. Gold is especially interested in the information that can be gleaned from concurrent assessments of biochemical and quantitative imaging biomarkers. She has been the recipient of government and industry-funded research grants, and has served as a consultant for WHO and OSHA.

## KAREN MESSING, CANADA

Professeure émérite, Département des sciences biologiques et chercheure, centre de recherche CINBIOSE, UQAM Université du Québec, Montréal - Canada

Karen Messing is professor emerita of ergonomics in the Department of Biological Sciences at the University of Quebec at Montreal. Her research deals with applications of gender-sensitive analysis in occupational health and with constraints and demands of work in the service sector, especially the effects of prolonged static standing. In addition to 145 peer-reviewed scientific articles, she has published several books, including *One-eyed Science: Occupational Health and Working Women* (1998) and *Pain and Prejudice: What Science Can Learn about Work from the People Who Do It* (2014). She co-founded the Gender and Work Technical Committee of the International Ergonomics. She has received several awards including the Governor General of Canada's "Persons" Award for advancing the status of women (2009) and the William P. Yant Award from the American Industrial Hygiene Association (2014) for "outstanding work in industrial hygiene". In 2018 she was named one of 21 Montréal "inspiring citizens".

## SARAH SHARPLES, UK

Horizon Digital Economy Research, Human Factors Research Group, University of Nottingham, Nottingham, United Kingdom

Sarah Sharples is Pro-Vice-Chancellor for Equality, Diversity and Inclusion for the University of Nottingham. Her work as a Professor of Human Factors has been applied to Transport, Healthcare and Manufacturing. She was President of the Chartered Institute of Ergonomics and Human Factors from 2015-16, and is on the Science Advisory Council for the UK Department for Transport. She is on the Council of the Engineering and Physical Sciences Research Council, and leads the national EPSRC Network Plus 'Connected Everything' which brings together communities including engineering, computer science and design to consider the future opportunities presented by Digital Manufacturing. She also leads the research project 'DigiTOP' which is developing tools and solutions to support the implementation of future digital manufacturing technologies. She is passionate about ensuring that we take a systems perspective to considering the role of and impact on people in all work to develop future technologies and solutions.

## KAREN WALKER-BONE, UK

Director Arthritis Research UK/MRC Centre for Musculoskeletal Health and Work, MRC Lifecourse Epidemiology Unit, Southampton United Kingdom

Karen trained as an academic rheumatologist with a special interest in occupation and musculoskeletal pain in Southampton, funded by an Arthritis Research UK Clinical Research Fellowship. Karen is based at the MRC Lifecourse Epidemiology Unit in Southampton where she is Professor and Honorary Consultant in Occupational Rheumatology and Director of the Arthritis Research UK/MRC Centre for Musculoskeletal Health and Work. She leads the multidisciplinary Centre and coordinates a programme of work to find cost effective ways to reduce the burden of disability for work caused by musculoskeletal disorders. She was awarded an Honorary Fellowship of the Faculty of Occupational Medicine in 2013. She also chairs the multi-disciplinary BSR/BHPR Special Interest Group in work and health.



## CME / EACCME | Continuing education

CME credits (ECMEC®s) by the European Accreditation Council for Continuing Medical Education (EACCME®) will be provided for full attendance at the conference.

Each participant will receive the number of credits he/she is entitled according to his/her actual participation at the event after completing the feedback form.

Please find below the breakdown of ECMEC®s per day:

02.09.2019 - 8.00

03.09.2019 - 8.00

04.09.2019 - 8.00

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## Endorsements



**ICOH**  
The International Commission  
on Occupational Health



**DIMEC**  
Department of Medical and Surgical Sciences  
DIMEC University of Bologna, Italy



**IEA**  
International Ergonomics  
Association



**SIML**  
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di Medicina del Lavoro

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## Scientific Programme

### Sunday 1<sup>st</sup> September

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6:00 PM - REGISTRATIONS OPENS

7:00-12:00 PM - WELCOME RECEPTION – COCKTAIL DINATOIRE – PALAZZO RE ENZO

### Monday 2<sup>nd</sup> September

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8:00 AM - REGISTRATIONS OPENS

8:30-9:15 AM - PLENARY SESSION - **Salone del Podestà**

**Keynote**

**New technologies have enhanced the quality and availability of measures of biomechanical risk factors.**

**How can we keep workers' digital footprint under control?**

*Sarah Sharples - Horizon Digital Economy Research, Human Factors Research Group, University of Nottingham, Nottingham, United Kingdom*

9:15-10:00 AM - PARALLEL SESSIONS

- **Symposium - Salone del Podestà**

**Newly developed and redesigned key indicator methods for assessment of different working conditions with physical workloads. Aspects of background, objectivity, reliability and validity. PART I**

*Chair: André Klussmann*

*Presenters: Klussmann André, Liebers Falk, Serafin Patrick, Schust Marianne, Hartmann Bernd, Gebhardt Hansjürgen*

- **Risk Assessment (Session 1) - Sala degli Atti**

*Chair: Francesco Violante*

What is the attributional fraction due to work for musculoskeletal disorders on a national level?

*Van der Molen Henk*

Proportion of upper extremity musculoskeletal disorders attributable to personal and occupational factors: Results from the French Pays de la Loire study

*Nambiema Aboubakari*

Music-specific and generic psychosocial stressors among performing musicians with various work arrangements

*Laura Punnett*

- **Special Session - Sala Re Enzo**

**MSD among Immigrant workers and Ageing, MS Health and Work**

*Chair: Acran Salmen Navarro*

Work-related musculoskeletal disorders preventive program on New York City vulnerable Immigrant working population: A Clinic / University - community participatory collaboration

*Acran Salmen Navarro*

Do work exposures help explain musculoskeletal disorder work absence health inequalities?

*Stock Susan*

Multisite musculoskeletal pain in migrants from the Indian subcontinent to the UK: A cross-sectional survey

*Ntani Georgia*

10:00-10:30 AM Coffee break

**10:30-12:00 AM - PARALLEL SESSIONS****● Symposium - Salone del Podestà**

**Newly developed and redesigned key indicator methods for assessment of different working conditions with physical workloads. Aspects of background, objectivity, reliability and validity. PART II**

*Chair: André Klussmann*

*Presenters: Klussmann, André, Liebers Falk, Serafin Patrick, Schust Marianne, Hartmann Bernd, Gebhardt, Hansjürgen*

**● MSD Case Definition and Surveillance (Session 1) - Sala Re Enzo**

*Chair: Roberta Bonfiglioli*

A review of international programmes for the prevention and management of musculoskeletal disorders

*Boocock Mark*

The surveillance of musculoskeletal disorders in Italy: findings from the MALPROF System

*Papale Adriano*

Carpal tunnel syndrome as sentinel for detrimental occupational hand activities: a nationwide Danish cohort study

*Tabatabaeifar Sorosh*

Severity of carpal tunnel syndrome and manual work: findings from a case-control study

*Mattioli Stefano*

Twenty years of CTS surveillance among diverse occupational groups

*Rosecrance John*

Prognosis of patients with suspected carpal tunnel syndrome in relation to occupational mechanical exposure of the wrist and impaired median nerve conduction

*Frost Poul*

Occupational risk factors for surgically treated carpal tunnel syndrome – a prospective cohort study of 220,610 Swedish construction workers

*Wahlström Jens*

**● Effective interventions to prevent MSD (Session 1) - Sala degli Atti**

*Chair: Laura Punnett*

Using a mobile app to conduct process evaluation in a participatory ergonomics healthcare intervention

*Chin Winnie*

Effectiveness of the multi-component Dynamic Work intervention to reduce sitting time in office workers – results from a cluster randomised controlled trial

*Renaud Lidewij*

Controlling Vibration Exposure when Drilling into Concrete: Findings from Two Studies

*Rempel David*

Effectiveness of a vacuum lifting system in reducing spinal loads during airline baggage handling

*Lu Ming-Lun*

Work ability and vitality in coach drivers: a RCT to study the effectiveness of a self-management intervention during the peak season

*Van Schaaik Art*

Systematic Evaluation of Engineering Controls to Reduce Muscular Loading during Patient Handling Tasks

*Kim Jay*

Psychosocial effects of workplace exercise – A systematic review

*Bordado Sköld Margrethe*

**POSTER SESSION** (Poster listed by identification number) - Sala del Quadrante*Chair: Andrea Farioli*

1. A multidisciplinary team to manage ergonomic hazard: Case report of a storekeeper with hand strain  
*Lim Joseph*
2. Designing and making smart class board into automatic height adjustable and determine the effect on user body posture  
*Habibi Ehsanollah*
3. The relationship between status ergonomic construction jobs and musculoskeletal disorders construction workers using check list NIOSH-CPWR  
*Habibi Ehsanollah*
4. Musculoskeletal disorders, ageing and overweight in the workforce - a prospective cohort study  
*Gram Bibi*
5. Relationship between depression and musculoskeletal disorders  
*Nakata Minori*
6. Comparison of musculoskeletal symptoms in blue-collar and white-collar workers in the previous seven days - analysis stratified by age  
*Cardoso Viviane de Freitas*
7. Influence of low and high cognitive loading on task precision during a 30-min tracking task in younger and older subjects  
*Florestan Wagenblast*
8. The Swedish Work Environment Authority introduces medical checks for hand-intensive work  
*Lorén Kersti*
9. The U.S. National Occupational Research Agenda for Musculoskeletal Health  
*Lu Ming-Lun*
10. Effectiveness of workplace interventions in the rehabilitation of musculoskeletal disorders among workers with physical employment: Systematic review  
*Sundstrup Emil*
11. The impact of office ergonomics intervention: a case study in 18 companies across Singapore  
*Rusli Noer Triyanto Rusli*
12. Sit-stand tables in overweight and obese computer workers: investigation of a comfortable pre-set time  
*Barbieri Dechristian*
13. Evaluation of the Current Advise for Return to Activities and Work after Total Knee Arthroplasty  
*Straat A. Carlien*
14. Supervisor's roles and responsibilities in preventing prolonged disability in workers with musculoskeletal disorders  
*Nastasia Iuliana*
15. Review of research, policy and practice on prevention of work-related Musculoskeletal Disorders (MSDs)  
*Sas Katalin*
16. An unobtrusive wrist orthotic for carpal tunnel syndrome intervention  
*Luong Pauline*
17. Comparison of municipal bus driver whole-body vibration exposures when operating a bus with an active, passive and static suspension bus seat  
*Peter W. Johnson*

**12:00-AM – 1:30 PM - PARALLEL SESSIONS****● Symposium - Salone del Podestà**

**Ergonomic Assessment Work-Sheet (EAWS): structure, application and validation in the industrial sector**

*Chair: Gabriele Caragnano*

*Presenters: Gabriele Caragnano, Fabrizio Caruso, Roberta Bonfiglioli, Martin Haselhuhn, Lidia Ghibaudo*

**● MSD Case Definition and Surveillance (Session 2) - Sala Re Enzo**

*Chair: Alexis Descatha*

Personal, biomechanical, psychosocial and organizational risk factors for carpal tunnel syndrome: a Structural Equation Modelling Approach

*Yves Roquelaure*

Correlations between pain in the back and neck/upper limb in the European Working Conditions Survey

*Rizzello Emanuele*

Work-Related Musculoskeletal Disorder Workers' Compensation Claims of the Low Back, Shoulder, Hand/Wrist, Knee, Elbow and Neck in the In-Home Care Industry in Washington State, 2006-2016

*Howard Ninica*

Predictors of Self-Reported Work-Preventing Upper Extremity Symptoms in Canadian Bovine Veterinarians

*Reist Robyn*

Disc herniation with radiculopathy: epidemiologic and economic indicators of compensation in the Pays de la Loire region

*Fouquet Natacha*

Using occupational injury and hazard surveillance in the development of safety interventions for professional loggers

*Rosecrance John*

Distribution of age, sex, and occupation of carpal tunnel syndrome patients using national health insurance data

*Kim Young-Ki*

**● Effective interventions to prevent MSD (Session 2) - Sala degli Atti**

*Chair: Stefania Curti*

Synthesizing the evidence on workplace practices and policies to prevent MSD

*Irvin Emma*

Results of a Participatory Ergonomics Intervention With Wearable Technical Measurements of Physical Workload in the Construction Industry

*Brandt Mikkel*

A sustainable participatory approach to reducing musculoskeletal hazards in long term care facilities

*Van Eerd Dwayne*

New strategies to commit subcontracting managers in MSD prevention

*Aude Cuny-Guerrier*

Does training duration of a worksite-supervised adapted physical activity program affect trunk functional capacities and pressure pain sensitivity over the low back among vineyard-workers?

*Balaguier Romain*

Smart workwear system with real-time vibrotactile feedback for improving postural behaviour in industry

*Yang Liyun*

Optimizing ergonomic working conditions by using a participatory program: the design of a goods-to-person picking system in a Belgian company

*Costers Ruth*

**1:30-2:30 PM Lunch time**

**2:30 – 4:30 PM - PARALLEL SESSIONS**

● **Symposium - Salone del Podestà**

**Title: Job exposure matrices for biomechanical factors: from validation to application**

*Chair: Alexis Descatha; Co-Chairs: Bradley A Evanoff, Johan H Andersen*

*Presenters: Laure Ngabirano, Ann Marie Dale, Marc Fadel, Bradley A Evanoff, Annett Dalboge, Alexis Descatha*

● **MSD Case Definition and Surveillance and Work Ability (Session 3) - Sala Re Enzo**

*Chair: Stefano Mattioli*

Validation of a conceptual model for shoulder pain risk factors

*Bodin Julie*

Work above shoulder level and shoulder disorders – a systematic review

*Wærsted Morten*

Longitudinal analysis of shoulder kinematics and muscle EMG in patients surgically treated for rotator-cuff tear

*Cutti Andrea Giovanni*

Occupational biomechanical risk factors for surgical treatment of subacromial impingement syndrome (SIS) in a 16-year prospective study among male construction workers

*Lewis Charlotte*

Occupational mechanical and psychosocial exposures and Subacromial Impingement Syndrome: a systematic review

*Andersen Johan H*

Cervical intervertebral disc herniation and occupational risk factors: a literature review

*Zunarelli Carlotta*

Occupational risk factors for hospitalization due to cervical disc disorder in a 29-year prospective study of Swedish male construction workers

*Jackson Jennie*

MRI lumbar disco-vertebral findings, age and manual material handling. A cross-sectional multicenter study

*Bonfiglioli Roberta*

Persistent postoperative pain after groin hernia repair in relation to occupational mechanical exposures

*Svensen Susanne Wulff*

Inguinal hernia and occupational physical exposure: systematic review and meta-analysis

*Kuijer Paul*

● **Gender and MSD and Work Ability (Session 1) - Sala degli Atti**

*Chair: Emma Irvin*

Are there sex differences in scaption torque steadiness?

*Oliveira Ana Beatriz*

Are there sex differences in the muscle activation and in the relationship between objective and subjective indicators of muscle fatigue in the neck/shoulder region during a repetitive task?

*Machado Cid Marina*

Are sex differences in neck/shoulder electromyographical changes induced by a fatiguing repetitive task affected by the choice of the fatigue criterion?

*Machado Cid Marina*

Evaluating the treatment of sex and gender when assessing methodologic quality in a systematic review of explanatory and prognostic studies of musculoskeletal disorders

*Stock Susan*

What are the determinants of the sex/gender difference in the duration of work absence for musculoskeletal disorders? a mixed studies systematic review

*Stock Susan*

Sex-specific effects of standing vs sitting on trunk and leg muscular and vascular outcomes during a repetitive manual work task

*Coté Julie*

Awareness, Skill Building and Behavior Modification Program amongst Community and Office Employees on Safer Use of Computing Technology Equipment (Laptops, Desktops, Hand-held Devices, including smart-phones)

*Madhwani Kishore P*

#### 4:30-6:00 PM - PARALLEL SESSIONS

- **Symposium - Salone del Podestà**

**Title: Exposure response relationship assessing biomechanical overload of lumbar spine and upper limbs by methods suggested in ISO standards**

*Chair: Deepak Sharan*

*Presenters: Enrico Occhipinti, Enrique Alvarez Casado, Natale Battevi, Daniela Colombini, Deepak Sharan*

- **Symposium - Sala Re Enzo**

**Methods for health risk assessment and risk factors identification of work-related musculoskeletal disorders.**

*Chair: Sunisa Chaiklieng*

*Presenters: Sunisa Chaiklieng, Pornnapa Suggaravetsiri, Worawan Poochada, Naruedee Poonkasem,*

- **Effective interventions to prevent MSD (Session 3) - Sala degli Atti**

*Chair: Benjamin Steinhilber*

Knowledge transfer and exchange for work and health research to practice

*Van Eerd Dwayne*

Operator-exoskeleton interactions: preliminary study on the acceptability of these devices

*Atain kouadio Jean Jacques*

Potential of back exoskeletons in limiting spinal muscles activity depends on their design and on task modalities

*Theurel Jean*

Postural consequences of the use of upper-limb exoskeletons during overhead work: influence of exoskeleton design?

*Desbrosses Kévin*

The effect of passive exoskeleton on the spatial distribution of low back muscles activity during simulated work conditions

*Vieira dos Anjos Fabio*

Efficacy, usability and acceptability of exoskeletons for workers assistance: A Systematic Review of current and potential application

*Carta Angela*

A pilot study evaluating the use of a passive exoskeleton as potential intervention for mitigating low back pain risk factors in farmers

*Thamsuwan Ornwipa*

## Tuesday 3<sup>rd</sup> September

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8:00 AM - REGISTRATIONS OPENS

8:30-9:15 AM - PLENARY SESSION - **Salone del Podestà**

**Keynote**

**Insights into workplace and personal factors that predict disability related to CTS: The NIOSH Consortium Study**

*Carisa Harris Adamson - Assistant Professor, University of California, Director, UCSF/UCB Ergonomics Graduate Training Program, Richmond CA, USA*

9:15-10:00 AM - PLENARY SESSION - **Salone del Podestà**

**Keynote**

**New findings from the Italian OCTOPUS and related studies on CTS**

*Roberta Bonfiglioli - Associate Professor of Occupational medicine Chair of the ICOH SC Musculoskeletal Disorders - Department of Medical and Surgical Sciences, University of Bologna, Italy*

10:00-10:30 AM Coffee break

10:30-12:00 AM - PARALLEL SESSIONS

● **Symposium - Salone del Podestà**

**New and Revised Exposure and Risk Assessment Methods For DUE MSDS**

*Chair: Carisa Harris Adamson*

*Presenters: Carisa Harris Adamson, Brad Evanoff, Lukas Mitterlehner, Britta Weber, Sean Gallagher*

● **MSD Case Definition and Surveillance (Session 4) - Sala Re Enzo**

*Chair: Susan Stock*

The Sleeping on the Floor and the Range of Pelvic Tilt in Korean College Students

*Yoon Jangwhon*

Occupational musculoskeletal disorders among forestry workers

*Pantea Codrina Petronela*

Musculoskeletal disorders stemming from working in the wind industry: Results of an updated scoping review

*Freiberg Alice*

The differences in the number of varicose vein patients according to occupational categories and working positions: Pilot study on the disease's correlation to work

*Lee Ilho*

Bus road drivers: implementation of a remote physical exercise program using smartphone: a protocol study

*Negreiros Alexandher*

Musculoskeletal disorders due to handheld devices: Changing patterns in the past 12 years

*Sharan Deepak*

Does screen work result in musculoskeletal symptoms? A systematic review and meta-analysis

*Coenen Pieter*

● **Effective interventions to prevent MSD (Session 4) - Sala degli Atti**

*Chair: Paul Kuijjer*

How do we measure adherence? The effect of different measures of exercise adherence during a workplace-based exercise training intervention for office workers

*Welch Alyssa*

Longitudinal monitoring of musculoskeletal disorders: the relevance for ergonomic interventions

*Major Marie-Eve*

The effects of an electro-mechanical seat suspension to reduce whole body vibration and low back pain in long haul truck drivers: Results from a randomized controlled trial

*Dennerlein Jack*

Supporting Return to Work after Total Knee Arthroplasty: Development of an Integrated Care-Intervention including eHealth and Goal Attainment Scaling

*Straat A. Carlien*

Workplace practices and research evidence in preventing prolonged disability in workers with musculoskeletal disorders

*Nastasia Iuliana*

A novel model for health examinations for workers exposed to hand intensive work – a process evaluation of the ergonomist's perspective

*Dahlgren Gunilla*

A model for risk assessment and health examinations for workers exposed to hand intensive work. The companies' experiences

*Eliasson Kristina*

## **POSTER SESSION** (Poster listed by identification number) - **Sala del Quadrante**

*Chair: Alysha Meyers*

- 18.** Implementing preventive interventions for work-related upper extremity disorders in agriculture: facilitators and barriers  
*Van der Molen Henk*
- 19.** Physical Exercise Intervention to reduce musculoskeletal disorders and improve work performance – a systematic literature search  
*Sjøgaard Gisela*
- 20.** A Participatory Ergonomics Research Model for Development of Interventions and Identification of Cultural Norms  
*Fulmer Scott*
- 21.** Gender differences on work-related musculoskeletal disorders among workers who perform their activities on sitting posture  
*Ana Beatriz Oliveira*
- 22.** If sternocleidomastoid muscle activation increased in women during the simulation of repetitive tasks could it predict greater risks of disorders?  
*Ana Beatriz Oliveira*
- 23.** Gender differences in the prevalence and intensity of neck, back and shoulder pain in Austrian bank headquarter workers - a secondary analysis of an observational study  
*Schwartz Bernhard*
- 24.** Investigation of morningness and eveningness and it's related of factors caused by shift working in hospital nurses  
*Habibi Ehsanollah*
- 25.** Presenteeism and Work-Related Musculoskeletal Disorders in Brazilian Nursing Workers  
*Baptista Patricia*
- 26.** Factors of success and of failure in the process of returning to work after surgery for a work-related degenerative shoulder injury: description of the sample  
*Desbrosses Kévin*
- 27.** The experience of nursing workers without work related musculoskeletal disorders on a sick team  
*Baptista Patricia*
- 28.** Work ability and self-rated health of workers with chronic musculoskeletal diseases: A prospective cohort study  
*Padula Rosimeire Simprini*

29. A multiprofessional care program to chronic work-related musculoskeletal diseases individual: a cohort prospective study  
*Padula Rosimeire Simprini*
30. The independent Association Between Number Of Pain Sites And Return To Work. An Explanatory, Prospective Cohort Study  
*Drongstrup Jesper*
31. Development and measurement properties of a firefighter-specific work limitations scale  
*Macdermid Joy*
32. Perceptions of facilitating factors and barriers when implementing activity based workplaces before and after implementation  
*Wijk Katarina*
33. Correlation between exposure to work-related musculoskeletal risk factors and self-reported musculoskeletal lower back and neck/upper limb symptoms: A cross-sectional study based on the fourth Korean Working Conditions Survey  
*Oh Sungsoo*
34. Consensus on testing and evaluation of occupational exoskeletons in the workplace, for a better integration  
*Atain Kouadio Jean-Jacques*
35. Patient Transfers and Risk of Back Injury: An Electromyographic Evaluation of Assistive Devices  
*Vinstrup Jonas*

## 12:00 AM-1:30 PM - PARALLEL SESSIONS

- **Symposium - Salone del Podestà**  
**Exoskeletons for industrial use**  
*Chair: Tessy Luger; Benjamin Steinhilber*  
*Presenters: Jean Theurel, Ulrich Glitsch, Tessy Luger, Idsart Kingma, Divya Srinivasan*
- **Symposium - Sala Re Enzo**  
**Time patterns of biomechanical exposures at work in prevention and health promotion related to MSD: activity, pauses and variation**  
*Chair: Kaj Bo Veiersted*  
*Presenters: Kaj Bo Veiersted, Suzanne Merkus, Pascal Madeleine, Padula Rosimeire Simprini, Svend Erik Mathiassen*
- **Ageing, MS Health and Work (Session 1) - Salone degli Atti**  
*Chair: Anne Marie Dale*
  - When musculoskeletal pain limits work capacity – results from the Senior WorkingLife study among 11,791 senior workers  
*Andersen Lars L.*
  - Synthesis of predictor factors for early departures of ageing workers by a systematic literature review  
*Pletea Elisabeta*
  - Musculoskeletal disorders as predictors of health-related job loss amongst older workers: Results from the HEAF Study  
*Walker-Bone Karen*
  - Informal caring responsibilities and poorer health amongst working 50-64 year olds: results from the Health and Employment After Fifty (HEAF) Study  
*Harris E. Clare*
  - Safer and healthier work at any age  
*Sas Katalin*
  - Obesity and the ability to work to older ages: insights from the Health and Employment After Fifty (HEAF) study  
*D'Angelo Stefania*

The contribution of excess body mass to the risk of all-cause and cause-specific disability retirement:  
A systematic review and meta-analysis

*Shiri Rahman*

1:30-2:30 PM Lunch time

2:30-4:30 PM - PARALLEL SESSIONS

● **Symposium - Salone del Podestà**

Multilevel inventory of methods for risk assessment of physical workload (MEGAPHYS) – A joint project of the German Federal Institute for Occupational Safety and Health (BAuA) and the German Social Accident Insurance (DGUV)

*Chair: Britta Weber; Marianne Schust*

*Presenters: Britta Weber, Marianne Schust, Ralph Bruder, Matthias Jäger*

● **MS Work Disability (Session 1) - Sala Re Enzo**

*Chair: David Rempel*

Do Pre-Operative Patient Expectations Regarding Work Ability Become True 6 Months After Total Knee Arthroplasty (TKA)? A Multicenter Prospective Cohort Study

*Kuijer Paul*

Prevalence and associated factors of musculoskeletal pain in artisanal fishermen in southern Brazil

*Cezar-Vaz Marta Regina*

Impact of first-line healthcare providers on injured workers' trajectories of care: a four jurisdiction critical analysis

*Hudon Anne*

Objective predictors of physical work ability in aged manual workers

*Norheim Kristoffer Larsen*

Musculoskeletal diseases mediate the association of work ability and work life satisfaction with intention to retire

*Nygård Clas-Håkan*

Measurement properties of instruments assessing permanent functional impairment of the spine: blending evidence and stakeholder perspectives

*Goes Suelen M.*

A trajectory of good workability: An analysis of workplace predictors over 6 years

*Oakman Jodi*

Is it possible to estimate health economics from work ability score in musculoskeletal in workers with musculoskeletal disorders?

*Hagberg Mats*

Muscle strain and postures during conventional and robotic-assisted laparoscopic surgery: A paired cross-sectional study

*Dalager Tina*

Calcium fluxes in work-related muscle disorders: implications from a rat model

*Barbe Mary F*

● **Work Ability (Session 1) - Salone degli Atti**

*Chair: Carisa Harris Adamson*

Quantification of stroke-induced proprioceptive and motor deficits to facilitate rehabilitation

*Acosta-Sojo Yabrianna*

Favorable changes in physical working conditions and risk of sickness absence: Analyzing a prospective cohort study as a pseudo-experiment

*Shiri Rahman*

QuickDecks: A new tool for sharing best evidence in back pain

*Irvine Emma*

Associations between muscular pain in neck and shoulders and psychosocial factors at work in relation to leisure physical activity among teachers

*Malinauskiene Vilija*

Correlation between fibromyalgia severity score and fitness for work: A cross-sectional study

*Shlomo Moshe*

Linking health care and workplace: role of occupational therapists in workplace based occupational health care to prevent MSA-related work disability

*Désiron Huget*

Neck, trunk, and upper arm posture variation during computer work at a sit-stand table in a real work setting

*Barbieri Dechristian*

Variation in upper trapezius and wrist extensor EMG among computer workers during sit-stand table use in a real work setting

*Barbieri Dechristian*

Implementing Activity-based Workplaces (ABW) and the importance of participating in process activities

*Bergsten Eva*

Evaluation of an Information Package on MSD Prevention for Small and Micro Business in Ontario, Canada

*Yazdani Amin*

#### 4:30-6:00 PM - PARALLEL SESSIONS

- **Symposium - Sala Re Enzo**

**SELFBACK, a digital health intervention to support self-management in low back pain**

*Chair: Karen Sogaard*

*Presenters: Karen Sogaard, Paul Jarle Mork, Mette Jensen Stochkendahl, Barbara Nicholl, Malene Jagd Svendsen, Louise Fleng Sandal*

- **Symposium - Salone del Podestà**

**The use of work-related PROMS in clinical care. Can the use of PROMS facilitate the dialogue between clinical care and occupational health?**

*Chair: Annechien Beumer*

*Presenters: Bert van de Wijdeven, Yasmayne Karel, Paul Kuijjer, Annechien Beumer*

- **Effective interventions to prevent MSD (Session 5) - Salone degli Atti**

*Chair: Susanne Wulff Svendsen*

Reducing postural exposure in repetitive manual handling using the Smart Workwear System – effects of vibrotactile feedback and verbal instructions

*Carl Lind*

The Economic Burden of Work-Related Musculoskeletal Disorders in Five European Countries

*Amirabbas Mofidi*

Investigating the Potential for Workplace Injury Tradeoffs: Needle-less Injection Tools in Pork Production

*Trask Catherine*

Implementing an ergonomics program on commercial construction worksites reduced new incidents of pain and injury: Results from a cluster randomized controlled trial

*Dennerlein Jack*

Physiological effects of two level compression socks on security guards during prolonged standing work

*Garcia Gabriela*

Short interruptions during full day computer work and trapezius muscle activity – a randomized laboratory study

*Läubli Thomas*

Process Evaluation of a Workplace-Based Exercise and Health Promotion Cluster-Randomised Trial to Increase Productivity and Reduce Neck Pain in Office Workers: a RE-AIM Approach

*Welch Alyssa*

## Wednesday 4th September

8:00 AM - REGISTRATION OPENS

8:30-9:15 AM - PLENARY SESSION - Salone del Podestà

**Keynote**

**Imaging and biochemical biomarkers research in non-traumatic musculoskeletal disorders (MSD). Practical recommendations**

*Judith Gold - Centre for Musculoskeletal Research, Department of Occupational and Public Health Sciences, University of Gävle, Gävle, Sweden. Gold Standard Research Consulting*

9:15-10:00 AM - PLENARY SESSION - Salone del Podestà

**Keynote**

**Frailty and pre-frailty are major determinants of inability to work at older ages: what can we do about it?**

*Karen Walker-Bone - Director Arthritis Research UK/MRC Centre for Musculoskeletal Health and Work, MRC Lifecourse Epidemiology Unit, Southampton United Kingdom*

10:00–10:30 AM Coffee break

10:30-12:00 AM - PARALLEL SESSIONS

- **Symposium - Salone del Podestà**

**Evidence-based, sustainable interventions: Do research and practice meet?**

*Chair: Laura Punnett*

*Presenters: Henk van Rhee, Jan Dul, Yves Roquelaure, Mohsen Zare, Kasper Edwards, Dwayne van Eerd, Maaïke Huijsmans*

- **MSD Case Definition and Surveillance (Session 5) - Sala Re Enzo**

*Chair: Brad Evanoff*

Impact of working technique on cumulative loadings among other factors

*Vallée Marcotte Jasmin*

Implementation of patient transfer technique and good perceived psychosocial working climate association with peak exposures of physical load among health care providers in nursing homes in Norway

*Amro Amin*

Characterizing musculoskeletal injuries in two public sector workforces with exposure to two different custodial populations

*Kurowski Alicia*

The BRAZilian eValuation of Occupational health (BRAVO) database: presentation of the workers' profile and prospects for future studies

*De Barros Fernanda Cabegi*

Prevalence of upper limb disorders and occupational health problems among the women brick molders of west bengal, india

*Das Banibrata*

Work-related polyneuropathy of upper limb

*Ishteryakova Olga*

Salient beliefs underlying the intention to diagnose WRMSD among General Practitioners: a qualitative study using Theory of Planned Behaviour

*Mohd Yusoff Hanizah*

**● Risk Assessment (Session 2) - Sala degli Atti**

*Chair: Andre Klussmann*

A critique of duty cycle and its role in assessing MSD risk

*Gallagher Sean*

Instrumental-based methods for biomechanical risk assessment

*Draicchio Francesco*

Musculoskeletal health in people on sick leave: Validation of the Norwegian version of the Musculoskeletal Health Questionnaire

*Tingulstad Alexander*

Sitting, standing and physical activity among male and female office workers of different age: behaviours examined using compositional data analysis

*Mathiassen Svend Erik*

The influence of nursing home, ward, eldercare worker and work situation on the use of assistive devices during resident handling

*Karstad Kristina*

Subjective criteria for knife sharpness evaluation in meat-cutting activities

*Savescu Adriana*

Psychophysiological reactions, stress and recuperation among telecommuting academics

*Widar Linda*

**POSTER SESSION (Poster listed by identification number) - Sala del Quadrante**

*Chair: Julie Coté*

36. Developing RAMP 2.0 - for enhanced applicability

*Rose Linda M*

37. The Upper limb neurodynamic test 1 in the clinical diagnosis of carpal tunnel syndrome

*Trillos Maria*

38. Worker's strategies analysis to prevent musculoskeletal disorders: the case of deburrers in the foundry sector

*Schoose Clara*

39. Occupational Injuries in Craft Beer Brewing Industry

*Brents Colleen*

40. Parsonage-Turner Syndrome: differential diagnosis of painful shoulder in a bus driver

*Barbieri Dechristian Franca*

41. Raynaud's phenomenon in the occupational context

*Barbieri Dechristian Franca*

42. Prevalence of and factors associated with nonspecific lower back pain in warehouse workers

*Martins Gomes Maryanne*

43. Prevalence of musculoskeletal pain and evaluation of postural risk among administrative workers at the Costa Rica Institute Technology

*Campos-Fumero Adriana*

44. Online dashboard for surveillance of ergonomic-related workers' compensation claims by industry and diagnosis category

*Meyers Alysha*

45. Difference between experts' and novices' footstep patterns during a palletizing task

*Vallée Marcotte Jasmin*

46. Work-related musculoskeletal injuries among health care workers handling patients - Brief statistical analysis

*Melo Daniel*

47. Evaluation of resilience in nursing workers in a teaching hospital  
*Baptista Patricia*
48. Evaluation of a passive back exoskeleton in simulated industrial tasks  
*Baer Mona*
49. Creating Awareness amongst Community and Office Employees on Safer Use of Computing Technology Equipment (Laptops, Desktops and Hand-held Devices)  
*Singh Jitendra Kumar*
50. Implementation of short passive and active breaks during simulated laparoscopic work  
*Luger Tessy*
51. Effect of telehealth program to office workers on knowledge, skills and on behavior: a secondary analysis of a cluster randomized controlled trial.  
*Padula Rosimeire Simprini*
52. The Workers Applied More for the Sick Days Secondary to Musculoskeletal Disorders in the Year of a Major Downsizing: An observed case report at a Korean manufacturing company  
*Yoon Jangwhon*
53. Lumbar disc surgery: is it only a sentinel event of spinal disease?  
*Fouquet Natacha*

#### 12:00-AM – 1:30 PM - PARALLEL SESSIONS

- **Symposium - Salone del Podestà**

- Effectiveness of interventions to prevent low back pain: insights from the field**

- Chair: Stefania Curti*

- Presenters: Henk van der Molen, Rahaman Shiri, Paul Kuijjer, Emma Irvin*

- **Effective interventions to prevent MSD (Session 6) - Sala Re Enzo**

- Chair: Minori Nakata*

Outcome of treatment of work-related myofascial pain syndrome using a sequenced interdisciplinary rehabilitation protocol

*Sharan Deepak*

Effectiveness of onsite occupational health clinics in management of work-related musculoskeletal disorders in information technology professionals

*Sharan Deepak*

Evidence Based Sustainable Interventions for Safer Working amongst Office Employees, Physicians and Paramedical Staff

*Madhwani Kishore P*

An on-line intervention tool for reducing musculoskeletal discomfort amongst individuals working with computers and laptops from home

*Madhwani Kishore P*

Integrated care for work participation among orthopaedic surgery patients – a systematic review with meta-analysis

*Coenen Pieter*

Comparisons of whole body vibration exposures and related musculoskeletal stress between single-axial passive and multi-axial active suspension in a mining vehicle application

*Kim Jay*

A Cochrane Review: Ergonomic interventions for preventing work-related musculoskeletal disorders of the upper limb and neck among office workers

*Victor CW Hoe*

- **Risk Assessment (Session 3) - Salone degli Atti**

- Chair: Lope H Barrero*

Reaction Parameters Linked to Cumulative Trauma Disorders during Use of Powered Tightening Tools: A Literature Review

*Mazaheri Ava*

A participative toolkit for workplace users to assess and control risk of musculoskeletal disorders (MSDs)

*Oakman Jodi*

Physical load of rescue workers during patient transport in stairwells

*Schiefer Christoph*

Motion-based estimation of back loading during manual material handling tasks

*Muller Antoine*

Low back pain risk assessment: combining trunk kinematic and electromyographic data through a deep learning neural network

*Delisle Alain*

Monitoring working activities with inertial and magnetic sensors in place of video cameras: what are the advantages?

*Ferrari Alberto*

In Vitro Fatigue of Human Flexor Digitorum Tendons

*Gallagher Sean*

**1:30-2:30 PM Lunch time & ICOH SC MSD Meeting**

**2:30 – 4:30 PM - PARALLEL SESSIONS**

● **Symposium - Salone del Podestà**

**Fatigue Manichaeism and Musculoskeletal disorders**

*Chair: Bernard J. Martin*

*Presenters: Karen Søgaard, Julie Coté, Marie Barbe, Sean Gallagher, Bernard J. Martin*

● **Work Ability (Session 2) - Sala Re Enzo**

*Chair: Andreas Seidler*

Alternations between physical and cognitive tasks – does temporal pattern and cognitive task difficulty influence fatigue development?

*Mixter Susanna*

Occupational and leisure time physical activity and multiple pain sites in construction and healthcare workers during 2-year follow-up

*Heggeland Marieke*

Mobile app for employees as intervention to provoke a healthy physical workstyle

*De Kraker Heleen*

What happens with ergonomics after relocation to a flex office?

*Wahlström Viktoria*

Working while working out – Using two types of dynamic office workstations (DOWs) with two intensities and the effects on tasks with various complexity

*Schellewald Vera*

Reasons for use and non-use of sit-stand workstations – results of a qualitative study among office workers with long-term access to sit-stand workstations

*Huysmans Maaïke*

Implementation of Ergonomic Intervention on Some Unorganized Sectors Workplaces at India

*Ghosh Tirthankar*

Inclusion of HFE Principles in the Development of a National Design Standard for Ambulances

*Yazdani Amin*

Inventory cost model with rest allowance based on effects of heat strain and metabolic cost

*Korkulu Sezen*

- **Risk Assessment (Session 4) - Sala degli Atti**

*Chair: Yves Roquelaure*

Proposal for an integrated multi-method holistic approach for risk assessment (and management) of biomechanical overload on the musculoskeletal system in healthcare workers of a large Italian University Hospital

*Sala Emma*

The Composite Strain Index (COSI) to evaluate the wrist's biomechanical overload in the milking routine: the example of the Italian dairy sector

*Masci Federica*

Novel instrumentation for measuring hand effort through pressure mapping and contact forces during actual task performance

*Jae Son*

A wearable system for automated assessment of Hand Activity Level - a pilot study

*Forsman Mikael*

A smart hand-wrist risk assessment method

*Forsman Mikael*

Narrative review of risk assessment methods applied in the agricultural setting for the prevention of musculoskeletal disorders

*Ilaria Denti Pompiani*

Ergonomic Risk Assessment and Process Efficiency in the Craft Brewing Industry: A Pilot Study

*Hancock Kyle*

Prevalence of musculoskeletal pain in children and youth in rural work and associated factors

*Modernel Xavier Daiani*

Manual force assessment using wearable pressure sensors: a case study

*Graziosi Francesca*

Use of Virtual Workplace Models and Predetermined Time Systems for Analysis of Work Loads

*Bonfiglioli Roberta*

#### 4:30-6:00 PM - PARALLEL SESSIONS

- **Symposium - Sala Re Enzo**

**Low Back Pain – Occupational and clinical aspects**

*Chair: Shlomo Moshe*

*Presenters: Shlomo Moshe, Ayala Krakov, Darya Levy Barak, Yael Sahar-Kostis, Yair Barak*

- **Symposium - Salone del Podestà**

**Beyond CTS: Findings on other health outcomes in recent large cross sectional and prospective studies**

*Chair: Carisa Harris*

*Presenters: Alysha R Meyers, Carisa Harris, Stephen Bao, David H. Seidel, Roberta Bonfiglioli*

- **Effective interventions to prevent MSD (Session 7)- Sala degli Atti**

*Chair: Dongmug Kang*

Telehealth with Extended Care to promote the quality of life of office workers: a cluster randomized controlled trial

*Padula Rosimeire Simprini*

Adherence of office workers to active and passive pauses at workplace

*Padula Rosimeire Simprini*

Design of a return-to-work program to improve productivity and reduce recurrence: Back Pain Case

*Lope H. Barrero*

Reducing MSD risk in the aged care sector using multi-factorial evidence-based interventions

*Rothmore Paul*

A Cochrane Review about the effectiveness of work breaks for preventing musculoskeletal symptoms  
*Luger Tessa*

Do high adherence to job rotation results in positive effects on the musculoskeletal symptoms, occupational risk factors perception and job satisfaction?  
*Comper Maria Luiza Caires*

Impact of Secondary Intervention on Musculoskeletal Disorder Development, Systemic Inflammation and Sensorimotor Behavioral Declines in A Rat Model  
*Barbe Mary*

## Thursday 5<sup>th</sup> September

8:00 AM - REGISTRATION OPENS

8:30-9:15 AM - PLENARY SESSION - **Salone del Podestà**

### Keynote

**When and how to think about sex/gender during an ergonomic intervention**

*Karen Messing - Professeure émérite, Département des sciences biologiques et chercheure, centre de recherche CINBIOSE, UQAM Université du Québec, Montréal - Canada*

9:15-10:00 AM - PLENARY SESSION - **Salone del Podestà**

### Special Session

**Exposure level assessment for causal attribution of MS diseases and Occupational Exposure Limits to prevent MS diseases and disorders.**

*Francesco Violante - Professor of Occupational medicine - Department of Medical and Surgical Sciences, University of Bologna, Italy*

10:00–10:30 AM Coffee break

10:30-12:00 AM - PARALLEL SESSIONS

- **Symposium - Salone del Podestà**

**Developing International Criteria for Work-Related Musculoskeletal Diseases: An Initiative of the Committee on Work-related Musculoskeletal Disorders of ICOH**

*Chair: Roberta Bonfiglioli*

*Presenters: David Rempel, Karen Walker-Bone, Alexis Descatha, Andreas Seidler, Paul Kuijer*

- **MS Work Disability (Session 2) - Sala Re Enzo**

*Chair: Adriano Papale*

Which workers in France are at high risk of long-term work absence due to work-related musculoskeletal disorders?

*Chazelle Emilie*

Individual Placement and Support as a model of vocational rehabilitation for patients unemployed with chronic pain: A feasibility programme

*Catherine Linaker*

Effects of an early multidisciplinary intervention on sickness absence in patients with persistent low back pain - a randomized controlled trial

*Mortensen Ole*

Prevalence of sickness absenteeism and presenteeism due to musculoskeletal disease in manufacturing workers

*Comper Maria Luiza Caires*

Prevalence of musculoskeletal complaints in minimal invasive surgery

*Steinhilber Benjamin*

Future work ability is not regularly discussed with their general practitioner by patients suffering from musculoskeletal disorders – results of a survey among patients of a German population-based integrated healthcare model

*Rieger Monika A*

Definition of work disability from shoulder pain in a large French population

*Godeau Diane*

Musculoskeletal disorders in children due to overuse of electronic devices: Risk factors and clinical features

*Sharan Deepak*

● **Occupational Exposure Limits (Session 1) - Sala degli Atti**

*Chair: Svend Erik Mathiassen*

Lifestyle risk factors in the incidence and prognosis of chronic pain

*Shiri Rahman*

Time-use composition of physical behaviors at work and sick leave trajectories due to musculoskeletal pain

*Hallman David*

Predictive equations for initial horizontal hand forces when pushing or pulling trolleys based on trolley weight

*Douwes Marjolein*

Improved Planning for Active Pauses during Computer Work via Ocular Biofeedback

*Samani Afshin*

Concordance between exposure to physical factors in the Italian and the US O\*NET database

*D'Errico Angelo*

How does heavy physical workload effect the progression of musculoskeletal pain? A cohort study of Swedish workers with pre-existing occasional pain

*Badarin Kathryn*

Prevalence and risk factors for musculoskeletal disorders in South African workers

*Nyantumbu-Mkhize Busisiwe*

**POSTER SESSION (Poster listed by identification number) - Sala del Quadrante**

*Chair: Francesca Graziosi*

54. The relationship between sustained inflammation and work-related upper limb disorders - preparation of a cohort study

*Läubli Thomas*

55. Associations of objectively measured forward bending at work with low-back pain intensity: a 2-year follow-up study of construction and healthcare workers

*Veiersted Kaj Bo*

56. Sitting dynamics are age-dependent during computer work

*Madeleine Pascal*

57. Change of Musculoskeletal symptoms and working condition in a car part assembling factory during 2004 ~ 2016

*Kang Dongmug*

58. A Mixed Methods Analysis of Farm Machinery Injury: Contributing Factors and Proposed Prevention Strategies

*Trask Catherine*

59. Musculoskeletal disorders risk factors among Ophthalmologists in the operating theatre

*Lee Lay Tin*

60. Reliability of an observation protocol for foot motion assessment in a palletizing task

*Vallée Marcotte Jasmin*

61. Can productive manufacturing layouts influence of the pauses and worker's health?

*Negreiros Alexandher*

62. Risk factors for work related musculoskeletal disorders in information technology professionals

*Sharan Deepak*

63. A holistic approach to a disability management program in Occupational Health management  
*Van Niekerk Catherine Sarah*
64. Correct identification of health promotion awareness to facilitate return to work  
*Minnie Denise*
65. The my relief project: a european online education programme for older workers with chronic low back pain  
*Cibelli Anna*
66. Why Workers Hesitate to Report Their Work-Related Musculoskeletal Disorders: A survey at a Korean manufacturing company  
*Yoon Jangwhon*

## 12:00 AM-1:00 PM - PARALLEL SESSIONS

### ● Symposium - Salone del Podestà

#### Musculoskeletal Injuries amongst Firefighters

*Chair: Joy C MacDermid*

*Presenters: Joy C MacDermid, Kathryn Sinden, Susan Stock*

### ● Risk Assessment (Session 5) - Sala Re Enzo

*Chair: Sean Gallagher*

Ergonomic risk assessment for work related musculoskeletal disorders in an orthopedic surgery team  
*Sharan Deepak*

Working in cold environments and chronic pain lasting  $\geq 3$  months, a cross-sectional study from The Tromsø Study 6  
*Farbu Erlend*

Non-explicit observational method is reproducible and valid for the analysis of occupational biomechanical exposure of workers  
*Valentim Daniela P*

Direct assessment of net spinal moments in subjects wearing a passive exoskeleton for trunk support in stooped working pose  
*Baten Chris*

### ● Ageing, MS Health and Work and Work Ability (Session 2) - Sala degli Atti

*Chair: Dwayne van Eerd*

Dose-response relationship between cumulative physical workload and osteoarthritis of the hip – a meta-analysis applying an external reference population for exposure assignment  
*Andreas Seidler*

Opioids prescribed to manage musculoskeletal pain often lead to opioid use disorder among construction workers  
*Dale Ann Marie*

Patterns in concurrent low back and neck/shoulder pain among eldercare workers - A one-year longitudinal study with 4-weeks measurements  
*Søgaard Karen*

The profile of people working in the social care sector in a cohort of 50-64 year-olds: results from the Health and Employment After Fifty (HEAF) study  
*D'Angelo Stefania*

Work-Related Musculoskeletal Disorders among Older Construction Workers in the United States  
*Dong Xiuwen Sue*

## 1:00-1:30 PM Concluding remarks & closing ceremony - Salone del Podestà

# Special Sessions





## MSD AMONG IMMIGRANT WORKERS AND AGEING, MS HEALTH AND WORK

### Work-related musculoskeletal disorders preventive program on New York City vulnerable Immigrant working population: A Clinic / University - community participatory collaboration.

*[Acran Salmen Navarro](#)*

Worldwide, nearly 200 million individuals migrate annually across national borders, an increase of 144% in the past 40 years. In 2017 there were over 250 million people living in a country other than their country of birth – an increase of 49% since 2000. More than 60% of these migrants move from developing to developed countries seeking better employment and economic opportunities (Global Conference of International Migration, 2005)

During their initial years in the receiving country, many immigrants experience occupational downgrading which occurs when there is a loss of occupational status or prestige between one's last job in the country of origin and first job in the receiving country. Often, immigrants are undervalued; having limited job opportunities that match their actual skills and educational level and this has a direct effect on their occupational health. Workers who are forced to migrate because of war, political or economic reasons carry an additional psychosocial factor from home, over and above the new challenges they will face in the foreseeable future, first while migrating and then in the receiving country (Crollard et al, 2012)

Work is a principal driver of current international migration, a primary social determinant of health, and a fundamental point of articulation between migrants and their host society. However, immigrants and migrants do not necessarily encounter better working conditions in their receiving countries. In fact, immigrants and migrants are frequently faced with precarious work environments, lacking in basic occupational health rights and working conditions (Schenker, 2010)

Efforts by international organizations to promote migrant health have traditionally focused on infectious diseases and access to healthcare, while international labor organizations have largely focused on issues of occupational health. The under-utilization of the domain of work in addressing the health of migrants is truly a missed opportunity for influencing worker well-being and reducing societal economic burden. In fact, research has shown the legal, socioeconomic and professional hierarchy status of migrant workers arriving in the US to be superior, in many cases, to that of their US-born counterparts, but that this health advantage may deteriorate over time (Garcini et al, 2018)<sup>4</sup>. An understanding of the relationships among migration, work, and health would facilitate further integration of migrant health concerns into the policy agenda of governments and international agencies that work at the nexus of labor, health and development (Flynn and Wickramage, 2017)

New York City has 3.3 million foreign-born immigrants, from more than 150 countries, who comprise nearly 40% of the City population. It is estimated that over 300 thousand are undocumented. Immigrants are employed at the same rate as U.S.-born New Yorkers and they work as many or more hours per week, as well as more weeks per year, compared to U.S.-born New Yorkers. The populations served by our clinic, The Bellevue / NYU Occupational and Environmental Medicine Clinic (BNOEMC) at Bellevue Hospital, the main hospital of NYC's public Health and Hospital System, include mostly

these low-income uninsured and underinsured immigrant working. The population, who are frequently at high risk for occupational diseases and injuries, are often overlooked and underprioritized as low-income working populations. The focus particularly emphasizes in the preventive approaches of Work-related musculoskeletal disorders that are particularly common and disabling in our patient population, which enables us to collaborate with other Bellevue clinics including rehabilitation, hand, orthopaedics, occupational and physical therapy and the emergency department to identify, diagnose and treat patients with work-related musculoskeletal disorders. Considering the difficulty to access workplaces, The BNOEMC has created a participatory model working synergistically in collaboration with community organizations, unions and proactive employers. In addition to a participatory city-wide train the trainer program and an ergonomic simulation lab, which will allow safe and accurate assessment to help us understand the detailed biomechanics of the physical activities believed to have caused or aggravated a Work-related Musculoskeletal Disorder in our patients. This understanding has allowed us to better design and communicate our recommendations for workplace modifications and to enable safe return to work, focusing on creating an inclusive preventive program and a sustained preventive culture.

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## Do work exposures help explain musculoskeletal disorder work absence health inequalities?

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**Background:** Musculoskeletal health inequalities are hypothesized to arise partly through exposure of low socioeconomic status (SES) groups to adverse working conditions. We sought to document such inequalities and test this hypothesis in a representative sample of workers in Québec, Canada.

**Methods:** Study population was workers  $\geq 15$  years, working  $\geq 15$  hours weekly from the 2014-15 Québec Population Health Survey (12,040 men; 12,271 women). In gender-stratified analyses, we evaluated the relationship between various SES indicators or immigrant status and non-traumatic work-related musculoskeletal disorder (WMSD) work absence using multivariable logistic regression, controlling for personal factors. The role of work exposures in the SES-WMSD relationship was assessed by evaluating changes in its magnitude when work exposures were added to regression models.

**Results:** In men and women, the likelihood of WMSD-related work absence was 77% and 49% higher, respectively, in those perceiving themselves as poor compared to those financially at ease, and 60% and 44% higher, respectively, in male and female immigrant workers. In men, likelihood of WMSD-related work absence was also higher in those in manual or mixed occupations, of lower socio-occupational class and with lower education. When adjusted for physical and organisational work exposures, the relationship between perceived poverty and WMSD-related work absence was diminished by up to 35% in men and 25% in women, primarily related to the effect of low work rewards and/or high physical demands. Adjustment for these exposures diminished the relationship between immigrant status and WMSD-related work absence by 11% in each gender. Physical work demands largely explained the increased likelihood of WMSD-related work absence in men in manual occupations (relation diminished 44%).

**Conclusions:** Social inequalities in musculoskeletal work absence were partly explained by adverse working conditions. Public policies that promote preventive interventions targeting working conditions in vulnerable populations could contribute to diminishing the burden of WMSD work absence.

## Multisite musculoskeletal pain in migrants from the Indian subcontinent to the UK: A cross-sectional survey

*Georgia Ntani<sup>1,2</sup>; Emanuele Rizzello<sup>3</sup>; Ira Madan<sup>4</sup>; Karen Walker-Bone<sup>1,2</sup>; David Coggon<sup>1,2</sup>*

*<sup>1</sup>MRC, Lifecourse Epidemiology Unit, University of Southampton, Southampton, United Kingdom; <sup>2</sup>Arthritis Research UK/MRC Centre for Musculoskeletal Health and Work, Southampton, United Kingdom; <sup>3</sup>Department of Medical and Surgical Sciences (DIMEC), University of Bologna, Bologna, Italy; <sup>4</sup>Guy's and St Thomas' NHS Foundation Trust, London, United Kingdom*

**Background:** We aimed to explore whether the prevalence of multisite pain changes when people migrate between countries with differing rates of symptoms; and if so, whether the change is apparent in first generation migrants, and by what age it becomes manifest.

**Methods:** We analysed data from an earlier cross-sectional survey, which assessed the prevalence of musculoskeletal pain and risk factors in six groups of workers distinguished by the nature of their work (non-manual or manual) and their country of residence and ethnicity (UK white, UK of Indian subcontinental origin and Indian in India). Effect estimates were summarised by prevalence odds ratios (ORs) with 95% confidence intervals (CIs).

**Results:** Among 814 participants (response rate 95.4%), 20.6% reported pain at  $\geq 3$  anatomical sites. This outcome was much less frequent in Indian manual workers than among white non-manual workers in the UK (adjusted OR 0.06, 95%CI 0.01-0.36), while rates in Indian non-manual workers were intermediate (OR 0.29, 95%CI 0.12-0.72). However, within the UK, there were only small differences between white non-manual workers and the other occupational groups, including those of Indian subcontinental origin. This applied even when analysis was restricted to participants aged 17 to 34 years, and when second and later generation migrants were excluded

**Conclusions:** Our findings suggest that whatever drives the higher prevalence of musculoskeletal pain in the UK than India is environmental rather than genetic, affects multiple anatomical sites, begins to act by fairly early in adult life, and has impact soon after people move from India to the UK.



## EXPOSURE LEVEL ASSESSMENT FOR CAUSAL ATTRIBUTION OF MSD

### Exposure level assessment for causal attribution of MS diseases and Occupational Exposure Limits to prevent MS diseases and disorders.

*Francesco Violante - Professor of Occupational medicine - Department of Medical and Surgical Sciences, University of Bologna, Italy*

**Background:** A wide variation exists in national statistics about occupational musculoskeletal diseases, more than in any other area of medical statistics. This is due to the sum of four uncertainties:

- variability in the case definitions of the diseases, lacking a uniform, objective, “gold standard”;
- variability in the definition of “what is the exposure”;
- variability in the measure of exposure, which is performed mostly with subjective observation;
- uncertainty in the exposure-effect relationship, which is the sum of the above uncertainties.

**Exposure levels for causal attribution of musculoskeletal diseases:** Causal attribution of musculoskeletal diseases to occupational exposure occurs at two levels: population and individual. The two levels, usually, use different criteria: at the population level the “de facto” standard are the Hill’s viewpoints, whereas at the individual level no standard exist, especially for dealing with the interaction between occupational and personal risk factors (co-causation).

**Occupational exposure limits to prevent musculoskeletal diseases and disorders:** Given the above uncertainties, it is not a surprise that no widely accepted occupational exposure limit exists for the variety of factors which are grouped under the umbrella term of “biomechanical risk factors”. As noted many years ago, we can recognize with sufficient accuracy exposures which are associated with high risk or minimal risk (if any). In between there is a wide “grey zone” in which we cannot define, with sufficient accuracy, a safe limit.

An additional issue is that, conceptually, the exposure-response relationship between biomechanical risk factors and diseases is U-shaped: that is, below certain level of “exposure” there is a risk as above higher levels.

**Guidelines:** The special session will give an overview of the available evidence and will offer practical advice to deal with current uncertainties.

# Symposia





## Newly developed and redesigned key indicator methods for assessment of different working conditions with physical workloads. Aspects of background, objectivity, reliability and validity.

### Symposium Organizer

*André Klusmann, Institute ASER Wuppertal; HAW Hamburg, Germany*

### List of Presenters

*Klusmann André, Institute of Occupational Health, Safety and Ergonomics (ASER) in Wuppertal; University of Applied Sciences (HAW) in Hamburg*

*Liebers Falk, Federal Institute for Occupational Safety and Health (BAuA) in Berlin  
Seraphin Patrick, Institute of Occupational Health, Safety and Ergonomics (ASER) in Wuppertal*

*Schust Marianne, Federal Institute for Occupational Safety and Health (BAuA) in Berlin*

*Hartmann Bernd, ARBMEDERGO Consulting, Hamburg  
Gebhardt Hansjürgen, Institute of Occupational Health, Safety and Ergonomics (ASER) in Wuppertal*

*Klusmann André, Institute of Occupational Health, Safety and Ergonomics (ASER) in Wuppertal; University of Applied Sciences (HAW) in Hamburg*

### Symposium abstract

**Introduction:** The impact of work-related musculoskeletal disorders is considerable. The assessment of work tasks with physical workloads is crucial to estimate the work-related health risks of exposed employees. The aim of this study was to develop and provide a set of validated methods for risk assessment of physical workload. The development and validation of the six screening methods was part of the joint project MEGAPHYS (multilevel risk assessment of physical workloads). The three already existing key indicator methods (KIM) for risk assessment regarding manual lifting, holding and carrying of loads; manual pulling and pushing of loads; and manual handling operations were adapted and renewed. Three further KIMs for risk assessment regarding whole-body forces, awkward body postures and body movement have been developed de novo.

**Methods:** All methods were validated regarding face validity, reliability, convergent validity, criterion validity and aspects of utility under practical conditions. A mixed-methods study was designed including, among others: application testing of the methods with company practitioners and a cross sectional study in companies of different sizes and branches in Germany. Workplaces were documented and analysed by observations, applying KIMs, interviews and assessment of environmental conditions. Furthermore, a survey among the employees at the respective workplaces took place with standardised questionnaires, interviews and physical examinations. The design of the study was described a-priori in study protocol (see <https://bmjopen.bmj.com/content/7/8/e015412.long>) and approved by ethics committees.

**Results:** 808 employees at 192 workplaces could be included in the cross sectional study and more than 1,600 work task evaluations have been carried out during the application testing by 85 potential users of the methods. The symposium will present

methodological background information and the design of the six new KIMs. The design of the field study will be described and the main results regarding the quality criteria will be provided.

## The draft of the new key indicator method “manual handling operations” (KIM MHO): Aspects of background, objectivity and reliability.

*André Klussmann, Patrick Serafin, Andreas Schäfer, Hansjürgen Gebhardt, Bernd Hartmann, Falk Liebers, Felix Brandstädt, Marianne Schust*

**Introduction:** Aim is to describe background of development of KIM MHO and selected results of testing of quality criteria objectivity, inter- and intra-reliability, as mentioned in the symposium summary above.

**Methods:** For testing of the quality criteria mentioned above, workshops were conducted with 12 participants (potential practitioners of methods). In each case, 10 work tasks were assessed (video-analysis). This evaluation was repeated 4 weeks later. A total number of  $2 \times 120 = 240$  assessments were executed. All 10 work-tasks were also assessed by experts (reference). For reliability, Intra-Class Correlation Coefficients (ICC, 2-way-random, absolute agreement, single) and for objectivity, weighted kappa were calculated as measures of compliance of KIM risk categories (RC).

**Results:** Objectivity: Experts and 12 participants agree in the same RC in 77 out of 120 cases (64%) ( $\kappa$ : .400 [.279-.521],  $p < .001$ ). Inter-rater reliability: Participants agree in the same RC in 90 out of 120 cases (75%) (ICC: 0.628 [.416-.856],  $p < .001$ ). Intra-rater reliability: In 93 out of 119 valid cases (78%), participants agree in the same RC as the first survey (ICC: .807 [.734-.862],  $p < .001$ ).

**Discussion:** The quality of KIM MHO according to the criteria tested could be regarded as good to satisfactory. Further development and testing is required.

## The draft of the new key indicator method “manual handling operations” (KIM MHO): Aspects of criterion validity.

*Falk Liebers, Patrick Serafin, Andreas Schäfer, Hansjürgen Gebhardt, Bernd Hartmann, Felix Brandstädt, Marianne Schust, André Klussmann*

**Introduction:** Aim of this presentation is to provide the methodological approach of the field study mentioned in the symposium abstract above and to describe the criterion validity regarding the prevalence of symptoms and WRULD of the renewed KIM MHO, version 2017.

**Methods:** Criterion validity was assessed regarding the risk categories (RC) of KIM MHO: RC0/1 – no or low risk (reference), RC2 - increased risk, RC3 - highly increased risk, or RC4 - high risk. Robust log-linear Poisson regression models were applied to obtain adjusted prevalence ratios (PR).

**Results:** In total 192 workplaces and 808 employees (age: 41.1[11.4] years, 15.5% women) could be included. KIM MHO was applied to 151 workplaces: 61 in RC0/1, 10 in RC2, 50 in RC3 and 30 in RC4, respectively 598 employees. Increase of 4-week-prevalence of symptoms of the hand/wrist region related to the assessed risk due to MHO could be proven: RC0/1: 1 (Ref., prevalence 14.0% [7.9%-24.8%]); RC2: PR 1.46 (0.61-3.50), RC3: PR 1.97 (1.16-3.36), RC3: PR 2.41 (1.50-3.86). This is also valid for symptoms in the elbow region and clinical conditions of the hand/wrist and elbow region.

**Discussion:** KIM MHO criterion validity could be regarded as good as the former version from 2011.

## The draft of the new draft key indicator method “manual lifting, holding and carrying loads” (KIM LHC): Aspects of background, objectivity, reliability and criterion validity.

*Patrick Serafin, André Klussmann, Andreas Schäfer, Hansjürgen Gebhardt, Bernd Hartmann, Felix Brandstädt, Marianne Schust, Falk Liebers*

**Introduction:** Aim is to describe background of development of KIM LHC and selected results of testing of quality criteria objectivity, inter- and intra-reliability, as mentioned in the symposium summary above.

**Methods:** See descriptions in the abstracts above.

**Results:** KIM LHC was applied to 173 workplaces: 59 in RC0/1, 27 in RC2, 39 in RC3 and 48 in RC4, respectively 710 employees. A significant increase of 4-week-prevalence of symptoms of the upper back region related to the assessed risk due to LHC could be proven: RC0/1: 1 (Ref., prevalence 6.0% [2.9%-12.2%]); RC2: PR 1.51 (0.76-2.99), RC3: PR 1.92 (0.95-3.88), RC4: PR 2.66 (1.32-5.32). Objectivity: Experts and 7 participants agree in the same RC in 90 out of 98 cases (92%) ( $\kappa$ : .879 [.804-.944],  $p < .001$ ). Inter-rater reliability: Participants agree in the same RC in 90 out of 98 cases (92%) (ICC: .880 [.776-.952],  $p < .001$ ). Intra-rater reliability: In 90 out of 95 valid cases (95%), participants agree in the same RC as the first survey (ICC: .941 [.913-.960],  $p < .001$ ).

**Discussion:** The quality of KIM LHC according to the criteria tested is good to satisfying. Limitations of study population and range of observed LHC have to be discussed. Further development and testing is required.

## The draft of the new key indicator method for “manual pushing and pulling of loads” (KIM PP): Aspects of background, objectivity, reliability and criterion validity.

*Marianne Schust, Patrick Serafin, André Klussmann, Andreas Schäfer, Hansjürgen Gebhardt, Falk Liebers, Bernd Hartmann, Felix Brandstädt*

**Introduction:** Aim is to describe background of development of KIM PP and selected results of testing of quality criteria objectivity, inter- and intra-reliability, as mentioned in the symposium summary above.

**Methods:** See descriptions in the abstracts above.

**Results:** KIM PP was applied to 173 workplaces: 110 in RC0/1, 38 in RC2, 20 in RC3 and 5 in RC4, respectively 710 employees. Increase of 4-week-prevalence of symptoms of the lumbar back region related to the assessed risk due to PP could be proven: RC0/1: 1 (Ref., prevalence 24.2% [17.2%-34.0%]); RC2: PR 1.19 (0.83-1.70), RC3: PR1.52 (1.13-2.04), RC4: NA due to small sample size). Objectivity: Experts and 6 participants agree in the same RC in 68 out of 78 cases (87%) ( $\kappa$ : .850 [.767-.933],  $p < .001$ ). Inter-rater reliability: Participants agree in the same RC in 70 out of 78 cases (90%) (ICC: .856 [.728-.945],  $p < .001$ ). Intra-rater reliability: In 67 out of 78 cases (86%), participants agree in the same RC as the first survey (ICC: .866 [.775-.918],  $p < .001$ ).

**Discussion:** The quality of KIM PP according to the criteria tested is good to satisfying. Limitations of study population and range of observed PP have to be discussed. Further development and testing is required.

## The draft of the new key indicator method “awkward body postures” (KIM ABP): Aspects of background, objectivity, reliability and criterion validity.

*Bernd Hartmann, Patrick Serafin, André Klussmann, Andreas Schäfer, Hansjürgen Gebhardt, Falk Liebers, Felix Brandstädt, Marianne Schust*

**Introduction:** The KIM ABP determines risks separately for back (standing, sitting upright or bending forward), upper extremities (raised arms / hands, below / above shoulder height ) and lower extremities (kneeling, squatting, permanent standing). Aim is to describe the background of development and selected results of testing (objectivity, inter- / intra-rater-reliability) as in the symposium summary.

**Methods:** See descriptions in the abstracts above.

**Results:** KIM ABP was applied to 173 workplaces: 156 in RC0/1, 1 in RC2, 7 in RC3 and 9 in RC4, respectively 710 employees. Increase of prevalence of symptoms of the target regions were found only in small amount. Objectivity: Experts and 5 participants agree in the same RC in 65 out of 70 cases (93%) ( $\kappa$ : .883 [.782-.985],  $p < .001$ ). Inter-rater reliability: Participants agree in the same RC in 68 out of 70 cases (97%) (ICC: .931 [.861-.974],  $p < .001$ ). Intra-rater Reliability: In 67 out of 70 cases (96%), participants agree in the same RC as the first survey (ICC: .946 [.914-.966],  $p < .001$ ).

**Discussion:** The quality of KIM ABP according to the criteria tested is good to moderate. Limitations of study population and range of observed ABP have to be discussed. Further development and testing is required.

## The draft of the new key indicator method “body movement” (KIM BM): Aspects of background, objectivity, reliability and criterion validity.

*Hansjürgen Gebhardt, Patrick Serafin, Andreas Schäfer, Bernd Hartmann, Falk Liebers, Felix Brandstädt, Marianne Schust, André Klussmann*

**Introduction:** Aim is to describe background of development of KIM BM and selected results of testing of quality criteria objectivity, inter- and intra-reliability, as mentioned in the symposium summary above.

**Methods:** See descriptions in the abstracts above.

**Results:** KIM BM was applied to 173 workplaces: 132 in RC0/1, 11 in RC2, 22 in RC3 and 8 in RC4, respectively 710 employees. As expected increase of 4-week-prevalence of symptoms related to the assessed risk due to BM could only be proven for hip region: RC0/1: 1 (Ref., prevalence 3.1% [1.2%-8.3%]); RC2: PR 0.23 (0.02-2.25), RC3: PR 2.38 (1.02-5.57), RC4: PR 1.51 (0.52-4.43). Objectivity: Experts and 6 participants agree in the same RC in 70 out of 78 cases (90%) ( $\kappa$ : .886 [.811-.960],  $p < .001$ ). Inter-rater reliability: Participants agree in the same RC in 70 out of 78 cases (90%) (ICC: .883 [.771-.956],  $p < .001$ ). Intra-rater reliability: In 66 out of 78 cases (85%), participants agree in the same RC as the first survey (ICC: .887 [.829-.927],  $p < .001$ ).

**Discussion:** The quality of KIM BM according to the criteria tested is good to satisfying. Limitations of study population and range of observed BM have to be discussed. Further development and testing is required.

## The draft of the new key indicator method “whole body forces” (KIM BF): Aspects of background, objectivity, reliability and criterion validity

*André Klussmann, Patrick Serafin, Andreas Schäfer, Hansjürgen Gebhardt, Bernd Hartmann, Falk Liebers, Felix Brandstädt, Marianne Schust*

**Introduction:** Aim is to describe background of development of KIM BF and selected results of testing of quality criteria objectivity, inter- and intra-reliability, as mentioned in the symposium summary above.

**Methods:** See descriptions in the abstracts above.

**Results:** KIM BF was applied to 172 workplaces: 126 in RC0/1, 17 in RC2, 4 in RC3 and 25 in RC4, respectively 702 employees. An increase of 4-week-prevalence of symptoms related to the assessed risk due to BF could only be proven for hip region: RC0/1: 1 (Ref., prevalence 3.1% [1.2%-8.3%]); RC2: PR 0.28 (0.02-3.71), RC3: NA due to small sample size, RC3: PR 3.06 (1.27-7.35). Objectivity: Experts and 6 participants agree in the same RC in 64 out of 96 cases (67%) ( $\kappa$ : .622 [.499-.745],  $p < .001$ ). Inter-rater reliability: Participants agree in the same RC in 78 out of 96 cases (81%) (ICC: .782 [.593-.922],  $p < .001$ ). Intra-rater reliability: In 65 out of 96 cases (72%), participants agree in the same RC as the first survey (ICC: .665 (.532-.766),  $p < .001$ ).

**Discussion:** The quality of KIM BF according to the criteria tested is good to satisfying. Limitations of study population and range of observed BF have to be discussed. Further development and testing is required.



## Ergonomic Assessment Work-Sheet (EAWS): structure, application and validation in the industrial sector

### Symposium Organizer

*Gabriele Caragnano, Partner PwC Italy, Operations, Milan, Italy - Technical Director Fondazione Ergo, Varese, Italy*

### Co-Organizer

*Roberta Bonfiglioli, MD, Associate Professor of Occupational Medicine, Department of Medical and Surgical Sciences, University of Bologna*

### List of Presenters

*(Chair) Gabriele Caragnano, Partner PwC EMEA Operations Leader, Milan, Italy and Technical Director Fondazione Ergo, Varese, Italy*

*Fabrizio Caruso, Senior Manager, PwC, Milano Italy – EAWS Operations Manager*

*Prof. Roberta Bonfiglioli, MD, Department of Medical and Surgical Sciences, University of Bologna, Italy*

*Lidia Ghibaudò, MP&C – DMA&E – Methods, Innovation & Virtual Ergo, FCA Group, Torino Italy*

*Martin Haselhuhn, Senior Manager Group Industrial Engineering, Volkswagen, Wolfsburg, Germany*

### Symposium abstract

Musculoskeletal disorders are among the largest contributors to disability worldwide affecting people across the life-course. Risk identification and design of interventions to reduce the rates of work-related musculoskeletal disorders need to be based on valid and reproducible methods.

The Ergonomic Assessment Work-Sheet (EAWS) is a **global standard** for the design of safe work methods, risk assessment and the prevention of biomechanical overload, mostly used in the industrial manufacturing sector. EAWS is a **comprehensive model, assessing the key risk factors on a unique scale** (body postures, forces, manual material handling of loads and repetitive motions of the upper limbs), designed to be connected with the most used predetermined time system (MTM) and to **drive productivity improvement initiatives**. A longitudinal validation study of EAWS is ongoing and the first preliminary results will be shared. ISO standards dealing with biomechanical load have clear limitations in the practical application on industrial manufacturing processes, due to the high level of complexity generated by the modern production systems. To make the ergonomic risk evaluation more accurate and reliable it is imperative to connect the ergonomic approach with advanced industrial engineering techniques. To improve the effectiveness of WMSDs prevention, it is fundamental to integrate the risk evaluation in the product and process design phase.

FCA and VW will present their global best-in-class examples of comprehensive integrated approaches to work design and ergonomics.

### Symposium structure

The first 3 presentations will set the scene and analyse the complexity of the application of ISO standards dealing with biomechanical load in the industrial manufacturing sector and propose an innovative approach to ergonomic risk evaluation (EAWS):

## How effective are the current ISO standards on work-related musculoskeletal disorders (WMSD) in the Industrial Manufacturing sector?

*Gabriele Caragnano*

ISO standards dealing with biomechanical load have clear limitations in the practical application on industrial manufacturing processes, due to the **high level of complexity** generated by the modern production systems. To make the ergonomic risk evaluation more accurate and reliable it is imperative to **connect the ergonomic approach with advanced industrial engineering techniques**. To improve the effectiveness of WMSDs prevention, it is fundamental to **integrate the risk evaluation in the product and process design phase**.

## EAWS (Ergonomic Assessment Work-Sheet) global standard in the industrial manufacturing sector

*Fabrizio Caruso*

EAWS is a **global standard** for the design of safe work methods and the risk assessment and prevention of biomechanical overload, mostly used in the industrial manufacturing sector. It is a **comprehensive model, assessing the key risk factors on a unique scale** (body postures, forces, manual material handling of loads and repetitive motions of the upper limbs), designed to be connected with the most used predetermined time system (MTM) and **drive productivity improvement initiatives**.

## Validation through longitudinal epidemiological study of the EAWS system for the assessment and prevention of biomechanical overload: baseline preliminary results

*Prof. Roberta Bonfiglioli*

The validity of the EAWS system is assessed by means of a cohort study carried out in a large manufacturing company. Independent researchers, blinded to each other, collected job exposure data using EAWS and health outcomes through a structured interview and a standardized questionnaire administered by an occupational physician. Symptomatic subjects underwent physical examination according to symptoms distribution. Workers demographics (e.g., age, gender, handedness, etc.), sports and hobbies, family and personal medical history as well as working history were collected. Preliminary results are presented. The baseline cohort is composed by 1357 subjects (938 manual workers and 419 clerks/non-manual workers). Data are analysed to estimate the prevalent cases of disorders and/or diseases affecting the musculoskeletal system in workers employed in manual tasks compared to non-manual jobs. The study is ongoing, results will shed lights on the validity of the EAWS system in the prevention of musculoskeletal disorders and on the multifactorial origin of these health outcomes.

The last 2 presentations will give 2 global best-in-class examples of comprehensive integrated approaches to work design and ergonomics in the automotive sector:

## **Organization, systems and techniques for the prevention of ergonomic risk in the FCA factories – Fiat Chrysler Automobiles**

*Lidia Ghibardo*

In recent years, cars' concept and manufacturing have been subject to radical changes due to market requirements and the new idea of smart factories. Industry 4.0 strengthened the trend of a strong customization of products under the conditions of highly flexible mass production. OEMs have had to improve technologies and automation by the introduction of more flexible assembly chains, manufacturing services and methods of job planning and intelligent support for workers in their increasingly complex work. Ever before, a human centered approach is required in all phases of a product development process in a smart factory.

Fiat Chrysler Automobile will present the approach implemented to fulfill these challenges, based on the integration of digital simulation techniques, holistic ergonomics assessment method, EAWS, and the ErgoUAS system for the ergonomic optimization of manual tasks and the line balancing.

This approach allows to manage critical issues and to optimize biomechanical overload and line balancing in the earlier phases.

## From Data Manager to Work Designer – Importance of EAWS in changing the IE professional family at Volkswagen – Volkswagen

*Martin Haselhuhn*

Increasing productivity, cost pressure and digitization and structural changes have a lasting impact on the Industrial Engineering family in the Volkswagen Group. The methods and tools provided also require a high amount of time for data generation. Furthermore, the cost-benefit pressure on already established methods with regards to the derivation of effective work design measures is growing. In this regard, first methodological approaches already exist to implement the simultaneous consideration of productivity and ergonomics for preventive design in the early phase of the planning process. The implementation of EAWS in the Volkswagen internal system "Arbeitsplan" has created a group-wide standard for ergonomic workplace assessment. This allows an assessment of the physical strain in vehicle production, but it has also limitations as a paper and pencil method in the system-technical implementation and international application. A variety of different methods, system implementations and evaluations of comparable load situations are the result. In addition, demographic developments are causing increasing heterogeneity in the workforce, requiring differentiated workplace assessments and design measures to ensure efficient and sustainable human resources deployment. Therefore, the spread of EAWS as an international standard must be pursued further. However, the strategic direction and development of EAWS regarding for example differentiated job evaluation depending on the managerial capacity, body-based assessments, the definition of digitization attributes of EAWS as well as the evaluation of tools in the workplace (including exoskeletons) of particular relevance is necessary. Volkswagen will advance this further development aspect as an active member of the EAWS User Group.

A first step is the establishment of HWD at Volkswagen, with which a uniform process analysis for method- neutral ergonomic workplace assessment can be ensured. At the same time, HWD enables the use of simulation tools for autonomous process planning. Furthermore, data analytics methods could be used to generate relevant data that uncovers the relationships between loads and diseases..



## Job exposure matrices for biomechanical factors: from validation to application.

### Symposium Organizer

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**Key words: job exposure matrix; public health; musculoskeletal; work; exposure**

### Symposium abstract

In the absence of individual level exposure data or historical data, job exposure matrices (JEMs) are commonly used in occupational epidemiology research. JEMs allow estimating participants exposures to chemical and physical risk factors based on job titles, industry information, and population exposure data. A JEM provides a means to assign exposure estimates to coded job titles for epidemiological studies. JEMs are an efficient method and decrease information bias between cases and non-cases, in addition to a more precise exposure estimation when only rudimentary data is available. With the overall goal to propose development of an international JEM (JEMINI: Job Exposure Matrix InterNational), we will present talks relevant to the cross-validation of JEMs and their applications. The presentation will show comparisons of JEM exposure estimates to self-reported exposures, direct observations, and JEMs between countries. Examples of research applications of JEMs in Europe and USA will be shown, and we will discuss the application of JEMs to public health surveillance and to compensation.

## Validity of a job-exposure matrix (JEM) score for carrying heavy loads compared to standardized self-reported evaluation in CONSTANCES cohort.

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**Background:** Job-exposure matrices (JEMs) were developed to provide an alternative to evaluation of past work exposure. This study compared assessment of exposure based on “JEM Constances” and self-reported (SR) exposure for carrying heavy loads (10-25 kg).

**Methods:** In the French CONSTANCES cohort at inception, JEM Constances was combined with job history to build a cumulative exposure score, and SR exposure (yes/no and time), which were available for 27,719 subjects. The validity of this score was assessed by Area under curve (AUC) of Receiver Operative Characteristics (ROC) curves, sensitivity, specificity and likelihood ratios, using SR exposure as reference. For both methods, associations with low back and knee pain were computed using polytomous logistic models. Additional analyzes compared old (>10 years) to recent (≤10 years) exposures.

**Results:** AUCs ranged from 0.795 (0.789-0.80) all period considered, to 0.826 (0.820-0.833) for recent exposure (≤10 years). Associations were observed with JEM's evaluation as well as SR, but with lower strength: for low back pain; ORSR=3.02 (2.79-3.26) vs ORJEM=1.70 (1.59-1.82) for severe pain (similar results for knee pain).

**Conclusion:** JEM Constances' evaluation of cumulative exposure for carrying heavy loads seems to be a valid method for past exposure, and even better when exposure is recent.

## Cross-national comparison between two general population JEMs of biomechanical exposures.

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Job exposure matrices (JEMs) for biomechanical exposures have been created in several countries. We compared individual and job-level exposures between general population JEMs from two different countries and examined exposure-disease associations for incident carpal tunnel syndrome (CTS) in the same study population. We assigned eight biomechanical exposures from the American O\*NET JEM, and nine exposures from the French JEM CONSTANCES to a cohort of 2393 American workers from several industries who had individually observed exposures. Comparing 28 a priori matched exposure pairs between the two JEMs at the level of the job titles showed better correlations (0.42 to 0.76) between the JEMs than when comparing exposures assigned at the individual worker level (0.06 to 0.48). Hazard ratios for incident CTS using continuous exposures ranged from 1.00 to 1.42 when using individually observed exposures, 1.08 to 2.05 when using the CONSTANCES JEM assigned values, and 1.31 to 2.01 when using O\*NET JEM assigned values. JEM exposure comparisons are affected by the distribution of individuals between different jobs in the sample. Cross-national comparisons of exposure-disease results were similar between both JEMs and the individually observed exposures. More cross-national comparisons may show the utility of combining JEMs in future studies.

## Association between occupational exposure and Dupuytren's contracture using a job-exposure matrix and self-reported exposure in the CONSTANCES cohort.

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**Background:** Although several studies highlighted an association between occupational exposure and Dupuytren's contracture (DC), they were often limited by the highly selected population. We aimed to study this association using a job-exposure matrix (JEM) and self-reported exposure in a large cohort.

**Methods:** From CONSTANCES, a French population-based prospective cohort, we retrieved sex, age, social position, alcohol and tobacco intake and diabetes. Lifetime exposures were assessed using JEM Constances, for participants whose work history was available, and using self-reported exposures. Surgery for DC was collected from the French Health Administrative database. Multivariate logistic regression models adjusted on confounders were built to assess association between surgery for DC and occupational exposures.

**Results:** Among the 23,795 subjects with available work history, 98 underwent surgery for DC. Adjusted odds ratio (aOR) was of 2.08 (1.03-4.2) for exposure to vibration and/or screwing for subjects <60 years old. Among the 81,801 participants with self-reported data, 367 underwent surgery for DC. aOR for exposure to arduous work and/or carrying heavy loads was of 2.01 (1.32-3.04) for subjects <60 years old.

**Conclusions:** Some work exposures are associated with DC when adjusting on confounders, mainly for younger subjects. Monitoring exposed workers is important to prevent possible future functional limitations.

## Current musculoskeletal pain is associated with exposure estimates from a general population JEM.

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We created a job exposure matrix (JEM) using self-reported general population physical exposure data from the French CONSTANCES study to enable large-scale studies of associations between workplace exposures and chronic diseases, including musculoskeletal disorders (MSD) [1]. We contrast associations between current MSD symptoms and exposure estimates from this JEM vs. individual self-report. Self-reported exposures from 35,526 workers in CONSTANCES were used to construct the JEM. In a validation set of 38,731 different CONSTANCES participants, we examined associations between current MSD pain and the reported frequency of 15 work exposures estimated by JEM or individual self-report. We calculated prevalence ratios (PR) between exposures and MSD pain, adjusting for age and gender, using log-binomial models. PR using the JEM were broadly consistent with PR calculated from individual self-reported exposures, though showed lower effect sizes. For example, “frequency of carrying loads >25kg” showed PR of 1.18 (JEM) vs. 1.22 (individual report) for current low back pain; 1.16 vs. 1.2 for knee pain, 1.12 vs. 1.17 for shoulder, and 1.20 vs 1.26 for hand. This JEM and others provide a robust assessment method for assigning current and cumulative workplace physical exposures in general population studies, and open new possibilities in quantifying risk of MSD.

[1] Evanoff, B.A., Yung, M., Buckner-Petty, S., Andersen, J.H., Roquelaure, Y., Descatha, A., Dale, A.M. (2019). The CONSTANCES job exposure matrix based on self-reported exposure to physical risk factors: Development and evaluation. *Occup Environ Med.*, DO: 10.1136/oemed-2018-105287

## Surgery for subacromial impingement syndrome in relation to upper arm elevation alone or combined with other occupational mechanical exposures: a nationwide Danish cohort study.

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**Background:** The aim was to compare exposure-response relationships between surgery for subacromial impingement syndrome (SIS) and upper arm elevation >90° alone or combined with other mechanical exposures.

**Methods:** We conducted a cohort study of the working population (N=2,374,403). 14,118 events of surgery for SIS occurred (2003-2008). Exposures were obtained by combining individual occupational codes with a job exposure matrix (JEM), which provided intensity estimates of upper arm elevation >90°, forceful shoulder exertions, and repetitive shoulder movements. For 10-year windows, we calculated the duration of arm elevation at specific intensities (low, medium, high).<sup>1</sup> Forceful shoulder exertions and repetitive shoulder movements were dichotomised. We used survival analysis.

**Results:** Exposure-response relationships were found for durations of arm elevation above minimal, reaching a maximum OR<sub>adj</sub> of 1.7 (95% CI 1.5-2.0). When combined with forceful shoulder exertions, the maximum OR<sub>adj</sub> increased to 2.0 (95% CI 1.9-2.1), while the combination with repetitive shoulder movements did not increase maximum OR<sub>adj</sub> much (OR=1.8 (95% CI 1.5-2.0)). When all three exposures were combined, OR<sub>adj</sub> increased to 2.2 (95% CI 2.0-2.4).

**Conclusions:** We found elevated risks of surgery for SIS for all intensities of arm elevation. The highest risks were found when arm elevation was combined with forceful shoulder exertions.

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2. Dalbøge A, Frost P, Andersen JH, Svendsen SW. Surgery for subacromial impingement syndrome in relation to intensities of occupational mechanical exposures across 10-year exposure time windows. *Occup Environ Med* 2018;75(3):176-82.

## Usefulness of a job-exposure matrix “MADE” as a decision tool for compensation of work-related musculoskeletal disorders.

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**Background:** We aimed to study the predictivity of a biomechanical job-exposure matrix (JEM) compared to data of National compensation health insurance for work-related disorders and injuries.

**Method:** We obtained compensation data of work-related musculoskeletal disorders from 2013 to 2015 (acceptance or rejection). We used a French JEM “MADE” to rate exposures and predict compensation results. Dataset was randomly divided into two subsamples to check the stability of the results. Receiver Operative Characteristic curves, sensitivity and specificity were estimated in each subsample using compensation results as the reference.

**Results:** In three years, 163,128 cases were available, with a high proportion of acceptance (94%). In the assessment subsample, best AUC ranged from 0.64 for shoulders disorder to 0.82 to knee disorders. The thresholds were over 0.90 for sensitivity and specificity in most cases, but none reached both 0.90 sensitivity and specificity for the same threshold. If two thresholds were considered, 28.7% of the sample fit under or over those. Results were similar in the other subsample.

**Conclusions:** “MADE” JEM showed to be accurate in terms of sensitivity or specificity, but not both at the same time. When using two thresholds, such matrix might be a tool used for improving compensation process.



## Exposure response relationship assessing biomechanical overload of lumbar spine and upper limbs by methods suggested in ISO standards.

### Symposium Organizer

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*Enrico Occhipinti, Scientific Director of Scientific Association EPM IES, Milan Italy*

*Enrique Alvarez Casado, CENEA Barcelona, Spain, Researcher of Scientific Association EPM IES*

*Natale Battevi, Researcher of Scientific Association EPM IES, Milan Italy*

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### Symposium Abstract

ISO standards (ISO 11228 series) and documents (ISO TR 12295 and 12296) suggest methods for risk assessment and management of different conditions of biomechanical overload (manual handling of loads; high frequency repetitive tasks; manual handling of patients, etc..) in some case reporting about a possible exposure/response relationship with Work Related Musculoskeletal Disorders (WRMSDs).

The aim of the symposium is to present recent and partially unpublished studies, performed in the framework of the Ergonomics of Posture and Movement International School (EPMIES), where some relevant health outcome (in the area of WRMSDs) has been related to exposure conditions evaluated by methods and criteria suggested by the ISO standards. The aim is to present updated details regarding the relationship between exposure (classified by the methods) and response (in terms of selected WRMSDs) and consequently to give a further contribution to the definition of occupational exposure limits to prevent WRMSDs.

The first three presentations cover respectively:

- 1.The relationship between the OCRA Checklist score and the prevalence of Upper Limb-WRMSDs in a large sample of workers exposed to different levels of biomechanical overload of the upper limbs.
- 2.The relationship between exposure to variable lifting tasks, evaluated by an extension of the RNLE method – namely the VLI approach, and the occurrence of acute lumbago.
- 3.A further validation study of the updated MAPO method (for the evaluation of patient handling tasks) using again, as outcome variable, the occurrence of acute lumbago.

The other presentations regard more peculiar studies focused respectively on the occurrence of lumbar disc herniation in workers (both genders) with high exposures to manual lifting and to the relation between biomechanical overload and WRMSDs in physiotherapists.

## Relationship between exposure to repetitive tasks assessed by OCRA Checklist and UL-WRMSDs: validation of the OCRA Checklist score as predictive of UL-WRMSDs.

*Enrico Occhipinti*

**Background:** The OCRA Checklist is suggested by the ISO TR 12295 as a useful method for screening exposure to repetitive tasks. While confirming the OCRA checklist key-values given in the standard, there was the need to define more accurate forecasting models for the expected prevalence of UL-WRMSDs based directly on the OCRA checklist scores.

**Methods:** A database concerning 11734 workers aggregated into 30 groups featuring different exposure levels and different prevalences of workers affected by one or more UL-WRMSDs was analyzed. The association (regression model) between the independent variable "OCRA checklist score" (CK) and the dependent variable "% of workers with UL-WRMSDs" (PA) was researched. By using the pre-established OCRA checklist key-values, macro groups for "insignificant", "borderline", "low-medium", "high" exposure were aggregated and the Prevalence Odds Ratio (POR) of each group with respect to the "insignificant" exposure group were computed (central value and 95% C.L.)

**Results:** A good association ( $R^2 = 0.86$ ;  $p < 0,0001$ ) is given by the linear regression equation  $PA = 0.742(\pm 0.055) * CK$ . The POR for "borderline", "low-medium", "high" exposure groups were respectively 2.18 (1.69-2.79), 3.65 (3.08-4.33), 3.78 (3.12-4.59)

**Conclusion:** The regression equation could be used (within defined limits) as a forecasting model of expected "% of workers with UL-WRMSDs" based on the "OCRA checklist score". The POR obtained for the different exposed groups confirm the general adequacy of the actual classification of the OCRA Checklist results but a more detailed analysis in the area of low-medium exposures is needed.

## Relationship between exposure to manual lifting tasks assessed by the Variable Lifting Index and Low Back Pain: validation of the VLI as predictive of acute lumbago.

*Enrique Alvarez Casado*

**Background:** An extension of the RNLE method for assessing highly variable manual lifting tasks (VLI) has been developed; this study evaluates the relationship between the VLI and the occurrence of acute low back pain (LBP).

**Methods:** A sample of 3402 participants from 16 companies was analysed. 2374 were in the exposed group involving manual lifting, and 1028 were in the reference group. The VLI was calculated for each participant in the exposed group. Occupational physicians collected LBP information. A subject was assessed as positive if she/he reported at least one episode of acute LBP in the last 12 months. The risk of acute LBP was estimated by calculating the odds ratio (OR) between levels of the risk exposure and the reference group using a logistic regression analysis. Both crude and adjusted ORs for body mass index, gender, and age were analysed.

**Results:** Both crude and adjusted ORs showed a dose-response relationship. As the levels of VLI increased, the risk of acute LBP increased. This risk relationship existed when VLI was greater than 1. In particular central adjusted ORs in relation to VLI categories resulted: 1.58 for  $VLI \leq 1$ ; 1.76 for  $VLI \leq 2$ ; 2.99 for  $VLI \leq 3$ ; 2.23 for  $VLI > 3$ .

**Conclusion:** Since for a VLI greater than 1 and up to 2 a mean OR of 1.76 exist and since the correspondent lower CL (at 95%) is slightly greater than 1, these results confirm that, considering the health effect "Acute LBP", a LI of 1 is a good discriminatory point between a still acceptable and a "risky" condition across all frequencies of lifting.

## Study on manual handling of patients with MAPO index: validation of risk indices (prediction of acute lumbago) through epidemiological studies.

*Natale Battevi*

**Background:** The number of operators exposed to patient manual handling is steadily increasing. The MAPO method was proposed in 1999 as a useful tool to estimate the risk from manual patient handling. Two cross sectional study was performed in 1999 and 2006 but now we have introduced same change in the method and for this reason, a new multi-centre study was conducted.

**Methods:** A multi-center study was conducted between 2014 and 2016 concerning 26 Italian hospitals all over Apulia Region. 116 wards were evaluated, with a total of 1998 exposed subjects. Risk was assessed by MAPO index and each subject included into the study was evaluated, by occupational physicians, for the presence or absence of acute low back pain during the last 12 months. Rough and multivariate logistic regression models were run to assess the relation between MAPO Index and acute low back pain.

**Results:** Analysis of the results confirms previous studies, demonstrating a positive trend between increasing levels of MAPO index and the number of acute low back pain episodes (trend 1.63 –  $p < 0.001$ ). Adjusting the results for selected confounding factors (i.e., gender, age and BMI) did not substantially alter the results.

**Conclusion:** MAPO methodology could potentially benefit the implementation of standards for safe patient handling and mobility defined by the National Institute for Occupational Safety and Health and the development of a monitoring program for integration of safety practices in healthcare institutions.

## Lumbar disk herniation, congenital or acquired? A case/control study in workers exposed to manual lifting (ML) of loads, evaluated using the RNLE method.

*Daniela Colombini*

**Background:** The paper reports the result of an epidemiological study on cases of herniated discs of the lumbo-sacral tract (HLS) in workers exposed to ML.

**Methods:** The study regarded a company with 160 employees: 96 (60%) females, 63 males (40%).

The assessment of the exposure to ML was conducted with the RNLE -Variable Lifting Index (VLI) method. Only cases of diagnosed HLS were considered.

**Results:** Tasks performed and exposures are subdivided into 3 bands:

- HEAVY DEPARTMENTS: VLI 4-5
- LIGHT DEPARTMENTS: VLI 2-3
- NO EXPOSURE

New workers are generally employed in HEAVY departments. Rotations between heavy/light departments and trolley guides are scheduled only after the onset of disease.

The HLS prevalences found are: males: 21% versus 4.9% in unexposed; females: 20% compared to 4.2% in the unexposed. These prevalences are 4-5 times higher than those not exposed to ML (high prevalence also of surgical interventions: 23%).

Incidences and latencies were calculated for females: prevalence at 20% up to 8 years of exposure, then peak at 36% between 9-12 years of exposure, then stabilized at 8%. Females, after 15 working years, due to the appearance of HLS, are exonerated from ML.

**Conclusion:** Regarding the HLS, some scientific work refer it as "congenital"; but just as much literature asserts the opposite. Epidemiological studies teach that when the occurrences of WMSDs significantly exceed those of unexposed populations, they constitute an unquestionable thesis for both occupational risk and professional causal relationship.

## Results of epidemiological study on biomechanical overload in physiotherapists.

*Deepak Sharan*

**Background:** Physiotherapists (PTs) are highly predisposed to Work Related Musculoskeletal Disorders (WRMSDs).

**Method:** Time-based Assessment Computerised Strategy (TACOS) method was used to evaluate the risk of WRMSD among 75 PTs and its relationship with musculoskeletal symptoms, exertion and workload. The median age was 28 years (60% female), working 9 hours daily, including 1 hour of breaks, 6 days a week.

**Results:** 82% of PTs reported pain. The predominant posture causing high risk was "lumbar spine fully bent with operational areas under the knee" (58%). The commonest site of pain was lower back (54%), neck (50%) and upper back (50%). 80% of the PTs did not exercise regularly. 76% of the subjects reported an adverse workstyle risk (total score >28). The perceived exertion and workload were also high as 74% of the PTs were in the scores of >15 (Borg CR 10) and >50 (NASA Task Load Index) respectively. 84% of the participants were in the High Risk / Very High Risk category according to the TACOS outcome.

**Conclusion:** Awkward postures should be monitored and eliminated by appropriate measures to reduce the risk of WRMSD among PTs. The other risk factors, i.e., psychosocial, exertion and workload need to be appropriately addressed.



## Methods for health risk assessment and risk factors identification of work-related musculoskeletal disorders.

### Symposium Organizer

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### Symposium abstract

**Background:** Persistent back pain, is known as an occupation-related problem. The nature of industrial process composes of sedentary posture and multi-task. Repetitive movements while prolonged hours might increase risk of the musculoskeletal disorders (MSDs). The objectives of this symposium are to present the new method of back pain prediction using MSDs risk matrix and risk factors identification from a cohort study design.

**Methods:** The exposure assessment to ergonomic factors was modified according to the basis of health risk matrix of combined subjective and objective assessment (severity of effects x likelihood of exposure) for LBP prediction. Methods were validated with the standard tools of subjective assessment (self-reported muscle discomfort of workers), and objective assessment by ergonomic tools i.e. Rapid Upper Limb Assessment (RULA), Rapid Entire Body Assessment (REBA), Rapid Office Strain Assessment (ROSA), surface electromyography (sEMG) and environmental monitoring of workstations in relation to workers' anthropometry. Two prospective cohort studies were conducted to new cases of shoulder pain and back pain and to identify risk factors related to back pain and shoulder pain of workers by multiple logistic regression analysis.

**Results:** Health risk on back pain development was indicated in call center workers, industrial workers, solid waste collectors along with high ergonomics risk. Muscle fatigue measured by sEMG at the baseline indicated predominantly on back muscle. The significant factors correlated with back pain were manual lifting, high workload

and inappropriate workstation. The high risk group is latter confirmed by the incidence of back pain (52.5%) and shoulder pain (85.3%) after six-months follow-up. Work experience and chronic diseases, personal factors, were the significant risk factors.

**Conclusions:** The discovered method of MSDs risk assessment matrix is useful for the surveillance of back pain and risk assessment. The finding of ergonomic risk and risk factors could be implied to ergonomics improvement by workstation modification.

#### *Sunisa Chaiklieng*

This study aimed to assess the health risk of occupational back pain (BP) and to identify risk factors correlated with BP among electronic workers at Northeast, Thailand. Data were collected from 354 workers by a self-report discomfort questionnaire, ergonomics risk assessment with Rapid Upper Limb Assessment (RULA) and the measurement of lighting intensity. The health risk matrix (Discomfort x RULA) was developed for BP risk assessment. The significant risk factors were identified by multiple logistic regressions analysis presented adjusted odds ratio (ORadj) and 95% confidence interval (95%CI). Almost workers were operator (92.1%), 75.7% had work experience <5 years, 99.7% worked overtime >3 h/d. Inspections with microscope (76.5%) did not meet the lighting standard and showed the significant poor lighting condition. RULA indicated that workers (57.6%) had high risk (implemented need). That highest proportion was illustrated at the machine control stations and manual handling materials. The health risk matrix presented back pain risk and the associated risk factors were inappropriate workstation (ORadj:3.45;95%CI:1.42–8.42) and manual lifting (ORadj:2.48;95%CI:1.13-5.44). The high risk at machine controlled station and inspection station must be implemented. Health risk matrix is useful for back pain surveillance screening prior to risk reduction to implementation in the electronic workers.

#### *Pornnapa Suggaravetsiri*

This 6-month prospective cohort study aimed to investigate low back pain (LBP) incidence and to identify risk factors related to LBP among electronic workers. A cohort group of 196 electronic workers was followed up and baseline measurements were done for ergonomics risk assessment with RULA, lighting and noise. Unacceptable ergonomics risk ranging between high to very high risk (implemented need) was found among workers and the majority of risk related to the sitting posture of workers (61.4%). Some lighting conditions were higher than the illuminance range, evident as glare problems at the inspection stations. Noise was higher than the regulation at punching area. The incidence of LBP was 43.9% (86 cases) at one month, 49.5% (97 cases) at three months and 52.5% (103 cases) at six months follow-up. Some workers visited the health care department to receive pain relief. Workers with work experience < 3 years (RR = 1.41; 95%CI: 1.03-1.90) and chronic disease (RR=1.41; 95%CI: 1.09-1.82) had significantly higher risk for LBP. It can be concluded that inspection and punching stations should be improved to provide safer working conditions. LBP surveillance should be carried out further among electronic workers who have less job experience and congenital diseases.

#### *Worawan Poochada and Sunisa Chaiklieng*

This was a cross-sectional study conducted among 30 call center workers who had working time at least 32 hours per week with computer at least 4 hours a day. The aims of this study were to investigate muscle fatigue and the risk of low back pain (LBP) development. Data were collected by Cornell Musculoskeletal Discomfort Questionnaires (CMDQ), and the Rapid Office Strain Assessment (ROSA) for prediction LBP development by health risk matrix (CMDQ x ROSA). Muscle fatigue was measured by surface electromyography (sEMG). These workers had ergonomics risk by

ROSA at moderate to high level. The complaints of musculoskeletal discomfort from low to high severity were at 43.3%. The potential risks of LBP development were found at moderate risk for 23.4% and at high risk level for 20.0%. Correlation between levels of LBP development and discomfort was very high (coefficient=0.914). Electromyogram indicated that 86.7% of workers had muscle fatigue on the left low back and 80.0% for the right low back. Workers of high ergonomics risk were more likely had the muscle fatigue than of the lower risk. This method of risk assessment could be applied to identify low back muscle fatigue and LBP development among similar group of workers.

*Naruedee Poonkasem and Sunisa Chaiklieng*

This study aimed to apply health risk assessment on low back pain (LBP) among solid waste collectors. The study was conducted among 42 solid waste collectors of local administrative organizations in one province of Thailand. Data were collected by using the questionnaire of musculoskeletal discomfort (severity and frequency). Ergonomics risk assessment by REBA and discomfort question were multiplier as the component of risk matrix. The results indicated that the highest numbers of workers had low back discomfort (37.83%). The severity of pain was at moderate (48.64%), followed by severe level (32.43%). REBA indicated the moderate risk (64.28%), followed by high risk (35.71%) at level 4 that because of posture to lean downwards for lifting (25.0%), holding trashcan (7.5%), and loading waste in the vehicle booth (100%). LBP risk assessment showed that 59.5%, 33.4% and 7.1% of workers had high risk, very high risk and moderate risk, respectively. The muscle fatigue measured by sEMG showed that 68.57% of workers who were the high risk group had low back muscle fatigue. That high ergonomics risk conditions play predominantly role on LBP development. There should be implemented soon to avoiding heavy load handling and supporting handling devices in order to prevent LBP among solid waste collectors.



## New and revised exposure and risk assessment methods for DUE MSDS.

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### Symposium abstract

Upper-extremity MSD include injuries of muscles, tendons, ligaments, and nerves in the shoulder, arm, elbow, forearm, hand and wrist. Historically, work-related upper-extremity musculoskeletal disorders (MSD) have comprised a significant portion of the number and cost of injuries in the workplace and continues to be widespread and costly. This symposium will present updates on applying new or revised risk assessment methods to data collected during large prospective studies. The use of video tracking to quantify repetitive hand motion and duty cycle will be compared to observer rated and video analysis techniques; discussion on how the definition of an exertion impacts exposure values will be discussed. Next, a comparison of results from the 2001 ACGIH TLV for Hand Activity (ACGIH, 2001) to the 2018 ACGIH TLV for Hand Activity (ACGIH, 2018) in a large prospective study of US workers (Kapellusch et al, 2014) will be presented followed by an overview of the Revised Strain Index and the Variable Revised Strain Index (VRSI) algorithm which aims to partially address a limitation of the Revised Strain Index (RSI) by enabling the quantification of efforts where the intensity of exertion and/or posture change during the exertion. The panel will finish with a discussion on the kinematic assessment index (KAI) to assess the risk of distal upper extremity complaints/disorders and the application of a fatigue failure model to assess risk of shoulder disorders.

## Defining repetitive hand exertions for exposure assessment.

*Carisa Harris, PhD Oguz Akkas, PhD, Stephen Bao, PhD, Jia-Hua Lin, PhD, Alysha R. Meyers, PhD, David Rempel, PhD, and Robert G. Radwin, PhD.*

Numerous criteria have been used for hand exertions (Stetson, et al., 1991; Wiktorin et al., 1993, Marshall and Armstrong, 2004; Bao, et al., 2006). Similarly, repetition has been quantified in various ways (Radwin et al., 1993; Moore and Garg 1995, Latko et al. 1997, ACGIH Worldwide, 2001). The Threshold Limit Value for Hand Activity Level (ACGIH Worldwide, 2018) exposure guideline has revised the criteria for hand exertions from the original guideline published in 2001, potentially leading to inconsistent interpretations of hand activity level (HAL). Repetition rate and duty cycle are therefore dependent on the category of forces considered. Bao, et al. (2006) observed that that different definitions of repetitive exertions lead to measuring different physical exposure phenomena and produce very different results. Furthermore, there were poor correlations between different measures of repetitiveness estimated using different methods. We compared observed HALs obtained for the NIOSH supported upper extremity consortium study against frequency and duty cycle computed HALs based on video records for the same task and applied different criteria for negligible, non-negligible, and forceful exertions. We defined an exertion as a visible hand or forearm muscular effort while grasping an object or applying a force (e.g. hold, manipulate, trigger, push, pull, or handle an object) during task performance, regardless of the force required. Exertions were categorized by their magnitude of force, ranging from negligible exertions (i.e. Borg CR10<1 or MVC≤10% level of force), to non-negligible exertions (i.e. Borg CR10≥1 or MVC>10% level of force) and forceful exertions (i.e. pinch force ≥ 9N or power grip force ≥ 45 N, or Borg CR10≥2).

## The revised 2018 acgih threshold limit value for hand activity: comparison to the 2001 acgih tlv for the prevention of carpal tunnel syndrome.

*Bradley A. Evanoff; Marcus Yung; Carisa Harris; Jay Kapellusch; Stephen Bao; Alysha R Meyers; Kurt T Hegmann; David Rempel; Ann Marie Dale*

ACGIH® develops voluntary workplace exposure indices, thresholds, and limits to prevent injuries due to biomechanical exposures. In 2001, a threshold limit value (TLV®) for Hand Activity was adopted to prevent MSD among workers performing repetitive single task jobs (ACGIH, 2001). Recent studies examined the risk of new cases of carpal tunnel syndrome (CTS) for exposures above and below the 2001 TLV (Bonfiglioli et al., 2013; Kapellusch et al., 2014) and concluded that it was not sufficiently protective of workers, leading to a revision of thresholds (Rempel, 2018). We will summarize the effect of applying the 2018 TLV® versus the 2001 TLV® to data from an occupational cohort study.

For each worker, we used the 2018 TLV® equations to categorize workers into: (1) below the Action Limit (AL), (2) between AL and TLV, and (3) above TLV and compared them to 2001 limits. The 2018 TLV® might have prevented 28% of CTS cases that occurred below the 2001 AL. Similarly, 26% of workers classified as below TLV by the 2001 thresholds would have been classified as above TLV by the 2018 threshold and might also have been prevented. The 2018 TLV® is demonstrated to improve the protection of workers who perform hand intensive tasks from risk of CTS.

## The revised strain index: a physical exposure quantification tool for detailed assessment and design of distal upper limb work.

*Jay Kapellusch, PhD*

**Background:** The Revised Strain Index (RSI) is a tool to quantify the physical exposures of distal upper limb exertions, tasks, and jobs. Like the 1995 Strain Index (SI) that preceded it, the RSI was built upon biomechanical and physiological principles, and refined based upon epidemiological evidence. Development of the RSI was motivated by identified weaknesses and limitations in the 1995 Strain Index, and was further informed by results of several distal upper limb psychophysical studies published across the past 25 years. This presentation will briefly: (1) introduce the RSI tool, (2) provide an example of how the tool is applied to a complex, multi-task job, and (3) present preliminary exposure-response results between CUSI score and CTS.

**Methods:** Five variables are evaluated in the RSI: (1) Intensity of exertion – expressed as percent of maximum voluntary contraction, or equivalent Borg CR-10 rating, (2) duration per exertion, (3) hand/wrist posture during exertion, (4) frequency of exertion, and (5) duration of exposure per day. Variables 1 to 4 are evaluated for each type of exertion (i.e., sub-task level analysis) and subsequently assigned a Multiplier that serves as a sort of penalty. The mathematical product of those Multipliers, including the Multiplier for daily exposure, yield the RSI score. For jobs consisting of a single task with a single exertion type, the RSI score alone characterizes the daily exposure. For tasks consisting of multiple types of exertions (i.e., complex tasks), an algorithm accumulates all sub-task RSI scores into a single task-level score called the Composite Strain Index (COSI). Similarly, for jobs consisting of multiple tasks, an algorithm accumulates all COSI scores into a single job-level score called the Cumulative Strain Index (CUSI). Together, these algorithms allow practitioners to quantify the total effect of individual exertions, thereby reducing necessary assumptions and facilitating rigorous analyses and design of both complex tasks and multi-task jobs.

**Results:** Preliminary testing of the RSI's association with risk of distal upper limb musculoskeletal disorders have been performed using a subset of data from the NIOSH CTS consortium in the United States that contain complete sub-task level information on exertions. These analyses include N=1,885 workers followed for up to 7 years.

**Conclusions:** A strong exposure-response relationship between CUSI score and incidence of CTS, with steadily increasing hazard ratios, has been identified.

## How to improve the revised strain index to enable the quantification of forces that change during physical exertion.

*Lukas Mitterlehner, Jay Kapellusch, PhD*

**Background:** The Variable Revised Strain Index (VRSI) algorithm aims to partially address a limitation of the Revised Strain Index (RSI) by enabling the quantification of efforts where the intensity of exertion and/or posture change during the exertion.

**Methods:** The VRSI divides an exertion into a finite number of slices, each of which can have unique force and posture without changing the frequency of exertion or duration of exertion of the effort. The algorithm was applied on three example tasks and compared to an averaging and a peak force level approach.

**Results:** For the three example tasks studied, peak force approach generated the highest RSI score, and the VRSI approach generated the lowest RSI score.

**Conclusion:** The VRSI is conceptually similar to the COSI and CUSI algorithms of the RSI and improves the RSI's ability to provide precise estimates of physical exposure from hand/wrist exertions with a minimum of assumptions. The VRSI is expected to be particularly useful for new task design and for development of engineering interventions

## Biomechanical wrist load indicators using technically measured data.

*B Weber, K Heinrich, D Seidel, I Hermanns, U Hoehne-Hückstädt, D Ditchen, L H Barrero, R Ellegast*

**Background:** Biomechanical overloads of the distal upper extremities (DUE) can be caused by different workload factors. Although measurement-based methods are well suited for assessing physical exposures, they are not yet widely used. As part of the MEGAPHYS(online) joint project, evaluation methods for the CUELA measurement system (Ellegast et al., 2009) have been updated. This work presents assessment approaches that describe the risk of musculoskeletal complaints and diseases (MSCD) of the DUE.

**Methods:** The load indicators are based on captured kinematic data of the DUE and recorded muscular activity of the forearm. The Repetition Score (RP) considers the mean angular velocity, the mean power frequency of the angular data and kinematic micro pauses (Hansson et al., 2009; Hansson et al., 2004). The categorization is based on the Latko scale (Latko et al., 1997). The Kinematic Assessment Index (KAlx) was developed based on the DIN 1005/4 and ISO 11226 standards and provides the time portion of non-recommended postures and movements. The evaluation of the force exertion was done on the basis of the 90th percentile of the %MVC values (P90 %MVC). A measurement-based combined load indicator (mTLV) was developed from the RP and the P90 %MVC according to the Hand Activity Level Threshold Limit Values [6]. All load indicators are validated against medically examined MSCD. This cross-sectional study included 808 employees (84.5% men) from companies in various sectors in Germany.

**Results:** The measurement-based wrist indicators showed several significant results. KAlx was positively associated with the prevalence of CTS. KAlx, RP, P90 %MVC and mTLV were positively associated with the prevalence of DUE arthrosis and wrist complaints. Indications were found for a positive association between mTLV and CTS.

**Conclusions:** The measurement-based load indicators for DUE appear to be applicable to a risk assessment of work activities.

## Development and validation of a shoulder risk assessment tool based on fatigue failure theory.

*Sean Gallagher, Dania Bani Hani, Richard Sesek, Mark Schall, Rong Huangfu*

**Background:** Shoulder disorders are a significant problem in industry; however, there are no tools available to quantitatively assess the probability of shoulder outcomes.

**Methods:** A fatigue-failure based shoulder risk assessment tool is presented that uses the load moment about the shoulder as a measure of stress, and compares this load moment to data on the maximum torque capability of the shoulder. The tool employs an S-N curve to estimate the cumulative damage (CD) per cycle for various shoulder moments. This damage per cycle estimate is then multiplied by the number of repetitions for a task to obtain the cumulative damage for that task. If multiple tasks are performed, the CD for each is summed to obtain a daily dose.

The shoulder tool was validated against a cross-sectional epidemiological study using original videotapes and data obtained during the study. One hundred randomly selected jobs were selected for analysis, most comprised of multiple shoulder tasks. Information about the repetition rate for tasks was derived from video analysis. Load weights were measured at the worksite and shoulder postures estimated from videos taken from multiple angles. Moments were estimated using the 3DSSPP program. Outcomes included first-time office visits (FTOV) for shoulder/neck pain, shoulder pain last year, and current shoulder pain. Logistic regression was used to analyze crude and adjusted odds ratios (ORs). Gender, age, and BMI were confounding variables.

**Results:** The log CD metric demonstrated significant associations for each outcome (both crude and adjusted analyses). In adjusted analyses, FTOV demonstrated an OR of 1.95 (95% CI: 1.16, 3.27), Pain Last Year had an OR of 3.87 (95% CI: 2.03, 7.39), and current pain had an OR of 3.49 (95% CI: 1.73, 7.06).

**Conclusions:** The new shoulder risk assessment tool based on fatigue failure theory demonstrated strong associations with injury reports and shoulder symptoms.

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## Exoskeletons for industrial use

### Symposium Organizer

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### Symposium abstract

Exoskeletons are mechanical structures worn on the body with the aim to support or assist the wearer in performing activities. So far, exoskeletons have mainly been developed for rehabilitation and military purposes. Rehabilitation exoskeletons aim to assist patients in their daily life or take over functions that cannot be executed by the patients themselves. Military exoskeletons aim to reduce the load on the body, mainly during heavy load carriage. Potential application of exoskeletons in industry is an emerging field since a couple of years. Now, many industries started pilot testing with various exoskeletons to evaluate their potential in their companies. Simultaneously, research institutes started investigating the effects of exoskeletons on the musculoskeletal system of humans.

Industrial exoskeletons are very present in the media and various statements on potentials and limitations of these assistive devices exist. With this symposium, we would like to support the scientific discourse on this highly relevant topic and bring together researchers and experts from different disciplines and countries to share their knowledge and experience on industrial exoskeletons.

This symposium will consist of two parts, during which five speakers of different countries and with different backgrounds will present their work. The first part of the symposium will be more general, within which the applications and pitfalls of exoskeletons in industry are discussed from both a scientific point of view and a practitioner point of view. The second part of the symposium will include presentations about several exoskeletons categorized to different body regions, i.e. the lower extremities, back and upper extremities. Three speakers will share their findings from laboratory and field studies within which they tested one or more exoskeletons.

After each presentation, there will be some time for discussion. At the end of the symposium, there will be time for a plenary discussion among presenters and audience.

## Occupational Exoskeletons: Overview of the Benefits and Limits for the Prevention of Work-related Musculoskeletal Disorders.

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**Background:** To deal with the prevalence of work-related musculoskeletal disorders (MSDs) in physically demanding tasks, research is now focusing on new issues, such as the use of exoskeletons.

**Purpose:** Based on the available evidence underlying the claimed efficiency of occupational exoskeletons in reducing biomechanical strains at work, this communication aims at discussing the benefits and potential musculoskeletal risks associated with using these devices. A further aim is to highlight the main deficiencies in current knowledge with the view to directing the research necessary for developing future generations of exoskeletons.

**Methods:** The present communication summarizes a literature analysis based on an electronic search, considering occupational applications of exoskeletons from January 1980 to December 2018.

**Results:** 25 articles evaluating the effects of occupational exoskeletons on upper limb and back muscle activity were considered relevant to discuss their results relating to the pathophysiological origins of MSDs.

**Conclusion:** Although the potential of exoskeletons to attenuate muscular strains in the back and upper limbs appears promising, the current state of knowledge does not allow the unreserved endorsement of using these technologies for the prevention of MSDs.

## Biomechanical Assessment of Exoskeletons for Industrial Use.

*Ulrich Glitsch<sup>1</sup>, Kai Heinrich<sup>1</sup>, Martin Liedtke<sup>1</sup>*

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In the past, exoskeletons have predominantly been used in the field of rehabilitation, in some cases with great success. In recent years, exoskeletons have increasingly been developed, including for industrial applications. An increasing number of biomechanical studies have reported significant assistive effects in a range of industrial tasks, including lifting, static forward bending postures and overhead work. The demonstrated effects are based on a range of kinetic, kinematic and physiological parameters. However, few studies have combined multiple analysis methods at the same time and discussed the overall benefits of an exoskeleton in an industrial application. Even where the exoskeleton delivers substantial support for a short moment during a working task, the overall benefit for the task as a whole may be much smaller. Typically, the exoskeletons produce their optimal support only under limited conditions, such as with an excessively forward-bent trunk. The present communication will adopt a combined biomechanical approach with the objective to produce measures relevant for the overall assessment of exoskeletons and useful for assessment at real-case workplaces in industry.

## A passive exoskeleton aimed to reduce long periods of standing work.

*Tessy Luger<sup>1,\*</sup>, Robert Seibt<sup>1</sup>, Monika A. Rieger<sup>1</sup>, Benjamin Steinhilber<sup>1</sup>*

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**Background:** This study investigated the influence of wearing a passive lower-limb exoskeleton on physical load, kinematics, postural control, and discomfort while performing a simulated assembly task.

**Methods:** Forty-five healthy males were exposed to simulated industrial work during three 21-min randomized exposures: standing without, high and low sitting on the exoskeleton. Postural control was recorded using a force plate, from which the mean center of pressure (COP), and minimum relative and absolute standing stability were calculated. Physical load and kinematics were continuously recorded by electrical activity of four muscles (trapezius, erector, vastus, gastrocnemius) and by neck and back flexion angles, respectively. Discomfort was recorded before and after each exoskeleton status on a 10-point Likert-scale.

**Results:** Relative standing stability decreased when the exoskeleton was applied with the lowest value for high sitting; however, COP remained within the base of support and absolute standing stability did not change. During sitting, vastus activity increased while gastrocnemius activity decreased compared to standing. Trapezius and erector activity showed only minor differences between exposures. Neck flexion was higher during standing than sitting; trunk flexion was smaller during standing than sitting. Standing without exoskeleton was related to less discomfort than sitting.

**Conclusion:** This exoskeleton seems to have low potential of decreasing low back physical loading in an ergonomic work situation. We recommend field studies to learn about usability in dynamic working situations and potential harming effects on, e.g., knees and passive structures.

## Biomechanical evaluation of active and passive exoskeletons aiming to reduce low-back loading during lifting.

*Idsart Kingma<sup>1</sup>, Axel S. Koopman<sup>1</sup>, Michiel P. de Looze<sup>1,2</sup>, Jaap H. van Dieën<sup>1</sup>*

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Low back loading during lifting is a risk factor for the development of low-back pain. Currently, passive and active exoskeletons are being developed, aiming to reduce low-back loading during lifting. We evaluated the effect of two passive exoskeletons (Laevo, a market available system; SPEXOR, a newly developed prototype) and one active exoskeleton (Robomate, a newly developed prototype) on spinal loading during lifting. Full-body kinematics, ground reaction forces and trunk muscle electromyography were measured during free-style lifts of 10-15 kg boxes from ankle height. Inverse dynamics were used to calculate L5S1 moments, taking into account exoskeleton moments measured (the active system) or estimated from angle-moment relations (the passive systems). With the Laevo and SPEXOR systems, moments were reduced by ~10% and ~20%, respectively, and lifting kinematics were largely unaffected. The support of the Laevo was lower than expected due to friction, limiting its effect during the upward phase of the lift. The Robomate reduced estimated peak spine compression by ~18%. The effect of the Robomate was for ~50% the result of slower lifting and for ~50% the result of actual support. The actual support was lower than anticipated due to failure of the motors to generate the target torques during upward acceleration. In conclusion, state of the art exoskeletons can reduce peak low-back loads in lifting by 10-20%.

## Effects of using passive upper extremity exoskeletons on physical demands and motor performance of force control and precision-control tasks .

*Denean Kelson<sup>1</sup>, Sunwook Kim<sup>1</sup>, Maury Nussbaum<sup>1</sup> and Divya Srinivasan<sup>1,\*</sup>*

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The potential use of industrial exoskeletons to mitigate musculoskeletal disorder risk in manual handling jobs is an emerging research topic. In this context, it is important to understand how passive upper-extremity exoskeletons affect the user's physical demands as well as motor performance. We investigated this on two types of tasks: an intermittent shoulder-loading task performed at 30% maximal torque; and a repetitive tool-pointing task requiring high precision. Both tasks were performed in a control (no exoskeleton) condition, as well as with two different exoskeletons – the Levitate Airframe and EksoBionics EksoWorks by a sample of sixteen young and healthy participants. Shoulder joint torque control (coefficient of variation) and end-point precision at target were used to quantify performance in the force- and precision-control task respectively. Muscle activities of the anterior deltoid and upper trapezius muscles were used to quantify physical demands. In general, exoskeleton use decreased muscle activation in all tasks; however, the extent of reduction, and the effects of exoskeleton use on performance showed complex effects that were dependent on factors such as device design (Levitate vs. EksoBionics), task plane (sagittal vs. scapular plane) and movement direction (vertical vs. horizontal). The implications of these findings will be discussed from a practical perspective of understanding exoskeleton design effects on diverse industrial tasks.



## Time patterns of biomechanical exposures at work in prevention and health promotion related to MSD: activity, pauses and variation.

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*Svend Erik Mathiassen, Centre for Musculoskeletal Research, Department of Occupational Health Sciences and Psychology, University of Gävle, Sweden*

### Symposium abstract

We know that several aspects of biomechanical (physical) work load increase the risk for musculoskeletal disorders, e.g. heavy manual handling, arm elevation at work, twisted forward bent back and lack of forearm rest in computer use. However, the time distribution of these mechanical exposures is an important property of the load, influencing loading and recovery of musculoskeletal tissues and thereby the risk for musculoskeletal disorders. Evidence of the effects of different temporal patterns of load is scarce which hampers guidelines and interventions in working life to prevent these disorders.

An example: Many occupations include work tasks requiring arm elevation without support, occasionally even with use of force; e.g. painters, electricians and hairdressers. Interventions such as offering scaffolds or levers may be a first choice, in being the most effective and even feasible solutions. However, sometimes it is not possible to avoid demanding arm postures, for instance for hairdressers, and it is therefore necessary to identify optimal temporal patterns of exposure and restitution, i.e. optimal patterns of variation, that will minimize the risk for musculoskeletal disorders.

How long time can activity be sustained before getting critical?

Is it sufficient to have microbreaks, or should longer, active pauses be recommended?

If so, how long should these pauses be, and how often should they occur?

What is a beneficial temporal pattern of tasks with different exposures, such as in job rotation?

These questions are important and they are not sufficiently answered today. This Symposium will not give the whole solution, but it will address some important questions.

This Symposium will focus on duration of constrained postures, sustained muscle activation and rest, frequency and duration of pauses as well as their contents, distribution of job tasks with different exposures, and issues pertinent to future research devoted to optimizing variation at work.

## Why this symposium? General introduction and in addition focus on time distribution of low-force exertions of the neck and shoulder.

*Kaj Bo Veiersted*

Time is crucial when assessing biomechanical exposure at work in the context of risk for musculoskeletal disorders (MSD). This presentation will give a short introduction to the topic and present an approach towards reducing risk of musculoskeletal disorders in occupations with low-force sustained exertions of the neck muscles.

Short interruptions in muscle activity during work tasks with low-force demands and muscle rest have shown to reduce risk for neck pain. But is it possible to quantify the length of periods with sustained muscle activity (continuous without interruptions) that may increase the risk for MSD? Time with sustained neck muscle activation (above 0.5% of maximal activity) for more than 8 min increased neck pain reports one year later in male forest machine operators. In younger workers (electricians and hairdressers) sustained neck muscle activity for periods longer than two min increased pain reports after half a year.

Guidance for potential time durations for sustained neck muscle activity may depend on age, gender and exposure type and level. So far studies has been performed on small samples. A study of pooled measurements of neck muscle activity related to development of neck pain is therefore wanted.

## Trapezius muscle activity and course of neck and shoulder pain throughout a 2-year period: a compositional approach.

*Suzanne Merkus*

In studying musculoskeletal disorders (MSD) of physically demanding occupations, traditional biomechanical approaches set out to assess 'extreme exposures', such as high peak loads, high frequency of heavy lifting, and prolonged duration of awkward postures. However, an approach that focusses on assessment of only 'extreme exposures' ignores potentially important effects on MSD of less extreme exposures, such as occurring during breaks or tasks with low exposure.

This presentation introduce a relatively new approach in occupational epidemiology, addressing the composition of exposures throughout the working day and it's effect on MSD. This compositional approach will be illustrated using data on upper trapezius muscle activity among construction and healthcare workers measured at baseline in a prospective cohort study. In this material, longer duration of muscle "rest" (activity <0.5% of the maximum voluntary exertion (MVE)) had a protective effect on neck and shoulder pain (NSP) throughout a 2-year follow-up, while longer duration of low-to-medium muscle activity (0.5-7%MVE) predicted higher NSP throughout the follow-up. More 'extreme' muscle activity (>7%MVE) showed no association with NSP. This suggests that consideration of the entire composition of exposures throughout the whole working day may provide more insight into the development of MSD than solely studying 'extreme' exposures.

## Effects of active pauses on muscle activity in the shoulder region.

*Pascal Madeleine*

Active pauses are referred to physical activity occurring during work breaks. Active pauses usually aim at decreasing the amplitude of the surface electromyographic (sEMG) of for instance the upper trapezius and redistributing muscular load by changing the spatial distribution of sEMG activity among muscles of the shoulder region. Still, the optimal timing scheme and contraction types (e.g. dynamic/static) are theoretically obscure including the sEMG metrics used to elicit active pauses and quantify their effects.

The presentation will deal with these three aspects and review the approaches including (i) biofeedback approaches used to elicit active pauses, (ii) the investigated active-pause regimes by comparing active and passive pauses as well as (iii) the sEMG metrics used to measure the effects of active among participants performing monotonous work. Moreover, emphasis will be given to the current limitations and scientific flaws in the existing literature.

## Job rotation for effective exposure variation: evidence, design and implementation.

*Rosimeire Simprini Padula*

Job rotation has been widely used as an organizational strategy in manufacturing industries and other occupational settings. Increasing variation in biomechanical exposure by alternating tasks in a job rotation scheme aims to reduce musculoskeletal complaints and prevent disorders among workers. However, despite the strong collective conviction that job rotation has positive effects on health and productivity outcomes, limited evidence supports its effectiveness. Why?

A brief review of published studies, and deployment experience in a large textile industry will feed this discussion. Is it possible to comprehensively identify relevant cognitive and biomechanical exposures of workers? Do the tasks included in the job rotation offer variation in exposure? What are the training requirements on workers when implementing the job rotation, considering the complexity of tasks? What are the positive and negative effects of job rotation on health and well-being? How effective is the job rotation in preventing musculoskeletal disorders, given that ergonomics improvements may already have been performed? How does organizational culture, specificity of tasks, and the profile of the workers influence the implementation of the job rotation? Do investments in job rotation pay off in terms of economics?

## Where are we going from here? Research priorities in the context of time, variation and disorders.

*Svend Erik Mathiassen*

Biomechanical exposure variation, defined as change in exposure across time, is generally accepted to influence fatigue, well-being, physical capacity, and disorders. Variation at work concerns how much exposure changes across time, how often it changes, and to which extent similar exposure sequences occur. Exposure variation in a job can be manipulated in three ways: changing contents or conditions in individual tasks, changing the time-line and proportions of tasks relative to each other, and adding new tasks to the job. Only few studies have been designed with these notions in mind. Thus, as of to-day, research cannot answer some of the most basic questions about variation at work and its effects. Which tasks can be effectively combined into jobs so that variation is sufficient, and so that organizations as well as individual workers will benefit, both on the short and long term? What is the optimal temporal structure of changes between tasks in a short (hours, days) and long (weeks, months, years) perspective? Future research should address such issues, based on a sound model of initiatives influencing variation, associations between variation and different relevant outcomes, and evidence on what would be feasible and effective interventions in working life.



## Multilevel inventory of methods for risk assessment of physical workload (MEGAPHYS) – A joint project of the German Federal Institute for Occupational Safety and Health (BAuA) and the German Social Accident Insurance (DGUV).

### Symposium Organizer

*Britta Weber, Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA), Sankt Augustin, Germany*  
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### List of Presenters

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*Ralph Bruder, Institute of Ergonomics & Human Factors at the Darmstadt University of Technology (IAD), Germany*

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*PD Dr. Matthias Jäger – Leibniz Research Centre for Working Environment and Human Factors at Dortmund University of Technology (IfADo), Germany*

### Symposium abstract

The overall objective of the MEGAPHYS project was to develop and evaluate a comprehensive harmonized inventory of methods for risk assessment of physical workload. Based on agreed evaluation standards, the existing method inventory was improved and new methods were added. The methods were tested and evaluated in field and laboratory studies.

Regarding to the level of analytic complexity and personal and time expense, the 'Key Indicator Methods (KIM)' are considered as specific screening tools. On the other hand, methods based on the 'Ergonomic Assessment Worksheet (EAWS)' are ranked as expert screening tools. At a complex level, physical workload can be assessed by technical field measurements of posture, movement, forces, heartrate etc. ('CUELA'). Biomechanical modelling in the laboratory is used to assess the resultant lumbar-spine forces with regard to overload risk ('The Dortmunder').

The MEGAPHYS-partners will present their joint approach, provide newly developed methods and present the evaluation results.

## The project MEGAPHYS - Multilevel risk assessment of physical exposures at work.

*Britta Weber, Marianne Schust, Felix Brandstädt, Dirk Ditchen, André Klussmann, Hansjürgen Gebhardt, Bernd Hartmann, Matthias Jäger, Andrea Sinn-Behrendt, Falk Liebers*

In the MEGAPHYS project, BAuA and DGUV, together with several research partners, have updated and harmonized the risk assessment instruments used in Germany. The aim was to draw up a scientifically sound inventory of coordinated methods at the various differentiation levels of risk assessment (special screening, expert screening, measurement-based analysis in field and laboratory). All typical forms of physical workload (manual material handling, repetitive work processes, whole-body force exertion, body postures and movements) and the body regions particularly affected (e.g. neck/upper back, lower back, shoulder-arm area, hand-arm area, lower extremities) were taken into account. The exposure assessment is based on a common understanding of the effects of workload types on individual body regions. A coordinated traffic light risk assessment concept is available for evaluation at all method levels. The improved and new methods were tested and evaluated in field and laboratory studies.

## Method level 'specific screening': Updated and newly developed 'Key Indicator Methods (KIM)'.

*Marianne Schust, Patrick Serafin, André Klußmann, Andreas Schäfer, Hansjürgen Gebhardt, Falk Liebers, Bernd Hartmann, Felix Brandstädt*

The existing key indicator methods (KIMs) 'Manual lifting, holding and carrying of loads', 'Manual pulling and pushing of loads' and 'Manual handling operations' were updated. Three further KIMs were developed: 'Whole-body forces', 'Awkward body postures' and 'Body movement'. The methods were validated regarding several quality criteria. The design of the study has been described in the study protocol (see <https://bmjopen.bmj.com/content/7/8/e015412.long>). The presentation will focus on the explanation of the six methods and their fields of application. On the basis of workplace analyses, working shift has to be subdivided into partial activities representing one of the six types of physical workload. 'Awkward body postures' can simultaneously arise in combination with other physical workloads. Then, rating points have to be defined for each partial activity, namely for the time duration and, depending on the type of physical workload, e.g. for force exertion, body postures, working conditions and work organisation. Time rating is multiplied with the sum of the other rating points. The result reflects the risk of adverse health effects and the need of occupational health prevention. KIMs allow identifying flaws concerning the work design and provide information regarding measures with the potential of reducing the risk of adverse health effects.

## Method level 'expert screening': Updated and new approaches for stress assessments.

*Ralph Bruder, Andrea Sinn-Behrendt, Karlheinz Schaub, Marius Oberle, Knut Berg, Jurij Wakula*

A concept with five levels has been developed for IAD-expert screening tools. The existing screening tool (level 1) for assessment of different kinds of physical workload (static working posture, action forces, manual material handling and repetitive loads / upper extremities) has been expanded at level 2. Specific aspects of work organization, working conditions, distribution of work load across the shift have been included into new worksheets. Two computer-aided tools - "Megaphys-MultipLa" and "Megaphys-MonKras" have been further developed on level 3. First tool can be used for assessment of multiple tasks deals with manual material handling (include different weights of objects). "Megaphys-MonKras" is useful for assessment of tasks with heterogeneous action forces. For the description of the time sequence/schedule of different kinds of physical workload a detection method ("stress matrix") was developed at level 4. Finally, a concept for "body segment"-related assessment was worked out on level 5. With this method, the physical work load can be assessed not only on a time basis, but also on a body segment basis. The "segment-based" approach was tested to evaluate the "working posture". Results of analysis of work load in the praxis were used for check of convergence and criterion validity of the tools.

## Method level 'technical field measurement': Updated and new approaches for exposure assessment.

*Britta Weber, Kai Heinrich, David Seidel, Ingo Hermanns, Ulrike Hoehne-Hückstädt, Dirk Ditschen, Matthias Jäger, Lope Barrero, Rolf Ellegast*

As part of MEGAPHYS, the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) developed body region-specific procedures for the description and evaluation of physical workload based on technically measured exposure data. According to the findings from occupational science and medicine, load indicators were developed for the body regions neck/cervical spine, shoulders/upper arms, elbows/forearms, wrists/hands, lower back/lumbar spine, hips and knees as well as for the cardiovascular system and energy expenditure. In the MEGAPHYS field study, the required load parameters were determined using the CUELA measurement system by kinematic analysis, electromyography and heart rate measurement. The load indicators were checked for criterion validity by linking them to the results of the medical examination carried out simultaneously in the field study. Several significant associations were identified between load indicators and different musculoskeletal complaints and diseases. This provides body region-specific approaches for quantifying and evaluating the physical workload, which can be used both for a comprehensive exposure assessment (expert measurement system) and with reduced measurement technology specifically for exposure assessment for selected body regions (tools for practitioners).

## Method level 'laboratory measurement / simulation': Deriving the "Revised Dortmund Recommendations".

*Matthias Jäger*

In ergonomic work design, measures of human physical capacity are required, i.e. criteria are needed to differentiate load and overload for avoiding biomechanical low-back overload, in particular. In a common biomechanical approach to evaluate manual materials handling and similar physical exposures, the compression component of the forces transferred via lumbar discs or vertebrae are compared with the ultimate compressive strength of lumbar-spine segments.

As one of MEGAPHYS' main topics, the data base of the "Dortmund Recommendations" provided in 2001 was updated. Accordingly, autopsy-material measurements were collected from literature and examined regarding several conditions. 66 newly discovered seemingly appropriate studies were currently collected via a systematic literature search, 11 of them were added for subsequent analysis. Nearly 4,000 values were compiled in total, nearly 1,200 remained for analysis. Based on gendered age relations, the "Revised Dortmund Recommendations" range between 5.4 kN among males aged 20 years and 2.2 kN for males of 60 years or older. In case of females, the corresponding limits amount to 4.1 and 1.8 kN for younger or older persons. Influences like shear or torsion as well as psychological or psychosocial risk factors remain here unconsidered due to the compression-related and biomechanical nature of the underlying approach.



## **SELFBACK, a digital health intervention to support self-management in low back pain.**

### **Symposium Organizer**

*Karen Søgaard, PhD. Center for Muscle and Joint Health, University of Southern Denmark, Odense, Denmark. Member of PREMUS*

### **List of Presenters**

*Paul Jarle Mork, Norwegian University of Science and Technology*

*Associate professor Mette Jensen Stochkendahl, University of Southern Denmark*

*Senior Lecturer Barbara I Nicholl, University of Glasgow*

*Malene Jagd Svendsen, National Research Centre for the Working Environment.*

*Assistant Professor Louise Fleng Sandal, University of Southern Denmark*

### **Symposium abstract**

Around 60% of care-seeking patients with low back pain (LBP) are occupationally active and LBP is one of the main causes of sickness absence and early retirement from work. Therefore, an evidence-based intervention targeting LBP and facilitating self-management is highly relevant in the perspective of work-related musculoskeletal disorders. In this symposium, we will present different features of a Horizon 2020 EU project “selfBACK” that started in 2016 and runs until the end of 2020. The project is focused on the development and testing of an evidence-based digital intervention supporting LBP self-management. The intervention is an add-on to usual care in the health care system and the approach is to provide the user with an app that can be consulted and used during daily life at home or at the workplace to support self-management and prevent recurrence of LBP. The first presentation will provide an overview of the selfBACK project and the current status. This will be followed up by a presentation of current guidelines and the scientific evidence that underpins the content of the selfBACK app. To increase the patient uptake of the selfBACK app a literature review was conducted looking into knowledge of barriers and facilitators to digital interventions for the self-management of LBP. A recent update of this initial literature search will be given as the third presentation. Development of the selfBACK app followed the principles of intervention mapping and this step by step process involving behaviour change theory will be described in the fourth presentation. Finally, a presentation of the results from a 6-week pilot trial including 54 patients with LBP will lead us into a discussion on how to measure adherence and compliance of self-management.

## **A brief overview of the development of selfBACK, a digital intervention for self-management in chronic low back pain.**

*Paul Jarle Mork*

LBP is a leading cause of disability worldwide. Most people with LBP have nonspecific LBP, that is, pain with an unknown pathoanatomical cause. Self-management in the form of physical activity and strength and flexibility exercises along with education constitute the core components of the management of nonspecific LBP. In the selfBACK project, we have developed a decision support system that improves, facilitates and reinforces self-management of LBP. The decision support is conveyed to the user via a smartphone app in the form of advice for self-management. Case-based reasoning, a technology that utilizes knowledge about previous cases along with data about the current case, is used to tailor the advice to the current user, enabling a user-centred intervention based on what has and has not been successful in previous cases. The effectiveness of selfBACK is currently being tested in a multinational, randomized controlled trial (RCT) that includes ~350 care-seeking patients in primary care with nonspecific LBP. Pain-related disability at 3 months measured by the Roland Morris Disability Questionnaire is the primary outcome. Process evaluation is being carried out as an integral part of the RCT to document the implementation and user experiences with selfBACK.

## **Clinical guidelines for low back pain, state of the art and implementation as self management?**

*Mette Jensen Stochkendahl*

This presentation will provide a brief overview of the evidence behind the latest versions of clinical guidelines for evidence-based treatment of LBP and how an extract of these guidelines have been built into the content of the selfBACK app. Globally, the guidelines endorse self-management, including patient education, monitoring of symptoms, and physical activity and exercises as the first line of treatment. Patient education includes information regarding the function of pain and its natural course aiming to reduce fear avoidance and consistently encouraging patients to remain active on and off work. These recommendations aim to empower the patient to take control and responsibility of their own condition and improve self-management through increased self-efficacy. Digital health interventions are increasingly being used as platforms for patient self-management not only for LBP but for a range of chronic illness. In general, digital health interventions aimed at promoting healthy behaviour, have the potential to reduce health service utilization and long-term sickness absence. The transfer of these principles to LBP rely on an operational definition of self-management, identification of the challenges with implementation of the self-management approach and an exploration of the relationship between self-management and self-efficacy.

## **Barriers and facilitators to patient uptake and utilisation of digital interventions for the self-management of low back pain. A literature review.**

*Barbara I Nicholl*

Adherence to clinical guidelines for self-management is challenging, especially for digital health interventions (DHIs) without individual feedback and reinforcement. This presentation will present a systematic review of the published qualitative literature to determine engagement strategies as well as barriers and facilitators affecting patient uptake and use of DHIs. Further, the aim is to develop a preliminary conceptual model of barriers and facilitators to uptake and utilisation of DHIs to support self-management of LBP. A systematic search of bibliographic databases was conducted for publications on back pain, DHI, and self-management. Data extracted on barriers/facilitators were analysed using a thematic approach, while engagement strategies were narratively described. Codes were mapped to constructs from Normalization Process Theory. More than 8000 publications were found but only 5 full text articles covering 4 studies were included in the review. Identified barriers and facilitators included the importance of functionality and general information technology issues; quality and quantity of content; tailoring of content; personal interaction; motivation and support. This systematic review identifies key barriers and facilitators to consider when designing DHIs to support the self-management of LBP and maximise user engagement. The findings will inform future DHI deployments to promote uptake and utilisation.

## **The intervention mapping process used in the selfBACK project to develop the content of the digital health intervention.**

*Malene Jagd Svendsen*

In the development of the selfBACK app, the expertise from five medical research teams and four technical partners were combined in the process. We utilised the Intervention Mapping approach that aims to facilitate participation and consultation of stakeholders, and provides a structure for the integration of theory, empirical findings and information collected from the target population. Evidence from systematic reviews and key papers on LBP was combined with theoretical models for behaviour change and stakeholder experience. A three-pronged program of strength and flexibility exercises of progressing difficulty levels; educational components in the form of advice, quizzes and tools; as well as monitoring and feedback of step counts, was developed and adapted to app format. This presentation will focus on the Intervention Mapping approach that provides a structured, step-by-step process to unravel a complex problem, and to design an evidence-based intervention embedded in behaviour change theory. The high level of transparency may help to inform future complex interventions and ensure effective implementation.

## Adherence and compliance in a digital intervention. The selfBACK pilot study.

*Louise Fleng Sandal,*

The degree to which participants are adherent or compliant to an intervention is significant to the anticipated effect. This presentation will discuss if and how adherence and compliance can be properly evaluated in a digital self-management intervention. In the selfBACK project, a pilot study was performed to investigate how LBP patients would interact with a self-management app. The selfBACK pilot study with a duration of 6 weeks, included 54 LBP patients in Denmark and Norway. Of these, 53 used the selfBACK app for all 6 weeks and 47 filled out the follow up questionnaire. An overall decrease in pain scores of around 2 points on the Roland Morris Disability Questionnaire was found at follow-up. Data on how the digital intervention was assimilated by users were obtained in terms of app data such as number of log-ins, report of performance, interactions with the app and similar variables. These data in combination with follow-up outcome data on LBP and function was used to define criteria for per protocol analysis of the final RCT study in selfBACK. Finally, we encourage a discussion on how the terms adherence and compliance as defined from a medical/pharmacological research tradition can be applied to digital and self-management interventions.



## The use of work-related PROMS in clinical care. Can the use of PROMS facilitate the dialogue between clinical care and occupational health?

### Symposium Organizer

*Annechien Beumer PhD, orthopedic and handsurgeon, Amphia Hospital Breda, The Netherlands and researcher at Coronel Institute for Work and Health, UMCA, Amsterdam, The Netherlands*

### List of Presenters

*Bert van de Wijdeven, Physiotherapist and director owner / founder Buro voor Fysieke Arbeid (agency for physical labor), St Oedenrode, The Netherlands*

*Yasmaine Karel, PhD, Physiotherapist, researcher and teacher at Avans University of Applied Science, Breda, The Netherlands*

*Paul Kuije, PhD, Human Movement Specialist Work at Coronel Institute for Work and Health, UMCA, Amsterdam, The Netherlands*

*Annechien Beumer, PhD, orthopedic and handsurgeon, Amphia Hospital Breda, The Netherlands and researcher at Coronel Institute for Work and Health, UMCA, Amsterdam, The Netherlands"*

### Symposium abstract

According to World Health Organisation (WHO) economically active people spend about 1/3 of their time at the workplace<sup>1</sup>. Health is influenced by work. Employment, type, conditions, quality of work<sup>2</sup> and position in workplace hierarchy all influence health. Employment itself is related to better health<sup>3</sup>. Conditions at the workplace may aggravate health problems and cause occupational diseases among which musculoskeletal disorders are commonest together with chronic respiratory diseases, noise-induced hearing loss and skin problems. These may lead to decreased productivity and absence from work. Occupational health services (OHS) monitor working conditions and workers' health and advise workers and employers on (improving) working conditions. According to WHO only 15% of workers have access to specialized OHS.

The curative sector, that focusses on treatment not prevention, could be beneficial for workers too by surveilling for work-related health problems and advising on (safer) working. This sector lacks knowledge and time to address this. Furthermore, a curative physician cannot assess the impact of work on a health problem or disease on working capability, if not additionally schooled.

Patient Reported Outcome Measures (PROMs) are used to analyze large groups of patients. PROMs assess health aspects and provide indications of outcome by measuring health at different times<sup>4</sup>.

Lately, PROMS are used to help patients and health care workers improve decision making and improve health care processes by assessing and comparing outcomes achieved by healthcare providers.

Work-specific PROMs can be cheap, fast, reproducible and easy to use tool to improve care for working people worldwide, that can be used in both curative setting and OHS. PROMs might also be useful to improve communication between the curative and informal sector by fast assessment of work-related problems in the curative sector, easy communication between the curative and OHS and assessment of the results of work-directed care.

## Attention to work-related Patient reported outcome measures (PROMs) could be an important aspect in the treatment of musculoskeletal complaints

*Bert van de Wijdeven*

In the Netherlands, around 400,000 people visit the physiotherapist every year with musculoskeletal work-related complaints.

To provide the right therapeutic guidance with these complaints, it requires specific knowledge, insight and skill. For instance: the recognition the complaints may be work-related, knowledge of the workload and of the possibilities for reducing it, insight into the influence that this workload has on the recovery process and how to dose it, skill in applying exercise and training programs that are focused on work and on returning to work.

It is of great importance that these skills can be applied methodically in the regular approach of the physical therapist. For people that have access to occupational health PROMs may be a way for the primary physiotherapist to communicate with other clinical and occupational health care workers. For the (increasing amount of) people that are self-employed or flexible in their work and cannot rely on work-related care PROMs may be an easy to use, reproducible and cheap way to monitor the effect the disease has on the work ability. . Ultimately, more attention for work and a methodical approach will lead to a major health gain: shorter illness, faster return to work and less recurrence.

## PROMs screening occupational health for general physiotherapists.

*Yasmine Karel,*

Musculoskeletal disorders (MDs) are a major health burden which negatively effects an individual's wellbeing<sup>5</sup>. The most common MDs patients consult primary care physiotherapists with are low-back-, neck- and shoulder pain<sup>6</sup>. Observational studies in physiotherapy showed that the majority of these MDs are work-related<sup>7,8</sup> leading to substantial problems in the work-place<sup>9</sup>.

Employees with MDs have to deal with their individual limits and work activities that trigger the complaints<sup>10</sup>. These employees are usually not fully aware how to influence their symptoms and often go beyond their individual limits<sup>11</sup>.

Specific interventions in the workplace try to help these patients lowering the workload, reducing stress or improving the patient's endurance/health status. Unfortunately, many workplaces do not have specific interventions or personnel focusing on the health of their employee<sup>12</sup>. In the Netherlands patients end up in the standard care pathway consulting primary care physiotherapists. They administer therapies to improve muscle endurance/strength or try reducing symptoms but don't have enough knowledge about work-related factors<sup>8</sup> nor pay enough attention to work-participation. Furthermore, there is a lack of cooperation between physiotherapists and occupational healthcare providers. Work-related PROMs might facilitate a dialogue with patients and other occupational health providers.

## WORQ: better informing knee surgery patients about work ability

*Paul Kuije*

The year 2025, the Netherlands: the most important work-related disease is ... knee osteoarthritis. The number of knee surgeries is increasing rapidly. To better inform patients about consequences for work and to stimulate work-directed care, the -Work, Osteoarthritis or joint-Replacement Questionnaire- (WORQ) was developed<sup>13</sup>. WORQ assesses patient-reported difficulty in 13 work-related knee-demanding activities. Examples of work-related knee-demanding activities are crouching and working with hands below knee-height. These activities are assessed on a 5-point scale from (0-4), resulting in a converted total score between 0 (extreme difficulties) to 100 (no problems).

WORQ consists of two constructs: 'knee coordination' and 'strenuous knee flexion', the reliability is good (ICC=0.97). The smallest detectable change for an individual and group are respectively 10 and 2 points. The minimal clinically important difference is 13 points. Therefore, the WORQ is responsive. A score of >71 means being satisfied with work ability with respect to the knee while a score of <50 means being unsatisfied. WORQ is a reliable, valid and responsive PROM and received the highest overall ratings in a review on the psychometric quality of PROMs for Total Knee Arthroplasty patients<sup>14</sup>.

## The use of the work-related PROM WORQ-UP in patients with Upper Extremity Complaints

*Annechien Beumer*

Complaints of arm, neck and shoulder are very common. The incidence ranges between 2 and 53 %<sup>15</sup>. 10–25% of workers report work-related pain of the arm, neck and shoulder<sup>16</sup>. Mental health issues and personal factors have been found to influence upper extremity complaints in workers too<sup>17,18</sup>. Many patients (26%) report a second period of sick leave resulting from the same injury<sup>19,20,21,22</sup>.

The Work-Related Questionnaire for UPper extremity disorders (WORQ-UP) is a work-related PROM developed to measure which limitations patients with upper extremity disorders experience in their ability to work to create a patient-centered treatment plan including work-directed care<sup>23,24</sup>. Work-specific PROMs are cheap, fast, reproducible and easy to use tools to assess musculoskeletal complaints having a correlation with work. These PROMs might close the communication gap between curative and work-directed care. WORQ-UP is currently used in clinical care by orthopedic surgeons, occupational therapists and physiotherapists to signal work-related upper extremity complaints and report to occupational health physicians. Further research will focus on its use in clinical care for prevention, work-directed care and patient information purposes as well as for occupational health workers to report back.

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## Evidence-based, sustainable interventions: Do research and practice meet?

### Symposium Organizer

*Laura Punnett, University of Massachusetts Lowell*

### List of Presenters

*Henk van Rhee & Jan Dul, Rotterdam School of Management, The Netherlands*

*Yves Roquelaure, Université d'Angers, France Yves Roquelaure (University of Angers, France), Fabien Coutarel (University of Clermont-Ferrand, France), Sandrine Caroly (University of Grenoble-Alpes, France), Mohsen Zare (University of Montbéliard, France)*

*Kasper Edwards, Danish Technical University, Lyngby, Denmark*

*Dwayne van Eerd, Institute for Work and Health, Toronto, Canada*

*Maike Huijsmans, VUMC, Amsterdam, the Netherlands*

### Symposium abstract

Health- and safety-focused intervention research typically entails a sequence from efficacy to effectiveness: first the intervention is tested under optimal circumstances, often experimentally, to assess the maximum health benefit obtainable. It is then evaluated in “real world” settings to assess the more realistic expected benefits after accounting for non-participation, non-compliance, and other barriers to achieving its full potential. The ideal effectiveness study design is generally considered the randomized clinical trial (RCT), which treats as a black box the contextual workplace factors that might have affected the outcome. Effectiveness research might or might not include process evaluation to illuminate the factors that supported and/or interfered with intervention success. Systematic reviews of the literature increasingly exclude studies which are not RCTs. However, OHS practitioners pay particular attention to context when searching for and using research evidence.

Meanwhile, there are important types of ergonomic interventions that can only be evaluated in the field, especially those involving organizational-level changes. Furthermore, workplace intervention research is carried out in ever-changing environments subject to economic, political, and social influences that often have negative impact on workplace ergonomics and worker health and safety. Yet the primary importance of production system developments for workplace decision-makers means that intervention uptake, effectiveness, sustainability, and generalizability may be largely determined by external factors. We will discuss the tensions between concerns for scientific validity, on one hand, and the importance of designing and implementing interventions that have some realistic chance of being implemented in today's and tomorrow's workplaces. The presenters will offer examples from their research in various national contexts and economic sectors. The discussion will address whether there are realistic approaches to workplace interventions that might achieve meaningful improvements in ergonomics, workers' musculoskeletal health and other outcomes while also improving or at least maintaining production system performance.

## What improves wellbeing and performance simultaneously? A study of measures taken by SMEs

*Henk van Rhee & Jan Dul*

In this uncommon research approach, we studied the effect of company-initiated organizational and workplace changes on performance and well-being without conducting any intervention ourselves. We followed 57 Dutch SME's (7-50 employees each) in the metal manufacturing industry, for two years. Numerous performance and well-being measures were collected at individual and company levels (baseline, after one year, after two years) through interviews and questionnaires for company owner/managers, questionnaires for employees, and observations of the production facility by OHS professionals. The companies took 567 measures (average 5 per year), ranging from small operational measures such as new tools and personal protective equipment to large interventions such as new machines, reorganization of the production process, and robotization. Nearly all measures were initiated by the director/owner; external actors had no effect. Eighty-one percent of the changes were motivated by performance and 15 percent by well-being. On average, measures that were motivated by performance increased both performance and well-being. Measures that were motivated by well-being had no effect on performance, nor on well-being. During the seminar we will discuss these remarkable results and - if replicated – their consequences for external actors such as government policy-setters, OHS professionals, labor inspectors, and trade unions.

## Ergonomics interventions in a truck manufacturing plant: Adapting to the ever-changing company context

*Yves Roquelaure & Mohsen Zare*

Preventing MSDs is a complex and difficult task requiring (i) analysis to precisely understand the complex relationships between work organization, production system, workers' biomechanical exposure and psychosocial factors and (ii) change (design) to act on the direct and indirect determinants of MSDs. The main paradigm of interventions at the company level rely on participatory ergonomics. Such interventions take place within a given context, at a given time, with a view to transforming work situations to improve them in accordance with health and efficiency criteria. Ergonomic intervention involves the implementation of an organized system of actions carried out in interaction with the key players in the organization. As shown by the French group for the "sustainable prevention of MSDs", such ergonomic intervention projects need to be co-constructed with the company's managers and stakeholders. If evidence-based intervention models and recommendations of good practices are useful, they should be adapted to each case since each ergonomic intervention is a unique process depending on the context of the company, and the many and varied adjustments done throughout the process contribute greatly to the impact and sustainability of the intervention. This presentation will discuss the interests and limits of evidence-based intervention models.

## Effect Modifier Assessment in organizational-level interventions – an approach to taking context into consideration

*Kasper Edwards*

Organizational-level interventions take place in working organizations whose main purpose is to service their clients, be it in a public or private setting. Such organizations do not pause to allow researchers to do their before and after intervention measurements *ceteris paribus*. Interventions focused at reducing MSD tend to disregard development of the production system which may easily influence the ergonomic intervention. Intervention research methods must take the context of the intervention into account when assessing efficacy and effectiveness of ergonomic interventions. We present results from an ergonomic intervention study and illustrate the vastly different conclusions that can be drawn from a normal versus context-sensitive analysis. The normal approach is constituted by the classic baseline, intervention, follow-up design often seen in “high-quality” RCT intervention studies. The context-sensitive approach is constituted by the Effect Modifier Assessment (EMA) method which identifies significant events during the intervention and classifies them as negative, none or positive effect modifiers. Events are also classified as part of the intervention or context. This allows a nuanced analysis of effect and its origin in relation to the intervention outcome. The normal analysis found the intervention to be a success with the context-sensitive identified significant positive effect modifiers.

## The best ‘available’ evidence for workplace MSD prevention

*Dwayne van Eerd*

Occupational Health and Safety (OHS) practitioners are busy individuals trying to help workplaces reduce MSD hazards and the resulting burden of injury. Many OHS practitioners report using research evidence but lack the time to search for and appraise research studies on relevant topics. The Institute for Work & Health (IWH) initiated a systematic review program to provide OHS practitioners and other stakeholders with current evidence to aid in their practice. IWH systematic reviews use a best evidence synthesis (BES) approach which was developed with input from OHS stakeholders. In a field where randomized controlled trials are rare, this approach allowed the synthesis of the best available evidence in a transparent and useful way for OHS stakeholders. This presentation will describe how we worked with stakeholders to develop our BES approach and how our stakeholders view and use the results from our reviews and the research literature in general. Part of our knowledge transfer and exchange approach is to build stakeholder capacity so they understand that a lack of available scientific evidence does not necessarily mean the interventions they employ are not effective. High quality OHS research is required but busy practitioners cannot always wait for it to create solutions.

## Using a research framework to identify the challenges in the prevention of health risks of too much sitting in the office

*Maike Huijsmans*

In a research framework for development and implementation of interventions to prevent work-related MSD(\*), we argued that research disciplines should be linked by following a sequence of six steps: the assessment of (i) incidence and severity of MSD, (ii) risk factors for MSD, (iii) underlying mechanisms; and (iv) development, (v) evaluation, and (vi) implementation of preventive interventions. This research framework can be applied to MSDs in office workers and their health risks from too much sitting, which has gathered interest in recent years. Using examples from our studies, we will illustrate what steps in the framework seem to work well and which would need improvement. Special attention will be paid to the involvement of stakeholders in intervention development and how profiling and targeting could be useful. Furthermore, we will discuss the challenges that we faced when evaluating a real-life, company-initiated intervention to reduce sitting in office workers in a randomized controlled trial. How to conduct a scientifically sound study that results in an intervention intense enough to result in an effect and that can be implemented in future practice without interference of (reliance on) a research team?

\* van der Beek AJ, et al. *Scand J Work Environ Health* 2017;43:526-539.



## Effectiveness of interventions to prevent low back pain: insights from the field.

### Symposium Organizer

*Stefania Curti, Department of Medical and Surgical Sciences, University of Bologna*

### List of presenters

*Henk van der Molen, Amsterdam UMC, University of Amsterdam, Coronel Institute of Occupational Health, Netherlands Center for Occupational Diseases, Amsterdam Public Health research institute, The Netherlands*

*Rahaman Shiri, Finnish Institute of Occupational Health, Helsinki, Finland*

*Paul Kuijer, Amsterdam UMC, Academic Medical Center, University of Amsterdam, Coronel Institute of Occupational Health, Netherlands Center for Occupational Diseases, Amsterdam Public Health research institute, The Netherlands*

*Emma Irvin, Institute for Work and Health, Toronto, Canada*

### Symposium abstract

Aim of this symposium is to provide some practical examples about the evaluation of preventive interventions in the field of musculoskeletal disorders with a specific focus on low back pain (LBP). LBP is a common health problem and a major cause of disability among people of working age. LBP has a high rate of recurrence with approximately one-half of patients that experienced a recurrence of LBP within one year after recovering from a previous episode. Different strategies for LBP prevention have been proposed. It is therefore important to know whether it is possible to prevent LBP and, if so, which interventions are most effective. We believe that this symposium would be of great interest to PREMUS participants by providing new insights from the field.

## Effect of job rotation on musculoskeletal disorders: a literature review.

*Henk F van der Molen*

**Background:** The aim was to summarize evidence on the effects of job rotation on musculoskeletal complaints and exposures related to musculoskeletal complaints.

**Methods:** We conducted a systematic search in three online databases to identify papers published in peer-reviewed journals between 1997 and 2013. Eligible studies compared job rotation to no rotation or different types of rotation within subjects or between subjects and measured (exposures related to) musculoskeletal complaints.

**Results:** Eight field studies and three laboratory studies of sufficient quality were used to summarize the following evidence: one field study showed positive results and one field study showed negative results for musculoskeletal complaints; two field studies showed positive results and two field studies showed inconsistent results for exposures; two field studies showed inconsistent results for musculoskeletal complaints and exposures. Three laboratory studies showed inconsistent results.

**Conclusions:** There is inconsistent evidence for job rotation as a strategy for preventing musculoskeletal complaints. Exposures from all work activities and body regions should be identified and assessed first, to determine if job rotation provides increased exposure variation and/or beneficial changes in mean exposures related to musculoskeletal complaints.

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## Exercise for the Prevention of Low Back Pain: Systematic Review and Meta-Analysis of Controlled Trials.

*Rahman Shiri*

**Background:** The effect of exercise in population-based interventions to prevent low back pain (LBP) and associated disability is still uncertain. The aim of this systematic review and meta-analysis was to assess the effect of exercise on LBP and associated disability.

**Methods:** Comprehensive literature searches were conducted in PubMed, Embase, and Cochrane Library from their inception through June 2017 and additional searches were conducted in Google Scholar and ClinicalTrials.gov. Randomized controlled trials (RCT) and non-randomised controlled trials (NRCT) were eligible for inclusion in the review if they compared an exercise intervention with usual daily activities and at least some of the participants were free from LBP at baseline. We used a random-effects meta-analysis, assessed heterogeneity and publication bias, and performed sensitivity analyses.

**Results:** Sixteen controlled trials (N=4310 participants) including 13 RCTs and 3 NRCTs qualified for meta-analyses. Exercise alone reduced the risk of LBP by 33% (risk ratio (RR)=0.67, CI 0.53-0.85, I<sup>2</sup>=23%, 8 RCTs, N=1634) and exercise combined with education by 27% (RR=0.73, CI 0.59-0.91, I<sup>2</sup>=6%, 6 trials, N=1381). The low back pain intensity (mean difference= -0.52, CI -0.95, -0.09, I<sup>2</sup>=10%, 4 trials, N=452) and disability due to LBP (RR=0.62, 95% CI 0.42-0.92, I<sup>2</sup>=63%, 5 trials, N=1130) were also lower in the exercise than control groups. Excluding the NRCTs and adjustment for publication bias did not change the results. There were only few controlled trials on healthcare consultation or sick leave for LBP, and meta-analyses of these trials did not show statistically significant protective effects of exercise.

**Conclusions:** Exercise reduces the risk of LBP and associated disability, and a combination of strengthening with either stretching or aerobic exercises performed 2-3 times per week can reasonably be recommended for the prevention of LBP in the general population. However, education about back disorders, ergonomic principles or exercise effects appears to have no additional beneficial effect on LBP.

## Everybody knows safe lifting involves using your legs to spare your back...

*Paul Kuijer*

**Background:** Seemingly everybody knows by heart what a safe lifting technique is: use your legs and not your back. This presentation addresses the following two questions: 1. Is What other occupational health interventions appear promising in preventing low-back pain?

**Methods:** Two systematic review studies were used to answer the aforementioned questions: a Cochrane systematic review (Verbeek et al. 2011) and an evidence-based multidisciplinary practice guideline to reduce the workload due to lifting for preventing work-related low back pain (Kuijer et al. 2014).

**Results:** The Cochrane review included nine RCTs (20,101 employees) and nine cohort studies (1280 employees). Studies compared training to no intervention (4), professional education (2), a video (3), use of a back belt (3) or exercise (2). Other studies compared training plus lifting aids to no intervention (3) and to training only (1). The intensity of training ranged from a single educational session to extensive personal biofeedback. None of the studies showed evidence of a preventive effect of training on back pain. The evidence-based multidisciplinary practice guideline stated that effective work-oriented interventions are patient lifting devices, lifting devices for goods, optimizing working height and reducing load mass. Worker-oriented interventions are not recommended, however, personal lift assist devices appear promising.

### **Conclusions:**

Unfortunately, lifting advice and training does not prevent back pain when compared to no intervention or alternative interventions and are therefore not recommended. Work-oriented interventions, like lifting devices for goods and optimizing working height, are recommended to reduce the risk of work-related low-back pain.

### **References**

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Kuijer et al. An Evidence-Based Multidisciplinary Practice Guideline to Reduce the Workload due to Lifting for Preventing Work-Related Low Back Pain. <https://aoemj.biomedcentral.com/articles/10.1186/2052-4374-26-16>

## Workplace- and System-based interventions on return-to-work and recovery for musculoskeletal conditions: a systematic review.

*Emma Irvin*

**Background:** The burden of managing musculoskeletal pain and injuries (MSDs) in the workplace is substantial. While overall rates of work injury have declined in most high-income countries, there have not been equivalent improvements in return-to-work. The primary objective of this review was to synthesize evidence on the effectiveness of workplace- and system-based interventions for RTW and recovery after a period of work absence.

**Methods:** The team of researchers and stakeholders followed a systematic review process developed by the IWH: research question formulation; literature search; relevance review; quality appraisal; data extraction; and evidence synthesis. Review steps were completed with two independent reviewers coming to consensus for each reference.

**Results:** Seven electronic databases were searched from January 1990 until September 2017. This comprehensive search yielded 10576 non-duplicate references. Our synthesis identified 72 studies examining three types of RTW outcomes (lost time, work functioning and associated costs) and four recovery outcomes (pain, psychological functioning, physical functioning and quality-of life). These studies examined interventions classified into three broad domains: healthcare provision, service delivery and workplace modifications. Our review identified that in most cases, interventions were multi-faceted and included multiple intervention components, sometimes operating across multiple domains. The most common RTW outcome reported was lost time. Among other RTW and recovery outcomes, studies varied widely in their inclusion. There is strong evidence that interventions encompassing multiple domains are effective in improving RTW outcomes in workers with MSD conditions.

**Conclusions:** While there is substantial research literature focused on RTW, only a small percentage of these intervention studies also include measures of recovery. Identifying effective intervention programs that facilitate RTW and recovery allows workplaces to implement empirically supported programs that benefit workers through improved function and reduced pain while reducing the economic burden associated with lost time.



## Fatigue Manichaeism and Musculoskeletal disorders.

### Symposium Organizer

*Bernard J. Martin, Center for Ergonomics - Department of Industrial and Operations Engineering, University of Michigan, Ann Arbor MI, USA*

### List of Presenters

*Karen Søgaard, Department of Sports Science and Clinical Biomechanics, Faculty of Health Sciences, University of Southern Denmark, Odense, Denmark*

*Julie Coté, Department of kinesiology and Physical Education, McGill University, Montréal, Qc, Canada*

*Marie Barbe, Department of Physical Therapy, School of medicine, Temple University, Philadelphia, PA USA*

*Sean Gallagher, Department of Industrial and Systems Engineering, Auburn University, AI, USA*

*Bernard J. Martin, Center for Ergonomics, Department of Industrial and Operations Engineering, University of Michigan, Ann Arbor MI, USA*

### Symposium abstract

Since “muscle fatigue” is simultaneously a benefit to the muscle and a degradation of its mechanical capacity it remains a controversial issue in ergonomics. Furthermore, muscle fatigue, which may be viewed as a protective mechanism, is most often the expression of the degradation of multiple mechanisms including physiological, neuromuscular and mechanical systems. These alterations led to consider muscle fatigue, and more particularly accumulation/lack of recovery, as a precursor to muscular disorders (MSDs). Another pernicious effect that has lead to controversy is that the effects associated with some fatigue mechanisms are not consciously perceived. This phenomenon, among others, has consequences for methods used to assess fatigue and their sensitivity to its mechanisms. Hence, the aim of this symposium is to present a spectrum of perspectives on localized muscle fatigue mechanisms to expose current state of the art knowledge and discuss their relative and/or respective contributions to MSDs. Physiological, neuromuscular and mechanical mechanisms associated with “muscle fatigue” will be presented by respected experts. The planed format of the symposium will be as follow: each presentation followed briefly by questions limited to specific details, then a general discussion engaging the presenters and audience will follow the presentations to promote further mutual understanding of fatigue-MSDs relationships and the development of investigations. The aim is to address the ultimate question: how much fatigue is healthy/risky.

## Muscle fatigue to prevent atrophy, pain and disorder.

*Karen Sjøgaard, Dalager T, Sjøgaard G*

*Department of Sports Science and Clinical Biomechanics, Faculty of Health Sciences,  
University of Southern Denmark, Odense, Denmark*

Exercise training studies at the workplace clearly show that with training the muscles not only become stronger but also have less pain. However, an important feature of the most effective training studies is the high intensity of the muscle activity that for each session secure fatigue or even exhaustion in the exercising muscles. In contrast, repetitive work at low intensity can be maintained for many hours without perceived fatigue development in spite of disruption of the intramuscular homeostasis. So, it is the type of fatigue that matters as well as the time for recovery from the specific exertions. This may explain the so called health paradox of physical activity at work and leisure showing a large number of positive effects of physical activity in leisure while occupational physical activity is associated mainly with detrimental effects, especially in MSD.

This may also be described as the u-shaped curve of exposure versus risk of developing MSD or in other words physical activity as both cause and cure of muscular pain.

Therefore "fatigue" may not be just good or bad. The fatigue related muscular changes may play a crucial role in the processes that evoke strengthening of the muscle tissue, improving of motor control etc. The delicate question is if we on an individual basis can identify the threshold for physical exposure - and for the lack of physical exertion that induces a risk of atrophy. This presentation will describe experience with Intelligent Physical Exercise Training, a conceptual model for optimizing the type of muscle fatiguing to counteract the deteriorating effect of occupational tasks.

## Chicken and egg issues in physiology of muscle fatigue.

*Julie Coté, Occupational Biomechanics and Ergonomics Lab, McGill University, Montreal, Québec, Canada*

**Introduction:** Muscle fatigue occurs along with physiological changes that reflect changes in the balance between muscular demand and vascular supply. We studied changes in muscular and hemodynamic measures at the lower limbs, the upper limbs and across the body during occupational fatiguing tasks.

**Methods:** Muscle activity amplitude and variability were calculated from surface electromyography (sEMG), and muscle blood flow was quantified using laser Doppler flowmetry (LDF). Asymptomatic adults performed fatiguing tasks until rating the task "difficult", or reaching 90min. In follow-up studies, muscle oxygenation (Near Infrared Spectroscopy) and thickness (Ultrasound) were measured throughout fatigue.

**Results:** During prolonged standing, lower limb blood flow and ankle sEMG amplitude and variability increased with fatigue. During computer work, there were negligible increases in upper limb blood flow except when concurrently pedaling, when blood flow increased in the forearm muscles. During upper limb tasks, sEMG amplitude and variability, and muscle oxygenation and thickness increased with fatigue.

**Discussion:** Muscular and vascular changes occurring with fatigue reflect changes in the control of different physiological systems. Detailed studies of the time course of changes, combined with advanced muscle imaging techniques, show promise in furthering our understanding, so as to better detect muscle fatigue onset, and prevent fatigue-related injuries.

## Peripheral tissue contributions to fatigue, and challenging the Cinderella Hypothesis.

*Mary F. Barbe, Department of Physical Therapy, School of medicine, Temple University, Philadelphia, PA USA*

The origin of muscle fatigue is complex. This presentation will revisit the Cinderella hypothesis and discuss peripheral tissue contributors to muscle fatigue, including changes in the peripheral nervous system, inflammation and tissue damage. Fatigue can arise with alterations in neuromuscular junctions, neurotransmitters released from peripheral nerves after tissue damage, and axonal neuropathy if compressive nerve injury develops. A beneficial release of cytokines occurs from muscles after exercise that can enhance myogenesis and hypertrophy, and macrophage influxes stimulate satellite cells involved in muscle regeneration. However, chronic inflammation, which can occur after prolonged high demand tasks, has a direct deleterious effect on skeletal muscles, decreasing force and muscle quality. Persistent elevations of systemic TNF $\alpha$  is thought a primary endocrine stimulus for contractile dysfunction. Dependent on the magnitude of mechanical myofiber damage, muscle strength can decline. Substantial muscle damage also induces myofiber apoptosis and a loss of muscle mass. Aging enhances muscle dysfunction due to age-dependent increases in inflammatory responses and cell apoptosis, and reduced repair mechanisms. Lastly, the Cinderella Hypothesis of a hierarchical recruitment of smaller motor units disproportionately over larger units, is under challenge. Postural muscle motor units are apparently recruited in rotation, highlighting the importance of relaxation time.

## Mechanical Fatigue of Musculoskeletal Tissues: Evaluating the Evidence for MSD Causality.

*Sean Gallagher, Department of Industrial and Systems Engineering, Auburn University, Auburn, AL USA*

Several lines of evidence provide evidence that a fatigue failure process may be a etiologic mechanism in the development of MSDs. These lines of evidence include in vitro studies of musculoskeletal tissues; tissue pathology results from animal studies, results of epidemiology studies, and others. However, the available evidence has never been rigorously evaluated with respect to established methods of evaluating whether fatigue failure might be a causal mechanism. This presentation will provide an assessment of the evidence of fatigue failure as a potential causal mechanism using the Bradford Hill criteria. The state of the current evidence will be discussed, as will the need for future research

## Prolonged standing work: addressing mechanisms to mitigate muscle fatigue.

*Bernard J. Martin<sup>1</sup>, G.M. Garcia<sup>2</sup>, T. Laübl<sup>3</sup>*

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Prolonged standing work is associated with musculoskeletal disorders and muscle fatigue is considered a precursor to musculoskeletal disorders. Muscle fatigue is complex as it involves multiple task-dependent mechanisms. Furthermore, muscle fatigue induced by prolonged low-level muscle contraction can persist several hours post work. The results of a series of standing work studies aimed at evaluating the effects of potential interventions on lower leg muscle fatigue have been integrated to address physiological and neuromuscular mechanisms. The influences of rest breaks distribution, foot-surface interface and dynamic activities on the fatigue of long duration are interpreted as a function of mechanisms underlying localized muscle fatigue. They also suggest that ergonomic interventions must be adapted to the type of activity performed in order to address the corresponding fatigue mechanisms. The long lasting effects of muscle fatigue induced by low level static contractions are mitigated by active disruption of physical monotony. Neither mats or sole interface, nor distribution of rest appear to be efficient or sufficient as interventions.



## Low Back Pain – Occupational and clinical aspects.

### Symposium Organizer

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### Symposium abstract

Low Back Pain (LBP) is an extremely common symptom in populations worldwide. The lifetime prevalence of LBP is reported to be as high as 84%, and the prevalence of chronic LBP is about 23%, with 11–12% of the population being disabled by LBP. This symposium is aimed to encourage discussion and brainstorming in the different aspects of LBP. We will try to cover several aspects of LBP, focusing especially on occupational aspects. Dr. Moshe will discuss different epidemiological aspects, especially the increase of disability-adjusted life-years in 2015 (54% since 1990), with the biggest increase seen in low-income and middle-income countries.

Dr. Levy-Barak will discuss LBP as an occupational disease with two major aspects – activities which are considered as risk factors for occupational LBP and professions which are considered more risky for occupational LBP.

Dr. Sahar-kostis will discuss the use of functional questionnaires in assessing fitness for work in LBP patients. The lecture will review the relevant questionnaires that may be put to practice while determining working abilities in LBP patients, with an emphasis on the use of the ODI (Oswestry Disability Index) questionnaire.

Dr. Barak will discuss the Occupational influences of Spondylolysis and Spondylolisthesis in young adults. Spondylolysis and spondylolisthesis are common findings in the population and may be of an occupational relevance. Better understanding of the etiology and progression of the situation may assist health care providers to prevent, assess the occupational aspects and deal with the professional challenge.

The final lecture, given by Dr. Krakov, will present practical recommendations for fitness for work and disability evaluation in LBP patients, based on our experience in Israel and according to the last scientific publications.

## Low back pain epidemiology.

*Shlomo Moshe<sup>1,2</sup>*

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*<sup>2</sup> Sackler Faculty of Medicine, School of Public Health, Tel-Aviv University, Tel-Aviv, Israel*

Low Back Pain (LBP) is an extremely common symptom in populations worldwide. The lifetime prevalence of LBP is reported to be as high as 84%, and the prevalence of chronic LBP is about 23%, with 11–12% of the population being disabled by LBP. LBP was responsible for 60.1 million disability-adjusted life-years in 2015, an increase of 54% since 1990, with the biggest increase seen in low-income and middle-income countries.

LBP is a complex condition with multiple contributors to both the pain and associated disability, including psychological factors, social factors, biophysical factors, comorbidities, and pain-processing mechanisms. Non-specific LBP has become a major public health problem worldwide.

Disability from LBP is highest in working age groups worldwide, which is especially concerning in low-income and middle-income countries where informal employment is common and possibilities for job modification are limited. Most episodes of LBP are short-lasting with little or no consequence, but recurrent episodes are common and LBP is increasingly understood as a long-lasting condition with a variable course rather than episodes of unrelated occurrences.

The global burden of LBP is projected to increase even further in coming decades, particularly in low-income and middle-income countries.

## Low Back Pain as an Occupational Disease.

*Darya Levy Barak<sup>1</sup>, Shlomo Moshe<sup>2,3</sup>*

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Low Back Pain (LBP) is a major cause of illness worldwide. It is the sixth leading cause of global disease burden and a major cause of leaving years with disability. Its lifetime prevalence is 50-85%. As such it is frequently encountered complaint among the working population. In 85% of cases the pain is idiopathic. The etiology of LBP is multifactorial, and it is estimated that 37% of cases are caused by occupational conditions. Other causes are genetic, environmental and biologic.

Occupational LBP is more prevalent among heavy physical workers, those engaged in manual lifting, whole body vibrations and awkward body postures. Lack of job satisfaction, higher job demands, and lower social support are related to worse prognosis and longer sickness absence. Occupational, psychosocial and organizational factors should be a part of patient's evaluation. Low back pain is also associated with direct and indirect medical costs, presenteeism and absenteeism.

In this presentation we will review the causal association between work and LBP in different occupations and employment conditions in order provide scientific recommendations and guidelines.

## The use of functional questionnaires in assessing fitness for work in low back pain patients.

*Yael Sahar-Kostis<sup>1,2</sup>*

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Low Back Pain (LBP) is known to be a major cause not only for disability but for loss of work productivity and numerous, prolonged absences from work. Although LBP is derived from many various pathologies, the assessment of fitness for work and the need for specific occupational restrictions often derive not only from the objective lesion and the occupational requirements, but also from a combination of the patient's disabilities, beliefs, pain notion and health perception.

There is a fairly wide use of questionnaires in the evaluation of LBP, focusing mainly on functional outcomes after conservative and surgical treatments. The use of such functional questionnaires in the context of fitness for work is proving to be a useful addition to the occupational physician's toolbox.

The lecture will review the relevant questionnaires that may be put to practice while determining working abilities in low back pain patients, with an emphasis on the use of the ODI (Oswestry Disability Index) questionnaire.

## Occupational influences of Spondylolysis and Spondylolisthesis in young adults.

*Yair Barak<sup>1</sup>, Shlomo Moshe<sup>2,3</sup>*

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Spondylolysis is a structural vertebral defect usually common in radiographic imaging and can be asymptomatic or connected to low back pain. This finding is rather common in adolescence especially in correlation to physical activity. Spondylolisthesis can be an advanced stage of spondylolysis when a movement of one vertebral body over the other occurs. The diagnosis of spondylolysis is based mainly on imaging.

The occupational relevance of spondylolysis and spondylolisthesis is not described in many studies and therefore can be evaluated along the connection presented in sport medicine and military medicine studies.

Many studies demonstrate high rates of spondylolysis in athletes in general and for some specific sports such as weightlifting, rowing and throwing sports even a higher rate. Occupational medicine studies found among taxi drivers connection between spondylolisthesis and the combination of physical activity, body mass index and seniority.

Spondylolysis and spondylolisthesis are common findings in the population and may be of an occupational relevance. Better understanding of the etiology and progression of the situation may assist health care providers to prevent, assess the occupational aspects and deal with the professional challenge.

## The Fitness For Work evaluation in Low Back Pain patients.

*Ayala Krakov<sup>1</sup>, Shlomo Moshe<sup>1,2</sup>*

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Fitness for work (FFW) evaluation by an Occupational Physician (OP) is the determination whether the patient is fit to perform his duties without risk to himself or others; it is based on the physician's knowledge of the nature of the patient's work and his physical and mental health condition. Loss of FFW (handicap of work ability) may result directly from an impairment (for instance, spondylolysthesis) or, more usually, from the resulting disability (sciatica). The simplified scheme of the International classification of impairments, disabilities, and handicaps should be used in order to determine FFW  
Clinical approach of back pain assessment: Anamnesis: Age, Violent trauma, Constant progressive pain, weight loss etc. Physical examination: Dermatomal distribution, Straight leg raising test etc. Unfortunately the correlation of symptoms and work capacity with x-ray/CT/MRI findings is poor. So, the role of imaging is limited. Therefore the recommendation mainly based on history and clinical examination. Although the diagnosis is frequent only few patients require spinal surgery.

Medical army profile: This medical profile in army service determines whether the service will be perform in combat units, maintenance units or clerical tasks. In other wards there is an army severity score scale for back pain and different occupations which can help in decision making while evaluating FFW



## Beyond CTS: findings on other health outcomes in recent large cross sectional and prospective studies.

### Symposium Organizer

*Carisa Harris, PhD, CPE*

*Asst. Professor, Department of Medicine, University of California, San Francisco, USA  
School of Public Health, University of California, Berkeley, USA*

### List of Presenters

*Alysha R Meyers, PhD; Division of Surveillance, Hazard Evaluations, and Field Studies; National Institute for Occupational Safety and Health, USA*

*Carisa Harris, PhD, CPE; Department of Medicine, University of California, San Francisco, USA; School of Public Health, University of California, Berkeley, USA*

*Stephen Bao, PhD; Safety and Health Assessment and Research for Prevention (SHARP) Program, Washington State Department of Labor and Industries, Olympia, Washington, USA*

*David H. Seidel; Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) Deutsche Gesetzliche Unfallversicherung e.V. (DGUV)*

*Roberta Bonfiglioli, MD; Occupational Medicine, Department of Medical and Surgical Sciences, University of Bologna, Italy*

### Symposium abstract

Historically, work-related upper-extremity musculoskeletal disorders (MSD) have comprised a significant portion of workplace injuries. The problem of work-related upper-extremity MSD has been, and continues to be, widespread and costly. Work-related upper-extremity musculoskeletal disorders (MSDs) continue to be a problem in countries like the US, and contribute to pain, discomfort, loss of productivity and disability (Martimo et al., 2009). In response to this, numerous large cross sectional and prospective studies were performed over the past 20 years to understand the relationship between personal, biomechanical, work psychosocial factors and risk of upper limb disorders. Initially, carpal tunnel syndrome was the focus of these studies since it typically has the highest medical and indemnity costs associated with it. Results found that peak force, % time spent in forceful exertion and forceful repetition rate were associated with higher rates of CTS (Harris-Adamson et al, 2014). Studies also found that the ACGIH Threshold Limit Value (TLV) for Hand Activity was not adequately protective of workers (Kapellusch et al, 2013; Bonfiglioli et al., 2013); since then the TLV and action limit (AL) have been lowered (ACGIH 2018). However, more recent analyses have looked at other end points such as rotator cuff tendinosis, elbow epicondylitis and wrist tendinosis. Further, recent analyses have looked at the relationship between these physical factors, median nerve symptoms and latency changes. This panel will present recent research from the US Upper Limb Musculoskeletal Consortium studies, the Italian OCTOPUS study and a recent large cross-sectional study in Germany.

## Biomechanical risk factors for rotator cuff tendinosis: a prospective study of 451 workers.

*Meyers, AR, Wurzelbacher, SW, Krieg, EF*

**Background:** Work-related rotator cuff tendinosis (RCT) is a major source of disability and expense. The aim of this study was to identify work-related biomechanical risk factors for developing dominant arm RCT using individual measures of exposure.

**Methods:** This prospective study of dominant side RCT included 451 workers from manufacturing and healthcare. Our case definition included self-report shoulder pain and pain during provocative tests at annual physical exams. Task-level biomechanical exposure measures for each worker included measures of hand exertions, repetition, duty cycle, vibration, and awkward shoulder postures. Hazard ratios (HR) and 95% confidence intervals (CI) were calculated with Cox proportional hazard models. Multivariate models were conducted separately for each exposure measure, controlling for confounding by personal factors and biomechanical exposures from other domains.

**Results:** After excluding 34 prevalent cases, we observed 39 RCT cases in 694 person-years (incidence rate=5.62 per 100 person-years, 95% CI=4.12, 7.69). We observed statistically significant ( $p < .05$ ), increased risk of developing RCT for each unit increase in age (in years, HR=1.05) and Body Mass Index (in kg/m<sup>2</sup>, HR=1.05). In multivariable analyses, we observed a statistically significant decreased risk of developing RCT for each unit increase in percent time working in shoulder flexion  $\geq 45^\circ$  (HR=0.06,  $p = .03$ ); however, a pattern of non-statistically significant (all  $p > .40$ ) increased incidence of RCT was observed for percent time spent in  $< 20\%$  range of motion for shoulder flexion (HR=3.23) or abduction (HR=1.40). Non-significant associations of increased risk were observed for exposure to other separate measures of biomechanical exposure.

**Conclusions:** There is no consensus on the best ways to characterize biomechanical exposures in the study of shoulder disorders such as RCT. Subsequent work will 1) include exposure to combinations of biomechanical exposures and 2) pool data with other studies.

## Biomechanical risk factors for distal upper extremity tendinosis.

*Carisa Harris, PhD, Oguz Akkas, PhD, Stephen Bao, PhD, Jia-Hua Lin, PhD, Alysha R. Meyers, PhD, David Rempel, PhD, and Robert G. Radwin, PhD.*

**Background:** Elbow epicondylitis and wrist tendinosis are distal upper extremity musculoskeletal disorders (DUE MSDs) that continue to be prevalent and costly in the workplace. The purpose of this study was to assess the relationship between biomechanical risk factors and distal upper extremity tendinosis (hand/wrist/elbow) using combined data from 3 large prospective studies in the United States.

**Methods:** Subjects from NIOSH, SHARP and UC San Francisco with individual exposure and health outcome data were combined for this analysis. Case criteria included a positive maneuver and the presence of one of five core signs (tenderness to palpation, redness, swelling, crepitance, or warmth). Approximately ten minutes of video was recorded for each task of each participant and analyzed frame-by-frame using multi-video task analysis (MVTA) (Yen, 1995).

**Results:** 1,442 subjects (44% female) with an average age of 40 years (SD=11) were included in this analysis. Being female (HR=2.86; 95%CI: 1.76-4.66) and over 40 years of age (HR=2.19; 95%CI: 1.04-4.59) increased the rate of hand/wrist tendinosis & elbow epicondylitis. Spending more than 25% time in forceful hand exertion was the primary exposure associated with distal upper extremity tendinosis. Total repetition rate had an elevated effect estimate but with wide confidence intervals (HR= 1.44; 95%CI: 0.74-2.81).

**Conclusion:** Similar to the findings on carpal tunnel syndrome, the % time spent in forceful exertion was an important risk factor associated with hand/wrist tendinosis and elbow epicondylitis; efforts to reduce the % time spent in forceful hand exertion may be beneficial for reducing the rate of distal upper extremity disorders including hand/wrist tendonopathies, epicondylitis, and carpal tunnel syndrome.

## Biomechanical and personal factors and incidence of lateral epicondylitis in a combined cohort of 1589 workers.

*Stephen S. Bao, PhD, Jay M. Kapellusch, PhD, Matthew S. Thiese, PhD, Andrew S. Merryweather, PhD, Kurt T. Hegmann, MD, MPH*

**Background:** The present study aimed at further investigating these relationships particularly focusing on comparisons of the combined biomechanical exposures quantified by three different methods (the ACGIH TLV for HAL, 1995 SI and a recently developed Cumulative Strain Index or CUSI) with different cut-points.

**Methods:** A cohort includes 1589 workers (973 or 61.2% females and 616 males) from 22 diverse workplaces at baseline and followed for up to six years. Worksite visits were carried out to collect relevant task information in order to calculate the combined biomechanical exposure indexes. Questionnaire interviews and physical examinations were conducted to identify LEPI cases.

**Results:** This cohort has a mean age of 41.4 years old (range: 18-72) and a mean BMI of 28.7 kg/m<sup>2</sup> (range: 16.0 – 58.6). The personal factors (age, gender and BMI) were significantly associated with the incidence of LEPI. Therefore, they were adjusted in all modeling with biomechanical exposures. Comparisons of the distribution of biomechanical exposure levels of various cut-points of the different combination index calculations showed that the 6.1 cut-point for the 1995 SI and the 14.8 cut-point for the CUSI categorized similar percentages of workers to the same risk levels as the ACGIH TLV for HAL (< AL vs. ≥ AL).

Analyses using Cox frailty models showed statistically significant effects between the combined biomechanical exposures and LEPI incidence when the exposure was quantified by the ACGIH TLV for HAL, the 1995 SI using cut-point of 6.1, and the CUSI using cut-point of 14.8. The lower cut-points for the 1995 SI and CUSI did not show statistically significant effects.

**Conclusions:** Both the 1995 SI and the newly developed CUSI were able to show statistically significant associations with LEPI at the higher cut-points. The lower cut-points were not sensitive enough to link higher biomechanical exposures to LEPI.

## Extension of a kinematic and force measurement-based tlv approach to assess workloads of the elbow joint – a field feasibility study.

*David H. Seidel, I Hermanns, K Heinrich, R Ellegast, M A Rieger, L H Barrero, B Weber, B Steinhilber*

**Background:** The Threshold Limit Value (TLV) is a well-known approach to assess work-related wrist loads. The aim of this work was to test a measurement-based TLV approach (mTLV) using kinematic and EMG data for the assessment of work-related wrist and elbow exposures.

**Methods:** Hand Activity Level was determined by a measurement-based repetition score of the wrist (based on the mean angular velocity, the mean power frequency of the angular data and kinematic micro pauses). It was combined with EMG data of the forearm muscles (P90 %MVC) using the TLV proceeding. This approach was also transferred to the elbow joint and was tested against health outcomes in the cross-sectional MEGAPHYS study (N = 808; 84.5% men). Statistical analyses were performed by Generalized Estimating Equation models.

**Results:** Positive significant associations were found between the mTLV (wrist and elbow exposures above the action limit threshold) and the prevalence of wrist and elbow complaints as well as the prevalence of arthrosis of the distal upper extremities. However, no significant associations were found for lateral or medial epicondylitis.

**Conclusions:** The mTLV approach revealed promising results for the wrist and the elbow. Further prospective studies are necessary, especially with regard to the transfer of this approach to the elbow and the derivation of corresponding thresholds.

## Predictors of symptoms severity and nerve conduction impairment in a large Italian cohort study.

[\*Roberta Bonfiglioli, MD\*](#)

The role of job-related and individual factors as predictors of symptoms severity and median nerve conduction impairment in workers affected by carpal tunnel syndrome (CTS) was studied in a cohort of industrial workers.

Manual work was assessed using Hand Activity Level (HAL) for repetition and normalized peak of force (nPF).

CTS cases were based on symptoms and positive nerve conduction studies. Different ways of expressing the severity of CTS are found in the existing literature and in clinical records. Symptoms characteristics (at night/awakening, during or after work, occurring during the day, on both day and night) and frequency (once a month, once a week, daily) were used to classify symptoms severity. Criteria adopted in severity grading of median nerve impairment were based on sensory action potentials and compound muscle action potential distal latency and sensory nerve conduction velocity of the median nerve at wrist level.

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## Developing International Criteria for Work-Related Musculoskeletal Diseases: An Initiative of the Committee on Work-related Musculoskeletal Disorders of ICOH.

### Symposium Organizer

*David Rempel, University of California, San Francisco, CA, USA*

### List of Presenters

*Chair: Prof Roberta Bonfiglioli, MD, University of Bologna, Occupational Medicine, Italy*

*David Rempel, MD; University of California, San Francisco, CA, USA*

*Karen Walker-Bone, MD; Medical Research Council, University of Southampton, UK*

*Alexis Descatha, MD, Assistance Publique Hopitaux de Paris; University of Angers, France.*

*Andreas Seidler MD, Institut und Poliklinik für Arbeits- und Sozialmedizin, Technische Universität Dresden. Medizinische Fakultät, Dresden, Germany*

*Paul Kuijer PhD, Amsterdam University Medical Centers – location AMC, Amsterdam, The Netherlands*

### Symposium abstract

Criteria for work-related musculoskeletal disease varies widely between countries. Criteria are used for many purposes including national surveillance in order to promulgate workplace preventative programs and for determining compensation for injured workers. Most countries have a List of Occupational Diseases, but these Lists tend to include few musculoskeletal diseases even though these musculoskeletal diseases are the most common causes of work-related disability and lost-time. Furthermore, the thresholds for compensation vary widely between countries. For example, for low back pain, the minimum work-related attributable fraction varies from 1% (California) to 70% (Switzerland). These differences in criteria contribute to large variations in national statistics on reported work-related diseases.

In 2018, The ICOH Committee on Work-related Musculoskeletal Disorders (Chair: Dr. Roberta Bonfiglioli) was tasked with creating an international process that would develop criteria for common work-related musculoskeletal diseases. This initiative began with the recruitment of experts in the field, the development of an overall framework for such criteria and is followed by the application of the framework to specific diseases. The Symposium will introduce a proposed framework and this will be followed by the application of the framework to the disease of work-related lumbosacral radiculopathy syndrome (LRS) with a focus on the quality of epidemiologic evidence, including interpretation of attributable risk; quality and exposure assessment and minimum criteria of exposure; and the consideration of non-occupational factors. Presentations on LRS will include (1) symptoms and examination criteria, (2) imaging, (3) minimum workplace exposure criteria, (4) the application of GRADE to work-place exposure, and (5) non-work factors. The presentations will be brief to allow for discussion and audience participation.

## A framework for developing criteria for work-related musculoskeletal diseases.

*David Rempel*

The proposed framework for developing criteria for specific musculoskeletal disorders will consider the role of medical, epidemiologic, workplace exposure, and non-occupational factors using an evidence-based approach. The overall approach builds on a probabilistic model that considers three areas: (1) criteria for the likelihood of the musculoskeletal disease, (2) criteria for the likelihood that task or job factors are associated to the disease, (3) likelihood that non-work factors are associated to the disease. Each of these is evaluated in more detail to determine the minimum contributing criteria that would be associated with different levels of confidence: not likely, possible, probable, very probable and certain. The user of the criteria can then select the appropriate level of confidence for the purpose. For example, for the reporting and collection of national statistics on work-related musculoskeletal diseases, a confidence level of possible may be adequate. However, for determination of financial compensation related to the disease, a level of probable may be necessary. The approach includes an overall probability matrix with the three considered areas. Ultimately, this initiative will lead to published criteria for the framework and for specific musculoskeletal diseases.

## Evidence-based symptom/examination criteria for Lumbo-sacral radiculopathy.

*Karen Walker-Bone*

Lumbo-sacral radiculopathy is the term used for pain caused by compression or irritation of the nerve roots of the lower back. It is very common in practice and surgical costs increased by 23% 1992-2003 in the developed world and yet diagnosis remains challenging. Symptoms and physical examination findings remain crucial components of the assessment of a patient with LSR with the specific aim of identifying the location of the lesion causing pain. However, there is no gold standard for this. A dermatomal distribution of pain is only reported in 16.3% of patients with L5 radiculopathy and only 3-22% of patients found to have compression intra-operatively reported dermatomal pain. Physical examination findings enhance diagnostic accuracy but still the combination of examination and symptoms only increases the agreement with MRI scan findings to 16-58%. Electrodiagnostic studies can further enhance the accuracy of clinical findings but these studies are only found to be abnormal in 50% of patients with LSR. Additional research is required to optimize the use of the existing diagnostic tools or develop new approaches.

## The role of imaging in the diagnosis of Lumbo-sacral radiculopathy.

*Alexis Descatha, (Audrey Petit , Yves Roquelaure)*

Whereas there is sufficient evidence of work-relatedness of low back pain, the question of the compensation is still debated in many countries. Relevant and accurate diagnostic criteria are crucial to support compensation. In this context, the usefulness of imaging for the diagnosis of lumbo-sacral radiculopathy was studied. Imaging is relevant to the search of a differential for serious underlying pathology requiring diagnostic confirmation in cases of red flag, though definition of red flags itself is subject of debate. However, the accuracy for detection detecting lumbar nerve root compromise is questionable especially for sensitivity (varying from 25 to 75%). In conclusion, though in some countries compensation requires positive imaging, the scientific evidence for support is limited. Having diagnostic criteria that include imaging and other objective components should be considered.

## Do we need minimum requirements for exposure definition and assessment for work-related LRS?

*Andreas Seidler*

Several studies have examined the risk of musculoskeletal diseases, particularly of LRS, by different physical demands, for example carrying or lifting of heavy loads; bending and twisting of the trunk, whole body vibration, and sitting. To allow for the derivation of a dose-response relationship, each study should fulfil the following minimum requirements of exposure assessment and documentation: it should give (1) separate exposure information for every job phase, at best for the whole occupational history, (2) the intensity and (3) duration of specific exposures for a „typical day“ (if necessary, for different types of workdays). For categorized exposure values, ranges and mean values should be given for all categories (also for the highest category). To calculate the exposure-response relationship between lifting or carrying of loads and LRS (Kuijer et al. 2018), the exposure was first transformed to a standard metric consisting of a dose per working day in terms of intensity (loads of more than 5 kg) and duration (at least 2 hours per working day). Next, the cumulative working years under exposure were calculated. The risk of bias for different types of exposure assessment (e.g. objective measurement, job-exposure matrices, self-reported exposure) is discussed in this presentation.

## GRADing Work-related Exposure for LRS.

*Paul Kuijer*

To assess the quality of evidence for the relationship between work-related risk factors and LRS, the Grades of Recommendations, Assessment, Development and Evaluation (GRADE) framework was used. GRADE has four levels of quality: high, moderate, low, and very low and uses the following seven factors to assess the quality based on data from a systematic review and meta-analyses: study strengths, consistency, indirectness, imprecision, publication bias, effect sizes and the presence of an exposure-response relationship. This presentation shows how we used GRADE to conclude that moderate to high-quality evidence is available that LRS can be classified as a work-related disease depending on the level of exposure to bending of the trunk or lifting and carrying. [Kuijer PPFM et al, Work-relatedness of lumbosacral radiculopathy syndrome. Review and dose-response meta-analysis, <http://n.neurology.org/content/91/12/558>]



## Musculoskeletal Injuries amongst Firefighters.

### Symposium Organizer

*[Joy C MacDermid](#) Western University, Canada; FIREWELL*

### List of Presenters

*[Joy C MacDermid PT PhD](#), Western University, Canada*

*[Kathryn Sinden](#), Lakhead University, Canada*

*[Susan Stock](#), University of Omtreal, Canada*

### Relevant Themes

Assessing exposure to risk factors for work-related musculoskeletal disorders

Gender and musculoskeletal disorders

Health-related work disability of the musculoskeletal system

Assessing exposure to risk factors for work-related musculoskeletal disorders

Rehabilitation/supportive conditions at work to improve work ability

### Symposium abstract

Firefighters have unique musculoskeletal risks due to the inherent training and emergency tasks required to perform their duties. Researchers from the FIREWELL collaboration will present research crossing multiple aspects of this problem. This symposium will address musculoskeletal injuries in firefighters including perspectives on the priority solutions and research questions, assessment of risks for musculoskeletal injury, interventions to promote recovery and the challenges and experiences in managing return to work.

Aims: To discuss challenges and innovations in dealing with MSK injury in firefighters, which represent a challenging and high-risk context for managing MSKD.

## Firefighter Perspectives of Musculoskeletal Injury Priorities and Related Research.

*JC MacDermid*

Introduction: Firefighters provide essential services that require high intensity performance in stressful situations. Shift work and physical exertion during training and fire ground situations place fire-fighters at high risk of musculoskeletal (MSK) injury and gradual onset disorders. The objective of this study was to identify and prioritize firefighters' needs and related work health research. Methodology: Fifty-two firefighters (42 males, 10 females) from fire services across Canada (Alberta, Atlantic Canada, British Columbia, Nunavut, Ontario, Quebec) were interviewed using a semi-structured guide. The phone interviews were recorded and transcribed verbatim. Descriptive content analysis identified themes. Results: General health and muscle sprains and strains (back, shoulders, knees) were the firefighters' most common mentioned health concerns. The impact of MSK injuries on firefighters' ability to do job tasks and maintain family life roles were concerns. Physiotherapy was identified as the most needed service to manage MSK injury. The unpredictable work environment of the fire service was acknowledged as a barrier to prevention. Firefighters expressed the need to develop treatment programs that were specific to their job demands. Conclusion: Firefighter-specific musculoskeletal prevention and rehabilitation programs that can be accessed at minimal cost are priorities.

## Wearable devices provide insight into physiological responses during 24 hour shifts.

*Kathryn Sinden*

**Introduction:** Identifying physiological response to work demands informs injury prevention strategies particularly regarding fatigue where fatigue is a risk factor for MSDs. Wearable technology enables real-time monitoring of functional load during work tasks. This presentation will cover general principles, options and challenges in using wearable devices to monitor physiological responses during active duty in firefighters. Presentation will include data presented from a series of career firefighters' during firefighting tasks over 1x24-hour shift.

**Methods:** Firefighters (age:  $M=34.5$  yrs,  $SD=8.1$  yrs; years of service:  $M=5.4$ ,  $SD=4.7$ ;  $n=10$ , 2=female) used wearable technology for 1x24 hour shift to measure functional load. Metrics of interest (heart rate-HR, breath rate-BR and heart rate variability-HRV) were partitioned into firefighting task classifications per documentation of shift activity. Sampling rate was 1Hz; individual and group means, standard deviation, maximum and minimum were calculated for each metric.

**Results:** Firefighting tasks were classified into station duties, fire, fire-false alarm, rescue/medical and public relations. Variability in call type across shifts was observed. Highest HR ( $M=96.7$ bpm,  $SD=14.9$ bpm), BR ( $M=21.9$ bpm,  $SD=7$ bpm) and lowest HRV ( $M=64.4$ ms,  $SD=39.4$ ms) were experienced during fire calls (30%). High HR ( $M=77.3$ bpm,  $SD=15.1$ bpm) and BR ( $M=18.8$ bpm,  $SD=4.5$ bpm) and highest HRV ( $M=100.1$ ms,  $SD=41.8$ ms) were experienced during rescue/medical calls (40%). Lowest physiological response was associated with false alarm fire calls (60%) (HR:  $M=68.6$ bpm,  $SD=10.1$  bpm), station duties (100%) (HR:  $M=69.7$ bpm,  $SD=9.1$  bpm) and public relations (HR:  $M=69.3$ bpm  $SD=9.1$  bpm).

**Discussion:** Unique insights into firefighters' on-shift physiological response were elicited suggesting feasibility of this approach. Fire calls were associated with higher physiological load and fatigue; rescue/medical and false alarm calls were associated with similar physiological loads.

## Issues and return to work for firefighters.

*Susan Stock*

This presentation will cover some of the challenges encountered in adapting and implementing a toolkit that has been widely used for developing a return to work plan for generic musculoskeletal disorders. Following a knowledge to action cycle process this presentation will cover some of the contextual issues including local regulations, policies, priorities, leadership with work issues including the emergency nature of firefighting and the difficulty in altering task demands. The experience working with a single fire service in Québec, Canada will be presented as a case study. Qualitative interviews conducted with firefighters who had been injured and gone through the return to work process were conducted. The concordance between these themes and the case study will be discussed.

## Challenges and opportunities in using video motion capture movement analysis to understand ergonomic risks in firefighters; and applications as training tools.

*Kathryn Sinden*

This presentation will cover the results of a series of studies that used Dartfish motion analysis and ergonomic tools commonly used in the workplace to assess firefighter tasks performed in a training centre (high-rise pack lift, stair climb with hose, hose drag). The pros and cons of this type of analysis will be discussed as well as data presented from a series of studies that define the kinematic patterns of these three tasks, evaluate differences between men and women firefighters performing the tasks and demonstrate physiological responses associated with these tasks. The data will demonstrate challenging methodological issues including the use of protective equipment and complex movements limiting the line of sight and tracking of movements. However, it will also present solutions. Further it will demonstrate that using these techniques we have been able to detect difference in kinematics between how men and women perform tasks; identify movement indicators and describe the reliability and validity of these techniques.

*Joy MacDermid*

This presentation will cover a scoping review of the literature demonstrating the type of research that has been conducted with respect to firefighter musculoskeletal health. The scoping review was conducted based on a systematic search of multiple databases including PubMed, Embase, CINAHL, and PsychInfo. . Twenty-six of the included studies investigated epidemiology of firefighter injuries, utilizing retrospective cohort (n=15), cross-sectional (n=8), and prospective cohort (n=3) study designs. Another two papers investigated primary prevention interventions, with one utilizing a pre-test post-test with a control group design and the other a prospective non-randomized controlled trial. One last paper conducted a focus group, utilizing a qualitative design with interviews conducted in focus groups. The most commonly examined MSK injuries were sprains and strains, included in 72% (n=21) of studies. The next most common MSK injuries were fractures (n=15; 52%) and dislocations (n=10; 34%). Noticeable gaps in the literature included intervention studies and inclusion of women firefighters. Trends in the literature will be presented with a discussion of what this means for optimizing future firefighter research.

# Oral Presentations



## What is the attributional fraction due to work for musculoskeletal disorders on a national level?

*Henk van der Molen<sup>1</sup>; Carel Hulshof<sup>1</sup>; Paul Kuijer<sup>1</sup>*

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**Background:** To explore the impact of work-related musculoskeletal disorders (WRMSDs) through estimations of population attributable fractions (PAFs) in a national context.

**Methods:** PAFs were calculated for seven prevalent WRMSDs using existing data on the prevalence of exposure to risk factors at work and the strength of their association with the specific disease based on systematic review studies. The seven prevalent WRMSDs are lateral epicondylitis, hip and knee osteoarthritis, lumbosacral radiculopathy syndrome, non-specific low back pain, shoulder soft tissue disorders and carpal tunnel syndrome. Prevalence figures for exposure to work-related risk factors were retrieved from the Dutch National Working Conditions Survey (NWCS) based on self-reports by approximately 40,000 workers. The risk factors retrieved from the reviews were matched with the available and dichotomized self-reported exposure items from the NWCS by two authors. PAFs were calculated according existing formulas: (proportion of workers exposed to risk factor) x (attributable risk due to exposure to risk factor).

**Results:** The seven frequently reported WRMSDs among the Dutch working population revealed PAFs varying between 7% and 25%. Lateral epicondylitis showed the highest attributable fraction with 25%. For hip osteoarthritis (17%), lumbosacral radiculopathy syndrome (14%), knee osteoarthritis (13%), non-specific low back pain (10%), shoulder soft tissue disorders (10%) approximately one in six to ten cases were attributable to work. The lowest PAFs was for carpal tunnel syndrome (7%).

**Conclusions:** The results show that a fairly simple approach may increase insight into the impact of WRMSDs independently of national social security regulations if PAFs can accurately be calculated. If so, these PAFs could also be calculated for various industry sectors and jobs when valid and reliable estimates of risk factors are available, thereby providing data to employers, workers, occupational health professionals and policymakers about the industrial sectors and jobs at risk. This might increase the sense of urgency for prevention of WRMSDs.

## Proportion of upper extremity musculoskeletal disorders attributable to personal and occupational factors: Results from the French Pays de la Loire study

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**Background:** Upper extremity musculoskeletal disorders (UEMSD) are one of the most common and costly occupational health problems. We aimed to assess the contribution of personal and occupational risk factors to the UEMSD burden at the population level.

**Methods:** A random sample of 3710 workers from the Pays de la Loire region in France were included by occupational physicians (OPs) between 2002 and 2005. Between 2007 and 2010, 1611 workers were re-examined by their OPs. Data on personal characteristics and working conditions were collected by a self-administered questionnaire, and UEMSD were diagnosed by OPs using a standardized physical examination. Subjects free from UEMSD at baseline were included in this study (754 men and 521 women, aged 20-59 years). Associations between UEMSD at follow-up and personal, biomechanical and psychosocial factors at baseline were assessed using logistic regression models. Population-attributable fractions (PAFs) were used to estimate the proportion of cases attributable to each factor included in multivariate models.

**Results:** During the follow-up period, 76 cases of UEMSD in men and 67 in women were diagnosed. In men, PAFs for factors associated with UEMSD in multivariate models were 18% (95% CI = 4 to 30) for age group 35-44, 29% (14 to 40) for age  $\geq$  45 (reference  $<$ 35 years), 44% (12 to 67) for high perceived physical exertion (Borg scale  $\geq$  13) and 17% (-4 to 37) for low social support. In women, PAFs were 62% (19 to 85) for body mass index  $\geq$  25.0 kg/m<sup>2</sup>, 23% (-12 to 53) for working with repeated and sustained arm abduction (60-90°) and 12% (-11 to 33) for working with arms above shoulder level ( $\geq$ 2 hours/day).

**Conclusions:** The study quantified proportions of UEMSD cases theoretically preventable at the population level and highlighted the importance of personal factors in women, and occupational factors in men in the subsequent occurrence of UEMSD.

## Music-specific and generic psychosocial stressors among performing musicians with various work arrangements

*Laura Punnett*<sup>1,2</sup>; *Jenny (In-Chae) Ro*<sup>1,3</sup>; *Robert A. Karasek*<sup>1,4</sup>; *Martin G. Cherniack*<sup>5</sup>; *Karen Sogaard*<sup>2</sup>

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**Background:** Professional musicians have physical and psychosocial occupational exposures with health implications. Most studies have focused on orchestra members, who (unlike many other instrumentalists) typically hold salaried, benefitted positions within hierarchical decision-making organizations.

**Methods:** A questionnaire was mailed to members of two U.S. musician local unions covering all employment arrangements and sources of income, not limited to music performance. Additionally, there were many questions about specific aspects of music practice, audition, performance, and general career satisfaction.

**Results:** Surveys were returned by 319 musicians, of whom about two-thirds held orchestral positions. Among both orchestral and non-orchestral musicians, there were multiple jobs, including teaching, freelance, and small ensemble performing (in roughly equal proportions). About one-third of respondents also held non-music jobs, ranging from clerical to construction.

Orchestral musicians, especially those working freelance, reported higher psychological demands, lower decision latitude, and lower job insecurity than non-orchestral musicians. They also reported more stressful aspects of practice and performance, such as competition with other instrumentalists, whereas non-orchestral musicians had more stress related to auditions. Among each of these groups, there were further differences according to type of work situation; e.g., both orchestra and non-orchestra musicians who also worked freelance were the sub-groups with the highest job insecurity.

**Discussion:** Musicians' perceptions of psychosocial stressors varied with employment arrangements, which were diverse and frequently overlapping. Potential selection bias may limit generalizability of these findings. Nonetheless, this study is distinctive in the variety of music work studied and the characterization of music-specific conditions that might cause psychosocial strain for professional musicians. When studying musicians' health, stressors specific to the technical demands of music performance should be characterized, in addition to more generic factors such as psychosocial demand/control and characteristics of precarious work.

## A review of international programmes for the prevention and management of musculoskeletal disorders

*Mark Boocock<sup>1</sup>; Liz Ashby<sup>1</sup>; Fiona Trevelyan<sup>1</sup>*

*<sup>1</sup>Health and Rehabilitation Research Institute, Auckland University of Technology, Auckland, New Zealand*

**Background:** Following changes to New Zealand (NZ) health and safety regulations in 2015, the Accident Compensation Corporation and WorkSafe NZ are developing a new strategic programme for the prevention and management of musculoskeletal disorders (MSD). As a precursor to this programme, a review was conducted of international approaches to MSDs prevention and management.

**Methods:** A search of 21 international health and safety websites was undertaken to identify legislative frameworks, terms and definitions, strategies and policies, and resources for the prevention and management of MSDs. This was supplemented with personal feedback from 10 international representatives with relevant expertise and knowledge of regulatory requirements for MSD prevention within their respective countries.

**Results:** Several strategies promoted the application of an ergonomics programme which fosters a holistic approach to MSD prevention and management, from the individual through to influences at the societal level. The risk management processes emphasised the importance of management commitment, worker participation, ergonomic assessments, multifaceted interventions, the application of hierarchy of control measures, and medical management. International tools and resources to support MSD programmes were wide ranging. The most comprehensive programmes implement a 'toolkit' of assessment methods that varied in complexity from simple checklists to more detailed risk assessment methods. As part of the compliance strategy, occupational health regulators placed importance on proactive inspections, supported by qualified health professionals.

**Conclusions:** MSD prevention and management approaches vary widely, both internationally and nationally (between states or provinces). Key themes extracted from the data included leadership and management, industry and service sectors awareness and motivators, worker participation, and public awareness and engagement. International MSD strategies promote a proactive, multi-faceted approach to reducing MSDs, recognising the importance of evaluating all types of hazards together (i.e. individual, physical, psychosocial, organisational and environmental). However, this approach was rarely transparent or embedded within the MSD risk management process.

## The surveillance of musculoskeletal disorders in Italy: findings from the MALPROF System

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**Background:** Occupational diseases data can guide efforts to improve worker's health and safety. We present two examples using MALPROF data, an Italian system for recording and surveillance of work-related diseases.

**Methods:** MALPROF archive classifies the work-related diseases according to the economic sector and job activity in which the exposure occurred. Occupational physicians of the Italian national health service evaluate the possible causal relationship with occupational exposures and store the data in the centralised database. The MALPROF system has the potentiality to detect those diseases whose occupational origin was not known (in general or in a specific sector) and whose activity sectors or job-titles were not known yet as potentially related to ill-health. For this purpose, we apply the proportional reporting ratio (PRR) used by the British Medicine Control Agency in the field of pharmacosurveillance, as already adopted by the French occupational disease surveillance system (RNV3P).

**Results:** Two examples of PRR calculation along with their 95% confidence intervals (95% CI) are reported here: 1) cervical disc herniation (ICD-9, 7220), and 2) internal derangement of knee (ICD-9, 717).

From MALPROF data, the PRR for cervical disc herniation in 1999-2010 was 36.64 (95% CI, 22.03-60.93) for air transport workers, 4.57 (95% CI, 3.28-6.37) for health care workers, and 2.47 (95% CI, 1.76-3.47) for drivers.

Exploring the musculoskeletal disorders in the largest sector of economic activity (i.e. the Construction sector), the PRR was lower for lumbar intervertebral disc disorders (PRR 1.22, 95%CI 1.10-1.34) in comparison to internal derangement of knee (PRR 9.20, 95%CI 6.04-14.01), showing an unattended higher risk for knee disorders in this relevant sector.

**Discussion:** MALPROF is a sensitive system for identifying possible associations between occupational risks and diseases. It can contribute to develop preventive measures, evaluate the effectiveness of preventive interventions and stimulate researches on new occupational risks and diseases.

## Carpal tunnel syndrome as sentinel for detrimental occupational hand activities: a nationwide Danish cohort study

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**Background:** We evaluated the use of incidence rates (IRs) of carpal tunnel syndrome (CTS) as sentinels that can identify job groups with high mechanical exposures to the wrist, and thereby signal detrimental occupational hand activities.

**Methods:** We conducted a nationwide register-based cohort study of all persons born in Denmark 1945-1994, who had at least 1 year of full-time employment 2009-2012. During follow-up 2010-2013, we identified first-time CTS diagnoses. We constructed job groups, which were sufficiently large to obtain robust IRs of CTS, and calculated sex-specific age-standardised IRs (SIRs) for each of these job groups. To validate the SIRs as sentinels, we linked occupational codes with a job exposure matrix, calculated a mean wrist load estimate for each job group, and plotted the wrist load estimates against the SIRs together with the linear regression line.

**Results:** A total of 1,171,580 men and 1,137,854 women were followed for 4,046,851 and 3,994,987 person-years, respectively. Twenty-eight job groups were constructed for men and 24 for women. We identified 4,405 cases of CTS among men and 7,858 among women, yielding crude IRs of 10.9 and 19.7 per 10,000 person-years. For men, the SIRs ranged from 3.7 to 23.7 per 10,000 person-years; for women from 10.1 to 42.9 per 10,000 person-years. For both sexes, there was a positive association between SIRs and wrist load estimates.

**Conclusions:** We found that sex-specific SIRs of CTS varied substantially between job groups and higher SIRs pointed to job groups with higher wrist load. Thus, elevated SIRs of CTS may serve as sentinels of detrimental occupational hand activities.

## Severity of carpal tunnel syndrome and manual work: findings from a case-control study

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**Objective:** Carpal tunnel syndrome (CTS) is a socially relevant condition. This case-control study aims to investigate the association between CTS severity and manual work considering personal anthropometric risk factors as well.

**Methods:** We consecutively enrolled one CTS case for two controls (subjects without clinical and electrophysiological CTS signs) regardless of age and gender who were admitted to the same three outpatient electromyography labs. CTS cases were grouped in three classes of progressive clinical and electrophysiological severity according to two validated five-stage scales. Anthropometric measures and occupational history were collected. Job titles were coded according to the International Standard Classification of Occupations (ISCO 88) by two occupational physicians who were blind to case/control status. Job titles were grouped in two main occupational categories: manual workers and non-manual workers. To assess the association between CTS severity and manual work, ordered logistic regression models (adjusted for age, sex, wrist-palm ratio and waist-stature ratio) were performed. Odds ratios (OR) and 95% confidence intervals (95%CI) were calculated.

**Results:** This case-control study enrolled 370 cases and 747 controls. After the exclusion of retired subjects, subjects older than 65 years and subjects with no information about occupational history, we included 183 cases and 445 controls in the main analysis.

For manual workers with respect to non-manual workers, the OR for the electrophysiological severity scale was 2.4 (95%CI 1.5-3.7). Regarding the clinical severity scale, the OR for manual workers compared to non-manual workers were 2.3 (95%CI 1.5-3.7).

**Conclusions:** This study confirms that manual work is an important risk factor for CTS. The association between manual work and CTS severity tends to increase from mild to severe stage of both electrophysiological and clinical scale.

## Twenty years of CTS surveillance among diverse occupational groups

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**Background:** Carpal tunnel syndrome (CTS) represents one of the major occupational musculoskeletal disorders among workers throughout the world. The purpose of this presentation is to describe a series of studies conducted by the author on the prevalence of CTS among workers from diverse occupational groups during a 20-year period.

**Methods:** More than 3,800 participant workers were recruited from various companies and trade organizations between 1992 and 2012 in the US, Hungary, and Italy. Structured interviews, symptom questionnaires, hand diagrams, and nerve conduction studies were used to determine the prevalence of CTS among workers. The surveillance case definition of CTS was based on characteristic hands symptoms and prolonged latency of the distal median nerve.

**Results:** Eight cross-sectional studies involving 3,822 workers from manufacturing, construction, agriculture, healthcare, and office environments were analyzed. The prevalence of CTS ranged from 1.5% to 55% depending on the occupational group. Newspaper workers in the office had the lowest prevalence of CTS while ewe shepherds in Sardinia had the highest prevalence. Body mass index and age were frequently and significantly associated with prevalent CTS. Within occupational groups, workers performing tasks that required overhead or high-intensity hand work had a significantly greater prevalence of CTS. Among some occupational groups, as few as 5% with CTS sought medical attention for their disorder.

**Conclusions:** CTS continues to represent a major occupational health concern, especially among workers performing hand and wrist intensive work tasks. These studies emphasize the need for continued development of administrative and engineering controls to limit the exposure to physical risk factors associated with CTS.

## Prognosis of patients with suspected carpal tunnel syndrome in relation to occupational mechanical exposure of the wrist and impaired median nerve conduction

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**Background:** Symptoms from the upper limbs suggestive of carpal tunnel syndrome (CTS) are common in working age people and often lead to referral for nerve conduction studies (NCS). For these patients, little is known about the course of symptoms and disability overall and in relation to occupational mechanical exposure of the wrist. Likewise, the prognostic value of impaired nerve conduction is largely unknown. The aim of this study was to evaluate occupational mechanical exposure and impaired median nerve conduction as prognostic factors for symptoms and disability among patients with suspected CTS.

**Methods:** We undertook a prospective study of consecutively included 18-65 year-old patients, referred for NCS on suspicion of CTS. Participants completed a questionnaire and underwent NCS at baseline. Information on job title was combined with a job exposure matrix to assess wrist exposure. Symptoms and disability were assessed 9-12 months after inclusion using the Levine symptom and functions scores as the primary outcome and the Disability of the Arm, Shoulder and Hand (DASH) score as a secondary outcome. We used linear regression to analyse the change of scores from baseline to follow-up.

**Results:** A total of 361 patients (72%) completed follow-up. For the Levine symptom score there was less improvement in case of high wrist exposure (-0.33 points; 95% confidence interval (CI): 0.61 to -0.05), while impaired nerve conduction at baseline was associated with larger improvement (0.21 points; 95% CI: 0.00 to 0.42). The associations with the Levine function score were weaker and no associations were found for the DASH score.

**Conclusions:** Among patients with suspected CTS, high wrist exposure predicted less improvement of symptoms and disability while impaired nerve conduction predicted larger improvement.

## Occupational risk factors for surgically treated carpal tunnel syndrome – a prospective cohort study of 220,610 Swedish construction workers

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**Background:** Carpal tunnel syndrome (CTS) is the most common upper extremity nerve entrapment syndrome. The aim of this study was to determine the association between occupational biomechanical exposures and occurrence of surgically treated CTS in construction workers over a 16-year follow-up.

**Methods:** A cohort of 220 610 male construction workers who participated in a national occupational health surveillance program (1971–1992) were examined prospectively (2001–2016) for surgically treated CTS. Cases were determined via a linkage with the Swedish Hospital Outpatient Register. Job title (construction trade), smoking status, height, weight and age were recorded on examination. Job titles were merged into occupational groups of workers performing similar work tasks and having similar training. Occupational biomechanical exposure estimates were assigned to each occupational group using a job exposure matrix (JEM) developed for the study. Poisson regression models were used to assess the relative risks for each biomechanical exposure. Relative risks were adjusted for age, surgical time period, BMI, and smoking status at first examination.

**Results:** There were 4048 cases of surgically treated CTS within the cohort which represented an incidence rate of 134 cases per 100 000 person years. Workers exposed to medium and high forceful handgrip factors had relative risks of 1.3 (95% CI 1.16-1.38) and 1.6 (95% CI 1.50-1.77), respectively, of undergoing surgical treatment for CTS compared to low exposed workers. Workers exposed to medium and high exposure to hand-arm vibration had relative risks of 1.3 (95% CI 1.19-1.34) and 1.2 (95% CI 1.07-1.28), respectively, of undergoing surgical treatment for CTS compared to low exposed workers.

**Conclusions:** In conclusion, forceful hand-grip work and exposure to hand-arm vibration increased the risk for surgically treated carpal tunnel syndrome

## Using a mobile app to conduct process evaluation in a participatory ergonomics healthcare intervention

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**Background:** Evaluation of effectiveness of participatory ergonomics interventions requires both outcomes and process metrics to examine whether goals are met and what factors contribute to success or failure. Mobile applications are an emerging medium to collect real-time data prospectively from study participants. The aim of this study is to examine process outcomes collected by a mobile app, for a participatory ergonomics intervention in six U.S. public sector healthcare facilities.

**Methods:** Study Design: Six healthcare facilities, paired by type of service, were recruited to the study and then randomized to immediate- or lagged-intervention status. Joint labor-management committees responsible for the environment of care are the locus of intervention. In the first period of this stepped-wedge study, three sites are being coached by researchers in a participatory workplace change process: Phase 1 involves initial brainstorming; Phase 2 explores root causes and solutions to a selected problem.

Data Collection: A mobile app was developed to record meetings held, attendance and attendee feedback, and time spent on project activities. Non-smartphone users were provided paper alternatives. Response rates and trends in responses over time were calculated. Comparisons were made between participant roles and sites as they progressed through the intervention.

**Results:** Meetings were 60-90 minutes every 1-4 weeks; 30-minute pre-meeting preparation and post-meeting debriefs were held between the study coach and committee co-facilitators. The first intervention site averaged 61% attendance per meeting, not including co-facilitators. Feedback response rates averaged 55%. During Phase 1 (6 meetings), more than half the respondents felt able to speak up and that their opinion was considered, while Phase 2 (6 meetings) neared universal agreement on both questions and additionally that facilitators effectively led meaningful discussions.

**Conclusions:** Engagement improved over time, but competing work demands affected meeting consistency and preparation time for co-facilitators, which may provide context for future intervention effectiveness.

## Effectiveness of the multi-component Dynamic Work intervention to reduce sitting time in office workers – results from a cluster randomised controlled trial

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**Background:** Prolonged sitting, which is highly prevalent in office workers, has been associated with several health risks. The objective of this study was to evaluate the Dynamic Work intervention and to determine its effect on reducing total sitting time 12 months after baseline.

**Methods:** In this two-arm cluster randomised controlled trial, 244 office workers of a large Dutch insurance company were included. The Dynamic Work intervention was a multi-component, real-life worksite intervention, containing environmental (e.g. sit-stand workstations), organizational (e.g. group sessions) and individual (e.g. activity/sitting tracker) components. Outcomes were assessed at baseline, post-program, and long-term (12 months after baseline). Primary outcome was total sitting time per day, objectively assessed using the activPAL activity monitor at long-term. Secondary outcomes included other total and occupational movement behaviour outcomes, health-related outcomes such as musculoskeletal complaints, and work-related outcomes such as sickness absenteeism. Differences between intervention and control group were assessed using multilevel analysis.

**Results:** Total sitting time at the long-term did not differ between the intervention and control group ( $\beta = -0.27$ ; 95%CI =  $-0.60 - 0.06$  hours /16 hour day). Secondary outcomes showed also no differences between the intervention and control group at post-program and long-term, with the exception of occupational steps, which showed a significant (913; 95% CI =  $381 - 1445$  steps/ 8 hour work day;) post-program (but not long-term) effect.

**Conclusions:** This study evaluated the effectiveness of a real-life worksite intervention to reduce sitting time and showed, in contrast to other studies, little to no effect. This may be due to the lower intensity of our intervention, including the only partial replacement of sit workstations, with a one-to-four ratio for sit-stand workstations. Future research should focus on the evaluation of more intensive real-life worksite interventions that are still feasible for implementation in daily practice.

## Controlling Vibration Exposure when Drilling into Concrete: Findings from Two Studies

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**Background:** Drilling large holes into concrete is commonly performed in commercial construction to attach anchor bolts and rebar in order to hang pipes or to add concrete to an existing structure. Exposure to vibration may lead to musculoskeletal disorders including hand-arm vibration syndrome. Findings from 2 studies evaluating the effects of force on bit and drill type on handle vibration levels are presented.

**Methods:** A validated robotic test bench system (Int J Ind Ergon 2017; 62:17-20) was used to repeatedly drive a drill bit, under force control, into concrete block (19 mm diameter, 100 mm depth), while both productivity and handle vibration were measured according to ISO standards (28927-10; 5349-1). The first study compared an electric rotary drill to a pneumatic rock drill of similar mass. The second study used an electric drill repeatedly drilling holes with different feed forces in the 120 to 220 N range.

**Results:** For the first experiment, the mean weighted total handle vibration was significantly lower ( $p=0.002$ ) for the electric drill ( $7.15 \pm 0.11$  m/s<sup>2</sup>) than the pneumatic drill ( $39.1 \pm 2.5$  m/s<sup>2</sup>). Productivity was not significantly different ( $p=0.15$ ) between the electric drill ( $9.09 \pm 0.09$  mm/s) and the pneumatic drill ( $8.69 \pm 0.37$  mm/s). For the second study, from 120 to 170 N of feed force, the total handle vibration level increased from 7.5 to 8.5 m/s<sup>2</sup> and productivity increased from 9.6 to 11.2 mm/s. However, between 170 and 220 N of feed force, changes in vibration level and productivity were negligible.

**Conclusions:** Contractors and construction workers should be advised to consider using an electric rotary drill instead of pneumatic drill for drilling into concrete. In addition, workers should be notified that applying large push forces to an electric drill does not increase productivity but may increase the risk of fatigue and injury.

## Effectiveness of a vacuum lifting system in reducing spinal loads during airline baggage handling

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**Background:** Information on spinal loads during use of lift assist systems for airport baggage handling is lacking.

**Methods:** We conducted a laboratory study to evaluate a vacuum lift system from a biomechanical loading perspective, particularly its potential to reduce lumbar spinal loads during baggage loading and unloading tasks commonly performed in the tarmac area of an airport. The vacuum lift system is specifically designed for airport baggage handling and lifting with the capacity up to 50 kg. Ten subjects performed the tasks using the industry average baggage weight of 14.5 kg on a typical two-shelved baggage cart with or without using the lift system (i.e. lifting technique). A fully balanced design (2 tasks x 2 shelf heights x 2 lifting techniques) was used to assess the within-subject effects of the treatments. Spinal loads were estimated via a well-established electromyography-assisted biomechanical model and were used as the outcome measures of the statistical model.

**Results:** On average, the vacuum lift system reduced spinal compressive forces on the lumbar spine by 39% and below the 3400 N damage threshold. The system also resulted in a 25% reduction in the anterior-posterior shear force at the L5/S1 inferior endplate level. A two way interaction of task and shelf indicated that among all four possible task and shelf combinations, loading baggage onto the top shelf resulted in largest magnitudes of spinal compression at the L3/L4 inferior plate, while unloading baggage from the top shelf resulted in lowest magnitudes of spinal compression.

**Conclusions:** Though impacts on feasibility or productivity were not assessed, this study provides evidence that a vacuum lift system reduces spinal loads during airline baggage handling. If manual baggage lifting is necessary, lifting bags from the conveyor or belt loader to the top shelf of a baggage cart should be avoided.

## Work ability and vitality in coach drivers: a RCT to study the effectiveness of a self-management intervention during the peak season

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**Background:** The aim of this RCT is to evaluate the use of a self-management-toolbox to maintain work ability in coach drivers during the peak season, where work ability and vitality are expected to decrease and work-related fatigue is expected to rise.

**Methods:** A randomized controlled trial with two equal sized arms took place in the coach sector during the peak season. The intervention group received a self-management intervention with tips to maintain work ability during the peak season. These tips were aimed at three domains: the work-recovery-rest balance, the food and drink uptake, and physical activity. At the beginning (March) middle (July) and end (October) of the peak season, work ability, vitality, work-related fatigue, psychosomatic health, sleep complaints, and perceived mental exertion of coach drivers were analysed by ANCOVA, corrected for baseline values. Additional process measurements were assessed in the intervention group to evaluate the intervention usage.

**Results:** In total 96 drivers participated in this study. Access to the toolbox did not result in significant differences between intervention and control group. In the entire population, work ability and vitality decreased significantly from 7.8( $\pm$ 1.3) to 7.3( $\pm$ 1.6) and from 63( $\pm$ 16.7) to 55( $\pm$ 18.7) while physical and mental work ability decreased from 7.8 and 7.9 to 7.4 and 7.1, respectively. Other variables as psychosomatic health complaints, sleep complaints and perceived mental exertion increased significantly. Although the tips in the toolbox were only used for 34% on average, drivers indicated that the tips did enhance their vitality.

**Conclusions:** The toolbox in this form (as self-management with no further support) is used too limited during the peak season and does not lead to a change in work ability and other variables. Since work and health parameters deteriorate during the peak season, it is evident that another implementation of tips is needed to ensure the maintenance or improvement of work ability during the peak season.

## Systematic Evaluation of Engineering Controls to Reduce Muscular Loading during Patient Handling Tasks

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**Background:** Manual patient handling activities pose various well-known physical risks including forceful exertion and awkward posture. Due to these risk factors, professional caregivers are ranked as one of the most dangerous occupation with the high prevalence of work-related musculoskeletal disorders (WMSDs), especially in the low back and upper extremities. To reduce such risk factors, this study evaluated commercially-available patient turning devices as potential engineering controls in reducing muscular loading while caregivers performed patient turning tasks.

**Methods:** In a repeated-measures experimental design, 10 professional caregivers (8 F and 2 M) performed standardized patient turning tasks. During the tasks, the muscle activity in the upper extremities (biceps, triceps, anterior deltoid, middle deltoid, and upper trapezius) and low back (erector spinae) were measured and compared between four different patient turning assisted devices: draw sheet, friction-reducing turning sheet, air-assisted lateral transfer device, and air-assisted turning device.

**Results:** There were significant differences in the muscle activities in biceps, triceps, and erector spinae between the devices ( $p$ 's < 0.01). The air-assisted turning device showed significantly lower muscle activities (21 to 44%) when compared to the other devices and the conventional manual turning with no assistive device (rotating a patient onto caregivers' sides by pulling the knee and shoulder of the patient). However, draw and friction-reducing turning sheets did not show any difference in muscle activities in the upper extremities and low back compared to the manual turning without assistive device.

**Conclusions:** The lower muscular loading in the low back and upper extremities indicates that the air-assisted turning device may have potential as an effective engineering control to reduce muscular loading and associated WMSD in the upper extremities and low back among caregivers.

## Psychosocial effects of workplace exercise – A systematic review

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**Background:** Studies have shown that workplace exercise interventions can reduce musculoskeletal complaints and pain among workers. Yet, implementing persistent use of the interventions at the workplaces has been a challenge. It is possible that the narrow focus on musculoskeletal complaints and physical challenges could be a part of the reason. Wellbeing at work and the level of sick leave and absenteeism in workplaces are affected by many interplaying workplace factors. Thus, interventions targeting several parameters to improve work environment and workers' health might strengthen incitements for implementation and maintenance of these. Improvement of the psychosocial factors after workplace exercise intervention has been proposed in some studies, but no systematic overview exists. This review aimed to evaluate the effects of workplace exercise interventions on 1) the psychosocial work environment and 2) mental health.

**Methods:** A systematic review was performed by screening four scientific databases (Pubmed, Cochrane Database, PsychInfo and Web of Science) for published randomized controlled trials in English from the period 1998 – 2018. The review followed the PRISMA statement guidelines using the Cochrane Tool for assessing risk of bias and the GRADE approach for assessment of quality. Database search, study screening and evaluation were performed by two researchers independently.

**Results:** 22 randomized controlled trials met the inclusion criteria. Substantial heterogeneity existed in the included studies regarding 1) study populations, 2) types of intervention, and 3) outcome measures. Quality assessment revealed a generally low level of quality in the studies included. This was partly because of the limited possibilities for blinding and for the self-reported outcome measures.

**Conclusions:** Workplace exercise interventions seem to have limited effects on mental health and the psychosocial work environment. Future studies should incorporate blinding and independent outcome measures.

## Personal, biomechanical, psychosocial and organizational risk factors for carpal tunnel syndrome: a Structural Equation Modelling Approach

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**Background:** Personal and medical factors are known to increase the risk of carpal tunnel syndrome (CTS). Above these factors, working conditions exposing to biomechanical stressors, psychosocial and organizational factors have also been identified as risk factors for CTS.

The aim of this longitudinal study was to explore the direct and indirect relationships between organizational, psychosocial and biomechanical factors and CTS in French workers.

**Methods:** Between 2002 and 2005, 3,710 workers were included in the Cosali cohort. In 2007-2010, 1,611 workers were re-examined using the same standardized clinical protocol. Subjects free from CTS at baseline were studied (n=804 men and 563 women). The relationships between organizational (work pace dependent on automatic rate/customers' demand), psychosocial (Job strain model), biomechanical (Borg's RPE, wrist bending, pinching, hand-transmitted vibrations) and personal (age, BMI) factors at baseline and incident cases of CTS at follow-up were analyzed using structural equation models (SEM), for each gender.

**Results:** For men, CTS was directly increased by biomechanical factors (standardized coefficient=0.37, p=0.003). No psychosocial factors had direct or indirect impact on CTS. Exposure to work pace dependent on automatic rate had indirect impact on CTS in increasing biomechanical exposure (0.20, p<0.001).

For women, CTS was directly increased by biomechanical factors (0.23, p=0.040) and age over 50 (0.15, p=0.030). No psychosocial factors had direct impact on CTS, but decision authority and skill discretion had indirect impact in decreasing biomechanical exposure. Exposure to work pace dependent on automatic rate had indirect impact on CTS in increasing biomechanical exposure (0.20, p<0.001) and in decreasing decision authority and skill discretion.

**Conclusions:** The study showed that biomechanical exposure had direct impact on CTS, while psychosocial factors (in women) and organizational factors (both genders) had indirect impact on CTS. These results support multilevel conceptual models linking work organization to musculoskeletal disorders.

## Correlations between pain in the back and neck/upper limb in the European Working Conditions Survey

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**Background:** Recent findings have suggested that an international variation in the prevalence of disabling pain among working populations is driven largely by factors predisposing to musculoskeletal pain in general and not specific to individual anatomical sites. This study uses data from two different survey of European Working Conditions Survey (EWCS) to confirm this hypothesis.

**Methods:** Using data from the fifth (2010) and the sixth (2015) EWCS, correlations between the one-year-prevalence of pain in the back and neck/upper limb among people of working age across 33 European Countries were investigated. Changes in pain prevalence between the two anatomical sites from 2010 to 2015 was also examined.

**Results:** More than 1000 participants per country were recruited in each survey with a response rates ranging from 11% to 78%. In 2010, the estimated one-year population prevalence of back pain ranged from 23% in Ireland to 67% in Portugal, and the one of pain in the neck/upper limb from 25% in Ireland to 69% in Finland, the prevalence of pain at the two anatomical sites being correlated across the 33 countries ( $r = 0.42$ ). A similar pattern was observed in 2015. For back pain, the percentage change in prevalence from 2010 to 2015 varied from -40.4% (Hungary) to +30.4% (Ireland), with a mean across countries of -2.7%. For neck/upper limb pain, the variation was from -40% (Hungary) to +42.1% (Romania), with an average of 0.0%. A strong correlation across countries in the change in pain prevalence at the two anatomical sites was found ( $r = 0.85$ ).

**Conclusions:** Our findings accord with the hypothesis that international variation in common pain complaints is importantly driven by factors that predispose to musculoskeletal pain in general.

## Work-Related Musculoskeletal Disorder Workers' Compensation Claims of the Low Back, Shoulder, Hand/Wrist, Knee, Elbow and Neck in the In-Home Care Industry in Washington State, 2006-2016

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**Background:** In the United States, healthcare is shifting to home-based care. This shift presents numerous risk factors to care providers for work-related musculoskeletal disorders (WMSDs), such as working alone, having little or no control over their work environment and high physical demands in the absence of patient-handling equipment. An examination of workers' compensation claims filed by these workers will help to better understand the types of injuries occurring and help guide injury prevention efforts.

**Methods:** Washington State's workers' compensation (WC) compensable WMSD claims from 2006 to 2016 were analyzed to understand the demographics of claimants, and the incidence and trends by WMSD type. Only WMSD claims for the low back, shoulder, hand/wrist, knee, elbow and neck covered by the state-run industrial insurance program were examined. The home-based care industry was defined as establishments providing nursing services, home health care services, chore services and home care assistance, and individuals employed by people to provide home care services.

**Results:** Between 2006 and 2016, the mean age of WMSD claimants was 45.3 years. Claimants over the age of 60 increased by 123%. Over three-quarters of claimants (77.2%) were overweight or obese (BMI  $\geq$ 25.0). The majority of claimants were female (91.6%). WMSDs accounted for 47% of the costs of all claims. The WMSD incidence rate was 66.2 claims/10,000 full time employees (FTEs). Back WMSDs had the highest incidence rate of 40.3 claims/10,000 FTEs. The WMSD incidence rate decreased by an estimated 45% over the study period. Neck WMSDs had the largest incidence rate decrease, an average of 16.5% each year. Shoulder WMSDs had the smallest average rate decrease, year-to-year (4.0%).

**Conclusions:** Though WMSD claims are decreasing in the home-based care industry, similar to WC claims in general, the burden remains high. As such, identifying WMSD trends is vital. WMSD injury prevention must consider an aging and heavier care provider population.

## Predictors of Self-Reported Work-Preventing Upper Extremity Symptoms in Canadian Bovine Veterinarians

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**Background:** Large animal veterinarians around the world have reported high rates of upper-limb pain, but the contributors are not clear. This study aimed to identify potential predictors of work-preventing upper extremity symptoms in bovine veterinarians working in Western Canada.

**Methods:** Multiple logistic regression was performed on data obtained from a cross-sectional postal survey that included data on 116 members of the Western Canadian Association of Bovine Practitioners, using a dependent variable of upper-limb symptoms that prevented the veterinarian from doing normal work in the past 12 months. Independent variables focused on personal and work characteristics of the participants. Hosmer-Lemeshow goodness-of-fit and significance ( $p < 0.05$ ) testing were used to select the final model.

**Results:** Height (continuous by cm, OR 0.93 [0.87-0.99]), number of other veterinarians in the practice (incremental by 1, OR 1.32 [1.05-1.66]), and practice type (mixed animal vs. primarily bovine, OR 3.20 [0.96-10.64]) were the predictors retained in the final model. No interactions were observed. Height was collinear with sex but chosen for the final model due to higher significance.

**Conclusions:** Veterinarians of shorter stature and those who have more practice colleagues had higher odds of reporting work-preventing symptoms. This makes sense as many tasks involving large animals are extremely physical, and having coworkers may make it more practical to take time off for rest or recovery (i.e. 'work prevention'). It was surprising that mixed animal practitioners had higher odds of symptoms, but this may speak to a healthy worker effect in this population. This study was conducted on both beef and dairy veterinarians, two very different jobs with workloads that vary seasonally, so future studies could focus longitudinally on only beef or dairy practitioners. As the majority of new veterinarians and students in North America are female (thus smaller statured), it is imperative that the causes and prevention of common veterinarian musculoskeletal symptoms be studied.

## Disc herniation with radiculopathy: epidemiologic and economic indicators of compensation in the Pays de la Loire region

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**Background:** Low back pain (LBP) is a major cause of work-related musculoskeletal morbidity. Only chronic LBP associated with disc herniation with radiculopathy (code M511 in the International Classification of Diseases, 10th revision) caused by vibration or manual handling of loads are taken into account by the French workers' compensation system (WCS). The aim of this study was to identify the industry sectors most in need of programs to prevent LBP using two indicators: the prevention index (PI) and the median total cost of sickness benefits (SB).

**Methods:** The WCS data were used to rank the 21 sections of the French statistical classification of economic activities in the European Community (2008 version) according to: i) the PI (computed from [1] the number of cases and [2] the mean annual incidence rate using the employed population from the 2009 INSEE census as a denominator), ii) the median total cost of SB (with the interquartile range) that compensates wage losses caused by sick leaves due to LBP. The analyses were conducted jointly in men and women, between 2010 and 2017 in the Pays de la Loire region.

**Results:** A total of 1,944 disc herniation cases were compensated. Construction was the first sector in terms of PI (n=572, incidence=6.1/10,000), followed by manufacturing (n=560, incidence=2.8/10,000). Both the wholesale and retail trade sector and the transporting and storage sector ranked third (n=277, incidence=1.8/10,000 and n=181, incidence=3.4/10,000, respectively). In terms of median total cost of SB, the three priority sectors were: 1) Real estate activities (30,523€ [4,652-48,378]), 2) Professional, scientific and technical activities (12,404€ [7,368-24,388]) and 3) Accommodation and food service activities (10,761€ [3,842-22,333]).

**Conclusions:** The results showed that the choice of the indicator influenced the rank of the industry sectors most in need of LBP prevention programs. Thus the use of complementary indicators can be useful to guide prevention policies.

## Using occupational injury and hazard surveillance in the development of safety interventions for professional loggers

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**Background:** Although the occupational injury rates for professional loggers in the U.S. have decreased in the past 20 years, logging-related injuries exceed the injury rate of all industries combined. The purpose of this study was to employ a combination of occupational injury and hazard surveillance tools as the basis for interventions to reduce the risk of mortality, injuries and MSDs among professional loggers.

**Methods:** Injury and hazard surveillance data sources included: 1) five years of logging injury and fatality claims (N=801) obtained from workers' compensation records; 2) perceptions of painful MSD symptoms by professional loggers (N=743) that completed the Nordic Musculoskeletal Questionnaire, and 3) focus groups with 63 professional loggers in Idaho and Montana. Frequency statistics were developed for demographics, injury claim variables, MSD symptoms, injury cost and focus group narratives. Chi-squared tests were performed to determine significant difference in the distribution of variables relating to the timing of claims and to determine if there was a significant difference in the number of claims by age group, level of experience, job type, claim type and body region.

**Results:** Inexperienced workers (<18 months experience) accounted for over 45% of injury claims. Sprain/strain injuries were the most common, accounting for 36% of claims, while fatalities had the highest median claim cost. Using regression models, workers using conventional logging systems involving chainsaws were associated with a significantly higher prevalence of MSD symptoms as compared to highly mechanized logging systems. Focus groups identified job tasks involving felling trees, skidding, and truck driving as having the highest risk for musculoskeletal injury.

**Conclusions:** Injury and hazard surveillance systems should be utilized in the development of targeted interventions to efficiently reduce the risk of injury among workers within the logging industry. Systematic based surveillance is useful in the development of safety interventions at the individual, task and operational level.

## Distribution of age, sex, and occupation of carpal tunnel syndrome patients using national health insurance data

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**Background:** Study on demographic and occupational distribution of carpal tunnel syndrome (CTS) among entire national population is not much. The purpose of this study was to investigate the differences in the number of carpal tunnel syndrome (CTS) patients in different occupations using national data. Also one of purpose of this study was to check the test the possibility of prospective cohort study using those data.

**Methods:** National Health insurance and national employment insurance data were linked to extract necessary data between 2008 to 2015 (Total subjects : 9,720,552, male : 5,978,213, female : 3,742,339). To select the subjects, the following diagnosis codes were used : G560 (Carpal tunnel syndrome), male : 107,518, female : 171,106. In addition, through the Korean Employment Classification of Occupations (KECO), occupations were divided into working styles (production workers and office workers). Operational definition of wrist use frequency with classified occupations into groups were used.

**Results:** As a result, the number of patients increased in the 50s according to age, and then decreased. The number of CTS patients was higher in women than in men (4572.2 vs 1798.5). It was higher in production workers than office workers (3812.2 vs 1867.4). The number of patients classified as high-wrist use was higher in production workers (4107.6 vs 1804.0). However, the number of office worker patients classified as less wrists use was higher showed higher occupations classified as less wrist use (1754.5 vs 2021.7). When they were combined into a type of business, they had the largest number of patients in the service industry (6315.3). First generation production (agriculture, fishery, forestry, 5208.5), simple labor, production (4773.0), and manufacturing (3478.6) were high.

**Conclusions:** We set up the method to link national health insurance and national employment insurance data. We categorized the possibility of occupational wrist utility. Those possible occupational wrist use occupational groups had high CTS rate.

## Synthesizing the evidence on workplace practices and policies to prevent MSD

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**Background:** Musculoskeletal disorders (MSD) continue to be a major burden for workplaces and workers as well as insurance and health systems. Evidence-informed approaches are desired, but research-to-practice gaps remain. One reason for gaps is research of sufficient quality is often not available. However, evidence-informed practice considers both scientific evidence as well as practitioner expertise. Our objective is to synthesize evidence from the scientific literature, practice evidence (policies and practices), and experiences from stakeholders.

**Methods:** Evidence from practitioners' expertise and worker experiences was collected using a web-based survey, focus groups, and interviews with representatives from various stakeholder groups from multiple sectors. We adapted the Public Health Agency of Canada's best practices portal to structure data collection of workplace practices and policies. Three sources of evidence (research findings, practitioner expertise and stakeholder experiences) are synthesized in this project.

**Results:** Survey results (n=442) reveal a number of prevention practices are in place at various workplaces. However, responses indicate workers and managers do not have similar experiences related to MSD prevention. Interviews/focus groups (n=28) identify themes related to employee input to solutions, the value of being heard, manager support, resource challenges, and conflicting priorities. Lack of supervisor support and knowledge about MSD were key barriers noted. Systematic review results include evidence from 61 high and medium studies addressing MSD. These studies described 30 different intervention categories, with strong evidence that resistance training has a positive effect. However, the level of evidence was too low to make recommendations for many other interventions.

**Conclusions:** The presentation will describe current policies and practices described by our practitioner and workplace audiences as compared to the scientific evidence. The discussion will outline the synthesis of evidence and co-creation (with OHS stakeholders) of a practical guide to help workplaces develop and implement effective practices and policies to prevent MSD.

## Results of a Participatory Ergonomics Intervention With Wearable Technical Measurements of Physical Workload in the Construction Industry

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**Background:** Construction work frequently involves heavy physical work, and a reduction of the physical workload should have high priority. Technological development has made it possible to obtain field measurements with surface electromyography (sEMG), heart rate monitor (HR), kinematics measured with inertial measurement units (IMU), and video recordings. Participatory ergonomics (PE) has shown promising results, but whether it can be used as a tool to reduce the physical workload during construction work remains unknown.

**Objectives:** This cluster randomized controlled trial investigated whether a PE intervention with technical measurements consisting of IMU, sEMG, HR and video recordings of physical workload reduced the number of events with excessive physical workload during a working day.

**Methods:** Eighty full-time male construction workers (19-67 years) were randomized at the cluster level (gang) to a PE intervention consisting of three workshops (7 gangs, 32 workers) or to a control group (8 gangs, 48 workers). The physical workload was recorded by using IMU, sEMG, HR and video recordings during a full working day at baseline and 3 and 6 months' follow-up. Based on the technical measurements, a custom-made computer programme detected the situations (events) where the construction workers were exposed to excessive physical workload. Differences in the number of events from baseline to follow-up between intervention and control were evaluated using linear mixed models (intention-to-treat), with the individual nested in clusters as a random factor.

**Results:** The results showed no change in the number of events with excessive physical workload. However, the intervention group decreased their general fatigue after a typical working day ( $P < 0.001$ ) and increased influence at work ( $P = 0.04$ ).

**Conclusion:** This PE intervention based on technical measurements did not reduce the number of events with excessive physical workload during construction work. However, the intervention led to decreased general fatigue and increased influence at work.

## A sustainable participatory approach to reducing musculoskeletal hazards in long term care facilities.

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**Background:** Musculoskeletal disorders (MSDs) are major sources of occupational injuries accounting for over 40% of all lost time claims in healthcare. Our objective was to understand the impact of a participatory organizational change (POC) health and safety program and stakeholder experiences on reducing MSD hazards.

**Methods:** This is an implementation study of a POC program in four not-for profit Ontario LTC homes. Based on a previous pilot study, data were collected using short surveys (health, symptoms/pain (VAS 1-10), self-efficacy (7-point scale)), observations (Quick Exposure Checklist (QEC scores)), and interviews/focus groups. Implementation process data was collected via interviews/focus groups according to a Quality Implementation Framework (QIF) (Myers 2102). Survey and observational data were analyzed descriptively. Transcripts were analyzed for emerging themes.

**Results:** Staff (n=96), managers (n= 35), and program champions (n=4) participated in the study. Survey and observational data revealed no statistically significant changes in pain scores, self-efficacy or observed exposures over 12 months. Interviews and focus group data showed participants reporting successful hazard control outcomes such as new laundry carts, practice changes for heavy lifting/moving, and dishwashing sink lifts. Overall the POC program implementation was considered successful. Themes reflecting the importance of creating and maintaining a structure for implementation were revealed (phase 2 and 3 of QIF). The POC program has been sustained and incorporated into existing health and safety procedures across sites (phase 4 of QIF). Improvements in communication and safety culture were facilitated by the participatory approach.

**Conclusions:** While health and symptom outcomes and observed postural hazards were not detected, POC program participants (management, program champions, frontline staff) reported satisfaction with the program. In addition, perspectives from all POC program stakeholders, including frontline staff, revealed sustained hazard identification and control processes and safety culture change one-year post-intervention. Sustainability was enhanced with opportunities to share solutions with other sites.

## New strategies to commit subcontracting managers in MSD prevention

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**Background:** The managers' commitment is one of the most important conditions for successful MSD prevention. The process to reach it varies with the context of the intervention. Description of strategies implemented by researchers in complex organizational context is however scarce in the literature. Literature points out research should focus on the strategies that commit subcontracting managers on MSD prevention, considering the complex nature of the relationships between stakeholders.

The aim is to analyse the process and strategies implemented to reach the commitment of senior subcontracting managers during research project on MSD prevention.

**Methods:** The method used is a post-study approach based on the reflexive practice, implemented by 2 researchers during a 3 sites research project in subcontracting meat-cutting sector. Reflexive practice aims to learn about researchers actions implemented to achieve a practical aim and to ask a previous theory. Data collected were based on context and on researchers' actions: the researchers' initial hypothesis, the projected method, the adjustment of the method to the subcontracting context and the final results.

**Results:** The results showed that 4 strategies from the literature were first applied to face with the specific context of subcontracting : (1) the organization of the managers stability (2) the analyzes of their tendencies to act (3) the transfer of MSD knowledge (4) the moderation of collective discussions on MSD problem. They were insufficient to overcome the subcontractors fear of a negative image compromising the durability of the commercial relationships with their contractors. A 5th strategy, shifting the focus of an MSD prevention towards a shared interest (knives sharpness), allowed them to take part in joint proposal with contractors and to reach the senior managers' commitment.

**Conclusions:** Those results increase the visibility of real strategies so as to favor their sharing with practitioners and researchers and future evaluation in the appropriate design method.

## Does training duration of a worksite-supervised adapted physical activity program affect trunk functional capacities and pressure pain sensitivity over the low back among vineyard-workers?

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**Background:** The prevention of work related musculoskeletal disorders (WMSD) affecting the low back represents a major issue among vineyard-workers. Numerous studies have reported the positive effects of worksite physical activity on WMSD. However, little is known about the optimal duration of such program. Therefore, this study was designed to evaluate the influence of the duration of two similar worksite supervised adapted physical activity (APA) programs on trunk muscle functional capacities and pressure pain sensitivity over the low back.

**Methods:** Thirty-three vineyard-workers from four vine-company were allocated to (1) a 2.5 months (n=16) or (2) a 6 months (n=17) supervised APA program. These programs included a daily warm-up of 15 minutes and two weekly sessions of trunk strengthening and flexibility exercises. The outcome measures were changes in trunk muscle endurance, trunk muscle flexibility and pressure pain thresholds (PPT) over the low back region. Measurements were performed (1) at baseline, (2) after 2.5 and (3) after 6 months.

**Results:** After 2.5 months, both groups significantly increased their trunk muscle endurance ( $P<0.05$ ) and increased PPT ( $P<0.05$ ). Between 2.5 and 6 months, trunk muscle endurance and PPT decreased for the 2.5 months group while the opposite was observed for the 6 months group ( $P<0.01$ ). The 6 months group had significantly larger changes than the 2.5 months group for the trunk muscle endurance tests and the PPT from baseline to 6 months and from 2.5 to 6 months ( $P<0.05$ ).

**Conclusions:** This study confirms that a worksite APA program can be used to improve trunk muscles functional capacities and decrease pain sensitivity over the low back among vineyard-workers. Interestingly, this study further highlights that a 6 months APA program is more effective than a 2.5 months APA program to reduce the risk of WMSDs of the low back.

## Smart workwear system with real-time vibrotactile feedback for improving postural behaviour in industry

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**Background:** A smart workwear system has been developed which can measure work postures of the trunk and upper arms, assess the risk, and give vibrotactile feedback based on the risk level. This study aimed to evaluate the effectiveness of the smart workwear system in improving workers' postural behaviour.

**Methods:** Eleven workers performed a material handling task in a manufacture company. The system consisted of two inertial measurement units and two actuators placed on upper back and dominant upper arm. Intermittent or continuous vibratory feedback was provided to the workers when they exceeded predetermined angular thresholds, i.e. 30° and 60° for upper arm, and 20° and 45° for trunk. The tests started without giving feedback as the Baseline, then two Training sessions with feedback and lastly Post-training without feedback, each consisting 3 work cycles. Repeated measures ANOVA was conducted.

**Results:** For the upper arm, comparing against the 50th percentile elevation angle at baseline (21.1°), significant decreases ( $p < 0.05$ ) were observed for Training1, Training2 and Post-training sessions of 2.5°, 2.4° and 1.7°, respectively. For the 90th percentile angle at the baseline (51.5°), significant decreases were observed for Training1 and Training2 of 7.0° and 7.8°. For Post-training, a decrease of 6.0° was observed ( $p = 0.066$ ). For the trunk, comparing against the 90th percentile flexion angle at baseline (28.8°), significant decreases were observed for Training1 and Training2 of 6.8° and 9.4°, and for Post-training a decrease of 5.3° ( $p = 0.081$ ).

**Conclusions:** The smart workwear system with real-time feedback showed a significant improvement in workers' postural behaviour during and after training. Therefore, the system has the potential to be used by workers, ergonomists, or employers to improve work technique and environment, to reduce risks of musculoskeletal disorders and obtain a more sustainable work. Future research will look into the effectiveness of different feedback types provided in the system.

## Optimizing ergonomic working conditions by using a participatory program: the design of a goods-to-person picking system in a Belgian company

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**Background:** Working at goods-to-person picking systems often comprise repetitive movements and static postures, both well-known risk factors for musculoskeletal disorders (MSDs). In a large Belgian company (>1000 employees) producing industrial vehicles and parts, new goods-to-person picking systems were designed by using a participatory approach to create optimal ergonomic working conditions.

**Methods:** In 2016, a three-step procedure was used to inform the design of the goods-to-person picking systems:

1. Observations of employees at working stations to get an overview of their processes, tasks, and actions.
  2. Interviews with employees at different levels to identify problems and solutions.
  3. Multidisciplinary group discussion with stakeholders about the results and advices.
- Additionally, electromyography (EMG) was used to measure muscle electrical activity in order to objectify ergonomic load at the old versus the new working station.

**Results:** Observations of five employees resulted in task analyses, and a list of 18 ergonomic (both physical and cognitive) risk factors and improvement proposals.

1. Interviews with six employees and one system expert yielded 24 points of improvement, and created a higher employee involvement to create optimal ergonomic working conditions.
2. The multidisciplinary group discussion (n=7) with stakeholders resulted in a consensus about solutions and a plan of action for each ergonomic optimization. The new working station showed an overall lower muscle electrical activity than the old working station. However, comparison was difficult because of the use of different subjects. Furthermore, the EMG measurements gave insights into the extent muscles were loaded during different actions, creating a higher awareness among employees (e.g.: influence of weight, pick direction, and working height).

**Conclusions:** By using a participatory solution-oriented approach, acceptance for the design of good-to-person picking systems was gained by workers of different levels in the company. Further follow-up and monitoring is important to maintain optimal ergonomic working conditions.

## Validation of a conceptual model for shoulder pain risk factors

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**Background:** A previous study explored the direct and indirect relationships between workplace risk factors, perceived stress, and shoulder pain in French male workers included in the Cosali study. The aim of the present study was to test the robustness of the model among men included in a study conducted in a manufacturer of pharmaceutical preparations.

**Methods:** The study used and compared longitudinal data from the Cosali study (n=334) and cross-sectional data from a manufacturer of pharmaceutical preparations (n=487). All workers completed the same self-administered questionnaire about personal and workplace risk factors. A conceptual model was defined on the basis of literature and authors' expertise. The model was tested in male workers included in the Cosali study and the robustness was tested in male workers of the manufacturer of pharmaceutical preparations. Structural equation modeling was used to test the direct and indirect relationships among the variables.

**Results:** Shoulder pain was directly increased by biomechanical exposure in both samples, and stress only in the manufacturer of pharmaceutical preparations. In both samples, psychosocial factors had indirect impact on shoulder pain in acting on biomechanical exposure and stress. Work pace dependent on automatic rate had indirect impact on shoulder pain in increasing biomechanical exposure and in decreasing decision authority and skill discretion, while work pace dependent on customers' demand had indirect impact on shoulder pain in increasing decision authority, skill discretion and psychological demand.

**Conclusions:** The study showed that biomechanical exposure and stress had direct impact on shoulder pain, while organizational factors and psychosocial factors had indirect impact. The "causal model" of shoulder pain obtained in a cohort of workers from general working population can be globally replicated in a specific industry. Results highlight that workplace interventions should act on multiple dimensions to ensure greater effectiveness.

## Work above shoulder level and shoulder disorders – a systematic review

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**Background:** Work with elevated arms is regarded an important risk factor for work-related shoulder complaints. This study reviews the literature on the association of work above shoulder level with shoulder pain and disorders.

**Methods:** A systematic literature search was performed in the databases Medline, Embase, and Health and Safety Science Abstracts, covering the period 01.01.1990 until 01.03.2018. Peer reviewed English language papers with prospective, case-control, intervention and cross-sectional designs were included. The papers were checked for quality with a scheme adjusted to the study designs. The quality scores were normalized to 100% and papers scoring less than 40% were excluded.

**Results:** Forty papers fulfilled the inclusion criteria and six of these were excluded for low quality score. The 34 remaining papers (sixteen prospective cohort, three case-control, fifteen cross-sectional and none with intervention design) were grouped according to exposure assessment method. Twenty papers used self-report in questionnaire or interview, four studies used job exposure matrix based on expert rating, five studies identified arm elevation in video recordings, and the last five studies used inclinometry to objectively measure the elevation of the upper arm. Outcome based on clinical assessment with a clinical diagnosis on a shoulder disorder was reported in sixteen papers, while self-reported shoulder pain only was reported in eighteen studies. Twenty papers reported statistically significant positive associations between exposure and shoulder pain or disorders. Only one paper reported a statistically significant negative association. Fifteen of the sixteen papers with clinical diagnoses as outcome found statistically significant positive associations. Eighteen studies reported three or more levels of exposure, allowing an evaluation of a possible exposure-effect relationship. Sixteen of these reported significant positive associations and thirteen showed results in agreement with an exposure-effect relationship.

**Conclusions:** This systematic review supports a positive association between work with elevated arms and shoulder pain and disorders.

## Longitudinal analysis of shoulder kinematics and muscle EMG in patients surgically treated for rotator-cuff tear

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**Background:** ISEO is the most documented protocols for the evaluation of shoulder kinematics. An on-going RCT aims to verify if ISEO, when used as biofeedback device, can improve the functionality of patients arthroscopically treated for rotator cuff tear. In this study, we report about the change of muscles onset during humerus movements, pre-op and along the course of rehabilitation.

**Methods:** Seventeen patients aged 35-65 y.o. were recruited, all arthroscopically treated for rotator cuff tear. Patients were evaluated before surgery (T0), and at 45 (T1) and 90 (T2) days after surgery with a Cometa EMG system. Each evaluation included the anterior Deltoid (D), Upper (U) and Lower (L) trapezius during humerus elevation in the sagittal (flexion-FL) and scapular (abduction-AB) planes. Five repetitions were executed and the third was used for the analysis. D, U and L onset was calculated using Noraxon® software, and data were used to complete frequency tables, describing the different muscle onset sequences.

**Results:** For FL, patients at T0 are clustered in two sequences: D-U-L and U-D-L, with L always last to start, which is suggestive of a compensation in elevation for the shoulder girdle as a whole. At T1 and T2 more patients show patterns in which L starts as second or first in the sequence, which is suggestive of an increased scapula control. For AB, patients at T0 are highly scattered, while at T1 they tend to shift to a U-D pattern, which is suggestive of an increased tightness of the complex. At T2, this clusterization decreases, with more patients having L as first or second muscle to become active.

**Conclusions:** The preliminary results of the RCT are suggestive of a stereotyped behavior of patients' pre-op for FE, which is not evident for AB. Particularly for FE, rehabilitation tends to make the lower trapezius active sooner.

## Occupational biomechanical risk factors for surgical treatment of subacromial impingement syndrome (SIS) in a 16-year prospective study among male construction workers.

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**Background:** Shoulder disorders are common in the general population, with an annual prevalence up to over 40% per 1000 person-years. One common disorder is subacromial impingement syndrome (SIS), where a narrowing in the subacromial space causes compression of the tendons or bursa by the surrounding tissues. When conservative treatments are not effective, surgical treatments is often the alternative. The aim of the current study was to assess the association between occupational biomechanical exposures and the occurrence of surgically treated SIS in a large construction worker cohort over a 16-year follow-up period.

**Methods:** A cohort of 280 747 male construction workers who participated in a national occupational health surveillance program (1971-1993) were examined prospectively (1987-2016) for SIS. SIS case status was defined by primary surgical treatment of diagnosis codes M75.1, M75.4, 726B, or 726C (ICD 10 and Swedish ICD 9 code systems), with data from the Swedish national registry for in- and out-patient surgery records. A job exposure matrix (JEM) was developed and biomechanical exposure estimates were assigned according to job title. Poisson regression models adjusted for age, BMI, smoking and a surgical time factor were used to estimate the relative risks (incidence rate ratios) of surgical treatment for SIS for each biomechanical factor.

**Results:** There were 1381 cases in the cohort, which corresponded to an incidence rate of surgically treated SIS over the 16-year observation period of 46 cases per 100,000 person years. Increased risk for surgically treated SIS was shown for working with elevated arms (RR=1.27, 95% CI=1.02-1.58), heavy upper arm loads (RR=1.75, 95% CI=1.48-2.08), high grip force (RR=1.64, 95% CI=1.40-1.93), working with hand tools (RR=1.46, 95% CI=1.26-1.70), working with hand tools in a fixed posture (RR=1.28, 95% CI=1.14-1.44), and working with hand-arm vibration (RR=1.30, 95% CI=1.09-1.55).

**Conclusions:** Working with elevated arms, high arm load, high grip force and vibrating handheld tools may increase the risk for SIS.

## Occupational mechanical and psychosocial exposures and Subacromial Impingement Syndrome: a systematic review

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**Background:** Subacromial impingement syndrome (SIS) is the most frequently diagnosed shoulder disorder, accounting for 44–65 % of all shoulder disorders seen in primary care. The purpose of this study was to examine which occupational mechanical and psychosocial exposures are associated with an increased risk of SIS.

**Methods:** A systematic literature search was performed in Medline, Embase and Web of Science up until 26th October 2016. Inclusion criteria comprised clinically or imaging assessed SIS together with occupational mechanical exposures (i.e. force, arm posture, repetition, hand-arm vibration (HAV) and the combination of different mechanical exposures) and psychosocial exposures (job demand, job control and social support). Meta-analysis of the included risk estimates was performed by applying a random effect model to each model separately. We constructed funnel plots to assess publication bias and forest plots to illustrate the summary odds ratios from the random effect models.

**Results:** A total of 5165 articles were identified including 1130 duplicates. From the 4035 articles, we excluded 2794 and 1121 articles based on title and abstract screening; after full paper reading, 50 studies were included. In meta-analysis, pooled OR of 1.44 (95% CI 1.14-1.75), 1.79 (95% CI 1.37-2.21), 1.72 (CI 95% 1.17-2.27), 1.31 (95% CI 1.00-1.62) and 1.81 (95% CI 1.37-2.10) were found for forceful shoulder exertion, arm posture, repetitive shoulder movement, HAV and the combination of different mechanical exposures, while pooled OR between 0.98 and 1.14 were revealed for job demand, job control and support.

**Conclusions:** We found moderate evidence of an association between forceful shoulder exertion, arm posture, repetitive shoulder movement, and strong evidence for the combination of different mechanical exposures and SIS, while limited evidence was found for HAV. No associations were found for psychosocial exposures.

## Cervical intervertebral disc herniation and occupational risk factors: a literature review

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**Background:** Cervical intervertebral disc herniation is a spine disorder that can severely limit workers' ability leading to long term disability claims. The aim of this study was to investigate the possible association between herniated cervical disc and occupational risk factors.

**Methods:** A systematic search was carried out in MEDLINE (PubMed) until March 2019. The search strategy was based on a PubMed search filter conceived to detect the putative occupational origin of a disease. Two reviewers independently screened titles and abstracts for eligibility. The full text of all articles potentially qualifying for inclusion were assessed by the same pair of reviewers. Disagreements were resolved by a third reviewer.

Observational studies on cervical intervertebral disc herniation and exposure to occupational risk factors were included.

**Results:** The electronic search retrieved 410 potentially relevant citations. Of these, 34 were assessed in full-text and 19 met the inclusion criteria. Two longitudinal cohort studies, two retrospective cohort studies, two case-control studies, three cross-sectional studies, and ten non-comparative studies were identified. The cohort studies showed a higher risk for cervical intervertebral disc herniation among professional drivers, astronauts, physicians/nurses and American football players. The case-control studies reported a higher risk for frequent lifting of heavy objects on the job, frequent diving from a board and bowling players. Non-comparative studies were mainly about cases of herniated cervical disc among pilots, astronauts, surgeons and parachutists.

**Conclusions:** These preliminary findings suggest that some working activities seem to be at higher risk for cervical intervertebral disc herniation. However, high quality studies are needed to determine the association between herniated cervical disc and occupational risk factors. Future studies should take into consideration non-occupational risk factors, including sporting and leisure activities.

## Occupational risk factors for hospitalization due to cervical disc disorder in a 29-year prospective study of Swedish male construction workers.

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**Background:** The aim of this study was to assess the associations between individual and occupational exposure factors and hospitalization for cervical disc disorder (CDD).

**Methods:** CDD was examined prospectively in a cohort of 278 319 Swedish male construction workers who participated in a national health surveillance program (1971-1993). Job title, smoking status, age, height, and weight were recorded on examination. Case data were obtained through linkage with the Swedish national in-patient hospital registry for the period 1987 – 2016; case status was defined by primary diagnosis code M50.0 (ICD-10) or 722.0, 722.4, or 722.7 (ICD-9). A job exposure matrix was developed and occupational exposure estimates were assigned by job title. Self-reported estimates of pain/discomfort from a subset of 87 500 workers were also linked to the database. Poisson regression models were used to estimate the relative risks (RR) for the biomechanical and self-reported factors with adjustment for smoking status, age, BMI and surgical time period.

**Results:** There were 562 cases of hospitalization for CDD; the incidence rate was 8.0 cases per 100 000 during the 29-year follow-up period. Smoking status, age, BMI and height were all associated with increased risk (RR 1.21-3.16). Occupational exposure to static work in non-neutral or extreme neck postures, and time spent in awkward postures showed the highest associations with CDD hospitalization (RR = 1.62 – 2.10). Upper arm load and time with arms above shoulders were also associated with increased risk (RR = 1.50 – 1.58). Workers who reported experiencing pain 'often' or 'very often' during the previous year for any of the neck, shoulder or upper back regions had a 3-fold increase in risk relative to workers reporting no pain.

**Conclusions:** Occupational non-neutral neck posture was associated with increased risk of hospitalization for CDD. Our data also suggest an exposure-response relationship for self-reported neck pain/discomfort and risk of hospitalization for CDD.

## MRI lumbar disco-vertebral findings, age and manual material handling. A cross-sectional multicenter study

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**Background:** The lumbosacral junction incurs in the greatest load, in terms of vertical and shear forces, during manual material handling. The aim of the study was to assess if lumbar vertebral body and disc changes are more common in people who perform manual material handling (MMH) and if lumbar vertebral body and disc changes are more prevalent in L4-L5 and L5-S1.

**Methods:** Observational, cross-sectional study design. Consecutive patients aged 20-70, referred for magnetic resonance imaging (MRI) of the lumbar spine were recruited in outpatient radiology units of three large hospitals in northern and southern Italy. History of personal and family musculoskeletal diseases and injuries, current and past manual material handling at work and during leisure time were assessed by interview and self-administered questionnaire. Neuroradiologists evaluated the prevalence of intervertebral disc and vertebral body changes using a standardized protocol.

**Results:** The study group consisted of 189 patients, 94 females and 89 males. Participants were classified according to their occupational exposure to MMH. In the multivariate model no association was found between MMH and vertebral body/intervertebral disc changes, whereas age over 45 years was consistently associated with DEBIT changes, Pfirrmann changes, osteophytes and Modic changes: the association was statistically significant at the conventional 5% level.

**Conclusions:** Age, and not MMH, seems to primarily affect the presence of intervertebral disc changes. Prospective studies are needed to better explore the relationship between manual material handling and the possible presence (and level) of lumbar vertebral body and/or disc changes.

**References:** Modic MT, Steinberg PM, Ross JS, Masaryk TJ, Carter JR. Degenerative disc disease: assessment of changes in vertebral body marrow with MR imaging. *Radiology* 1988;166:193-9

Pfirrmann CW, Metzdorf A, Zanetti M, Hodler J, Boos N. Magnetic resonance classification of lumbar intervertebral disc degeneration. *Spine (Phila Pa 1976)* 2001;26:1873-8

## Persistent postoperative pain after groin hernia repair in relation to occupational mechanical exposures

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**Background:** Current evidence is insufficient regarding the risk of persistent postoperative pain (PPP) after groin hernia repair in relation to occupational mechanical exposures. We have shown that the percentage of patients with sickness absence >2 weeks within 8 weeks after surgery increased with exposure from 15% to 53%. This finding could not be explained by exposure-related complications that lead to reoperation, but might be due to an increased risk of PPP in relation to occupational exposures. The aim of this study was to evaluate the risk of PPP after groin hernia repair in relation to occupational lifting and standing/walking.

**Methods:** We conducted a six month follow-up study of men, who were registered with a groin hernia repair in the Danish Hernia Database from January 1 2015 to October 31 2016, and who were alive, living in Denmark, and active in the labour market in the week before surgery. All cohort members received a questionnaire six months after surgery. Exposure estimates were allocated to the cohort members by combining their self reported job titles with a job exposure matrix. The outcome was PPP defined as  $\geq 2$  on a numerical rating scale (range 0-10) during activity six months postoperatively. Prevalence ratios of PPP were estimated using Poisson regression analysis.

**Results:** A total of 2,609 patients (54%) returned the questionnaire and 2,508 contributed to the analyses. PPP was reported by 473 men (19%). An increased risk was observed in the group lifting >1,000-6,125 kg/day compared with the minimally exposed group; prevalence ratio 1.44 (95% confidence interval 1.16-1.79). For standing/walking >6 hours/day versus <4 hours/day a prevalence ratio of 1.18 (95% confidence interval 0.92-1.0) was found.

**Conclusions:** The risk of PPP after groin hernia repair was elevated among men with occupational lifting exposures >1,000 kg/day. This finding suggests a preventive potential.

## Inguinal hernia and occupational physical exposure: systematic review and meta-analysis

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**Background:** Inguinal hernias are among the most common surgical pathologies especially among men, with an incidence of about 50.000 cases annually in the Netherlands. Better understanding whether occupational physical exposure contributes to the onset and/or worsening of this pathology, might show the relevance of prevention at work. Therefore, the aim is to assess whether occupational physical exposure is a risk factor for an inguinal hernia.

**Methods:** A systematic review was performed using the database PubMed until May 14th 2018. Inclusion criteria were all studies describing original data, reporting about clinically assessed inguinal hernias among a working population and classifying exposure in at least high and low physical workloads. Two reviewers independently checked these criteria. References of included studies were also checked to find relevant other studies. Only high quality studies were used for the meta-analysis.

**Results:** The search resulted in 564 studies of which 14 fulfilled the inclusion criteria. Three studies could be used for the meta-analysis including 614 inguinal hernias among 3641 workers. A random-effects model showed a pooled Odds Ratio of 2.30 (95%CI 1.56-3.38) indicating that high occupational physical exposure is a risk factor for an inguinal hernia. This finding seems especially true for male workers having a lateral inguinal hernia and standing for more than 6 hours per day or lifting more than 1000 kg per day, even after taking into account increasing age as a personal risk factor.

**Conclusions:** Occupational physical exposure appears a risk factor for a clinically assessed inguinal hernia. This finding hopefully contributes to increase awareness among clinicians, occupational health professionals, policymakers, employers and workers for prevention of inguinal hernias, especially at worksites where a large number of workers have to stand prolonged or lift a lot.

**References:** Vad MV, et al. Inguinal hernia repair among men in relation to occupational mechanical exposures and lifestyle factors: a longitudinal study. <https://oem.bmj.com/content/oemed/early/2017/05/24/oemed-2016-104160.full.pdf>

## Are there sex differences in scaption torque steadiness?

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**Background:** Sensorimotor performance of females and males is an important biological aspect. It may help to understand the causes of the higher prevalence of work-related musculoskeletal disorders in the neck/shoulder region of females compared to males. The purpose was to investigate if there are sex differences in torque steadiness during dominant isometric shoulder scaption.

**Methods:** Seventeen females ( $26.12 \pm 3.97$  years,  $58.76 \pm 8.83$  kg,  $163.65 \pm 5.34$  cm) and 17 males ( $23.53 \pm 2.45$  years,  $76.85 \pm 9.84$  kg,  $176.35 \pm 6.50$  cm) without disorders in the neck/shoulder region participated. Torque steadiness was evaluated during three isometric contractions (10-s duration each), performed with the dominant arm abducted at  $90^\circ$  at both 20% and 35% of peak torque (PT). Stability time (ST) was identified in the torque signal to avoid errors of the adjustment phase. Standard deviation (SD), coefficient of variation (CV) and median frequency (MF) values were calculated from ST. Two-way mixed ANOVA was applied considering sex (females and males) and intensity (20%PT and 35%PT).

**Results:** There was a significant effect on the interaction intensity x sex for the SD values ( $P < 0.001$ ). Sex differences occurred in both intensities, with lower SD values among females compared to males ( $P < 0.001$ ). Females have also presented lower MF values than males ( $P < 0.01$ ). There was no significant effect on the interaction intensity x sex or main effect of sex for CV and ST values.

**Conclusions:** Females had lower and less frequent torque fluctuations than males during scaption. The sensorimotor performance observed among females may increase their occupational exposure compared to males because sensorimotor strategies with less variation may demand always the same neuromuscular structures of the neck/shoulder region, imposing overload on motor units and muscles involved in the motor action.

## Are there sex differences in the muscle activation and in the relationship between objective and subjective indicators of muscle fatigue in the neck/shoulder region during a repetitive task?

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**Background:** The aim was to investigate if there are sex-specific effects of fatigue on neck/shoulder surface electromyography (sEMG) and on the relationship between sEMG and perceived exertion during a repetitive task performed at/above shoulder level.

**Methods:** The sEMG of the clavicular (CUT) and acromial (AUT) parts of upper trapezius, middle trapezius (MT), lower trapezius (LT), serratus anterior (SA) and anterior deltoid (AD) muscles were recorded from 20 females and 20 males. They performed a repetitive task requiring upper limb movements at/above shoulder level until exhaustion. For the sEMG analyses, the last 30sec of the first and the last minutes of the task were considered as pre- and post-fatigue, respectively. Ratings of the neck/shoulder perceived exertion (RPEN/S) were evaluated through the Borg CR10 Scale, and the scores obtained at the end of the first and last minutes of the task were considered. The effects of Time (pre- post-fatigue) (Wilcoxon Signed Rank Test) and Group (females/ males) (Mann-Whitney U test) were evaluated on the sEMG signal. Correlations between the sEMG of each muscle and the scores obtained from the Borg CR10 Scale were evaluated (Spearman) at both pre- and post-fatigue.

**Results:** There was a higher activation of the CUT, AUT, SA and AD in both groups and of MT in males at post- compared to pre-fatigue ( $P < 0.01$ ). Females showed higher activation of CUT, AUT, and AD at the pre-fatigue, and of AD at the post-fatigue compared to males ( $P \leq 0.035$ ). There was a positive moderate correlation between sEMG of SA and RPEN/S at pre-fatigue, but only in males ( $r_s = 0.48$ ,  $P = 0.03$ ).

**Conclusions:** Neck/shoulder perceived exertion was associated to the activity of an important shoulder stabilizer (SA muscle) in males, which may indicate sex differences in the motor strategies adopted by males and females during a repetitive, highly demanding, and fatigue-inducing upper limb task.

## Are sex differences in neck/shoulder electromyographical changes induced by a fatiguing repetitive task affected by the choice of the fatigue criterion?

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**Background:** The aim was to investigate if using different criteria to identify fatigue induced by a repetitive task changes the outcomes of sex differences in muscle activation of the neck/shoulder region.

**Methods:** Twenty females and 20 males participated. Surface electromyography (sEMG) was recorded from the clavicular (CUT) and acromial (AUT) parts of upper trapezius, middle trapezius (MT), lower trapezius (LT), serratus anterior (SA) and anterior deltoid (AD) muscles, during a fatiguing repetitive task performed at/above shoulder level. Ratings of the neck/shoulder perceived exertion (Borg-CR10) were recorded at the end of every minute. Two fatigue criteria (FC) were considered in sEMG analyses: when an 8/10 score or higher was first reported (STOPBorg) and when the subject was no longer able to perform the task (task failure, STOPTF). Results (root mean square - RMS and median frequency - MF) from the last 30sec of the first minute (pre-fatigue) were compared to both last 30sec from the last minute (post-fatigue, STOPTF), and from the minute that subjects reported 8/10-BORG-CR10 score (post-fatigue, STOPBORG). Two-way mixed ANOVA was applied considering time and sex.

**Results:** For RMS, both FC showed sex differences for AUT and AD ( $P \leq 0.04$ ). There were sex differences in CUT at STOPBorg ( $P = 0.04$ ), but not at STOPTF ( $P = 0.06$ ). In all cases females showed higher RMS than males, regardless of the FC. For MF, both FC showed the same sex differences ( $P \leq 0.02$ ), with females having lower values for LT and higher values for AD than males, regardless of the FC. Both FC showed changes in RMS and MF for some muscles after fatigue, regardless of group ( $P \leq 0.01$ ).

**Conclusions:** Defining fatigue from perceived exertion or task failure does not change the sex differences in sEMG outcomes: at both Borg of 8/10, and at task failure, the same sex differences are observed.

## Evaluating the treatment of sex and gender when assessing methodologic quality in a systematic review of explanatory and prognostic studies of musculoskeletal disorders

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**Background:** Sex and gender differences in work roles and exposures may be instrumental in the higher incidence, poorer prognosis, and longer disability experienced by women with work-related musculoskeletal disorders (MSD). The objective of this study was to develop and apply criteria for assessing the treatment of sex/gender when evaluating methodologic quality of quantitative and qualitative primary studies during a systematic review identifying determinants of the sex/gender (s/g) differences in duration of MSD work absence.

**Methods:** We developed criteria for assessing whether sex/gender were adequately addressed in primary prognostic studies, based on elements proposed by the Sex & Gender Methods Cochrane Musculoskeletal Group and in existing literature. Criteria from the Quality in Prognostic Studies (QUIPS) instrument (Hayden et al 2013) were used for evaluation of risks of bias in quantitative studies, and, in qualitative studies, from the NICE Methodology Checklist for Qualitative Studies (2009). The proposed criteria for assessing sex/gender were added to these instruments, applied to 19 quantitative studies and 5 qualitative studies included in the review, and results summarised.

**Results:** We identified 16 sex/gender-related criteria for evaluation of methodologic quality of primary studies: 3 address study research question and/or conceptual framework, 5 address research design, 4 address analysis and 4 address interpretation of results.

Quantitative studies were less likely than qualitative studies to present a sex/gender conceptual framework (<17-43% vs 75-100% studies), to consider s/g at an individual, organizational/system and/or societal level (29% vs 75%) or consider how to apply/translate results based on sex/gender differences (43% vs 75%). Few quantitative or qualitative studies adequately took s/g into account in describing research design.

**Conclusions:** There is a need to better address sex/gender in WMSD systematic reviews. We propose 16 s/g criteria to take into account when designing new studies and evaluating methodologic quality of studies in systematic reviews.

## What are the determinants of the sex/gender difference in the duration of work absence for musculoskeletal disorders? A mixed studies systematic review

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**Background:** In Quebec, over the past 15 years, duration of work absence for work-related musculoskeletal disorders (MSD) has been rising in both genders but remains considerably higher among women. We sought to identify determinants of the gender gap in MSD work absence duration through a mixed studies systematic review.

**Methods:** We searched the 2000-2017 scientific literature in 21 bibliographic databases for quantitative and qualitative studies of explanatory/predictive factors of MSD work disability duration among workers using sex and/or gender-based analysis. Selected quantitative studies were assessed for risk of bias with the QUIPS instrument (Hayden et al, 2013) and qualitative studies with the NICE Methodology Checklist for Qualitative Studies (2009), to which 16 criteria for evaluating treatment of sex/gender were integrated. Lower quality studies were excluded from further analysis. Evidence synthesis for quantitative studies was done using GRADE adapted to prognostic studies and for qualitative studies using meta-ethnography, followed by a mixed synthesis.

**Results:** Of 1,180 search results, 14 quantitative and 4 qualitative studies met selection and methodologic quality criteria. The synthesis of qualitative studies suggested that inequities in division of domestic duties, lack of family support, women's reduced access to modified work and re-training, and gender-biased attitudes of health and insurance system gatekeepers hindered women's return to work. Moderate evidence for the following explanatory factors was found in gender-stratified quantitative studies, in women: combination of working  $\geq 40$  hours/wk and having dependents, low supervisor support, feeling one's doctor didn't listen; in men: combination of working  $\geq 40$  hours/wk and high physical demands, perceiving oneself as underemployed.

**Conclusions:** In the mixed synthesis we propose a conceptual model of determinants of sex/gender differences in MSD work disability, most modifiable that can be acted upon to reduce duration of women's work absence. They include factors in personal/home life, workplace, healthcare, insurance-disability management spheres, influenced by the larger socio-political-cultural-legislative-macroeconomic context.

## Sex-specific effects of standing vs sitting on trunk and leg muscular and vascular outcomes during a repetitive manual work task

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**Background:** Both prolonged sitting and standing have negative impacts on vascular and musculoskeletal outcomes associated with workplace health. However, whether both sexes are equally affected is not well known.

**Methods:** Sixteen young asymptomatic adults (8 women) attended two sessions, on two separate days, where they performed the same repetitive box-folding task in a laboratory for 34min in either a sitting or a standing posture. Bilateral surface electromyography (sEMG) was recorded from the trunk (lumbar Erector Spinae (ES), Rectus Abdominis (RA), External Oblique (EO)) and hip (Gluteus Maximus (GM)) muscles to measure activity amplitude (RMS) and cross-correlations across 30s samples. Laser Doppler flowmetry was recorded at the soleus and foot, and blood pressure was measured at the ankle. Repeated measures ANOVAs were applied with conditions of posture, time and sex.

**Results:** GM RMS was higher during standing ( $p = 0.038$ ), but was not different between sexes, and there were no effects on GM bilateral cross-correlations. Women displayed a trend towards higher RA amplitude, and significantly higher RA-ES cross-correlations especially in standing (posture x sex interactions,  $p = 0.057$ ,  $p = 0.034$ ). Women also displayed higher ES-EO cross-correlations ( $p = 0.049$ ). Men's vascular measures were more affected by posture, with higher blood flow when standing compared to sitting (posture x sex interaction,  $p = 0.036$ ), whereas posture did not affect any of the women's vascular measures. The standing posture, in general, was associated with greater lower limb blood flow and blood pressure, compared to the seated posture.

**Conclusions:** Results indicate that work posture differentially affected men and women, with impacts on women's trunk muscular outcomes, and men's lower limb vascular outcomes. More studies are needed to determine if these sex differences in short-term effects of work posture can help explain sex differences in mechanisms of work-related health.

## Awareness, Skill Building and Behavior Modification Program amongst Community and Office Employees on Safer Use of Computing Technology Equipment (Laptops, Desktops, Hand-held Devices, including smart-phones)

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**Background:** Computers and Handheld devices (HHD) combine advanced computing capability, like internet communication, information retrieval, video, e-commerce, etc. that makes the device a necessity for modern lifestyle, as currently not only IT industry, but modern day office-goers, our family members and school children, students in colleges are using these devices, experiencing discomfort and even serious injuries necessitating physiotherapy, pain management and surgeries.

**Methods:** There is an urgency to create awareness on safer use of Computers and HHD in maximum individuals in shortest time, develop trainers who can train family members and colleagues to become trainers (TTT). In this way ergonomics awareness can be achieved widely.

A KAP study was carried out in 12 different sessions, town-hall lectures, small groups of participants, social community gatherings like rotary club meetings and their respective office employees.

**Results:** Effective awareness on working safely with computers and HHDs was organized in different groups in twelve sessions. Participants ranged from 26-40 years (40.34%) followed by 20-25 years (33.54%). When successfully implemented, 95% participants reported these awareness sessions were extremely practical and useful, however opining that session duration could be shortened.

**Conclusions:** All physicians today share a responsibility to educate community on safer use of computing technology devices, based on ergonomics principles. A detailed chapter on ergonomics should be included in the medical curriculum so that undergraduate medical students are made aware of the prevention and control of occupational morbidities like WRMSDs.

## Knowledge transfer and exchange for work and health research to practice

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**Background:** Workplace injury such as MSD can be burdensome for individual workers, workplaces, medical systems, and insurance systems. Research to practice is important for the prevention of MSD and other workplace injuries. Knowledge transfer and exchange (KTE) is the practice of generation, synthesis, and dissemination of research so that it can be put into practice. The objective is to present a synthesis of the literature describing KTE activities relevant to workplace audiences.

**Methods:** A rapid review of the literature was conducted with comprehensive search strategies, developed using terms for knowledge transfer and occupational health and safety, in six electronic databases (Medline, Embase, ERIC, Social Sciences, Web of Science, and Business Source Premier). References of relevant documents and hand-searching complimented the search. Documents describing a KTE approach for workplaces were reviewed. KTE data were extracted and synthesized according to a framework by Lavis (2003) (What, To whom, By Whom, How, and With what effect). Information about the conceptual guidance of the KTE approaches was also extracted.

**Results:** Literature searches yielded 34 documents that described 23 different KTE approaches to reach workplaces. KTE approaches addressed workplace and intermediary audiences. KTE methods and outcomes varied greatly according to context. However, there were common elements: targeting workers as a key audience, involving researchers in dissemination, and using multiple dissemination methods. Dissemination methods consistently included direct interaction but also featured printed materials. Many KTE approaches were guided by conceptual frameworks.

**Conclusions:** Common elements related to audience, activities and impact were found in the literature that can help to guide future KTE approaches. Including workers as an audience and researchers as disseminators in a multi-faceted approach along with in-person meetings and printed material are important aspects of KTE for work and health. Effective KTE is important to get research into practice for the prevention of MSD.

## Operator-exoskeleton interactions: preliminary study on the acceptability of these devices

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**Background:** Exoskeletons are emerging within companies. They are presented as systems to compensate for the efforts and to assist the operator and eventually to limit or reduce MSDs. The objective of this study is to analyse the question of the acceptability of these devices by operators.

**Method:** A questionnaire was developed from psychological models dealing with acceptability. It is composed of 6 dimensions (usability, utility of the device, health and safety aspects ...). 40 people from 5 different sector companies responded to this questionnaire (logistic, food industry, automotive)

**Results:** Regarding the usability of exoskeletons, the results show that the operators who accept the device are "somewhat in agreement" and "strongly agree" respectively for 50% and 43% of them on the ease of use of the device, 50% and 36% on the ease of moving and 71% and 29% on the possibility of making movements with the exoskeleton. For the operators who reject the system the opinions are positive for the ease of use (50% are "rather agree" and 20% "moderately agree"). However, regarding the "ease of movement" and "of displacement", an increase of the "moderately agree" to the detriment of the "rather agree" is observed compared to the operators who accept the device. Regarding the utility of the exoskeletons, more than half of the operators who accept or reject the device, think that their performance is identical with or without exoskeleton. In terms of health and safety, these systems are perceived as relieving physical effort especially in case of pre-existing back pain. However the appearance of new pain is reported (neck, shoulders and legs).

**Conclusions:** These results inform on the quality of the operator-exoskeleton interaction, and allow to consider some physical, but also psycho-social and accidental risk factors at the users especially in the case of non-acceptability

## Potential of back exoskeletons in limiting spinal muscles activity depends on their design and on task modalities

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**Background:** Back-support exoskeletons (EXOBK) are developed to prevent the occurrence of low back pain, by reducing lumbar muscles activity during bending tasks. Disparities in the protocols of previous researches created some confusion about the reductions of the back muscles activity to expect when using an EXOBK. This study tested the influence of exoskeletons design, and trunk inclination (TI), on the EMG activity of Erector Spinae muscles (ES) during bending tasks.

**Methods:** 15 men performed two experimental load-handling tasks (8kg), both with a mechanical-designed EXOBK (EXO1), a textile-designed EXOBK (EXO2), or without equipment (FREE). The tasks consisted in a sagittal lifting/lowering task (LLT) (TI: from 95° (bended) to 5° (standing) then to 95°), and a 15-s static holding task (SHT) (TI ≈ 85°). EMG was analyzed during SHT, overall LLT, and over 8 consecutive phases (P), each corresponding to 25% of the range of motion during lifting (P1 to P4) and lowering (P5 to P8)).

**Results:** During overall LLT, averaged ES activity was similar whatever the assistive condition. The reductions of ES activity with exoskeletons, in comparison with FREE, depended on the TI and on the device (EXO1: -12% ( $p < 0.05$ ) for P3 ( $47^\circ > TI > 25^\circ$ ); EXO2: -16% ( $p < 0.05$ ) for P2 and P7 ( $70^\circ > TI > 25^\circ$ ). During SHT, P1 and P8 (LLT), the use of EXO1 increased ( $p < 0.05$ ) the ES activity in comparison with EXO2 (+73%) and FREE (+41%). This last result could suggest an eventual change in the coordination of spine extensor muscles with the exoskeleton.

**Conclusions:** The efficiency of passive EXOBK in limiting spinal muscles activity depends on the interaction between the EXOBK design and the work posture. To allow a relevant use of EXOBK, this interaction has to be assessed before its integrating in the workplace.

## Postural consequences of the use of upper-limb exoskeletons during overhead work: influence of exoskeleton design?

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**Background:** There is a consensus about the efficiency of passive upper-limb exoskeletons (EXOUL) in reducing shoulder strains associated with lifting the arms (i.e. overhead work: OHW). But, supported by a large disparity in the design of the EXOUL, confusion exists among previous studies about the potential consequences on postural strains. This work aimed to characterize the acute postural adaptations (muscles activity and balance) during an experimental exoskeleton-assisted OHW task.

**Methods:** Participants (15 males and 15 females) performed a static OHW task (a 8kg load maintained with 90° shoulder and elbow flexion during 15s) in three conditions of assistance: with a 9kg full-arm EXOUL (EXO1, Stronger, Exhaus, France), a 3kg upper-arm EXOUL (EXO2, Skelex, Netherlands) and without equipment (FREE). The EMG activity of shoulder (Anterior Deltoid (AD)) and postural (Tibialis Anterior (TA) and Erector Spinae (ES)) muscles are bilaterally recorded. The oscillations of the center of pressure (COP) are also analyzed with a force platform. One-way analyses of variance (ANOVA) were conducted to assess differences between conditions.

**Results:** During this static OHW task, both exoskeletons significantly ( $p < 0.001$ ) decreased the EMG activity of AD and ES compared to FREE (respectively, EXO1: -56%; EXO2: -54% and EXO1: -61%; EXO2: -50%). ES muscles activity was lower for EXO1 than for EXO2 ( $p < 0.05$ ). None of these devices affected the activity of TA. The use of EXO1 significantly decreased (-17%,  $p < 0.05$ ) the amplitude of COP antero-posterior oscillations, compared to FREE. In contrast, the use of EXO2 had not any effect on this parameter.

**Conclusions:** The use of EXOUL appeared efficient in limiting both shoulder and postural muscles strain during static OHW. The design of EXOUL could impact the control of postural balance, modifying weights distribution, particularly in the antero-posterior axis.

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## The effect of passive exoskeleton on the spatial distribution of low back muscles activity during simulated work conditions

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**Background:** This study question whether the use of passive exoskeleton affects the level of back muscles' activity, quantified from multiple surface electromyograms (EMGs), during simulated working conditions.

**Methods:** Ten male volunteers performed two tasks with and without a passive exoskeleton: static holding with trunk flexion (45 degrees) for at least 5 minutes and a repetitive lifting task for 10 minutes, where they lifted and lowered (cycle) a box at a fixed cadence. Monopolar surface EMGs from the lumbar erector spinae muscles were sampled bilaterally with 16x4 grid of electrodes (inter-electrode distance: 10 mm). From single-differential EMGs, the Root Mean Square (RMS) values were computed over 1s epochs for the static task while for the dynamic task, RMS values were calculated over the whole lifting and lowering phases separately. RMS maps were obtained by averaging RMS values at 10% increments in time over the duration of task. For each task the degree of activity, averaged across greatest RMS channels in the map, was computed for the maps obtained at beginning, mid and end of task. A 3-way ANOVA was applied to assess the effect of Time, Device and Side on the degree of activity (post-hoc Tukey and significance level of 5%). Borg scale was also applied to evaluate the subjective effort.

**Results:** Our main results revealed lower level of lumbar muscles' activity (~10%) and Borg values with than without exoskeleton throughout static task. For lifting phase, no significant attenuation effect of exoskeleton on muscle activity was observed while for lowering phase, the use of exoskeleton induced a decrease of activity (~10%). Borg values were similar with and without exoskeleton for dynamic task.

**Conclusions:** These results suggest the passive exoskeleton attenuates the lumbar muscles' effort especially for static task, with implications on the prevention of musculoskeletal disorders.

## Efficacy, usability and acceptability of exoskeletons for workers assistance: A Systematic Review of current and potential application

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**Background:** To summarize the state-of-the-art of current literature about the use of exoskeletons for biomechanical overload reduction among worker.

**Methods:** A literature search was conducted in PubMed, Scopus, WebofScience and Embase from 2014 to 2019, using specific keywords: "exoskeleton" OR "wearable device" OR "assistive device" OR "wearable robot" AND "work" OR "worker" OR "working" OR "profession" OR "occupational activity". Inclusion criteria have been defined: observational and experimental studies, both from peer-reviewed journals and conference proceedings, working setting or work purposes, English language. Study quality was assessed by the Newcastle Ottawa Scale. Data was reported according to the PRISMA statement.

**Results:** From the database search, 6461 references (511 from Pubmed, 2728 from Scopus, 2705 from WebofScience, 517 from Embase) were retrieved and screened based on their titles and abstracts; of these, 150 full-text papers were obtained for further assessment. A total of 45 articles, including active and passive exoskeletons study, were finally included in this review. About the body structures assisted by device, spine (13 studies), upper limbs (19 studies), lower limbs (7 studies) or several body districts at the same time (6 studies) were investigated. The device's effectiveness was evaluated by different parameters: muscle effort (with surface electromyography, the Borg scale and/or questionnaires); cardio-metabolic engagement; kinematics parameters; workers' performance, usability and acceptance (mostly with questionnaires). Selected studies show an overall good impact on musculoskeletal effort but some authors suggested the need of improving workers usability and acceptance and the possible assessment of overload redistribution (i.e. from spine to upper limbs), with zero final benefits.

**Conclusions:** Exoskeletons use is increasing in order to reduce biomechanical overload and improve work performance: the available literature shows promising results. Further studies in real working environments are needed in order to better define their advantages for workers, in terms of fatigue reduction and usability while maintaining safe working

## A pilot study evaluating the use of a passive exoskeleton as potential intervention for mitigating low back pain risk factors in farmers

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**Background:** Agricultural tasks frequently present a risk for low back pain. Wearable exoskeleton structures may provide back support during manual tasks and thus prevent low back pain among farmers. The ultimate goal of this study is to determine whether exoskeletons can reduce musculoskeletal demands during farm tasks. This preliminary laboratory-based experiment was conducted to identify farm tasks which could benefit from the exoskeleton and to develop a study design for a subsequent field-based study.

**Methods:** A healthy participant performed three simulated tasks: 1) symmetric lifting and lowering a 4-kg weight from ankle to waist height for 15 repetitions; 2) asymmetric lifting and lowering task at the same weight, height, and frequency; and 3) sustained trunk bending while performing a hand-intensive simulated machinery maintenance task. All tasks were performed both with and without a passive exoskeleton. Surface electromyography was recorded from the erector spinae and normalized to a reference voluntary contraction. Between-worker electromyography variance from a previous study (133 measurements) supplemented pilot data for a priori power calculation for a paired t-test to determine sample size for the field study.

**Results:** The exoskeleton appeared to reduce muscle activity during all simulated tasks, showing a median difference over all tasks of 8.0% (ranging from 2.2% to 14.3%); median reductions with the exoskeleton were 12.3% for task 1, 4.4% for task 2, and 7.5% for task 3. To achieve the statistical power of 0.80 at p-value 0.05, 18 participants would be required.

**Conclusions:** This study investigated potential exoskeleton impacts on muscle activity during simulated tasks involving repetitive lifting and sustained trunk bending, which will be mirrored to common farm tasks. Findings contributed to the study design for the upcoming field study where actual farm tasks will be assessed with a statistically rigorous sample size.

## The Sleeping on the Floor and the Range of Pelvic Tilt in Korean College Students

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Sitting and sleeping on the floor on a daily basis can alter the alignment of pelvis and the adjacent articulations. The purpose of this study were to compare the range of pelvic tilt 1) by testing position; 2) between the male and the female participants; and 3) between the bed and floor sleepers. Eighty-one college students (45 femaleS and 36 maleS) agreed to participate in measuring the maximal anterior and posterior pelvic tilt with the PALM in sitting and standing. The 39 participants who slept in the bed longer than 15 years were classified as the bed sleepers (BS) and the 42 participants who shorter than 5 years were classified as the floor sleepers (FS) in this study. In general, the anterior pelvic tilt was greater ( $p < .01$ ) in standing ( $9.8^{\circ} \pm 5.8^{\circ}$ ) than in sitting ( $0.8^{\circ} \pm 8.3^{\circ}$ ) and the posterior pelvic tilt was less ( $p < .01$ ) in sitting ( $-17.9^{\circ} \pm 6.7^{\circ}$ ) than in standing ( $-6.8^{\circ} \pm 3.8^{\circ}$ ). The anterior pelvic tilt in standing was greater ( $p = .02$ ) in the females ( $11.1^{\circ} \pm 5.7^{\circ}$ ) than in the males ( $8.3^{\circ} \pm 5.5^{\circ}$ ), and in sitting, it was greater ( $p = .02$ ) in the females ( $11.1^{\circ} \pm 5.7^{\circ}$ ) than in the males ( $8.3^{\circ} \pm 5.5^{\circ}$ ). The posterior pelvic tilt in standing was  $-6.6^{\circ} \pm 3.4^{\circ}$  in the males and  $-7.0^{\circ} \pm 4.1^{\circ}$  in the females, and in sitting, the males ( $-19.7^{\circ} \pm 7.1^{\circ}$ ) showed greater ( $p = .03$ ) posterior tilting than the females ( $-16.5^{\circ} \pm 6.1^{\circ}$ ). The anterior pelvic tilt in standing was greater ( $p < .01$ ) in the BS ( $12.3^{\circ} \pm 5.1^{\circ}$ ) than in the FS ( $7.6^{\circ} \pm 5.4^{\circ}$ ) and in sitting it was  $2.5^{\circ} \pm 8.0^{\circ}$  for the BS and  $-0.8^{\circ} \pm 8.4^{\circ}$  for the FS. The posterior pelvic tilt in standing was  $-7.1^{\circ} \pm 3.7^{\circ}$  in the FS and  $-6.5^{\circ} \pm 3.9^{\circ}$  in the BS, and in sitting, it was  $-18.5^{\circ} \pm 7.0^{\circ}$  in the FS and  $-17.3^{\circ} \pm 6.4^{\circ}$  in the BS. The range of pelvic tilting in these college students showed large variability and further studies are needed to understand its relationship with the prevalence of the lower back disorders in their later life.

## Occupational musculoskeletal disorders among forestry workers

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**Aim.** Starting from the sparse literature data regarding information on the topic of professional diseases of workers from forest exploitations that operate under conditions of unfavourable macroclimate, vibration exposure, weight manipulation and vicious postures, we conducted a study on the vertebral column occupational pathology in this category of workers.

**Material and method:** The study was performed during the 2017-2018 period. The analyzed lot includes 144 workers (107 mechanic woodcutters and 37 machine operators) from a territorial unit of Romsilva Romania. Selection/inclusion criteria were: >15 years of experience in the profession, at least 3 risk factors (unfavorable macroclimate, vibration exposure, weight manipulation, awkward postures), spinal symptomatology (lumbar pain, paresthesia and functional impotence at the level of lower limbs). For selection, we used a questionnaire tailored to the goals we set for ourselves. All subjects were subsequently evaluated and investigated in a Clinic of Occupational Diseases for diagnosis and for therapeutic and recovery regimens.

**Results:** Occupational musculoskeletal disorders were reported in 31 workers (21,5%)

**Conclusions:** This article represents the first study in Romania regarding the vertebral column professional pathology in workers with such a specific occupation. The obtained results encourage us to take a step forward to the adoption of measures for the improvement of the technological processes and for the instatement of some legislative measures at national level for the health protection of forestry workers in Romania.

**Keywords:** mechanical woodcutters, machine operators, occupational diseases

## Musculoskeletal disorders stemming from working in the wind industry: Results of an updated scoping review

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**Background:** Working in the surroundings of operating onshore and offshore wind farms poses several work-related risks for the employees', also in regard to physical strains (e.g., lifting/carrying heavy loads, working in twisted upper body positions, overhead work, climbing, or restricted movements). To date, it is unclear, whether occurring musculoskeletal health impacts result from such strains.

**Methods:** An update of an already published scoping review was done, focussing on musculoskeletal disorders. The updated literature search was carried out by one reviewer and comprised a database search in CINAHL, EMBASE, MEDLINE, SCOPUS, and the Web of Science on 19th February 2019, a fast forward search with all included studies, and screening the reference lists of all included articles. Possibly eligible full texts were double checked by a second reviewer. Data extraction was executed by one reviewer and double checked by a second one. Disagreements were solved by discussion or consulting a third reviewer. Study methods were critically appraised. Results were summarized tabularly and descriptively.

**Results:** Overall, three relevant studies were retrieved. According to a systematic review, no literature on the association between working on onshore wind turbines and musculoskeletal disorders was found. A later published cross-sectional study showed a 1-year prevalence of low back pain among personnel of onshore wind farms of 88.74%, but without comparing it with the prevalence of a control group. A qualitative study from the offshore setting documented musculoskeletal short-term and long term health impairments like back or knee problems among workers.

**Conclusions:** Even though working on onshore and offshore wind turbines exposes workers to physical strains that may pose a risk for the musculoskeletal system, the scientific evidence on the topic is sparse. Thus, high-quality observational studies investigating the association between working on onshore and offshore wind turbines and musculoskeletal disorders are warranted.

## The differences in the number of varicose vein patients according to occupational categories and working positions : Pilot study on the disease's correlation to work

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**Background:** This study was performed in a subset of the nationwide pilot study to link national health insurance and employment insurance data. The purpose of this study was to investigate the differences in the number of varicose vein (VV) patients in different occupations and positions and to conduct a prospective cohort study afterward.

**Methods:** We linked National Health insurance and national employment insurance data between 2008 to 2015. In addition, through the Korean Employment Classification of Occupations (KECO), occupations were divided into working styles (production workers and office workers). And classified occupations into groups that were judged to mostly stand, sit, walk during work in both production and office workers. The results were represented as the number of individuals diagnosed with these diseases out of 100,000 individuals in a period of 8 years.

**Results:** The number of patients increased in the 40s according to age and higher in female (3503.7 vs 1584.1). It was higher in production workers than office workers (2717.2 vs 1824.9). Compared to working position in working styles, the highest occurrence occurred in judged to walk mostly during work, followed by stand, sit in production (2906.3 vs 2691.6 vs 1169.0) and office workers (2772.0 vs 2075.4 vs 1707.1). When comparing the working position by gender in working styles, the number of patients was higher in judged to walk mostly during work, followed by stand, sit in males. But, in production women, the occupations that judged to stand were higher than to walk in production women (4726.4 vs 4130.4). In the case of office women, occupations that judged to sit are higher than those that stand (2582.2 vs 2566.7).

**Conclusions:** We categorized the possibility of occupational position during work. In most occupations, there were many VV patients that mainly walk during working. The prospective cohort using national data linkage and operational occupational risk grouping can be introduced in Korea.

## Bus road drivers: implementation of a remote physical exercise program using smartphone: a protocol study

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**Background:** Bus road drivers have poor health due to work, aggravated by lack of sleep, eating habits, and physical inactivity. Objectives: To evaluate the effect of a remote physical exercise program by smartphone to reduce physical inactivity (primary outcome), improve sleep quality and general health (secondary outcome) of road drivers.

**Methods:** Hybrid study design, to randomized controlled trial (RCT), two-arm control (orientation) and intervention (orientation and physical exercise), double blind (participant and evaluator). Two thousand professional bus road drivers male, over 25 years of age will be enrolled and randomized blinded. All participants will receive guidance on general health and the importance of physical exercise. The remote physical exercise programs will have duration between 2 until 20 minutes (warm-up, stretching, resistance) stimulated to be performed at least three times a week (motivation and stimulus strategies such as reminders, motivational videos, weekly goals, rankings and competition among participants). The primary (physical activity level) and secondary outcomes (sleep and general health) will be evaluated by the mixed linear model at baseline and after three, six, nine, twelve months and groups will be analyzed by intention to treat.

**Results:** It is expected that participants in the physical exercise will be good adherence of the physical exercise program through applications, improvement in physical activity levels, with improvement of all indicators.

**Conclusions:** This study will allow to know the profile of bus road drivers workers, the difficulties and benefits of a remote physical exercise program by Smartphone to improve health behaviors.

**Keywords:** Exercise, Occupational, Health Job, Sleep, Satisfaction, Human Engineering, Quality of Life.

## Musculoskeletal disorders due to handheld devices: Changing patterns in the past 12 years

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**Background:** Excessive and improper usage of hand-held devices (HHD) has been associated with a high prevalence of Musculoskeletal disorders (MSD).

**Methods:** 183 HHD users (aged 5-60 years, including 16 younger than 18 years) with MSD were studied to find out the risk factors and clinical features of MSD, outcome of treatment and comparing the patterns of MSD in the past 12 years. The inclusion criteria were a minimum of 25 text messages or emails from the HHD per day, browsing the Internet or playing games for more than 1 hour per day, which was followed by the onset of symptoms. After the diagnosis, all the patients underwent rehabilitation for 2 to 4 weeks using a sequenced protocol.

**Results:** 72.5% were male (median age 23 years). The commonly used HHD were touch screen smartphones (57.4%), followed by iPhones (21.9%) and blackberry (20.8%). Right upper limb musculoskeletal symptoms (72%) were predominant. Individuals who typed with the thumb alone reported symptoms more commonly. Myofascial Pain Syndrome of adductor pollicis, 1st interossei and extensor digitorum communis, and Tendinosis of extensor pollicis longus were recorded in all the individuals. 58% also had Thoracic Outlet Syndrome and 28% Fibromyalgia Syndrome. After rehabilitation there was significant reduction in pain levels ( $p < 0.01$ ). The chief difference in the past decade was relatively increased prevalence in females, decreased age at the onset of symptoms, less musculoskeletal symptoms related to the use of Blackberry (perhaps indicating reduced usage of the device) compared to touch screen smartphones, more symptoms on the right side (indicating usage of device with a single hand) and a higher prevalence of associated Thoracic Outlet Syndrome.

**Conclusions:** HHD that promote typing predominantly with the thumbs should be avoided. The nature of MSD has changed in the past decade due to changes in design of HHD and usage patterns.

## Does screen work result in musculoskeletal symptoms? A systematic review and meta-analysis

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**Background:** It has often been suggested that screen work, such as on a desktop, laptop, notebook or tablet computer, is associated with musculoskeletal symptoms. However, a current overview of the evidence and quantification of the effect size is lacking. We aimed to systematically review the longitudinal association of exposure to screen work with neck and upper extremity symptoms.

**Methods:** We searched electronic databases (PubMed, Embase, Cinahl and Scopus) and screened references for eligibility. Only prospective studies on the association of exposure to screen work and musculoskeletal symptoms were included. Studies were described regarding their extracted data and risk of bias score, and we conducted a meta-analysis.

**Results:** After screening 3,423 unique references, 19 articles (12 studies, n=18,538) were included. Overall, we found an increased occurrence of musculoskeletal symptoms with increasing exposure to screen work (relative risk, RR [95% CI]: 1.11 [1.03 1.19] with an increment in 10 hours/week or 10 clicks or strokes/minute). Findings were inconsistent with weaker effect sizes when screen work was assessed using software recordings (RR: 1.05 [0.91 1.21]) than when using self-reports (RR: 1.14 [1.03 1.19]). Also, we identified studies reporting different musculoskeletal symptoms outcomes (i.e., self-reported neck/shoulder and distal upper extremity symptoms and diagnosed carpal tunnel syndrome). The most recent exposure assessment reported was from 2005, meaning that only studies on desktop computer use, but not on contemporary screen use, such as using a laptop, notebook and/or tablet, were identified.

**Conclusions:** We found an 11% increased risk of musculoskeletal symptoms with screen work, but from heterogeneous studies in terms of musculoskeletal outcome and measurement of exposure to screen work. We currently lack evidence from contemporary screens, such as from laptop, notebook or tablet computers.

## How do we measure adherence? The effect of different measures of exercise adherence during a workplace-based exercise training intervention for office workers

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**Background:** Participant adherence to exercise training protocols is a key to their success. However, no single agreed method exists for defining and measuring adherence to exercise-based interventions. Adherence of 70% is a commonly used threshold for adequate adherence, but is not consistently measured, complicating analyses of the dose-response relationships between training and outcomes.

**Methods:** A workplace-based combined intervention (ergonomic assessment plus resistance training sessions three times per week for 12 weeks) was delivered to 381 office workers across 14 organisations during a cluster-randomised trial in Brisbane, Australia. Data collected from observations once a week (n=381) and diary-based self-reported adherence to all sessions (n=269) were analysed to examine four definitions of adherence and their variations between and within individuals: observed adherence (AO); diary self-reported adherence (AD); regular adherence (AR; participating at least one session per week; observational and diary data); and training volume (ATV; diary-based).. Per-protocol adherence was defined as adhering to  $\geq 70\%$  of sessions.

**Results:** Mean adherence was 59% (SD 26%) for AO, 64% (SD 22%) for AD, and 26% of participants achieved AR of 100%. Per-protocol adherence was achieved by 35% of participants using AO, 49% using AD and 61% using AR ( $\geq 70\%$  weeks). Full (100%) adherence was achieved by 4% of participants using AO and 2% using AD. Mean ATV was 13,362kg (range 482 to 49,533kg; SD 7,820kg). Correlation between all measures was statistically significant ( $p \leq 0.05$ ). Strong ( $r \geq 0.8$ ) correlations were found between attendance-based measures, but correlations between attendance-based adherence and ATV were much weaker ( $r \leq 0.6$ ).

**Conclusions:** Per-protocol adherence varied from 35 – 61% depending on definition which will impact on intervention outcomes. Understanding the relationship between different adherence definitions and primary outcomes is a key to effective measurement and intervention design.

## Longitudinal monitoring of musculoskeletal disorders: the relevance for ergonomic interventions

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**Background:** It remains difficult to include a longitudinal follow-up of musculoskeletal symptoms in ergonomic interventions. The aim of this project was to develop indicators for monitoring and analyzing the evolution of WMSDs in this context.

**Methods:** **Data were collected in two assembly-line plants (crab plants) with 16 female** workers (8 in Newfoundland and 8 in Quebec) with at least 14 years of seniority and having already experienced pain at work. Musculoskeletal health indicators (pain symptoms and functional limitations) were followed through repeated interviews during the season. Pain intensity was recorded using body maps where subjects indicated the level of pain for each body part at the start and end of their shifts during two consecutive years.

**Results:** An important finding obtained from this study is the identification of WMSD indicators and profiles. These indicators concern WMSD chronicity, specificity (profiles of diffuse and/or specific pains), temporal course (through working day, during the season and across the two seasons), anatomical location and number of anatomical locations. Also, results show an increase between the start and the end of the work shift of the number of body regions with pain and average pain intensity. Furthermore, the absence of full recovery between the end of one shift and the start of the next was cumulative over the season. These results demonstrate the importance of considering the temporal course of WMSDs evolution and its variability while conducting ergonomic interventions. The indicators and profiles could be integrated in the conduct of an ergonomic intervention as a method of longitudinal analysis of WMSD to help target priority work situations or to evaluate implemented projects.

**Conclusions:** This study highlights the usefulness to integrate a longitudinal follow up of WMSDs and to develop tools adapted for monitoring the evolution of WMSDs during ergonomic interventions.

## The effects of an electro-mechanical seat suspension to reduce whole body vibration and low back pain in long haul truck drivers: Results from a randomized controlled trial

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**Background:** Through a randomized controlled trial, we tested the hypotheses that truck drivers with low back pain who received a new electro-magnetic active seat will 1) have reduced WBV exposure and 2) report reduction in low back pain (LBP) and related disability compared to drivers who received a new version of their current seat model (passive air suspension seat).

**Methods:** We recruited drivers from five trucking terminals of a US trucking company. Driver eligibility requirements included report of LBP, job with no manual handling requirements, use of a single designated truck, and 1-year company tenure. Eligible drivers were assigned to either Seat A (Intervention) – the BoseRide® electro-magnetic active seat or Seat B (reference) a new version of their current seat (passive air suspension seat) via block (terminal) randomization. Both groups received ergonomic training on seat adjustments. Surveys pre and 3, 6, 12, 18, and 24 months post intervention measured LBP (0-10 scale) and the Oswestry LBP Disability Index. In a subset of drivers, WBV exposures were collected per the ISO 2635-1 WBV standard for 1-2 hours sessions pre and post interventions.

**Results:** Of the 136 eligible drivers, 70 drivers were assigned Seat A and 66 Seat B. WBV exposures significantly decreased post intervention for Seat A ( $p < 0.01$ ) but not for Seat B ( $p = 0.15$ ). LBP scores were significantly lower post intervention in both groups. At 3 months, pain decreased  $-1.3$  [ $-0.8$  -  $-2.1$ ;  $n = 46$ ] for Seat A, and  $-1.5$  [95% CI:  $-0.9$  -  $-2.0$ ;  $n = 41$ ] for Seat B. Similarly, the LBP disability index improved significantly post intervention in both groups.

**Conclusions:** New seat suspension technology reduced WBV exposure. Providing new seats and ergonomic training related to seat adjustments appears to be a way to improve low back pain and function in truck drivers.

## Supporting Return to Work after Total Knee Arthroplasty: Development of an Integrated Care-Intervention including eHealth and Goal Attainment Scaling

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**Background:** Work absence is high among total knee arthroplasty (TKA) patients: about 30% of the patients do not return to work (RTW) after surgery. However, usual care of these patients is often not aimed at participation. With osteoarthritis expecting to become the world's fourth-leading cause of disability in 2020, improved perioperative care enhancing RTW after TKA is crucial. In this study we aimed to develop an integrated care program for the enhancement of RTW after TKA, based on focus groups and a systematic review.

**Methods:** Focus groups with 17 working age TKA patients were conducted to examine the need for guidance on postoperative (work) participation. Additionally, a systematic review was performed to identify and evaluate articles describing intervention components that achieve accelerated RTW after orthopedic surgery<sup>1</sup>.

**Results:** The TKA patients expressed the need for guidance and recommendations regarding resumption of activities. The review showed that perioperative care using targeted referral of orthopedic surgeons to case-managers (e.g. physical therapists or occupational physicians), goal attainment scaling (GAS) and eHealth yielded promising effects on RTW after surgery<sup>1</sup>.

**Conclusions:** Based on our focus groups and a systematic review of the literature, we have developed an integrated care-program consisting of three components: 1) an active referral of the patient by the orthopedic surgeon to a case-manager, 2) a personalized rehabilitation program using GAS, and 3) a patient tailored eHealth intervention including the use of an activity tracker. The latter component will be operationalized using the Dutch eHealth portal IkHerstel ('I Recover') which has shown to be effective in other patient populations<sup>2</sup>. A multicenter RCT will be performed testing the effectiveness of this integrated care program on RTW and patient inclusion starts September 2019.

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## Workplace practices and research evidence in preventing prolonged disability in workers with musculoskeletal disorders

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**Background:** Few efforts have been made until now to document actual workplace practices promoting a sustainable RTW process for employees with work-related musculoskeletal disabilities (WRMDs), and how they are similar or different from what is recommended. The objective of this study was to compare how actual workplace practices reflected (or not) the essential activities recommended by the literature.

**Methods:** First a systematic integrative literature review was performed to identify essential activities for RTW (actions by key actor and by phase). Systematic searches of the literature published between 1986 and 2017 in 11 occupational health databases and web sites were conducted by a specialized librarian. Secondly, a multiple case study was performed in four companies. Each case encompassed all the RTW management procedures and practices of a specific organisation. Multiple sources of data were used: written policies and interviews with different categories of actors. For each case, between 5 and 17 interviews were conducted with key workplace actors (e.g. manager, supervisor, union representative, and worker) and workers, absent from their regular work during more than three months. Finally, for each case and globally, the actual actions performed by a category of key actors in order to accomplish RTW were compared with the recommended actions in the literature.

**Results:** The comparison of the best practices gleaned from the literature with the actual practices of the companies described in the multiple case study brought to light some similarities and discrepancies. The gaps concerned the different ways of carrying out the activities essential to sustainable RTW, the structures and resources made available to facilitate the actions associated with these essential activities, and the lack of formalization of policies.

**Conclusions:** The documentation of these discrepancies through the organisations contributed to a better understanding of practical realities impeding implementation, as well as to the elaboration of some specific and overall recommendations.

## A novel model for health examinations for workers exposed to hand intensive work – a process evaluation of the ergonomist's perspective

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**Background:** The Swedish Work Environment Authority is presently revising the current provision and is considering introducing health examinations, HEs, for workers exposed to hand intensive work (HIW). A participatory model for HEs for workers exposed to HIW, including screening, risk assessments, HE, feedback to employer and action for risk reduction has been proposed.

The purpose of this study is to explore how ergonomists experience the HE-HIW model and to identify different determinants as feasibility, value and barriers that facilitate or hamper the use of the model.

**Method:** In cooperation with their contracted occupational health services, 10 companies from different sectors with HIW (e.g. assembly, cleaning, laboratory technicians), participated. The model was presented for first line manager, health and safety representative and an OHS ergonomist during a workshop. The steps in the model were carried out during 6 months. The occupational ergonomists were interviewed individually before, during and after the process. Qualitative content analysis is used. Findings are based on 2/10 interviewees.

**Results:** The experiences of the model indicate that it worked well, however in some cases minor adjustments were done to enhance fitting to the client organization. There are examples that using the model was perceived as fun, interesting, meaningful. The whole model is described as having great value on one hand and on the other hand less value if it is a small well functioning work place. The interviewees describe good communication, well-functioning collaboration at an equal level between the company and the ergonomist creating a smooth process, great meaningfulness and values of the model's systematic structure and steps that makes it possible to repeat. Insufficient IT-support of the ergonomist was described as a hampering factor.

**Conclusions:** The two interviewees describe a variation of examples of the models feasibility, values and hampering factors when using the HE-HIW model.

## A model for risk assessment and health examinations for workers exposed to hand intensive work. -The companies' experiences.

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**Background:** The purpose of the study was to explore how companies experienced various components in a participatory model focusing on screening, risk assessment, health examination and feedback.

**Methods:** Ten companies from sectors with exposure to hand intensive work (e.g. assembly, cleaning, laboratory technicians) participated. Each company was represented by a first line manager, a health and safety representative and the company's contracted ergonomist. The process started with an introductory workshop where the participating companies planned their individual processes. The company representatives did screening for presence of hand intensive exposures at the workplace without the involvement of the ergonomist, who in the next step, performed risk assessments of selected hand intensive work-tasks in the company, and conducted health examinations of exposed employees. Thereafter, the ergonomist reported the findings back to the companies. To evaluate the experiences, interviews with the company's representatives were performed at two occasions during a six months period. Transcribed interviews were analysed using content analysis.

**Results:** Several employers described an uncertainty regarding the screening phase, expressing a lack of guidance. The risk assessment phase was perceived as very rewarding. Emphasis was put on the value of risk assessments being performed by an external expert with competence in ergonomics, something that according to the company led to a comprehensive assessment identifying previously unidentified risks. Most often, the health examination phase was performed at the premises of the company, which was considered time efficient and convenient. Regarding the feedback phase, the companies valued to get a written report followed by an oral presentation from the ergonomists highly. An overarching value of the coherent model among both company representatives and the employees was increased awareness of risks related to hand intensive work.

**Conclusions:** In main, the model was perceived as valuable increasing risk awareness. However, the evaluation identified that clearer guidance is needed in some of the phases.

## When musculoskeletal pain limits work capacity – results from the SeniorWorkingLife study among 11,791 senior workers

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**Background:** Due to demographic changes across Europe there are strong political interests in maintaining the labour force by prolonging working life, i.e. increasing retirement age. Health problems, e.g. musculoskeletal pain, may be a barrier to continue working in this age group. The SeniorWorkingLife (Danish: SeniorArbejdsLiv) project investigates push and stay mechanisms for labour market participation – now and in the future - among older workers ( $\geq 50$  years).

**Methods:** In July 2018, 30,000 Danes age 50 or older (18,000 employed, 7,000 unemployed, 3,000 voluntary early retirements, 2,000 disability pensions) were invited to participate, of which 15,905 (53.0%) replied to the entire questionnaire and 18,022 (60.1%) replied at least in part. The present analyses are based on responses about musculoskeletal pain from 11,791 employed individuals, who were divided into four groups according to physical work demands. Statistical weights were used to make data representative. The study is registered in ClinicalTrials.org (NCT03634410).

**Results:** Daily or weekly musculoskeletal pain was common and experienced by 45% (95% CI 44-46%,  $n=5725$ ) of those with seated work and 70% (65-74%,  $n=759$ ) of those with the most strenuous physical work. Among those with pain, work limitation due to pain was much more pronounced among those with the most strenuous physical work (47%) compared with those with seated work (11%). Stratifying responses for lifestyle did not change the overall picture (healthy vs unhealthy: seated 10% vs 14% and strenuous physical work 46% vs 48%).

**Conclusions:** Musculoskeletal pain is not only more common, it also limits work to a higher extent, among those with strenuous physical work than those with seated work. These results highlight the need for solutions at the workplace – e.g. better organization of work, use of assistive devices etc – to allow people with pain to perform their work without being limited due to the pain condition.

## Synthesis of predictor factors for early departures of ageing workers by a systematic literature review

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### Abstract

**Background:** Early work departures (voluntary, early retirement or disability pension) heavily affects the economy of most countries and therefore identifying predictor factors could allow implementation of preventing strategies.

**Methods:** By combining a literature review using PRISMA protocol into three databases and a snowball search, after applying inclusion and exclusion criteria, we finally selected 36 relevant studies.

**Results:** The selected factors were grouped into three axes: early retirement, disability pension and working beyond retirement. We considered for each axe, social, work and physical/mental parameters.  
Early retirement positive predictor factors are low income, feeling pushed out by their employer, low control work or recognition and declined mental and physical health. Favourable to disability pension, we identified low education, level of influence at work or recognition from management, evening work, low job control, high demands, physical workload and persistent pains.  
Working beyond retirement is positively influenced by financial high levels, with entrepreneurial attitudes, feeling full of life, high work time control, being physically active, good health and low physical load.  
High degree of work control, autonomy and feeling appreciated at work have a negative impact on early retirement. The disability pension is negatively influenced by workplace interventions. On the other hand physical workload or the presence of chronic diseases do not encourage to work after retirement.

**Conclusions:** The systematic literature analysis allowed us to identify the predictor factors of early work departures of ageing people. This is the first step for an observational study for our ageing working population in Luxemburg, which could then be extended to other countries.

Key words: early retirement, disability pension, working beyond retirement, ageing worker, self-assessed health.

## Musculoskeletal disorders as predictors of health-related job loss amongst older workers: Results from the HEAF Study

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**Background:** Demographic changes have prompted governments to encourage workers to work to older ages. We investigated the main determinants of health-related job loss over two years of follow-up in the HEAF study, evaluating the contribution of MSDs to job loss at older ages.

**Methods:** The HEAF study recruited >8000 people aged 50-64 years through primary care registers in UK 2013-14. Anonymised patient data for HEAF participants was available through the Clinical Practice Research datalink. HEAF participants told us about their work at baseline and were sent annual questionnaires which enquired whether or not they had stopped work mainly or partly because of their health. We explored which health conditions predicted a first exit from employment for health reasons between baseline and 2-year follow-up using Cox's proportional hazards modelling. People who remained in work or left their job for reasons other than health were censored in the survival analysis.

**Results:** 4888 people had information at baseline and at least one of the two follow-up surveys, were successfully linked with the CPRD records and were ever in paid employment >20 hours/week. Health-related job loss was reported by 277 people, and 945 left work not for health reasons, leaving 3666 in work throughout. Amongst men, sleep disorders, hypertension, cardiac conditions, common mental health conditions (HR 2.89, 95% CI 1.22-6.79), inflammatory arthritis (HR 2.89, 95% CI 1.5-9.69) and connective tissue disorders (HR 4.52, 95% CI 1.05-19.29) predicted health-related job loss. In women, the health predictors were: sleep disorders (HR 1.77, 95% CI 1.08-2.88); lower limb osteoarthritis (HR 2.32, 95% CI 1.40-3.87) and inflammatory arthritis (HR 3.26, 95% CI 1.39-3.87).

**Discussion:** MSDs contribute importantly to health-related job loss at older ages, particularly among women. To effectively retain our older workers, we may need different strategies for men and women and for jobs that are more commonly performed by one or other gender.

## Informal caring responsibilities and poorer health amongst working 50-64 year olds: results from the Health and Employment After Fifty (HEAF) Study

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**Background:** With increased UK pensionable age, people are now expected to work to older ages, but may also have informal caring responsibilities for family members which constrain their capacity to work and could affect their health. To explore this we investigated the relationship between caring duties and health outcomes, in the Health and Employment After Fifty (HEAF) study.

**Methods:** The HEAF study is a cohort of 8,134 men and women aged 50-64 years recruited from 24 English general practices. Socio-demographic, lifestyle and health characteristics were elicited by postal questionnaire, along with hours/week giving personal care to someone in the home/family. Objective clinical information about diagnoses and medications was retrieved from health records. Work-related and health risk factors for caring  $\geq 20$  hours/week (vs no hours) were explored using logistic regression with adjustment for age and social class.

**Results:** 644 (17.4%) men and 1,153 (26.0%) women had caring responsibilities; of these, 93 (14%) and 199 (17%) reported caring for  $\geq 20$  hours/week respectively. Carers were less likely to be working, with those combining work and caring (41 men, 90 women) more likely to be part-time/working shifts. Amongst working men, self-reported musculoskeletal pain, poor/fair self-rated health, depression and sleep problems were more prevalent but not significantly ( $p > 0.05$ ) associated with caring. Among working women, caring for  $\geq 20$  hours/week was associated ( $p < 0.05$ ) with a doubling of the prevalence of these same health outcomes and also with increased prevalence of common mental health problems or prescription for mood disorder (OR=1.95, 95%CI 1.22-3.12) and regional pain (OR=1.77, 95%CI 1.09-2.87) in the year prior to HEAF baseline.

**Conclusions:** The requirement to be a carer is common in the HEAF cohort. Those both working and caring have poorer health than non-caring workers, particularly women. There is a clear need for better support for older workers with informal caring responsibilities.

## Safer and healthier work at any age

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**Objectives:** During 2013-16, EU-OSHA carried out a series of studies on ageing, work, and OSH. The objectives were, among others, to assess the prerequisites for an OSH system to meet the challenges of an ageing workforce, provide state-of-the-art information to support policy development.

**Methods:** A series of complementary studies were carried out to:

- Review and analyse OSH policies in relation to ageing, sustainable work, employability and return-to-work
- Describe and analyse examples of good OSH and age management practices
- Review literature on ageing, health and work, including gender aspects

**Results:** Some findings in relation to MSDs:

The prevalence of MSDs increases with age, probably as part of the normal ageing process; the increased prevalence of MSDs with age is most pronounced in workers involved in physically demanding jobs, irrespective of age.

The implications of increased cumulative exposure to MSD hazards resulting from longer working lives present a challenge for OSH and the sustainability of work.

More needs to be done to support individuals with chronic MSDs in staying at work or returning to work.

MSDs can have a major impact on the sustainability of women's work. More attention needs to be given to risk prevention in jobs predominantly carried out by women and the double workload of family carers.

Based on good practice cases reviewed it appears that in the context of an ageing workforce, OSH measures in workplaces aiming at retaining older workers often focus on MSDs prevention, as it appears to be a major challenge for prolonging the working lives.

Often simple measures can facilitate continued working, and the same measures may benefit the whole workforce.

**Conclusions:** A life-course approach and comprehensive measures, including OSH, WHP and HR, are key for ensuring sustainable work. MSDs prevention has a major importance in this context.

## Obesity and the ability to work to older ages: insights from the Health and Employment After Fifty (HEAF) study

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**Background:** The combination of an ageing workforce and an epidemic of obesity could carry important health and economic implications. Within a cohort of older workers we explored the relationship between body mass index (BMI) and health-related job loss (HRJL) over 2 years of follow-up.

**Methods:** The Health and Employment After Fifty (HEAF) study is a cohort of 8,134 adults aged 50-64 years, recruited from 24 English general practices. Participants completed annual questionnaires since baseline providing information about their work, health, and finances, and consented to us obtaining their coded health information from the Clinical Practice Research Datalink (CPRD).

Multiple-record Cox's proportional hazards models were used to examine the association between BMI and time to first HRJL by 2-year follow-up, separately by gender. Results were expressed as hazard ratios (HRs) and confidence intervals (95% CIs) and pertain to 4,724 people ever in work during 2 year follow-up, who consented to data linkage with CPRD, reported height and weight, and were not underweight (BMI < 18.5).

**Results:** A total of 101 men and 152 women experienced a HRJL. Age-adjusted risk of HRJL was 2.5 times greater among morbidly obese women (2.6% of the total, BMI > 40 kg/m<sup>2</sup>) than normal weight women (95% CI 1.2, 5.3). This association was robust to adjustment for socio-demographic, lifestyle factors and health conditions such as musculoskeletal disorders and common mental health disorders. Work factors such as job dissatisfaction and being unable to cope with physical or mental work demand, attenuated this effect. There was no relationship between BMI and HRJL among men.

**Conclusions:** Morbid obesity in women is associated with increased risk of leaving work for a health-related reason. Strategies that promote maintenance of a healthy body weight may help to retain older workers in the workforce.

## The contribution of excess body mass to the risk of all-cause and cause-specific disability retirement: A systematic review and meta-analysis

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**Objective:** We aimed to determine the effects of excess body mass on all-cause and cause-specific disability retirement.

**Methods:** Literature searches were conducted in PubMed, Embase and Web of Science from their inception through November 2018. Twenty-five studies consisting of 2,160,858 individuals qualified for a meta-analysis. We used a random-effects meta-analysis, assessed heterogeneity and publication bias, and performed sensitivity analyses.

**Results:** Individuals with overweight or obesity more commonly granted all-cause and cause-specific disability retirement than normal weight individuals. Individuals with obesity were at 43% (Hazard ratio [HR]=1.43, 95% CI 1.29-1.59, N=241,084 participants) higher rate of all-cause disability retirement, 65% (HR=1.65, CI 1.44-1.90, N=1,605,144) higher rate of disability retirement due to musculoskeletal diseases, 29% (HR=1.29, CI 1.04-1.61, N=1,554,925) higher rate of disability retirement due to mental disorders and at 180% (HR=2.80, 95% CI 1.85-4.24, N=1,519,770) higher rate of disability retirement due to cardiovascular diseases compared with normal weight individuals. The corresponding percentages for overweight were 14%, 27%, 0% and 73%. Overweight and obesity increased the risk of all-cause disability retirement in both men and women. Moreover, the associations were not due to bias or confounding.

**Conclusions:** Obesity markedly increases the risk of disability retirement, particularly disability retirement due to musculoskeletal and cardiovascular diseases. Since the prevalence of obesity is increasing globally, disease burden associated with excess body mass and disability retirement consequently are projected to increase.

## Do Pre-Operative Patient Expectations Regarding Work Ability Become True 6 Months After Total Knee Arthroplasty (TKA)? A Multicenter Prospective Cohort Study

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**Background:** Worldwide, the incidence of Total Knee Arthroplasty (TKA) is increasing in the working population. Only 71–83% of these patients with a TKA return to work after 3–6 months. Little is known whether pre-operative patient expectations regarding the ability to perform work-related activities are in line with the actual post-operative ability. Therefore, the research question is: 'Are patient expectations regarding ability to perform work-related activities in line with the actual ability 6 months after TKA?'

**Methods:** A multi-center prospective cohort study was performed among 236 working TKA patients in the Netherlands. Pre- and post-operative, the reliable and valid 13-items Work Osteoarthritis or joint-Replacement Questionnaire (WORQ) was used to assess expected and actual ability to perform work-related activities at 6 months after surgery, like kneeling and lifting. The WORQ scores range from 0 ('extreme difficulties') to 100 ('no difficulties at all'). Differences pre and post TKA surgery were tested using Mann-Whitney test.

**Results:** The response rate was 85% (n=201). The median age of working TKA patients was 59 years (52% female). Pre-operative, the expected WORQ score for 6 months post-operative was 75 [InterQuartile Range (IQR) 60-85]. Six months post-operative, the WORQ score was 67 [IQR 54-81]. This difference was statistically significant (p=0.003).

**Conclusions:** Pre-operative patient expectations regarding ability to perform work-related activities were higher than the actual ability 6 months after TKA. Variation in preoperative and 6 months postoperative ability was large between patients. Therefore, clinicians should incorporate these expectations into their preoperative advice regarding work ability after TKA.

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## Prevalence and associated factors of musculoskeletal pain in artisanal fishermen in southern Brazil

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**Objective:** to identify the prevalence of musculoskeletal pain in artisanal fishermen and associated factors.

**Method:** This is a descriptive study, with a quantitative approach. It was developed with 250 artisanal fishermen in southern Brazil. For the data collection, a semi-structured questionnaire was used. In the bivariate analysis the t-student test for independent samples was applied. In the comparison of proportions, Pearson's chi-square or Fisher's exact tests were used. For control of confounding factors, the Poisson Regression analysis was used. The level of significance was set at 5% ( $p \leq 0.05$ ).

**Results:** Of the total sample ( $n = 250$ ), 216 fishermen (86.4%) reported to feel work-related discomfort. The most frequent pain sites are the lumbar region (65.2%), the dorsal region (24.6%) and the arms (14.8%). In the bivariate analysis there was a significant association of the report of work-related musculoskeletal pain with lower family income and robust time variable versus hours of work performance. Through the Poisson regression analysis, it was found that fishermen with a minimum wage income have an increase in the prevalence of body pain in 17% when compared to those with higher salary. In addition, female fishermen have an 11% increase in the likelihood of experiencing work-related bodily discomfort.

**Discussion:** Studies confirm the findings of this study, proving that the lower and upper limbs are the main sites affected by musculoskeletal pain at work, and are mainly affected by low-income female fishermen (1,2).

**Conclusions:** It was verified the need to carry out risk intervention activities adapted to the reality of artisanal fishermen, aiming at a better understanding of the musculoskeletal pain at work to which they are exposed.

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## Impact of first-line healthcare providers on injured workers' trajectories of care: a four jurisdiction critical analysis

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**Background:** First-line healthcare providers (HCPs) are the primary access point to injured workers' benefits, and their roles are expanding at a time when workers' compensation (WC) resources are constrained. Given the critical influence of HCPs on workers' care trajectories, our research seeks to critically compare first-line providers' impact on care for workers with musculoskeletal injuries, in Ontario and Quebec (Canada), Washington State (United States) and Victoria (Australia).

**Methods:** A critical interpretive synthesis of peer-reviewed scientific literature was first conducted. The search yielded 59 relevant publications. Concepts and themes in these papers were compared and interpreted using tables and conceptual maps. This analysis was supplemented by 34 qualitative interviews with key informants across the four jurisdictions. Central aspects of these interviews were then mapped to the synthesis findings to provide a rich portrait of first-line providers' impact on care.

**Results:** Of the 59 papers, 91.5% were published after 2000 and more than 1/3 in the last five years. Three themes emerged from the synthesis: 1) how policies governing first-line HCPs modulate workers' access to care, 2) how these providers' roles, practices and training shape disability management, and 3) how quality of care and disability outcomes are evaluated. Publications lacked a focus on how HCPs can shape workers' trajectories and quality of care. Mapped analysis of interviews showed that HCPs' care decisions are highly determined by their jurisdiction's WC policies and do not always correspond to their preferred clinical pathway.

**Conclusions:** While a growing research literature addresses the roles of first-line providers for injured workers, it is limited by a focus on providers' practices and it does not sufficiently question how these can influence the quality and trajectories of care for workers. A clearer understanding of how complex factors influence the way healthcare is provided will help orient future policy changes.

## Objective predictors of physical work ability in aged manual workers

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**Introduction:** Aging is associated with a reduction in physical performance that may challenge aged manual workers' physical work ability. We aimed to explore which physical performance outcomes would be associated with self-reported physical work ability among workers in their last two decades of working life.

**Methods:** Male manual workers aged 50-59 (n = 44) and 60+ years (n = 52) were recruited. Physical performance outcomes included maximal handgrip strength (HGS), fat percent, forced expiratory volume after 1 s (FEV1) and spinal flexibility (lower values express greater flexibility). Physical work ability was assessed by a single-item question where the workers rated their physical work ability on a 5-point scale: poor, fair, good, very good or excellent. Responses were dichotomized into either 1 (good, very good, excellent) or 0 (poor, fair) and multiple logistic regression analysis with backwards elimination and a stopping value of  $\alpha = 0.15$  was used to investigate the association between physical performances (HGS, fat percent, FEV1 and spinal flexibility) and physical work ability using z-scores of the outcomes.

**Results:** In the 50-59 yr group, the multiple logistic regression model explained 7.5% of the variance in physical work ability and included only spinal flexibility (OR 0.6, 95% CI 0.3 to 1.2). Contrary, the model in the 60+ yr group explained 39.7% of the variance in physical work ability and included HGS (OR 2.4, 95% CI 1.1 to 5.1) and FEV1 (OR 2.9, 95% CI 1.3 to 6.6).

**Conclusions:** Muscle strength and lung function were related to greater physical work ability among workers in their sixth but not fifth decade of life. This suggests an increased reliance on musculoskeletal and pulmonary capacity among the oldest of workers, possibly explained by the aging process.

## Musculoskeletal diseases mediate the association of work ability and work life satisfaction with intention to retire

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**Background:** Longevity in the population has triggered a need for prolonging working careers. We investigated whether work ability and work life satisfaction predict intention to retire and if musculoskeletal diseases (MSD) are probable mediators of this association.

**Methods:** Men and women (51 to 67 years) participated in a survey among Finnish postal service workers (N=1466). Mixture modelling was used to detect the developmental pathways of work life satisfaction (WLS) by using self-reported retrospective answers on four lifetime points. Generalised linear model was used to estimate the relative risk for the association between the work ability score and WLS and intention to retire and generalized structural equation modelling was used to perform the MSD mediation analysis.

**Results:** In all 41% of the respondents had intentions to retire early, before the statutory pension age. Four distinct pathways of WLS were identified: high (33%), moderate (35%), decreasing (23%) and low (9%). About 40% had excellent work ability followed by moderate (34%) and poor (26%), 33% of the respondents had a MSD. Compared to the subjects with good/excellent work ability, those with poor had a 1.6 fold probability to retire early. The adjustment with MSD contributed for 19% attenuation of these associations. Likewise, compared to those with a high level of WLS, those with a decreasing WLS had a 1.4 fold probability to retire early. The adjustment with MSD contributed for 38% attenuation of these associations. MSD mediated 18% of the effect in the association between work ability and intention to retire and 12% in the association between WLS and intention to retire.

**Conclusions:** Workers with poor work ability and poor work life satisfaction were more likely to retire early compared to those with a good work ability and a satisfied work life. These differences were largely explained by the presence of MSD among those with poor work ability and poor WLS.

## Measurement properties of instruments assessing permanent functional impairment of the spine: blending evidence and stakeholder perspectives

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**Background:** Permanent functional impairment (PFI) of the spine is a rating system widely used to establish levels of financial compensation. However, the measurement properties of PFI instruments are not yet established. The purpose of this study was to conduct a systematic review of measurement properties of instruments assessing spinal PFI and to determine the clinical utility of instruments.

**Methods:** Two reviewers independently screened sources and extracted data on measurement types, study design, and the degree of agreement. The COSMIN checklist was used to evaluate the methodological quality of studies. Clinical utility was determined by a focus group with clinicians and policymakers; data were transcribed and analyzed using a thematic approach.

**Results:** Thirty-nine studies were included in the review (reliability=8, validity=32, and responsiveness=2). The 'permanent' aspect of the PFI construct was not identified and a measure of 'functional impairment' was considered as providing the best available evidence. Considerable heterogeneity precluded meta-analysis. The reliability was at an acceptable level but presented 'inadequate' (n=5) or 'doubtful' (n=3) methodological quality. The validity studies were separated into two sub-groups, one with Range of Motion (RoM) measures and the second with instruments other than for RoM assessment. Both sub-groups presented an unacceptable level for validity and presented "doubtful" to "adequate" methodological quality (n=24). Responsiveness studies were not sensitive to changes over time and their methodological quality were 'inadequate'. The focus group themes demonstrated that both clinicians and policymakers were dissatisfied with the existing state of the literature on PFI.

**Conclusions:** Substantial gaps in the literature were identified, particularly a dearth of longitudinal studies tracking the stability of functional impairment and whether PFI instruments can predict this stability. Future studies should consider better reporting of gold-standard instruments to assess PFI of the spine, provide clear measures of PFI, and follow COSMIN recommendations with regards to methodological quality.

## A trajectory of good workability: An analysis of workplace predictors over 6 years

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**Background:** Workability has been identified as important predictor of sustainable employment. With increasing pressure to stay at work for longer, maintenance of good workability is an important contributor to extended workforce participation. This study aims to identify workplace predictors of workability trajectories over a six-year period.

**Methods:** Data was collected at four time points (2003-2009), from Finnish food industry workers (N = 866). Work ability scores were collected at each time point. Other baseline measures included musculoskeletal pain in four anatomical sites. In addition, work related physical strain, repetitive movements, awkward postures and mental strain were also measured. Trajectories of work ability during six-year of follow-up were modelled using growth mixture modelling (GMM). Logistic regression analyses were used to identify the association of good work ability trajectories with multisite pain and other work-related factors.

**Results:** Three trajectories of work ability score were identified good (90.7%), decreasing (4.7%) and increasing (4.6%). Most workers reported good to very good work ability throughout the follow-up, with only a few (≈10%) reporting either decreasing or increasing work ability. Results from multivariate analysis showed that multisite pain significantly reduced the likelihood of having good workability (3 sites: OR 0.37, 95% CI 0.15–0.88; 4 sites: OR 0.30, 95% CI 0.13–0.70). Although work related factors were associated with the good work ability trajectory in the crude model, this significance was not retained in the multivariate model.

**Conclusions:** Workplace prevention strategies are required to identify factors associated with the development of multisite pain and then the subsequent development of risk mitigation strategies. Prevention of multisite pain is required to facilitate the maintenance of good workability and enable workers to extend their working lives.

## Is it possible to estimate health economics from work ability score in musculoskeletal in workers with musculoskeletal disorders?

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**Aim:** Does the work ability score correlate to loss of productivity for workers with musculoskeletal disorders?

**Methods:** 140 person from a cohort of 32-34 years old random population sample answered a mobile phone app with WPAI-GH and work ability index in addition to questions about income. Work ability score (0-10) is a single question in the work ability index questionnaire that have shown good agreement with the work ability index. WPAI-GH (Work Productivity and Activity Impairment questionnaire General Health) is probably the most used instrument for assessing economic consequence of ill health. It has been translated to more than 100 languages. We examined the relation between WPAI derived economic loss and work ability score. Analysis was done with SAS 9.4.

**Results:** The mean work ability score for total sample was 7.1 and for those who had musculoskeletal disorders it was 6.8 (NS). The mean percent overall work impairment due to health was for those with musculoskeletal disorders 35% and for those without 29%. The worktime loss due to health was and corresponded to a mean of 250 € per person and month with musculoskeletal disorders. The regression between overall work impairment and work ability score was for the total sample:  $\text{work impairment} = 0.92 - 0.09 \times \text{work ability score}$  ( $P < 0.001$ ,  $R^2 = 0.42$ ).

**Discussion:** There was a fair relationship between estimates of work impairment and work ability score. When estimating cost due to work time loss and health effect on productivity the work ability score may give some indication on health economic effects but estimates have some uncertainties.

## Muscle strain and postures during conventional and robotic-assisted laparoscopic surgery: A paired cross-sectional study

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**Background:** Little is known about the physical demands of surgeons performing conventional laparoscopy (LAP) and robotic-assisted laparoscopic surgery (RALS). The purpose was to compare muscular workload, work posture, and perceived physical exertion (RPE) of surgeons during the performance of these surgical modalities in abdominal bowel surgery.

**Methods:** Thirteen surgeons with experience in advanced LAP and RALS performed one of each modality. Surface electromyography (EMG) was recorded from forearm, shoulder, and neck muscles, and expressed relative to EMG maximum (%EMGmax). The static, median, and peak level of muscle activity were calculated, and an Exposure Variation Analysis (EVA) was conducted. Postural observations were carried out every ten minutes, and RPE before and after each surgery was recorded. To test for differences between LAP and RALS, we conducted a paired t-test regarding muscle activity and RPE, and a Pearson chi-square regarding postural observation.

**Results:** Overall, independent of surgical modality, the static level was roughly 3%EMGmax, the median level about 6-8%EMGmax, and the peak level between 10-15%EMGmax. Differences were present for forearm muscle activity, with higher static, median and peak levels when performing LAP compared with RALS. Left shoulder displayed higher peak muscle activity in RALS compared with LAP. The EVA analysis demonstrated a sustained static muscle activity pattern for the forearm muscles in RALS, and in the shoulder muscles in LAP. The neck muscles showed an equally sustained muscle activity pattern. Postural observations disclosed a significantly higher demand for change in work posture in LAP compared with RALS. After surgery RPE showed no difference between LAP and RALS.

**Conclusions:** Independent of surgical modality, minimally invasive surgery is physically demanding. Both modalities offer long-term static postures but with more recommendations for LAP to change work posture immediately. By and large LAP induces the highest muscular activities, while RALS requires more sustained low level activity.

## Calcium fluxes in work-related muscle disorders: implications from a rat model

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**Background:** Ca<sup>2+</sup> regulatory excitation-contraction coupling properties are key topics of interest in the development of work-related muscle myalgia, and may constitute an underlying cause of muscle pain and loss of force generating capacity. A well-established rat model of high repetition high force work (HRHF) was used to investigate if such exposure leads to an increase in cytosolic Ca<sup>2+</sup> concentration, ([Ca<sup>2+</sup>]<sub>i</sub>), changes in sarcoplasmic reticulum (SR) vesicle Ca<sup>2+</sup> uptake and release rates, and increased discomfort and muscle strength declines.

**Methods:** Seven female, Sprague-Dawley rats performed an operant high repetition high force task for 6 weeks before collection of supraspinatus, trapezius, extensor digitorum and flexor digitorum muscles, bilaterally. The same muscles were collected from 6 control animals, bilaterally. Muscles were assayed for Ca<sup>2+</sup> release and uptake rates in sarcoplasmic reticulum (SR) vesicles; and for pCalmodulin kinase (pCam; indicative of [Ca<sup>2+</sup>]<sub>i</sub>), ryanodine receptor 1 (RyR, related to SR Ca<sup>2+</sup> release), SERCA1 (a Ca<sup>2+</sup> ATPase that regulates SR Ca<sup>2+</sup> uptake), and Calsequestrin-1 (Casq1, buffers Ca<sup>2+</sup> inside SR) protein expression using Western blot assay. Voluntary motor behaviors related to task performance were assayed in HRHF task rats, as were sensorimotor behaviors suggestive or indicative of discomfort in both groups.

**Results:** Six weeks exposure to HRHF increased indicators of fatigue, pain behaviors and [Ca<sup>2+</sup>]<sub>i</sub>, the latter indicated by increased pCam, as well as the Ca<sup>2+</sup> handling proteins RyR1 and Casq1 accompanied by an increased SR Ca<sup>2+</sup> uptake rate. This demonstrated a work-related altered myocellular Ca<sup>2+</sup> regulation, SR Ca<sup>2+</sup> handling, and SR protein expression.

**Conclusions:** These disturbances may mirror intracellular changes in early stages of human work-related myalgic muscle. Increased uptake of Ca<sup>2+</sup> into the SR may reflect an early adaptation to avoid a sustained detrimental increase in [Ca<sup>2+</sup>]<sub>i</sub>, similar to previous findings of deteriorated Ca<sup>2+</sup> regulation and impaired function in fatigued human muscle.

## Quantification of stroke-induced proprioceptive and motor deficits to facilitate rehabilitation

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**Background:** Physical rehabilitation after stroke is critical to promote recovery, improve patient's independence, and reduce cost of outpatient costs. However, traditional and current therapy approaches have ignored intrinsic hemispheric asymmetries and rarely differentiate the specific sensory and/or motor deficits after stroke. Their precise identification is necessary to adapt rehabilitation procedures facilitating recovery and return to work. The purpose of this study was to assess the functioning of the sensory and motor components of each upper limb/hemisphere system of stroke patients in order to determine the primary source of impairment.

**Methods:** Two types of experiments involving the same muscles in the same posture were conducted to quantify stroke-induced proprioceptive and motor deficits: (I) proprioceptive asymmetry between the left and right sensorimotor systems in the reproduction of a reference upper limb joint imposed passively or from movement illusions induced by muscle tendon vibration, (II) motor asymmetry in the sense of effort and force control of the left and right motor systems when reproducing in isometric conditions reference exertions or tracking a random moving target by elbow extension.

**Results:** 1) Sensory and motor matching errors different significantly between mild and moderate stroke patients, (2) Alteration of position and movement sense asymmetry between right and left systems are significant, (3) Motor deficits appear to affect the limb ipsilateral to the moderate stroke.

**Conclusions:** The differentiation of stroke induced sensory and motor deficits is possible. The concomitant alteration of sensory and motor systems may be related to stroke severity. Asymmetry reduction or exacerbation, which does not mean greater errors, must be carefully analyzed when comparing to intrinsic asymmetries in healthy controls.

## Favorable changes in physical working conditions and risk of sickness absence: Analyzing a prospective cohort study as a pseudo-experiment

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**Objective:** To determine whether favorable changes in physical workload and environmental exposures reduce the number of sickness absence (SA) days using observational cohort data as a pseudo-experiment.

**Methods:** The data from the Finnish Helsinki Health Study included three cohorts of employees of the City of Helsinki (2000/2002-2007 [N=2927], 2007-2012 [N=1686] and 2012-2017 [N=1118], altogether 5731 observations). First, we estimated the propensity score of favorable changes (reduction in exposures) in physical workload and environmental factors during each 5-year follow-up period on the baseline survey characteristics using logistic regression. Second, we created and stabilized inverse probability of treatment weights for each participant using the propensity scores. Lastly, we used generalized linear model and fitted negative binomial regression models for over-dispersed count data to estimate whether the favorable changes decrease the risk of short- or intermediate-term ( $\leq 14$  days) and long-term ( $> 14$  days) SA using employer's register data.

**Results:** During a 5-year follow-up, 11% of the participants had favorable changes in physical workload factors, 13% in environmental factors, and 8% in both factors. The incidence of both short- or intermediate-term and long-term SA were lower in employees with favorable workplace changes compared to those without such changes. The reductions were largest for long-term SA. Reporting favorable changes in both workload and environmental factors reduced the number of SA days by 41% within one year after the changes and by 32% within two years after the changes.

**Conclusions:** This pseudo-experimental study suggests that improving physical working conditions is effective in the prevention of SA.

## QuickDecks: A new tool for sharing best evidence in back pain

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**Background:** It is important to create different summary products in addition to scientific publications to support claims about interventions based on evidence from Cochrane Reviews. The Cochrane Back and Neck Group (CBRG) created a product that would decrease the burden and yet encourage the use of evidence from Cochrane reviews for busy researchers and clinicians. The aim of this project was to create a product to share findings from Cochrane reviews to provide a quick snapshot of the evidence in an accessible format.

**Methods:** QuickDecks are created for each Back and Neck focused intervention systematic review and classified into 8 different intervention themes. They consist of three summary slides with a standard format presenting objectives, methods, results and conclusions of the review. QuickDecks, prepared by the CBRG, are sent to the review authors for approval. PDF versions of the slides are available for anyone to download and PowerPoint versions are available upon request.

**Results:** QuickDecks have been promoted through the CBRG Twitter, Facebook, newsletters and email communications. Since the QuickDecks have been available to download in August 2014, there has been a lot of positive feedback and a large number of downloads and an average of 600 views/month. We will present the top 10 most downloaded reviews.

**Conclusions:** QuickDecks are a new tool used to share evidence and promote uptake of Cochrane review findings.

## Associations between muscular pain in neck and shoulders and psychosocial factors at work in relation to leisure physical activity among teachers

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**Background.** The objective of the present study was to investigate the associations between psychosocial factors at work and psychological distress, muscular pain in neck and shoulders among secondary school teaches in Kaunas, Lithuania in relation to leisure physical inactivity.

**Methods.** The representative sample consisted of 725 teachers from Kaunas (Lithuania) in 2014-2015. Mean age of the participants was 49.92 years (SD: 9.11). 22-item Negative Acts Questionnaire (H. Hoel & S. Einarsen) was used to measure exposure to workplace bullying, Goldberg 12-item General Health Questionnaire - psychological distress, Theorell & Karasek Demand-Control questionnaire - psychosocial job characteristics. Muscular pain in neck and shoulders was assessed by self-report, asking if teachers were diagnosed or cured pain during the last year. Associations between psychosocial job factors, psychological distress, leisure physical activity (Godin Q) and pain in neck and shoulders were analyzed by the method of structural modelling (Mplus). Approximate meanings of the relevance of indices were good (RMSEA, CFI, TLI). The associations between investigated factors in a sample of teachers are shown in the path analysis diagram.

**Results.** The direct path was found from high job demands to pain in neck and shoulders (SE: 0.19,  $p < 0.05$ ) and from psychological distress to pain in neck and shoulders (SE: 0.22,  $p < 0.001$ ). The significant indirect path from low leisure physical activity to muscular pain in neck and shoulders through psychological distress has been identified (SE: -0.028, 95% CI: -0.048 – -0.012). In addition, the significant indirect path from negative acts to muscular pain in neck and shoulders through psychological distress was found (SE: 0.072, 95% CI: 0.01 – 0.177).

**Conclusions:** Significant associations were found between psychosocial factors at work, low leisure physical activity and psychological distress among secondary school teachers. This study confirms the necessity of interventions related to psychosocial factors at work and health behaviours in the workplaces.

## Correlation between fibromyalgia severity score and fitness for work: A cross-sectional study

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**Background:** Fibromyalgia significantly affects the quality of life, professional, social and personal performance of patients, causing disability. Several studies have found that fibromyalgia patients have decreased work fitness and get high disability ratings, and that decreased work performance correlates with the severity of fibromyalgia symptoms.

**Objectives:** To examine the correlation between the diagnosed fibromyalgia severity score as measured by the questionnaire, and the patient's fitness for work.

**Methods:** In this cross-sectional study patients' fitness for work was evaluated by an occupational physician and the ACR diagnostic criteria questionnaire. The data was then collected and statistically analyzed for correlation.

**Results:** The correlation between the Symptom Severity Score (SS score) Part 2b (0-3 scale) and loss of working capacity was found to be statistically significant ( $r_s=0.23$ ,  $p=0.04$ ). No correlation was found between loss of working capacity and any other part of the questionnaire.

**Discussion:** We found a correlation between the SS Score Part 2b (0-3 scale) and loss of working capacity. No correlation was found between loss of working capacity and any of the other questionnaire variables.

**Conclusions:** Although we found some correlation between SS Score Part 2b and fitness for work more research with larger samples and more heterogenic populations is

Correlation between the loss of working and various signs and symptoms of the fibromyalgia syndrome as defined by the ACR

p	Correlation with loss of working capacity	Average score	Criterion
0.05	0.41	14.00 ± 3.64	WPI Score
0.32	-0.06	2.74 ± 0.54	Fatigue
0.45	0.01	2.60 ± 0.60	Waking unrefreshed
0.31	0.06	2.20 ± 0.90	Cognitive symptoms
0.45	0.01	7.61 ± 1.43	SS Score part 2a
0.07	0.19	2.28 ± 0.52	SS Score part 2b
0.25	0.07	9.91 ± 1.75	SS Score (2a+2b)
0.04	0.23	20.36 ± 6.43	Part 2b – number of symptoms
0.18	-0.12	2.78 ± 1.44	Mets

## Linking health care and workplace: role of occupational therapists in workplace based occupational health care to prevent MSA-related workdisability

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**Background:** The aging work-force and the claim for people with dis-abilities to participate in the open labour market forces governments and employers to employ workers with functional limitations. Occupational therapists (OTs) focus on maintaining or regaining employment for individuals with specific functional problems( e.g.; MSA), implementing ergonomic knowledge and provide advice and training to prevent MSA-related work-disability.

**Methods:** Using a qualitative studydesign in 7 different companies, specific MSA-riskanalysis were realised (e.g.; KIM-tool, NIOSH, REBA, WHI) and used as basis ergonomic optimisations (in behaviour of workers and in design and organisation of the workplace).

Participatory observation (n = 211) was used to measure the workers awareness and to found their motivation to engage in implementing advised optimisations. Workers appreciation was measured by research specific questionnaires and worker-interviews (n = 175).

Topic interviews were used to question implementation of OTs'compentencies with production-leaders and company responsables (n = 17).

**Results:** In all companies, advice for work-disability prevention resulted in 1) tailored trainings for workers and for training peer-trainers, 2) instruction sessions to enhance awareness and; 3) workplace based advice. Moreover, the participatory ergonomic sessions lead to company-specific approaches such as introducing peer-coaching, including ergonomics into production oriented workinstructions, connecting quality-standards to time use and a protective performance of tasks by implementing ergonomic advice on behaviour and workplace design.

Workers highly appreciated to be directly involved but questioned sustainalibity of their behaviour, indicating a need for more permanent attention on individual base.

Production leaders and comapny responsables recognised the added value of OTs' competencies but questioned the sustainable implementability based on current legislagtion on occupational health and wellbeing.

**Conclusions:** Adding OTs' competencies to floor-based management of preventing MSA-related workdisability has the potential to enhance individual oriented ergonomic support. More longidutdinal follow-up will be needed to measure sustainable effects.

## Neck, trunk, and upper arm posture variation during computer work at a sit-stand table in a real work setting

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**Background:** Computer work is generally associated with constrained postures and sedentary behaviors. Sit-stand tables have been suggested as an effective intervention to promote changes in gross body posture, and thus reduce sitting. However, few studies have addressed to what extent sit-stand table usage affects posture variation in other body regions. The aim of this study was to examine neck, trunk and arm postures among office workers with access to sit-stand tables.

**Methods:** Twenty-four office workers (16 females, 8 males; mean age 41 (SD9) years) participated. At entry, workers received sit-stand tables, which were then used for two months. Neck and trunk flexion, and right upper arm elevation (RUA) was recorded on three consecutive days, two hours/day, during the last week of table use. Minute-to-minute variability for the three postures during sitting (CWsit) and standing (CWstand) computer work was obtained for each participant. Job variance ratios (JVR) were calculated for the actual work, and for other combinations of CWsit and CWstand by simulation<sup>1</sup>.

**Results:** CWsit and CWstand were performed for 72% and 28% of the time spent at the computer. Minute-to-minute variability was larger in CWsit than in CWstand for all three postures, and the difference CWsit-CWstand was largest for RUA [median 1.7 (IQR -0.2-1.7)<sup>o</sup>], followed by trunk [1.6 (0.9-3.0)<sup>o</sup>] and neck [0.9 (0.0-3.1)<sup>o</sup>]. During actual work, JVR was between 1 and 3 for most participants. Simulations suggested that maximum variability would occur at a combination of 40-80% CWsit and 20-60% CWstand.

**Conclusions:** Neck, trunk and arm posture variation during computer work can be increased by manipulating proportions of time spent sitting and standing at a sit-stand table. The tentative "optimal" proportions reported here could be a benchmark for occupational health professionals.

## Variation in upper trapezius and wrist extensor EMG among computer workers during sit-stand table use in a real work setting

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**Background:** Computer work is generally associated with constrained postures and low muscular demands. Sit-stand tables have been suggested as an effective initiative to change working postures during computer work, but the effect of this intervention on muscle activation has rarely been studied. The aim of this study was to document variation in shoulder-arm muscle activation among office workers using sit-stand tables.

**Methods:** Twenty-four office workers (16 females, 8 males; age  $41 \pm 9$  years) participated. At entry, workers received sit-stand tables and ergonomics information, and then used the table for two months. Muscle activity of right and left upper trapezius and wrist extensors (RUT, LUT, RWE and LWE, respectively) was recorded during three consecutive days (two hours each day) in the last week of sit-stand table usage. Periods of computer work in sitting and standing positions (CWsit and CWstand, respectively) were identified by on-site observation, and synchronized with the EMG recordings. Variability (min-min SD across 1-minute bins, %MVE) was calculated for each EMG recording in CWsit and CWstand.

**Results:** During the 62 minutes of EMG recorded during computer work, CWsit was performed for 72% and CWstand for 28% of the time. The mean minute-to-minute variability of trapezius EMG was larger ( $P < 0.05$ ) during CWsit (RUT 3.9 (SD between workers 1.6) %MVE; LUT 3.9 (SD 2.3) %MVE) than CWstand (RUT 3.0 (SD 1.5) %MVE; LUT 3.2 (SD 1.9) %MVE). The mean minute-to-minute variability in RWE was also larger during CWsit (3.3 (SD 1.4) %MVE) than CWstand (2.9 (SD 1.3) %MVE). For LWE, variability did not differ between CWsit and CWstand.

**Conclusions:** Sitting and standing computer work was associated with different extents of variation in shoulder-arm muscle activity. Thus, sit-stand tables may introduce beneficial exposure variation into the work of office employees.

## Implementing Activity-based Workplaces (ABW) and the importance of participating in process activities

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**Background:** Activity based workplaces (ABW) are implemented by many organizations, but there is a lack of systematic evaluations to identify factors influencing outcomes of the implementation process. We systematically followed the implementation and this particular study aims to explore if the number of attended (four optional) process activities influenced the intermediate implementation outcomes, knowledge, office rules, information and support.

**Methods:** In Sweden, a large government agency implemented ABW to improve working conditions and support work ability. ABW is open-plan offices with unassigned desks in workspaces to support different work characteristics, e.g. silent or interactive work. Part of the implementation strategy focused on four optional process activities to prepare employees for work in ABW, Ergonomics seminar, ABW Management Information, ABW Workshop, ABW Inspiration seminar. Objectives were to increase knowledge about ABW, understand office rules, facilitate process transparency by information and support. All eligible employees were addressed with a questionnaire 3 months before moving to ABW and questions were asked about attendance to the activities and perceptions about the process considering knowledge, office rules, information and support. Focus group interviews were also held before relocation.

**Preliminary results:** The questionnaire response rate was 455 (59%). 52% of employees did not attend any of the activities during implementation. Among the 48% attending one or more of the four process activities, the knowledge about ABW, understanding of office rules and satisfaction with information and support increased linearly (all  $r > 0.3$ ,  $p < 0.001$ ) with the number of activities attended. Those not attending showed worse outcomes than those attending one activity ( $p < 0.001$ ). In accordance with quantitative results the interviews confirmed the perception of satisfaction with the implementation process among those attending activities.

**Conclusions:** When implementing ABWs companies should not only offer, but emphasize participation in the implementation activities for a successful implementation with employees prepared for ABW.

## Evaluation of a Information Package on MSD Prevention for Small and Micro Business in Ontario, Canada

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Musculoskeletal Disorders (MSD) prevention in micro (< 5 employees) and small businesses is difficult yet a large proportion of people work in such firms. They are thus important target for prevention activities. Micro and small businesses do not typically have either the human or financial resources necessary to develop formal health and safety programs. The traditional cycle of recognize, assess, control and evaluate is challenging for workplace hazards related to MSD in small businesses. The purpose of this paper is to evaluate knowledge utilization in micro and small businesses' of a information package on MSD Prevention.

We have previously shown good conceptual use of knowledge after exposure to the package but here we follow up on a new sample of businesses to further evaluate instrumental knowledge use in a new sample of workplaces. The package distributed consists of a folder with information describing MSD and how to use the enclosed materials - seven "mini-posters" with simple graphics showing major MSD risk factors with general controls. It also contained a poster summarizing the messages in the package. We visited a convenience sample of small business in the Waterloo Region of Ontario province in Canada and a follow up visit was done 10-14 days later to evaluate the effectiveness of this knowledge utilization approach.

A total of 259 firms participated in both interviews. In 46% of the participating firms there was instrumental change or intention to change: Changes included process changes (such as changes in the position of frequently used item), new equipment (including adjustable computer screens or raising table heights) and extra training (including posting posters, how to use equipment and encouragement to take breaks).

This study concludes that knowledge utilization strategies for micro and small businesses should focus on targeted intervention considering the resource and capacity limitation of these businesses.

## Reducing postural exposure in repetitive manual handling using the Smart Workwear System – effects of vibrotactile feedback and verbal instructions

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**Background:** We have developed an ambulatory wearable system for assisting risk assessment and automated training to reduce adverse postural exposures. This study evaluated the effects of direct vibrotactile feedback using the system and verbal instructions on reducing high upper arm elevation angles (UAEA) in manual letter sorting.

**Methods:** Six women and seven men with a mean (SD) age of 22.8 (3.7) years, body mass of 73.0 (12.5) kg, and stature of 172 (13) cm, volunteered to participate. They performed simulated letter sorting while wearing a prototype of the Smart Workwear System. The system measured dominant UAEA using an inertial measurement unit. A vibrotactile actuator attached to the dominant upper arm provided intermittent and continuous direct vibrotactile feedback for UAEA  $\geq 30^\circ$  and  $\geq 60^\circ$ , respectively. After familiarization, the participants sorted 30 letters in five scenarios: baseline, verbal-1, vibration-1, verbal-2 and vibration-2. They were instructed to sort the letters at a self-selected pace. For the verbal scenarios, they were additionally instructed to reduce dominant UAEA, and additionally minimize vibrotactile feedback for the vibration scenarios. Repeated measures ANOVA was computed of time with UAEA  $\geq 60^\circ$  and  $\geq 45^\circ$ .

**Results:** Direct vibrotactile feedback was associated with significantly ( $p < 0.05$ ) reduced proportions of UAEA  $\geq 60^\circ$  (41–48%) and UAEA  $\geq 45^\circ$  (36–40%), while verbal instructions were associated with significantly ( $p < 0.05$ ) reduced proportions of UAEA  $\geq 60^\circ$  (29%) and UAEA  $\geq 45^\circ$  (21–30%). Compared to solely giving verbal instructions, direct vibrotactile feedback was associated with a significantly ( $p < 0.05$ ) reduced proportion of UAEA  $\geq 60^\circ$  by up to 27% and up to 24% for UAEA  $\geq 45^\circ$ .

**Conclusions:** This study points to that both direct vibrotactile feedback and verbal instructions can influence postural behavior in letter sorting and can contribute to reducing high upper arm elevation. Additionally, direct vibrotactile feedback seems more effective in reducing high upper arm elevation compared to solely verbal instructions.

## The Economic Burden of Work-Related Musculoskeletal Disorders in Five European Countries

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We estimate the economic burden of Work-Related Musculoskeletal Disorders (WMSDs) for five European Countries. The burdens identified reflect the amount that would be realized if there were no WMSDs in the reference year.

We use a “bottom up” approach to estimate the economic burden of WMSDs from a societal perspective for Finland, Germany, Italy, The Netherlands, and Poland. Three broad cost categories are considered—direct health care, indirect productivity, and intangible health-related quality of life costs. Newly diagnosed cases from calendar year 2015 were estimated using three source of incidence data, compensated cases, non-compensated cases (from each country official record) and cases estimated using attributional fraction (AF) from the Institute for Health Metrics and Evaluation.

Total number of compensated WMSDs per 100,000 employed are highest for Germany (59), followed by Italy (55), The Netherlands (27), Finland (7) and Poland (1). Non-compensated WMSD cases follow a similar pattern and are almost 2 times the compensated ones. Cases estimated via AF have different country rank orders with the highest for Italy (2,487), followed by Poland (2,472), Finland (2,390), Germany (2,362) and The Netherlands (€2,183). Average per case costing is highest for The Netherlands (€75,342), followed by Italy (€58,411), German (€44,919), Finland (€43,069) and Poland (€38,918). In terms of costs per working population, the value is highest for Italy (€4,956), The Netherlands (€2,930), Poland (€2,793), Germany (€2,527) and Finland (€2,331).

Despite improvements in the measurement of work injury and disease burdens in recent year, estimating the number and cost of WMSDs continues to be a challenge. Compensated cases do not reflect the full magnitude of case arising from workplace exposure, due to high levels of underreporting and in some cases, under coverage. Our estimates provide a basis for undertaking economic evaluations of prevention efforts and can serve as a template for monitoring and evaluation at the country level.

## Investigating the Potential for Workplace Injury Tradeoffs: Needle-less Injection Tools in Pork Production

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Increasing intensification in swine production has led to new and specialized technologies, but the occupational health and safety impacts are rarely quantified in the business plans for adoption. Needle-less injection has potential to increase productivity and eliminate needle stick injury in workers, but it is not clear whether these benefits offset high capital investment and potential increases in musculoskeletal loads.

The ergonomic assessment continuously recorded 1) electromyography (EMG) of finger/wrist flexor and extensor muscles in the forearm, and 2) finger, hand, and wrist kinematics during 565 injection trials. All injections were performed by swine production workers in a swine barn. The economic evaluation employed probabilistic scenario analysis using workers' compensation claim data as well as injury, cost, and production data gathered from interviews with swine producers in Manitoba and Saskatchewan.

In terms of ergonomics, average muscle activities were lower with the needle-less injector than the conventional needle, but the rate of injection was much higher, which could lead to higher cumulative loads in a day. While the range of wrist and finger flexion was similar between injectors, the angular velocity was higher during conventional needle injection. In terms of economics, rates of needle-stick injury went down with no measureable effect on upper limb musculoskeletal disorders, resulting in lower costs for needle-less injectors. The net benefit of needle-less injection was slightly higher than conventional needles and accumulates over time; the conventional method is beneficial for barns with 300 sows or less. Needle-less injection duration was 40% faster once workers acclimatized, but large start-up costs mean economic benefits are realized only after the first year.

Findings indicate that well-designed technologies have the potential to achieve the dual ergonomics goals of enhancing human wellbeing and system performance.

## Implementing an ergonomics program on commercial construction worksites reduced new incidents of pain and injury: Results from a cluster randomized controlled trial

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**Background:** Soft tissues injury prevention programs (aka ergonomics programs) on construction sites are rare; however, construction workers have high rates of MSDs. Through a cluster randomized controlled trial on 10 (5-pairs of) sites, we tested the hypotheses that construction workers on sites with an ergonomics program will report improved ergonomic practices and decreases in pain/injury compared to workers on sites without the program.

**Methods:** We developed an ergonomics program for commercial construction sites that included 1-hour foreman training, 15-minute tool-box for workers, task preplanning protocol that included soft-tissue injury hazards and controls, weekly inspections for good and bad examples of ergonomics solutions, weekly reports to foremen and weekly tips/seen on site example displayed on a site poster implemented as part of a continuous improvement cycle. Pairs of construction work sites were recruited and block randomized within a general contractor. The program ran for 6 weeks. Worker surveys measured workers perception about ergonomic practices, physical demands, and injury/pain at baseline (program initiation or new worker orientation n = 607), follow up 1 (program end, n = 256), and follow up 2 (six months, n = 116). Analytical models controlled for covariates and matched pairs.

**Results:** At the end of the six-week program (Follow Up 1), ergonomics practices improved on the intervention worksites (beta = 0.18, [95%CI 0.03, 0.33]). In addition, workers on intervention sites reported reduced new injury and pain since baseline at the end of the six-week program compared to the control sites (OR = 0.59 [95%CI: 0.43, 0.80]) but not significantly six months later (OR = 0.56 [95%CI: 0.20, 1.59]). Process tracking revealed barriers to subcontractors implementing many of the program components including task preplanning.

**Conclusions:** The intervention had positive effects on ergonomic practices and reduced the incidents of new injuries and pain.

## Physiological effects of two level compression socks on security guards during prolonged standing work

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**Background:** Prolonged standing work has significant effects on lower-leg muscle fatigue, edema and performance. Ergonomic interventions to mitigate these effects are needed. The aim of this study was to evaluate the physiological and perceptual effects of two level compression socks used by security guards during prolonged standing work.

**Methods:** Twenty guards (males) between 20-60 years old working almost exclusively in the standing posture for 12 hours a day were tested with one of the two compression socks randomly assigned (15-20mmHg or 20-30mmHg) during two consecutive work-days after a day of rest. Lower-leg muscle twitch force (MTF), volume, and discomfort perception were measured before and after each work day. Measures were compared to two control days in which the guards wore their regular socks. Standing, walking and sitting durations were evaluated using an accelerometer.

**Results:** Standing work induced a significant decrease of lower-leg MTF after 12 hours work regardless of the socks used. However, full recovery was observed after 12 hours of rest. Lower-leg edema was significant after prolonged standing work but receded to baseline level after 12 hours of rest regardless of the socks used. A tendency of muscle fatigue induced alteration was observed on MTF and edema immediately after the second day of standing work but it was not statistically significant. Neither MTF nor edema were influenced by the sock type. Perception of lower-leg discomfort increased significantly after 12 hours of work only for those using the 15-20 mmHg socks. However, no significant change was observed after 12 hours of rest or after the second work-day.

**Conclusions:** 12 hours of prolonged standing induced similar physiological effects but alterations did not persist after 12 hours of rest. The tested compression socks do not seem to produce any significant benefit over normal socks in term of muscle fatigue, edema or discomfort.

## Short interruptions during full day computer work and trapezius muscle activity – a randomized laboratory study

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**Background:** Long-lasting low-level activity of the trapezius muscle appears as a crucial link in the pathway from workplace physiological and psychological demands to the development of myalgia of the trapezius muscle. In order to lay an empirical foundation for the prevention of trapezius myalgia, we compared trapezius muscle activity during computer work with and without interruptions.

**Methods:** 30 healthy adults without chronic neck pain participated in a laboratory study designed to simulate two full workdays of computer work with and without frequent interruptions. Computer work was divided into five different working tasks of 50 min each and consisted of “typing”, “elevated desk typing”, “solitaire”, “stroop test”, and “puzzle”.

Bipolar surface EMG was recorded from the descending part of the trapeze muscle and was normalized to a submaximal reference voluntary activation (RVA) and was expressed in % RVA. The following parameters were calculated: rest time, the 10th, 50th and 90th percentile. Rest time was defined as the percentage of the duration with the EMG below 5% RVA. In addition, personality traits (anxiety level), and musculoskeletal discomfort were evaluated.

**Results:** Rest time ranged between 0% and 100%. It significantly differed between the five tasks and was shortest at “elevated desk typing”. The daily trend between the experimental and the control day did not differ. P10, p50 and p90 also showed large variability between the subjects and significantly differed between the five tasks. Anxiety levels were not clearly correlated with EMG parameters. Local discomfort significantly increased during the experimental session.

**Conclusions:** In computer work, the level of trapeze muscle activity and the length of rest time strongly differ between subjects. Ergonomic shortcomings (too high table height) strongly increased muscle activity and reduced rest time. In this small sample, relationships between anxiety level and muscle activity were not significant.

## Process Evaluation of a Workplace-Based Exercise and Health Promotion Cluster-Randomised Trial to Increase Productivity and Reduce Neck Pain in Office Workers: a RE-AIM Approach

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**Background:** The RE-AIM methodology was used to examine the implementation of two workplace-based interventions in a cluster-randomised trial and explore variations across organisations. The trial compared ergonomic assessment plus either exercise training (EET) or health promotion information (EHP) interventions, showing that EET provides greater benefit than EHP for health-related productivity loss, but both interventions provide similar benefits for neck pain.

**Method:** Employees (n=763) from 14 organisations in Australia were randomly allocated by work team to EET (n=50 clusters; n=381 participants) or EHP (n=50 clusters; n=382 participants) for 12 weeks with monthly follow-up to 12 months. Data were interrogated to report on the RE-AIM dimensions (reach, effectiveness, adoption, implementation and maintenance). Qualitative and quantitative data were collected from participants, research team observations and organisations.

**Results:** Organisation-level adoption (66%) was high. Overall reach was 23%, but varied from 9% to 84% across organisations. Participants were generally representative of the recruitment pool. The interventions were implemented with minimal protocol variations and high staffing consistency, but organisations varied in their provision of resources (e.g. training space, seniority of liaisons). Mean adherence was 56% during the intervention period (41% to 71%) for EET and 56% (28% to 77%) for EHP. At 12 months, regular adherence was reported by 15% of EET and 62% of EHP participants. Changes varied between organisations for health-related productivity loss (from -0.2 to 0.5 days) and neck pain (from -1.0 to 0.9 out of 9), with no clear pattern emerging to indicate the source of the variation and no clear relationship between the two outcome measures.

**Conclusions:** The variations in health-related productivity loss and neck pain reported between organisations could not readily be explained by variations in the RE-AIM domains and their relationship was inconsistent. Future multi-site interventions should capture more detailed information on organisational factors to better understand the source of variation.

## Impact of working technique on cumulative loadings among other factors

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**Background:** Variation in working techniques is thought to prevent overuse injuries (Srinivasan et al., 2012). Variable anthropometry among individuals contributes to low back loadings (Srinivasan et al., 2012). The impact of technique and anthropometry on low back loadings, however, has never been quantified in a box transferring task. Consequently, the goal of this study was to quantify the impact of anthropometric and technique parameters on asymmetrical and cumulative loadings.

**Methods:** Participants (n=65) transferred four boxes back and forth from a conveyor to a hand-trolley 32 times. Kinematic and ground reaction forces were used as inputs for a 3D biomechanical loading model able to estimate the net moments at L5/S1 (Plamondon et al., 2014). Mean cumulative moments of the 32 transfers in sagittal flexion and asymmetry at the L5/S1 joint were estimated. Anthropometric characteristics, handling duration and inter-trial variability in net moments at L5/S1 (normalized to upper body weight) were used as predictors of the dependent variables. Stepwise multiple linear regressions were done to identify the elements that significantly determined mean cumulative moments acting on the back.

**Results:** About 64% (in sagittal flexion) and 48% (in asymmetry) of the variance in mean cumulative moments at L5/S1 was explained by a four-variable model. Transfer duration (in sagittal flexion) and upper body weight (in asymmetry) showed a significant positive linear association with cumulative loadings, and explained 34% and 35% of the variance, respectively. A significant positive linear association was found between cumulative loadings and inter-trial variability in net moments at L5/S1 ( $p < .001$ ).

**Conclusions:** Working technique, defined by transfer duration and inter-trial variability in net moments at L5/S1, positively influenced cumulative back loadings. These results indicated that variation in working techniques while performing the same task may not be sufficient to prevent workers from overuse injuries (Srinivasan et al., 2012). Still, more kinematic data are necessary to accurately represent working techniques.

## Implementation of patient transfer technique and good perceived psychosocial working climate association with peak exposures of physical load among health care providers in nursing homes in Norway

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**Background:** Working in nursing homes with responsibility to handle patients could be physically demanding, mainly due to many lifting and transfer tasks. Physical exposure as peak exertions of the neck and back muscles may cause musculoskeletal complaints. Introduction of patient transfer technique as well as a good psychosocial climate could promote beneficial working technique to reduce exposure. The aim of the study is to evaluate association between use of patient transfer technique, good perceived social climate and physical exposure in nursing homes.

**Methods:** A total of 40 employees at eleven nursing homes in the large Oslo region were included. A questionnaire assessed patient transfer and psychosocial environment, here exemplified by two questions. Do you practice what you learned about patient transfer techniques? (5 point scale, dichotomized by totally agree or not). Social climate was assessed by three questions; What is the climate in your work unit; encouraging and supportive, trustful and relaxed and comfortable climate? (mean of 5-point scale, dichotomized by rather/very much or less). The muscle activity in the Trapezius muscles and Erector Spinae muscles were obtained by electromyography (Mobi 8) during a full-shift. Peak exposures was defined as short muscle activity above 80% of maximal reference activation.

**Results:** If you totally agree that you practice what learned about patient transfer techniques most peak exposures were lower than if you don't. Peak exposures were also lower if you perceive good social climate (3 peak exposures per hour in neck muscles vs ten for less,  $p < 0,1$ ).

**Conclusions:** This study shows that using of patient transfer technique in clinical practice and good perceived social climate are associated with physical exposure among health care providers in nursing homes. Implementation of patient transfer technique and good perceived psychosocial working climate could be important to reduce mechanical workloads.

## Characterizing musculoskeletal injuries in two public sector workforces with exposure to two different custodial populations

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**Background:** U.S. correctional facilities and mental health hospitals often serve similar populations: approximately 40% of correctional inmates have mental health conditions, while others with criminal behavior records are hospitalized for mental health care. Being in close contact with custodial populations comes with risk of assault. We compared rates of assaults, and of musculoskeletal disorders (MSDs) resulting from assaults, in both workforces.

**Methods:** We obtained ten years of workers' compensation claims (WCCs) and workforce full-time equivalents (FTEs) from Connecticut Department of Corrections (DOC), and three years of WCCs and FTEs for one Massachusetts Department of Mental Health (DMH) hospital with a large "forensic" patient population. We analyzed "accident type," "nature of injury," and "body part." In both datasets, nature of injury included coding for MSDs, which were primarily strains and sprains.

**Results:** For accident type, 14% of WCCs at DOC (n = 1,427) were "violence/assault" (incidence rate (IR) 2.2/100 FTEs), while 76% (n = 675) at DMH were "patient assaults" (IR 30/100 FTEs). For nature of injury, 60% of all DOC claims (n = 6,133) were MSDs, and the IR was 9.3/100 FTEs. Of those, 697 MSDs resulted from assaults, and 1,154 were overexertion injuries due to restraint activity (combined IR 2.8/100 FTEs). In this subgroup, 35% of claims involved the upper extremity, 24% back, and 22% lower extremity. At DMH, 26% of claims (n = 235) were for MSDs, and the IR was 10.4/100 FTEs. A total of 144 MSDs resulted from assaults (IR 6.4/100 FTEs). In this subgroup, 35% of injuries were to "multiple body parts," 30% upper extremity, and 11% the back.

**Conclusions:** Although the two workforces have similar inmates, DMH employees experienced higher rates of assault and subsequent MSDs. Corrections facilities likely provide more physical and procedural protections for their staff than do mental health facilities.

## The BRAZilian eValuation of Occupational health (BRAVO) database: presentation of the workers' profile and prospects for future studies

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**Background:** Studies with a large working population are scarce in Brazil. The assessment of workers in different settings enables outlining a comprehensive profile, which can be compared to that of other countries. The aim of this study was to describe the BRAVO database.

**Methods:** Recruitment was carried out in administrative, educational, cleaning, maintenance and manufacturing sectors, elder care institutions and a zoo in cities located in the southeastern region of Brazil. The variables included in the database were sex, age, daily working hours, job seniority, education level, BMI, physical activity during leisure time, smoking, alcohol intake and job title. Musculoskeletal symptoms (Nordic Musculoskeletal Questionnaire), fatigue (Need for Recovery scale), work ability (Work Ability Index) and stress (Job Content Questionnaire) were also evaluated. The BRAVO database is composed of different primary studies that had received approval from ethics committees. Descriptive analysis was performed.

**Results:** A total of 1233 workers were included in the database. The sample was composed of 387 (31.4%) male and 846 (68.6%) female workers ranging in age from 19 to 71 years (mean:38.6; SD:11.0). Daily working hours ranged from 6 to 66 hours (mean:22.1; SD:8.5) and job seniority ranged from 0 to 540 months (mean:164.7; SD:105.6). Education level ranged from illiterate/incomplete elementary school (n=112 workers in the fields of cleaning and maintenance and at the zoo) to a postgraduate degree (n=193 administrative workers and university professors). The prevalence of musculoskeletal symptoms in at least one body part in the previous 12 months was 68.2%. The most affected regions were the lower back (38.9%), shoulders (37.2%) and neck (36.9%).

**Conclusions:** The BRAVO database is comprised of a large sample of workers from a wide range of fields. The main weaknesses of the database are the lack of standardization for some questions and missing data. Despite this, the BRAVO database enables studying and comparing different types of Brazilian workers.

## Prevalence of upper limb disorders and occupational health problems among the women brick molders of west bengal, india

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**Background:** Women play a significant role in the Indian economy, and they are regarded as the backbone of the brickfield industry. This present study aims to estimate the prevalence of upper limb disorders and occupational health problems compared to the control population.

**Methods:** 72 women brick molders were selected randomly from different brickfields of West Bengal, and 75 women control subjects were also chosen randomly who generally performed different household work. The Nordic Questionnaire was applied to assess the discomfort felt among both groups of workers in the upper extremity of the body and the RULA posture method was done to evaluate the work stress during their job. Cardiovascular and thermal stresses were also assessed to evaluate the occupational health problems among study population.

**Results:** From the result of the study it was revealed that upper limb MSD was a significant problem among women brick molders, primarily involving the hand (97.6%), shoulder (94.1%), wrist (72.9%) and fingers (56.5%).. The analysis of RULA posture analysis stated that the posture requires investigation and changes immediately. This study also stated that there was a significant difference ( $p < 0.05$ ) in hand-grip strength measured at 90° elbow flexion and 180° elbow flexion just after stoppage of work between the women brick molders and the control subjects. Questionnaire studies shows that most of the women brick molders suffered from musculoskeletal problems (85%), respiratory problems (72%), followed by gastrointestinal problems (43%), skin problems (41%) and eye irritation (38%).

**Conclusions:** From the observation and analysis of the result it was concluded that women brick molders are engaged continuously in highly repetitive hand-intensive jobs and they suffer from discomfort feeling at the upper extremities like the hands, shoulder, wrists, and fingers region. The pain was feeling intense with continued work, followed by a decrease in the handgrip strength.

## Work-related polyneuropathy of upper limb

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**Background:** Polyneuropathy - one of the leading nosologic forms of work related musculoskeletal disorders (31%).

**Objective:** studying of occupational diseases of peripheral nervous system - polyneuropathy of upper limb.

**Patients and methods:** examination with stimulation electromyography (EMG): 151 patients with occupational polyneuropathy, 15 patients with polyneuropathy non work-related.

**Results:** Most patients (77%) observed with hand-arm vibration syndrome, and the rest - with polyneuropathy from functional overload. Polyneuropathy non work-related: alcohol polyneuropathy, myelopathy, the post traumatic polyneuropathy, endocrine disorders. The average value of residual latency (RL) at stimulation of motor fibers of the median nerve was 3,1-3,3 ms. The nerve conduction velocity (NCV) decreased to 47,4-47,6 m/s. With stimulation of ulnar nerves RL was 2,5-2,8 ms; NCV - 47,8-48,3 m/s. In assessing the state of sensory fibers decreased the amplitude of the sensory response to 3,9-4,5 $\mu$ V; average NCV for sensory fibers was 45,2-44,4 m/s.

Patients with polyneuropathy non work-related are have symptoms of the underlying disease, the localization process more often in the lower extremities (60%) and more pronounced changes in indicators EMG. Residual latency can be as high 4,0ms and more; NCV for sensory fibers is reduced to 37-34,5 m/s.

**Conclusions:** 1) To verify the diagnosis requires the use of EMG. Characteristic sign the occupational polyneuropathy is obligatory presence of sensory nerve disorders of the upper extremities. 2) Clinical and functional differential diagnosis with polyneuropathy non work-related is desirable. Violations indicators EMG more pronounced when polyneuropathy non work-related.

## Salient beliefs underlying the intention to diagnose WRMSD among General Practitioners: a qualitative study using Theory of Planned Behaviour

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**Background:** Earlier studies have demonstrated the high prevalence of potentially work-related musculoskeletal disorders (WRMSD) among patients seen by General Practitioners (GP). Thus, to have good WRMSD surveillance data, especially in countries with lack of occupational services, GP should diagnose WRMSD. Nevertheless, there is a lack of prior research that looks into the motivation of GP to diagnose WRMSD among their patients. Thus, this study explored the salient beliefs that influence the intention of GP to diagnose WRMSD using the Theory of Planned Behaviour.

**Methods:** This qualitative study involved in-depth interviews among 16 GP throughout Malaysia. They were recruited through purposive sampling. Semi-structured questionnaire was developed to explore the behavioural, normative and control beliefs of diagnosing WRMSD. Responses were transcribed verbatim and analysed for thematic content.

**Results:** Respondents believed that there are consequences for themselves, their patients and the patients' employers when they diagnose WRMSD. Negative consequences for GP were mainly related to the reactions of employers such as termination of panel contract. For patients, punitive actions by employers were the major concern. Whereas for employers, the key concerns were patients abusing the diagnosis to their advantage, and possible intervention by enforcement authorities. Positive consequences included business opportunities for GP, appropriate patient management and opportunity for employers to improve the workplace. Employers and patients were cited as major influences affecting their intention to diagnose WRMSD. Availability of guidelines and having occupational physician for referral were among the commonly cited facilitators for diagnosing WRMSD. Barriers included the inability to get good ergonomic exposure history from patients, time constraints for detailed investigation, uncertainty on who to bear the cost of investigations and the presence of non-occupational risk factors.

**Conclusions:** The underlying beliefs that influence the intention of GP to diagnose WRMSD mainly revolve around the patients, their employers and the GP themselves.

## A critique of duty cycle and its role in assessing MSD risk

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**Background:** A duty cycle (DC) is defined as the fraction of a cycle during which a system is active. The concept of duty cycle has been frequently employed in electronics applications; for example, to quantify the amount of time an electronic switch is powered on versus off. In such applications, the load magnitude tends not to vary, only the pulse width relative to the cycle time. Duty cycle is also used to examine work/rest periods for musculoskeletal tissues during work. However, unlike electronics applications, musculoskeletal loading is highly variable in nature, which may impact the interpretation of duty cycle.

**Method:** Various duty cycle scenarios were analyzed with respect to estimated cumulative damage development using a data set on tendon cyclic (dynamic) loading and creep (static) loading responses presented by Wang, Ker, and Alexander (1995). These scenarios included: (a) a high stress (80% ultimate stress)/short DC (20%) task versus a low stress/long DC task; (b) Two conditions with equal duty cycles but with one experiencing cyclic loading and the other creep loading during the active phase; and (c) Two conditions with the same stress load and equivalent DCs but different cycle times (5 versus 10 seconds).

**Results:** Analysis of scenario (a) demonstrated that the high stress/short DC resulted in 53 times higher cumulative damage than the low stress/long DC condition. In scenario (b), the cyclic loading condition results in triple the cumulative damage compared to the static load despite equivalent DCs. Further, in scenario (c), the longer DC led to 23% higher cumulative damage compared to shorter DC, despite equivalent duty cycles.

**Discussion:** Results of this analysis suggest that the interpretation of the effect of DC can be complicated by the nature of loading experienced. A limitation of this analysis is that DC also may have physiological effects (not considered here).

## Instrumental-based methods for biomechanical risk assessment

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**Background:** The hypothesis underlying this paper is that wireless miniaturized wearable technologies for online, real-time monitoring of work activities might improve the risk assessment by adapting it to all the workplace setups. The aim of this paper is to describe recent uses of wearable sensors for biomechanical risk assessments in the prevention of WMSDs with a focus on inertial measurement units (IMUs) and surface electromyography (sEMG) sensors. The risk assessment techniques need an update because they are mainly based on observational and subjective approaches (Takala et al. 2010) and don't take into account the recent use of collaborative assistive technologies introduced in industry (Industry 4.0) to assist workers and reduce the physical effort i.e. wearable trunk and upper-limb exoskeletons (de Looze et al. 2016).

**Methods:** Articles written until 7 May 2018 were selected from PubMed, Scopus, Google Scholar and Web of Science using specific keywords. Several instrumental-based tools for direct instrumental evaluations providing real-time measures of risk of exposure have been examined.

**Results:** Instrumental approaches based on IMUs and sEMG sensors have been mainly used to classify lifting tasks into low, medium and high risk categories. As regard the risk assessment in the context of rating of standard methods, innovative on-body wireless IMUs and sEMG sensors network based methods have been developed for real-time ergonomic assessment in industrial manufacturing to obtain input for standardized methods (i.e. NIOSH Lifting Equation, Rapid Upper Limb Assessment (RULA) and Strain Index (SI)).

**Conclusions:** Results of this review shed light on the fact that the recent miniaturization procedures and the necessity to follow a constantly evolving manual handling scenario is prompting instrumental-based methods for biomechanical risk classification. The use of new technologies for biomechanical risk assessment, is only at its initial stage. It will be necessary to facilitate evidence-based medicine/policy/legislation multistep scientific approaches.

## Musculoskeletal health in people on sick leave: Validation of the Norwegian version of the Musculoskeletal Health Questionnaire

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**Background:** The Musculoskeletal Health Questionnaire (MSK-HQ) is a recently developed generic questionnaire that consists of 14 items assessing health status in people with musculoskeletal disorders. The objective was to translate the MSK-HQ into Norwegian and perform validation in people on sick leave with musculoskeletal disorders.

**Methods:** A prospective cohort study was carried out in Norway on people between 18 and 68 years of age and on sick leave due to a musculoskeletal disorder. The participants were recruited through the Norwegian Labour and Welfare Administrations webpages during November 2018-January 2019.

Translation and cross-cultural adaption of the MSK-HQ were performed according to published guidelines. Internal consistency was assessed by Cronbach's alpha. Convergent and divergent construct validity were assessed by eight a priori defined hypotheses regarding correlations between the MSK-HQ and health-related quality-of-life (HRQOL) by EQ-5D-5L, psychosocial risk profile by the Örebro Musculoskeletal Pain Screening Questionnaire short form and the Keele STarT MSK tool, self-perceived work ability, self-perceived health, physical activity, number of sick days and work presenteeism. Correlations were analyzed by Spearman's- or Pearson correlation coefficient and interpreted as high with values  $>0.50$ , moderate between 0.30-0.49, and low  $<0.29$ .

**Results:** A total of 535 patients, mean age (SD) 48.2 (10.6), 304 women (56.8%), were included. The mean (SD) MSK-HQ sum scores (min-max 3-56) were 27.6 (8.2). Internal consistency was 0.86. Construct validity was supported by the confirmation of all hypotheses ( $>75\%$ ); high correlation with HRQOL, psychosocial risk profile, and self-perceived health; moderate correlation with physical activity, self-perceived work ability, and work presenteeism; and low correlation with the number of sick days (median 60 days).

**Conclusions:** The Norwegian version of the MSK-HQ was developed and demonstrated high internal consistency and good construct validity when used among people on sick leave due to musculoskeletal disorders.

## Sitting, standing and physical activity among male and female office workers of different age: behaviours examined using compositional data analysis

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**Background:** Excessive sitting is an increasing concern in working life. Negative health effects may, to some extent, be mitigated by interrupting prolonged sitting by standing or more active behaviours, like walking. Alternations between these behaviours may also influence variation in neck-shoulder-arm exposures, and thus musculoskeletal disorder risks. This study examined time spent sitting, standing and active among office workers, and determined the extent to which these behaviours differed by gender and age.

**Methods:** Ninety-nine workers at a Swedish government agency (50/49 men/women; mean(SD) age 47.1 (9.0) years) wore a thigh accelerometer (Actigraph GT3X) for five working days. Data were processed to give the percentage of time spent sitting in short (<30 min) and long ( $\geq$ 30 min) bouts, in standing, and in more active behaviours. In adding up to 100%, such data are constrained and inherently dependent. This requires further examination to be performed using Compositional Data Analysis (CoDA). Thus, Isometric Log-transformed Ratios were constructed, describing sitting vs. non-sitting (sit/nonsit), short-bout vs. long-bout sitting (shortsit/longsit), and standing vs. active (stand/active). These ratios were examined for pairwise correlations, and for associations with gender and age.

**Results:** On average, workers spent 28.9%, 42.2%, 21.6%, and 7.3% time in shortsit, longsit, standing, and active. Sit/nonsit correlated negatively with shortsit/longsit ( $r=-0.49$ ) and stand/active ( $r=-0.64$ ); shortsit/longsit correlated positively with stand/active ( $r=0.19$ ). Gender showed small associations with all three ratios (partial- $\eta^2=0.01-0.03$ ;  $p=0.08-0.43$ ). Stand/active increased with increasing age (partial- $\eta^2=0.07$ ;  $p=0.01$ ), while sit/nonsit and shortsit/longsit were very weakly associated with age (partial- $\eta^2=0.01$  and  $0.01$ ;  $p=0.26$  and  $0.40$ ).

**Conclusions:** Workers spending more time sitting also spent a larger part of that time in long, uninterrupted sitting bouts. However, when not sitting, these workers were more physically active than workers who sat less. These behaviours differed little by gender and age, besides older workers being relatively less active during non-sitting periods.

## The influence of nursing home, ward, eldercare worker and work situation on the use of assistive devices during resident handling

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**Background:** The purpose of the study is to investigate to what degree the use of assistive device during resident handling in eldercare is explained by the levels: nursing home, ward, eldercare worker, and work situation.

**Methods:** This study used data from the multilevel dataset; The DOSES Cohort. We used real-time observations to determine the use of assistive devices during resident handling. In total, 3695 resident handling tasks were observed within 1306 different work situations, performed by 549 eldercare workers at 126 wards in 20 nursing homes. The eldercare workers used assistive devices in 1691 (46%) of the observed resident handling tasks. We performed a nested analysis of variance to calculate the proportion of variance in use of assistive devices during resident handling, explained by the levels: 1) nursing homes, 2) wards within nursing homes, 3) individual eldercare workers within wards, 4) work situations within eldercare workers, and 5) events occurring within work situations.

**Results:** All five levels included in the analysis contributed to the total variability in use of assistive devices during resident handling. The largest source of variance was within work situations (71%). Nursing homes, wards within nursing homes, eldercare workers within wards and work situations within eldercare workers contributed with 4%, 8%, 8% and 9%, respectively.

**Conclusions:** Events occurring within work situations explained by far the most of the variability in the use of assistive devices during resident handling in eldercare work. This finding indicates that interventions with the purpose of increasing the use of assistive devices should focus mainly on specific events in the work situations. However, there may be some benefits from targeting higher levels of the organization as approximately a quarter of the variability was explained by other levels within nursing homes.

## Subjective criteria for knife sharpness evaluation in meat-cutting activities

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**Background:** The cutting ability of the knife, the knife sharpness (KS), has been identified as an integral determinant of biomechanical and psychosocial risk factors in the dynamic of musculoskeletal disorders (MSD) appearance. Knife sharpness is influenced by different factors, particularly the maintenance operations, such as sharpening and steeling, and the conditions in which they are carried out. The objectives of the present study were to define the factors and qualitative evaluation criteria for the KS according to the profession (meat cutter or sharpener) and the complexity of knife maintenance organisation (individual and centralized sharpening).

**Methods:** Data collection was based on field observations and individual semi-structured interviews with 28 meat cutters and with 7 sharpeners. The participants were invited to express their opinions on the criteria of KS evaluation as well as the perceived factors of KS quality. According to the content analysis method, the data were processed in two steps: (1) identification of categories of subjective criteria and perceived factors of KS quality and (2) analysis of these categories according to the profession and knife maintenance organisation.

**Results:** Data analysis allowed to identify different subjective KS evaluation criteria: physical, visual, auditory and productivity. The results showed that there were divergences in subjective criteria and factors of KS quality according to the profession. The perceived factors were related to the activity of meat cutters and sharpeners and a "bad KS" was often attributed to the sharpener for the meat cutters and reciprocally. This observation was related to a deficiency of communication between the professions. The results showed that the criteria and factors cited by the operators depend on the profession of the worker and on the way that maintenance operations are organised.

**Conclusions:** The proposed factors, as well as the sharing of subjective KS evaluation criteria, should be taken into account for developing MSD prevention strategies that reflect as closely as possible the real work situations.

## Psychophysiological reactions, stress and recuperation among telecommuting academics

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Telecommuting is a working arrangement that is highly adopted among academic staff. This may be a cause or a consequence of expanding demands on productivity, efficiency and availability of academic staff. A previous study on white-collar workers at a government authority showed higher cardiovascular arousal during work at the office, but less recovery after working from home. To our knowledge, these findings have not been confirmed or refuted in other populations. As part of an ongoing study, we aimed to determine whether there is a difference in perceived stress and psychophysiological reactions during work at the central workplace (CW) compared to work performed away from the central workplace (OCW) among academic staff. In addition, recuperation after work performed at the two locations were compared. For each subject, saliva cortisol was collected regularly throughout each of two working days in the same work week (i.e., one full day CW and one full day OCW). Before and after each working day, the subjects rated their stress and fatigue on 100 mm Visual Analogue Scales (VAS) where higher values imply more stress and fatigue, and the difference in ratings within a day (i.e., after-before) was calculated. In the morning after each of the working days, the subjects rated how recuperated they felt on VAS where higher values imply more recuperation. Cortisol values were analyzed using repeated measures analysis of variance with Day (2 days) and Time of day (6 time points) as within-subjects effects. Self-ratings were compared using paired-samples T test. In all tests, the level of significance was  $p=0.05$ . Preliminary results show no significant differences between days in cortisol curves ( $F=0.62$ ;  $p=0.685$ ), stress ( $\Delta\text{stress}=2$  for CW and  $-1$  for OCW;  $p=0.604$ ), fatigue ( $\Delta\text{fatigue}=7$  for CW and  $6$  for OCW;  $p=0.837$ ) and recuperation ( $51$  for CW and  $61$  for OCW;  $p=0.094$ ).

## Outcome of treatment of work-related myofascial pain syndrome using a sequenced interdisciplinary rehabilitation protocol

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**Background:** Myofascial pain syndrome (MPS) is a common cause of Work-Related Musculoskeletal Disorder (WRMSD).

**Methods:** A retrospective study was conducted among 23000 clients diagnosed with WRMSD, with a mean age of  $32 \pm 4$  years to estimate the prevalence of MPS and to describe the clinical features and outcome of treatment. The relevant clinical data were extracted from the treatment chart from a tertiary level Rehabilitation Centre or on-site Occupational Health Clinics. All the clients received a sequenced, interdisciplinary treatment protocol incorporating combination of trigger point therapy, dry needling, muscle energy technique, myofascial release, taping, psychological approaches, yoga, exercises and ergonomic modifications.

**Results:** 86% of participants were diagnosed to have MPS. The commonest region affected was the upper back (58%), followed by the low back (48%). 82% were male and 60% worked for 8-12 hours. The commonest job categories of the participants were Software Engineers (35%), Managerial (32%) and Application Engineers (18%). Prolonged sitting, lack of rest breaks, lack of tray for keyboard and mouse (when required), and poor posture was found to be the commonest risk factor. Associated co-morbidities were Hypovitaminosis D (24%), Hypermobility joints (18%), Low Bone Mineral Density (12%), Hypothyroidism (6%) and Hyperuricemia (6%). The commonest symptoms were Regional pain (82%), Stiffness (64%), Weakness (30%), Disturbed Sleep (30%), Fatigue (24%), Generalised pain (18%), Tingling (18%) and Numbness (16%). There was a significant reduction ( $p < 0.05$ ) in pain following the rehabilitation. 94% of the subjects made a complete recovery, whereas 6% recovered partially but were able to continue working full-time without absenteeism.

**Conclusions:** In view of the high prevalence of MPS in this study, healthcare professionals dealing with musculoskeletal pain need to be trained in the current approaches to diagnose and manage MPS. A comprehensive, protocol-based interdisciplinary approach was found to be successful in the management of MPS.

## Effectiveness of onsite occupational health clinics in management of work-related musculoskeletal disorders in information technology professionals

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The aim of this study was to find out the outcome of management of WRMSDs in on-site occupational health clinics in an IT company over a 11-year period. The study covered 12000 employees who were diagnosed by an experienced occupational health physician to have a WRMSD. All the employees then underwent an ergonomic workplace analysis and protocol-based rehabilitation for the WRMSD by specially trained occupational physiotherapists. The employees were reviewed by the OHP monthly and at the completion of rehabilitation. After the rehabilitation, the VAS scale showed significant reduction in pain levels ( $p < 0.01$ ). 74% had reported reduced productivity due to the WRMSD, which improved markedly after the rehabilitation. 94% of workers reported complete resolution of symptoms and 6% reported partial resolution of symptoms but could work without restriction. No employee had to take leave for more than 7 days or leave the job due to WRMSD. The onsite occupational health clinics was effective in the management of WRMSD in the IT companies. A comprehensive ergonomic program that involves primary prevention of WRMSD through ergonomic changes in jobs, early detection of WRMSDs through surveillance, and early treatment of WRMSDs with an emphasis on early return to modified work is recommended.

## Evidence based sustainable interventions for safer working amongst office employees, physicians and paramedical staff

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**Background:** Use of computers and hand-held devices increase risk of musculoskeletal disorders (MSDs). More time spent on this activity in faulty postures, higher the risk of acquiring them. Today, top priority in offices and community is creating awareness on safe working postures and training individuals on sustainable behavior change to work ergonomically.

Hence training interventions for ensuring wider coverage of office ergonomics awareness to promote safer working and suggesting sustainable programs for behavior change were explored.

**Methods:** A cross-sectional study was conducted (September 2018 – April 2019), encompassing 1] corporate office employees of multinational corporations selected from India and South East Asia including Indonesia & Singapore, 2] Hospital staff, Medical College & MBA college students in India, 3] General & Occupational Health Physicians at Seoul and Philippines. The participants (n=725) were divided into 2 groups to study the effect of interventions; (a) detailed training: forty minutes lecture by investigator with a power point presentation (n=622) using a mock workstation and (b) short training: live ten minute demonstrations (n=103) using a live workstation on office premises.

**Results:** While detailed training enhanced awareness >95% and short training >97%, the latter was much appreciated and educated more individuals. From statistical analysis, quick training was found superior in providing comprehensive training and influencing behavior modification in India, however in other countries, it was found superior in knowledge enhancement, skills enrichment in addition to providing comprehensive training (p< 0.05)

**Conclusions:** As few attend deep training, the quick ten-minute demonstration is highly promising as it is very simple to understand, practical, easily replicable, yields increased awareness with wider coverage in a short time, instilling a feeling of caring and confidence amongst participants towards following a robust office ergonomics control program in offices and could lead to propose as a best practice for the community and corporate offices globally.

## **An on-line intervention tool for reducing musculoskeletal discomfort amongst individuals working with computers and laptops from home**

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Emphasis on maintaining safe work postures, ergonomic arrangement of workstations, optimizing chair functions & performing desk stretches, thereby reducing musculoskeletal discomfort is necessary for behavior modification, as employees today work from home, with flexible work hours. An on-line web-based technique to promote safer working and achieving behavior change when working from home was evaluated.

A cross sectional study was done by visiting homes in 3 housing estates in Kolkata. A pretested Nordic questionnaire was sent on-line to the study participants. After completing questionnaire, they were immediately trained on correct postures and office ergonomics with animation graphics. After 3 months, the same questionnaire was sent to all participants who responded earlier.

Of 410 participants, who responded, 49.50% had musculoskeletal symptoms, 61.60% lower back pain, 52.40% upper back pain, 58.30% wrist pain, 42.5% shoulder pain and 39.20% knee pain. The percentages are high as some participants had multiple complaints. Subsequent 3-month evaluation showed a significant 41-50% decline in symptomatology. We conclude that intervention with web-based animation graphics is a highly efficient technique to create office ergonomics awareness and sustained behavior modification. It has potential to become a best practice in remote locations and where language is a barrier for communication.

## Integrated care for work participation among orthopaedic surgery patients – a systematic review with meta-analysis

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**Introduction:** Orthopaedic surgery is primarily aimed at pain reduction and restoration of function. However, care focussing on return to work (RTW) and other activities of daily life is often lacking. Integrated care, like active referral to case-managers, goal-directed rehabilitation or e/mHealth might enhance work participation and performance of activities. We systematically reviewed the effectiveness of integrated care interventions for orthopaedic surgery patients.

**Methods:** A search in Medline, EMBASE and CINAHL was performed until February 2018 and two reviewers independently screened references and potentially full papers for eligibility. Studies describing controlled trials evaluating the effectiveness of integrated care interventions on work participation and performance of activities were included. We performed data-extraction, risk of bias assessment, and a meta-analysis in case of sufficient homogeneity.

**Results:** After screening 5,941 records, we found four studies evaluating work participation (n=1,182) and seven studies regarding performance of activities (n=700). Work participation was defined as work status or time to RTW and performance of activities was mostly self-reported. Integrated care reported a statistically significant effect in one study: 10% not returning to work instead of 18%. However, time to RTW was not significantly different after integrated care versus usual care, 29 vs 45 weeks and 7 vs 5 weeks, respectively in two other studies. One study did not report RTW 'due to the large number of participants not working at baseline'. Our meta-analysis showed that integrated care was effective in improving performance of activities (mean difference [95% CI]: 4.0 [2.0 6.0], scale 0-100).

**Conclusions:** Integrated care for orthopaedic surgery patients showed positive effects compared to usual care for work participation and performance of activities. However, effect sizes were small and inconsistent. High quality studies on especially work participation are needed to better inform patients, practitioners and policy makers regarding benefits of integrated care after orthopaedic surgery.

## Comparisons of whole body vibration exposures and related musculoskeletal stress between single-axial passive and multi-axial active suspension in a mining vehicle application

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**Background:** Mining vehicle operators are exposed to high levels of whole body vibration (WBV) due to rough terrain in the mining environment. WBV has been associated with work-related musculoskeletal disorders (WMSDs). Mining vehicle operators' WBV exposures consist of highly impulsive and substantial non-vertical components (e.g., lateral vibration). However, the current industry standard seats are known to have limited performance in reducing the non-vertical exposures. Therefore, this study aimed to evaluate the relative effectiveness of a multi-axial (lateral + vertical) active suspension in reducing overall WBV exposures and related musculoskeletal stress as compared to an industry standard single-axial (vertical) passive suspension seat.

**Methods:** In a repeated-measures laboratory study with 13 subjects, actual field-measured mining equipment vibration profiles were recreated on a 6-degree-of-freedom motion platform. With the subjects sitting in each seat, WBV exposures were collected per the ISO 2635-1 WBV standard; net joint torques were measured in the low back (L5/S1) and neck using a 3-D motion capture system; and muscle activity was measured in low back (erector spinae) and neck (splenius capitis) using electromyography.

**Results:** The multi-axial active suspension seat was more effective in reducing vertical (Z-axis) WBV exposures as compared to the current industry standard passive suspension seats ( $p < 0.001$ ). However, no differences in lateral (Y-axis) WBV exposures were found between the seats. Relative to the single-axial passive suspension seat, the multi-axial active suspension seat reduced the lower low back joint torques in the sagittal plane ( $p=0.01$ ), while no significant differences in the low back and neck joint torques were found in the coronal plane between the two seats. The variability of muscle activity in the low back and neck were relatively high and hence no statistical significant differences were observed.

**Conclusions:** The lower joint torque and muscle activity suggest that the multi-axial suspension may have potential to reduce musculoskeletal stress and disorders.

## A Cochrane Review: Ergonomic interventions for preventing work-related musculoskeletal disorders of the upper limb and neck among office workers

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**Introduction:** Work-related upper limb and neck musculoskeletal disorders (MSDs) are one of the most common occupational disorders worldwide. Ergonomic interventions are likely to reduce the risk of office workers developing work-related upper limb and neck MSDs. The aim of the study is to assess the effects of ergonomic interventions for the prevention of work-related upper limb and neck MSDs among office workers.

**Methods:** Ten databases and the World Health Organization's International Clinical Trials Registry Platform were searched. Randomised controlled trials (RCTs) of ergonomic interventions for preventing work-related upper limb or neck MSDs among office workers were included. Data which are judged to be sufficiently homogeneous were included in the meta-analysis.

**Results:** Fifteen RCTs (2165 workers) were included. The main findings were there is moderate-quality evidence that an arm support with an alternative computer mouse (two studies) reduced the incidence of neck or shoulder MSDs (risk ratio (RR) 0.52; 95% confidence interval (CI) 0.27 to 0.99), but not the incidence of right upper limb MSDs (RR 0.73; 95%CI 0.32 to 1.66); and low-quality evidence that this intervention reduced neck or shoulder discomfort (standardised mean difference (SMD) -0.41; 95% CI -0.69 to -0.12) and right upper limb discomfort (SMD -0.34; 95% CI -0.63 to -0.06). Other interventions showed inconsistent evidence.

**Conclusions:** There are evidence that the use of an arm support together with an alternative mouse may reduce the incidence of neck or shoulder MSDs. Further high quality studies are needed to determine the effectiveness of these interventions among office workers.

## Reaction Parameters Linked to Cumulative Trauma Disorders during Use of Powered Tightening Tools: A Literature Review

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**Background:** The impact of physical reactions on human operators generated by handheld powered tightening tools has been researched by evaluating various parameters, here referred to as 'reaction parameters'. The objective of this literature review is to investigate which reaction parameters commonly are assessed during physical load evaluations of tightening tools, as well as reported correlations between reaction parameters and risk of developing cumulative trauma disorders (CTDs). An additional aim is to map exposure limits established for reaction parameters and identify knowledge gaps regarding tightening tool impact on operators, if any.

**Methods:** A systematic approach was adopted to review relevant literature, following the PRISMA flow-diagram. Synonyms of defined keywords were combined for search in 3 databases. 76 articles were read and evaluated against inclusion criteria, of which 47 articles were included in a qualitative synthesis. An overview of the assessed reaction parameters was obtained, as well as suggested linkages between these parameters and risk of injury development.

**Results:** Main parameters studied in literature are reaction force/torque (79%) and handle displacement (74%). Impulse and handle velocity are studied in 26% and 15% of the articles, respectively. 51% of the studies also report a correlation between assessed reaction parameters and risk of developing CTDs. Three studies present exposure limits for reaction parameters. 1/3 of the studies were conducted on electric tools, whereas approximately 2/3 were performed on pneumatic tools.

**Conclusions:** There is a knowledge gap concerning several reaction parameters and their implications for developing CTDs, especially regarding impulse, tool handle velocity/acceleration and grip force. Their influence is suggested to be explored in further studies. Establishing exposure limits related to the reaction parameters would translate the scientific knowledge into industrially applicable recommendations. Further, the need for studies on electric tools is evident, due to a shift in the industry from pneumatic to electric tools.

## A participative toolkit for workplace users to assess and control risk of musculoskeletal disorders (MSDs)

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**Background:** No existing MSD risk assessment tool covers the full range of biomechanical and psychosocial hazards, and most workplace managers are unaware of requirements for effective MSD risk management. Accordingly, current workplace risk assessment methods ignore some potentially important hazards.

Addressing this situation, A Participative Hazard Identification and Risk Management (APHIRM) toolkit has been developed, incorporating an innovative risk assessment procedure.

**Methods:** Data collection methods were formulated within a theory-based framework and implemented in four large workplaces. Risk assessment methods included: physical measurements and analyses by an experienced ergonomist; observation-based ratings by non-experts; and an employee survey (ratings of own hazard exposures, and outcome scales: discomfort/pain, and whether time lost; stress; fatigue). Workplace records of MSD-related lost time injuries were also obtained.

**Results:** Factor analyses of survey responses (n=493), identified a range of work-related constructs which were then used in regression analyses. A model predicting Discomfort/Pain Scores was highly significant (adjusted R<sup>2</sup>=0.31); workplace predictors were: Biomechanical hazards; WOAQ (psychosocial hazards); Work faster for deadlines, targets; and Workload (Beta=0.292, 0.242, 0.152, 0.145 respectively; p=0.001 or less). Time employed in the job was also significant. For employees with discomfort/pain (n=387), a logistic regression model predicting whether they took time off due to pain was highly significant (Nagelkerke R<sup>2</sup>=0.22) with WOAQ score as the only workplace predictor (Wald=51.9, p=0.000). Other predictors were Discomfort/pain score, Time in the job, and Gender. Scores derived from employee ratings of their hazard exposure levels were much stronger predictors of discomfort/pain and lost time than were scores from the other risk assessment methods.

**Conclusions:** This employee survey provides a valid means of assessing MSD risk. The survey has been incorporated in the APHIRM toolkit, along with participative procedures to facilitate development, implementation and evaluation of MSD risk control actions targeting hazards identified by data analyses as most influential.

## Physical load of rescue workers during patient transport in stairwells

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**Background:** Patient transportation on staircases is a demanding task for paramedics. Higher risk of MSD by handling heavy weights could be reduced by special patient transportation devices (PTD). As new types of PTDs are available, this study compares the physical load by using different PTDs and the potential of load reduction.

**Method:** 16 male paramedics (age:  $29 \pm 3.3$  years; height:  $181 \pm 6$ cm) transported in pairs a patient dummy (75kg plus 20kg measuring technology) over two floors downstairs, using a common type (evacuation sheet (ES)) and an alternative type (sled-type evacuation sheet (SES)) of PTD.

On-body motion tracking was done using the inertial CUELA measuring system in combination with force grips mounted to the PTDs to measure three-dimensional hand forces (HF). The subjects also rated their perceived exertion (RPE) using the different PTDs.

Lumbosacral-disc compressive forces (LCF) were estimated applying the current version of the biomechanical model "The CUELA Dortmunder" [1, 2].

Hand forces and LCF for each transport cycle were identified and the RPE level were calculated for the group and tested for significant differences.

**Results:** The results for the ES (P95-HF:  $506 \pm 32$  N; P95-LCF:  $4.1 \pm 0.4$  kN) were significant higher than those for the alternative SES (P95-HF:  $360 \pm 36$  N; P95-LCF:  $3.1 \pm 0.7$  kN). The RPEs for the ES ("somewhat hard" to "hard exertion") were also significantly higher than the ratings for the SES ("light" to "somewhat hard").

**Conclusions:** The study results indicate that the physical load of paramedics during transport in stairwells could be reduced by the tested alternative PTD.

[1] M. Jäger, A. Luttmann, R. Goellner und W. Laurig, The Dortmunder: Biomechanical Model for Quantification and Assessment of the Load on the Lumbar Spine, SAE Transactions, 2001.

[2] R. Ellegast, I. Hermanns und C. Schiefer, Workload assessment in field using the ambulatory CUELA system, Digital human modeling, 2009.

## Motion-based estimation of back loading during manual material handling tasks

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**Background:** A clear relationship between back disorders and physical load has been established. Numerous studies evaluating back loading during manual material handling (MMH) tasks were based on a motion-capture system associated with force plates. Their use reduces the ecological aspect of the tasks by constraining the analysis area to the force plates. Recent methods allow the estimation of external forces from only motion data. Hence the objective was to validate back loading obtained only from motion data during realistic MMH tasks.

**Methods:** The estimation of external forces (acting on the feet and hands) was based on a previous approach using a contact model with optimization techniques [1], initially developed to estimate ground reaction forces. From a set of hypothesized contact points between the subject and the environment (ground and load), external forces were calculated as the minimal forces at each contact point while ensuring the dynamic equilibrium. With an inverse dynamic method, back loading assessed from the L5/S1 joint moments was computed using the estimated external forces. The proposed method was validated on 65 subjects performing MMH tasks which consisted of transferring 128 boxes from a conveyor to a hand trolley. Motion data were based on an optoelectronic motion-capture system. Ground reaction forces from a force plate were used for the validation of the method.

**Results:** By averaging the results of all experiments, the correlation coefficient between the measured and estimated L5/S1 joint moments was 0.95 for the flexion/extension component and the associated RMSE was 14 Nm.

**Conclusions:** The proposed method showed that back loading can be estimated during MMH tasks from only the motion data. It improves the ecological aspect of the tasks by not constraining the movement area and the handling techniques.

### References:

[1] Fluit, R. et al. (2014). Prediction of ground reaction forces and moments during various activities of daily living. *J Biomech*, 47(10), 2321-2329.

## Low back pain risk assessment: combining trunk kinematic and electromyographic data through a deep learning neural network

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**Background:** Low-back loading during manual lifting is recognized as a risk factor for low-back disorders. However, there are still few field-assessment methods for estimating low-back loadings continuously. We propose to combine trunk kinematic data from two inertial sensors and surface electromyography (EMG) from two muscles to feed a deep learning neural network in order to estimate the L5/S1 joint moment.

**Methods:** Data from three previous laboratory studies provided manual material handling trials diversity in terms of expertise (30 experts, 22 novices), sex (33 males, 19 females), fatigue and tasks across 52 subjects, for a total 1200 minutes of handling. Six characteristics based on the kinematics of two segments (upper trunk and pelvis) and 50 characteristics derived from the EMG of a muscle pair (longissimus at L1, bilaterally), served as a total of 56 inputs to a long short-term memory network. Classical grid search was performed to adjust the parameters of the stacked networks. Training used 85% of the time series data, and 15% of the data was kept for external validation. The criterion L5/S1 joint moment was computed from a bottom-up inverse dynamic model, using a force-plate and the kinematic data from an optoelectronic system.

**Results:** Performance on the external validation data demonstrates a median coefficient of determination ( $r^2$ ) of 0.80, and a median root mean square (RMS) error of 20 Nm in flexion-extension (< 20%). Lateral flexion results were inferior ( $r^2 = 0.6$ , and RMS = 14 Nm). The approach is robust to muscle fatigue and can also estimate cumulative L5/S1 joint moment with less than 10% error.

**Conclusions:** A field-assessment method is available for estimating the L5/S1 joint moment continuously during handling. Only two inertial sensors (upper trunk and pelvis) with the surface EMG from the longissimus muscle bilaterally are needed, without any prior calibration.

## Monitoring working activities with inertial and magnetic sensors in place of video cameras: what are the advantages?

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Recognizing and monitoring human motor activities that might cause Work-related Musculoskeletal Disorders (WMSDs) is of great importance in the prevention of occupational diseases and the assessment of workplace safety. In turn, deterioration of workers' physical health and loss of workdays impact not only their well-being, but also European countries economy.

Video footage analysis is the standard for assessing biomechanical overload. This method requires minimal hardware set-up and does not interfere with workers activities. However, it lacks objectivity, allows to estimate the kinematics just in 2D, and its accuracy depends on the operator's ability and the working context [1].

Nowadays, inertial and magnetic sensor units (IMUs) might open a new perspective in the objective measure of WMSDs. They consist of lightweight sensing units which typically comprise a 3D accelerometer, gyroscope, and magnetometer. Small-size and wireless data transmission allow one to collect data on work activities under free conditions and over extended periods of time. Usually, on-board processing allows fusing inertial and magnetic data in a Kalman filter in order to obtain 3D orientation estimates for both static and dynamic movements. Body postures and joints kinematics are then obtained using a biomechanical model based on anatomical reference systems [2].

In this study, multiple workers were instrumented using 5 IMUs (WaveTrack®, COMETA, IT) and video recorded during their working tasks. One of the most challenging acquisition due to the environmental conditions dealt with deboning of chicken meat. IMUs allowed the reconstruction of joint angles of elbows and shoulders in the three main anatomical planes. Video footage was processed with Kinovea but the identification of anatomical landmarks of the upper limbs was difficult due to the presence of the clothes. Hence, the agreement between IMUs and video was not always good.

[1] Valero E. et al. Appl Ergon 2016; 54:120-130

[2] Cutti AG. et al. Med Biol Eng Comput 2010; 48:17–25

## In Vitro Fatigue of Human Flexor Digitorum Tendons

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**Background:** There is mounting evidence that occupational tasks involving force and repetition cause musculoskeletal disorders (MSDs) in a manner resembling the fatigue failure process of materials. Implementing this knowledge into ergonomics risk assessment tools can increase accuracy and allow for the assessment of cumulative risk from multiple tasks. This study derived the in vitro fatigue failure model for the flexor digitorum profundus (FDP) and superficialis (FDS) tendons, often associated with carpal tunnel syndrome and trigger finger, to be implemented into risk assessment tools for the upper limb.

**Methods:** Eighteen specimens were quasi-static tensile tested for ultimate tensile strength (UTS). Thirty-five specimens were tested for modeling the fatigue life using a sinusoidal wave pattern. Three levels of maximum stress were established: 40% (3Hz), 60% (2Hz), and 80% (1Hz) of UTS.

**Results:** Results from the quasi-static test ranged from 23.9 MPa to 53.8 MPa UTS with a mean value of  $41.13 \pm 10.1$  MPa. For the fatigue life tests, a high degree of variability was found within each test level, yet a linear regression model still found stress to be a highly significant variable ( $p$ -value = 0.003). A power model was fit to the data, resulting in:

$$S = 0.8618 * N^{-0.073}; (R^2 = 0.6904)$$

where S is the normalized stress (%UTS) and N is the number of cycles expected to endure until macroscopic failure. The ultimate strain, measured from the cross-head displacement, had a mean value of  $11.0 \pm 3.1\%$ .

**Conclusions:** The Distal Upper Extremity Tool (DUET) has demonstrated high success predicting pain and injury outcomes by utilizing a risk algorithm derived from the in vitro fatigue of human foot tendons. This study enhances that tool by deriving the fatigue failure model for the tendons actually associated with the MSDs that DUET aims at predicting, carpal tunnel syndrome (CTS) and trigger finger.

## Alternations between physical and cognitive tasks – does temporal pattern and cognitive task difficulty influence fatigue development?

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**Background:** Some evidence suggests that alternations between physical and cognitive work tasks may be a viable option for job rotation, since production can be maintained without excessive fatigue. Effects on fatigue and pain of the temporal distribution of physical and cognitive tasks are, however, uncertain. The aim of this study was to examine development of fatigue and pain during physical and cognitive work tasks of different difficulties, alternating in different time patterns.

**Methods:** Fifteen women performed alternating bouts of a physical task (phys) and a cognitive task (CT) for a total of 100 minutes. Four experimental conditions were tested in a repeated-measures design. Conditions 1 and 2 consisted of five long-cycle sequences (phys+CT, 14+6 minutes), and in conditions 3 and 4, 10 short-cycle sequences (7+3 minutes) were performed. Each temporal pattern was completed with an easy or a difficult CT. Muscle fatigue was assessed using surface electromyography (EMG) from the right trapezius, and perceived fatigue and pain in the right shoulder was assessed using CR-10 ratings. Effects of time and experimental condition on these outcomes were tested using ANOVA.

**Results:** Perceived fatigue and pain in right shoulder after pipetting work bouts increased in all four conditions (long-cycle, fatigue  $F=5.68$ ,  $p<0.001$ , pain  $F=4.12$ ,  $p=0.01$ ; short-cycle, fatigue  $F=10.59$ ,  $p<0.001$ , pain  $F=5.45$ ,  $p<0.001$ ). Trapezius EMG did not change significantly across work bouts (long-cycle,  $F=2.14$ ,  $p=0.09$ ; short-cycle,  $F=1.03$ ,  $p=0.42$ ). Irrespective of the temporal alternation pattern, neither EMG nor fatigue and pain were influenced by CT difficulty (CT main effect and CT×time interaction: EMG, all  $F\leq 2.5$ ,  $p\geq 0.1$ ; fatigue and pain, all  $F\leq 2.0$ ,  $p\geq 0.7$ ).

**Conclusions:** The temporal pattern of alternations between a repetitive physical task and a CT did not influence fatigue development, and the difficulty level of the CT did not significantly influence fatigue and pain, irrespective of the temporal alternation pattern.

## Occupational and leisure time physical activity and multiple pain sites in construction and healthcare workers during 2-year follow-up

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**Background:** Occupational physical activity (OPA) is often associated with higher prevalence of musculoskeletal pain, while leisure-time physical activity (LTPA) is associated with a reduction in musculoskeletal pain. The purpose of this study was to examine this health-paradox by analysing the association between OPA and number of pain sites (NPS), the association between LTPA and NPS, and whether a possible association between OPA and NPS was moderated by LTPA.

**Methods:** At baseline, 99 workers (construction n=45; healthcare n=54) wore Actiheart®4 (Camntech, Cambridge, United Kingdom) monitors for 1-4 consecutive days, during work and leisure. As a measure for physical activity we calculated the average duration (hours) with work  $\geq 33\%$  of the heart rate reserve (HRR), and the average duration (hours) with leisure  $\geq 40\%$  HRR. At baseline and every 6 months for two years, participants reported on NPS (0-9). Confounder adjusted associations between HRR and NPS were examined using linear mixed models for the whole sample and stratified by sector.

**Results:** OPA measured as time  $\geq 33\%$  HRR was not associated with NPS ( $\beta=0.025$ , 95% CI -0.29 -0.34) in the whole sample, nor when stratifying by sector (construction:  $\beta=0.31$  95% CI -0.26-0.88; healthcare: -0.086 CI -0.5-0.33). Increased LTPA time  $\geq 40\%$  HRR showed a decrease in NPS ( $\beta= -0.97$  95% CI -2.0-0.05); the negative association was stronger for healthcare ( $\beta=-1.83$  95% CI -3.7-0.04) than construction workers ( $\beta=-0.74$  95% CI -2.0-0.55). LTPA  $\geq 40\%$  HRR did not modify the association between  $\geq 33\%$  HRR at work and NPS ( $\beta=-0.03$  95% CI -0.61-0.56).

**Conclusions:** OPA measured with time  $\geq 33\%$  HRR was not associated with NPS in construction or healthcare workers. In contrast, our results suggests LTPA may be associated with fewer pain sites in healthcare workers. The health-paradox is partially supported for healthcare workers, as longer durations of OPA did not reduce NPS, while LTPA had a tendency to do so.

## Mobile app for employees as intervention to provoke a healthy physical workstyle

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**Background:** Ergonomic interventions often focus on the implementation of new technical aids or organizational measures. The impact of these interventions strongly depend on how much the newly introduced aids or methods are used in practice. It is therefore important to pay attention to employee behavior and workstyle. The aim of the app we developed is to support employees in making healthy and well considered workstyle choices during their day-to-day work tasks that involve high physical load.

**Methods:** During the development of the app we simplified well established risk assessment tools such as NIOSH and HARM (Douwes and de Kraker, 2014) and made them applicable at the individual level. Data from these tools is combined with standardized questions on physical complaints and local muscular discomfort. Dominant behavioral change theories were selected for moments of interaction with the employee. The app was evaluated at three companies in different sectors. The evaluation of the app focused on usability, risk-awareness and impact (preventive actions taken and solutions implemented).

**Results:** The first phase of the app contains a self-assessment in which the employee performs his own risk-assessment. The results of the self-assessment are returned to increase awareness of the users physical workload. Subsequently, an action plan is offered to reduce the physical workload (phase 2) and reminders and encouragements are given to increase compliance (phase 3). Results of the evaluation show that risk-awareness improves among users of the app and that reminders from the app are considered helpful. App-use did not (yet) lead to the implementation of new measures.

**Conclusions:** A mobile app for employees seems a useful addition to the currently existing preventive interventions, especially regarding risk awareness. Implementation of the app can, through an increase in risk-awareness and employee motivation, lead to a higher impact of ergonomic interventions.

## What happens with ergonomics after relocation to a flex office?

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**Background:** Flex offices have increased in popularity. In a flex office employees do not have personal workstations, but choose a workstation depending on work task. Theoretically this could increase variation, but could also lead to a deterioration of the ergonomic situation. The aim of this study was to evaluate how workstation ergonomics are affected when relocating from cell office to a flex office.

**Methods:** This longitudinal study used parallel mixed method design. A total of 220 employees relocated from a cell office to a flex office. Focus group interviews with questions about ergonomics were performed at 6 and 18 months after relocation. Sit comfort, work posture and musculoskeletal symptoms were assessed by questionnaires at 6 months before and 18 months after relocation.

**Results:** Employees discussed sitting, standing and ergonomics intertwined in the interviews. Ergonomic equipment was overall perceived as good although adjustments of chairs were perceived as difficult and time consuming, and the importance of ergonomic training was highlighted. Strategies for ergonomic adjustments of workstations varied, some never adjusted the chairs while some always did. In the interviews some employees reported increased headache, back- or neck pain while many did not experience any changes of musculoskeletal symptoms. In the questionnaires ratings for sit comfort and work posture decreased ( $p < 0.001$ ) from baseline to 18 months. Symptoms from the neck increased ( $p = 0.007$ ) between baseline and 18 months, but no statistically significant changes were seen for the back, lower extremities, headache or muscle tension.

**Conclusions:** The ergonomic situation worsened and neck symptoms were more common 18 months after relocation to a flex office. Organizations should implement mandatory ergonomic training and purchase equipment easy to adjust. More studies on ergonomic aspects in flex offices are needed.

## Working while working out – Using two types of dynamic office workstations (DOWs) with two intensities and the effects on tasks with various complexity

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**Background:** DOWs have proven to be an effective measure for the prevention of physical inactivity at office workplaces. Therefore, possible effects of using a cycling and a pedalling device with two different intensities on cognitive performance and office work were assessed in a laboratory study.

**Methods:** The study was conducted as a randomized trial, where 40 participants were required to complete task batteries while using one of the DOWs. The task battery consisted of tasks assessing inhibition, short-term memory, selective and sustained attention and text processing, precision when using the mouse and mathematics. Participants completed this task battery in a simple and in a complex version while being seated, while using the DOW with a light (45 % HRmax) and with a moderate (55 % HRmax) intensity. Contents of the tasks varied within, the order of the intensities and the type of task battery (simple and complex) were randomized. For the comparison of intensities of using DOWs to working while seated, a repeated measures analysis of variance (rANOVA) was used.

**Results:** No significant effects were found for the intensity of using DOWs on cognitive performance compared to the seated control condition. Furthermore, there were significant detrimental effects on mouse work (score in the simple mouse task, score and latency in the complex mouse task) and on the accuracy in the complex text processing task. The work performance did not differ between the two intensities. Additionally, no significant effects were found comparing the two types of DOWs.

**Conclusions:** It can be concluded that using both types of DOWs does not interfere with work performance, except for tasks requiring a high motor control.

## Reasons for use and non-use of sit-stand workstations – results of a qualitative study among office workers with long-term access to sit-stand workstations

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**Background:** Earlier, in a questionnaire study among computer workers with long-term access to sit-stand workstations we found that users and non-users of sit-stand workstations have different perceptions on the use of their sit-stand workstation. The aim of the present study was to further explore the reasons for use and non-use of sit-stand workstations in this population in order to inform the development of targeted interventions to reduce sedentary behaviour at work.

**Methods:** In a qualitative study, four focus group interviews (n=20) were held with office workers who have had long-term access to a sit-stand workstation; two groups with users of the sit-stand workstation and two with non-users. Following a semi-structured interview guide, reasons for use and non-use of the sit-stand workstations and perceptions on how to increase the use were discussed. Data were transcribed verbatim and analysed using ATLAS.ti software. Two data coders used thematic analysis to code all data.

**Results:** The main reasons for using the sit-stand workstation in a standing position were related to health benefits. Non-users mentioned more often general health benefits (e.g. increased blood flow), while users mainly mentioned specific short-term musculoskeletal health benefits (e.g. relieving back and neck problems). Reasons for non-use were mostly related to the persistent habit of sitting and to practical reasons (e.g. time to adjust the workstation to a standing position, limited working space, wearing uncomfortable shoes). Two suggestions were formulated to increase future use of sit-stand workstations: i) information on health hazards and benefits of sitting, standing and moving; and ii) reminders (e.g. screen prompts) to break up sitting time.

**Conclusions:** Users and non-users differed with respect to their views on the health benefits of using sit-stand workstations. This implies that different intervention approaches may be needed for different user groups to prevent prolonged sitting in the office.

## Implementation of Ergonomic Intervention on Some Unorganized Sectors Workplaces at India

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A large number of workers are involved with different types of jobs in the informal or unorganized sectors in developing countries. The workplaces under these sector share the common characteristics, viz., intense human labor, prolonged work hours, no work-no pay system, irregular work schedule and lack of safety standers.

In the present article, three different sectors were identified and 100 male workers were randomly selected from these each unorganized sectors of sand core worker, goldsmiths and carpenter from West Bengal, India. Physical parameters of the workers of this study were measured. A detailed questionnaire study on discomfort feeling was done by the modified Nordic questionnaire. The existing workstations were assessed by the measurement of work areas. Analysis of body posture was done to evaluate the work stress during their job. A new ergonomic intervention was introduced to the unorganized sectors with their active suggestions. Subjects were interviewed at the end to ascertain intervention acceptance.

The study revealed that all these three unorganized sectors jobs are performed in awkward postures, with the potential risks of musculoskeletal disorders primarily affecting the low-back region.

The modified process at sand core process enhanced productivity in both types of core making processes. Blowing Pipe activity of the goldsmiths increases the fatigue of facial muscles. An ergonomic intervention (hand air pipe) eliminate the hazards of manual Blowing Pipe activities of the goldsmiths. As indicated by RULA action levels, most of the postures adopted by carpenters with existing handle are awkward and non-liner in nature. Ergonomically modified handles of hand saw reduce the fatigue of hand muscles and improve the carpenter health during work.

### **Keywords**

Intervention, Productivity, Health, Safety, Unorganized Sectors

## Inclusion of HFE Principles in the Development of a National Design Standard for Ambulances

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**Background:** The design of ambulances play a significant role in how emergency medical services personnel perform their duties. Unfortunately, conventional ambulance designs have been often placed EMS personnel in health-compromising situations, contributing to the high rates of injury and fatality among EMS personnel, and their early retirement on medical grounds. A Canadian research and development study was launched to develop a standard for ambulances with the inclusion human factors and ergonomic (HFE) principles.

**Methods:** In order to inform a standard that is inclusive of HFE and consistent with existing practices, a series of three research studies were conducted and triangulated to develop a seed document for the Standard. This paper discusses the results of an environmental scan of jurisdictionally relevant guidelines to extract its considerations for HFE, a series of interviews with key informants to understand the current application of HFE in the design, and procurement processes of ambulances, and a scoping review of evidence-based HFE intervention studies.

**Results:** Findings from these studies provide different aspects to the seed document. The scoping review reveal that the majority of research on HFE interventions for EMS personnel focus on identifying the problem. Also, the environmental scan reveals that there is a variety of guidelines used by different provinces in Canada and that they does not consider HFE principles. The interview study of key informants revealed the barriers to incorporate HFE principles into ambulance design standard and how the standard could be used within the EMS work system. The seed document generated by the triangulation of the three data source is used as a working document for a multi-stakeholder technical committee of 39 members from academia, manufacturers, labour, and government.

**Conclusions:** Incorporating HFE principles into design of equipment and tools used by workers could be done through a consensus based multi-stakeholder approach. This will ultimately result in better buy in from users.

## Inventory cost model with rest allowance based on effects of heat strain and metabolic cost

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**Abstract:** The heat stress management is vital for preventing any work-related disorders that can occur due to heat strain, such as muscle cramping, loss of consciousness and even death in some extreme cases. In this paper, we integrated rest time formulation with heat strain (Brake & Bates, 2002) to a new inventory cost model based on metabolic cost for preventing heat exposure. The effects of heat strain and rest allowance on the total cost of logistics operation and the economic order quantity (EOQ) model were investigated. The problem studied in this paper was transportation of fixed amount of raw materials by manual material handling with hand trolley and the study covers picking, storing and pushing motions for manual handling of the products. The developed new model considered the rest time for metabolic cost higher than the limiting metabolic rate for different quantities of handled items and item weights. The result of comparison with the EOQ implemented that our new model percentage saving from using heat strain and rest time was equal to 4.3% in the total cost of production line supply process. The result of parametric analysis have shown that higher the weight of item, higher the rest time necessary for preventing heat strain. Conclusively, the developed model analysis results were shown that the developed method using the heat strain and rest allowance concept with metabolic cost is appropriate to integrate ergonomic aspects into formal inventory cost model and for practices.

**Keywords:** Ergonomics, Manual material handling, Production line supply, Occupational heat stress

## Proposal for an integrated multi-method holistic approach for risk assessment (and management) of biomechanical overload on the musculoskeletal system in healthcare workers of a large Italian University Hospital.

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**Background:** healthcare workers operate in an occupational sector characterized by considerable organizational and content complexity. Here, we propose an integrated innovative approach for risk assessment of biomechanical load on upper limbs, lower limbs and spine.

**Methods:** the working group, composed by occupational physicians and members of the internal prevention and protection service, carefully revised the job plans of all the workers operating in different departments of a large University Hospital (about 7000 workers). Each job was scanned in elementary tasks and related biomechanical risk factors (strength, incongruous posture, repetitiveness), that were in turn measured in their extent and duration. Such methodology does not lead to the calculation of a synthetic risk index, but allows the work plans to be broken down and possibly reorganized into individual tasks, each classified according to three risk levels (acceptable, doubtful, dangerous). For each task, the risk level is obtained by integrating the results of more risk assessment methods among those proposed by the international literature.

**Results:** We present the results obtained carrying out our method on both nurses and support operators working in a medical and a surgical department. Each risk determinant was characterized in terms of duration and extent for all the tasks carried out, such as patient hygiene, patient dressing and mobilization, room and operating room sanitation, bed making, instrument sterilization, diagnostic interventions, patient transport, etc.

**Conclusions:** the proposed approach represents a technical-organizational instrument for risk assessment and management in an extremely complex sector such as healthcare. Among others, the careful analysis of job plans and related risks allows the occupational physician to express proper conclusions about work ability, pathological workers can be better located and preventive measures can be adopted in a more targeted way. As a consequence, collaboration between management and health and safety company figures is facilitated.

Keywords: healthcare workers, risk assessment, biomechanical overload

## The Composite Strain Index (COSI) to evaluate the wrist's biomechanical overload in the milking routine: the example of the Italian dairy sector

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Despite the mechanization of the modern dairy industry, in Italy the milking routine still requires the workers to perform multiple and repetitive subtasks such as udders' pre dipping, wiping/stripping, milking cluster attaching and udders' post dipping.

The purpose of the research were: 1) to assess a task-level Composite Strain Index (COSI) (1) from the milking subtasks, determined using the revised strain index (RSI); 2) to evaluate if the milking parlor configurations affect the biomechanical overload of the wrist in milking parlor workers.

The study was conducted in Lombardy region (Italy), where a sample population of forty milkers was recruited from twenty-one farms, representing the most widespread parlor configurations: parallel, herringbone and rotary. Five working cycles were observed for the dominant upper limb of each worker, for a total of 584 tasks. A RSI score was assigned to each milking subtask (pre dipping, wiping/stripping, attaching and post dipping). This method evaluates five task variables: intensity of exertion, duration of exertion, exertions per minute, hand/wrist posture and duration of task per day. This first evaluation allowed us to run the COSI assessment. This algorithm basically integrates biomechanical stressors when a task consists of exertions that are performed at different force levels and/or have different durations of exertion, and summarizes them at the task level. A COSI was obtained for each milking routine and the results were compared among the three parlor configurations. Data processing and statistical analyzes were performed using the programming language "R: A Language and Environment for Statistical Computing" - version 3.3.2.

The results showed that the algorithm classified as hazardous milking cycles in the herringbone and parallel milking parlors more than in the rotary ones. COSI is also demonstrated to be a useful method for assessing the risk of biomechanical overload in multiple and complex tasks jobs as the milking routine.

## Novel Instrumentation For Measuring Hand Effort Through Pressure Mapping And Contact Forces During Actual Task Performance

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**Background:** Five of the top 10 industries reporting work-related musculoskeletal disorders (WMSD), rely heavily on the use of hand tools. Understanding the forces on the hand in various tasks could allow human factors engineers to design better products, clinicians to understand hand strength required for a given profession, and safety regulators to specify standards for safe-working conditions. However, measurement of forces during common industrial activities has traditionally been challenging due the size, inflexibility, and obtrusiveness of common force measurement sensors such as load cells.

**Methods:** A hand contact pressure mapping system in the form of a wireless, wearable glove (TactileGlove by PPS) was developed. The TactileGlove is composed of 65 distinct capacitive based tactile sensing elements spread across the hand area (8 per finger, 9 per thumb, and 16 per palm) for meaningful and unobtrusive (2mm thin) measurements. Three pilot studies in hand tool ergonomics, establishing requirements for a product, and quantifying effort required to cut with a dull and sharp knife were conducted using the TactileGlove.

**Results:** The system was shown to be capable of resolving pressures as low as 0.1 N/cm<sup>2</sup> (1 kPa, 0.15 psi) and forces of 0.05 N (0.01 lbf), while having sufficient dynamic range to accommodate and measure peak pressures of 50 N/cm<sup>2</sup> (552 kPa, 80 psi). Sampling rate of 40Hz was sufficient for many measured daily activities such as lifting, grasping, controlling and industrial work.

**Discussion:** The amount and nature of data is much more complex than data from pressure, force and even flat pressure mapping sensors. Incorporating the TactileGlove into controlled studies enables researchers to assess the effort required for a task and quantify improvements from optimizing designs and processes. However, standard methods of analyzing the data are needed to establish safe threshold policies for workers.

## A wearable system for automated assessment of Hand Activity Level - a pilot study

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**Background:** Repetitive hand activity is a risk factor for work-related musculoskeletal disorders. The American Conference for Government Industrial Hygienists (ACGIH) threshold limit value (TLV) for hand activity is commonly used for risk assessments based on the observational method Hand Activity Level (HAL) and level of effort. HAL can be obtained objectively by video tracking (Akkas et al., 2015).

The aim was to develop and test a method using inertial measurement units (IMUs) and electromyography (EMG) for automated assessment of HAL and the TLV for repetitive manual tasks.

**Methods:** One 27-year 182-cm tall man participated. Three IMU sensors were attached along the dominant arm (back of the hand, forearm near wrist, upper arm). Bipolar EMG were picked-up from the wrist flexor muscle. The sensors were Bluetooth-connected to a laptop.

One camera was placed at the dominant side of the participant to record seven metronome-guided load transfer tasks of different frequencies and duty cycles (HAL-table-values: 1.2–5.5; Radwin, et al., 2015), with 0.25-kg (first) and 1-kg boxes. The computer vision HAL was used as the standard reference.

**Results:** Two average square root measures of the IMU sensors proved useful, of the 0.5-Hz high-pass filtered rectified acceleration from the hand, and of the rectified gyro-signal of the upper arm (UpperArmGyro). These measures correlated significantly with the 14 vision HAL-values, 0.96 (both).

The 95-percentiles (P95) of the EMG max-normalized RMS-level were in average 8.9 and 5.3%max for the seven trials per box. If using these EMG-values, the most rapid task of light weight and the two most rapid tasks of heavy weight (0.5, 1.3 and 0.7) were above the action limit of ACGIH, but still below the TLV-level.

**Conclusions:** Despite the need for further studies, the results indicate a potential for a smart objective HAL version - based on mobile devices and today's inexpensive electronics - with the possibility to cover full work days.

## A smart hand-wrist risk assessment method

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**Introduction:** Work-related musculoskeletal disorders in e.g. the hand/wrist are still common. Researchers in Lund have demonstrated a quantitative wrist angular velocity to wrist-related disorders relation (Nordander et al. 2013), the risk increases with force. They have recommended a median level action limit of 20 °/s. Assessments and analyses are today expensive and complicated. In this project we have developed an inexpensive and practical method.

**Methods:** A Smartphone was Bluetooth-connected to two IMU-devices and to an electromyography (EMG; bipolarly from the wrist flexors) amplifier for muscular activity. Wrist velocity was assessed from the absolute gyroscope signal from the back of the hand minus ditto from the forearm. The size of the errors were preliminary estimated by testing the system with large arm movement and fixed zero movement (the wrist was fixed to a ruler). A laboratory trial carried out with a box-transfer task, seven different paces, repeated twice with box weights of 0.25 and 1 kg. Further, the system was used in a field study with seven workers within hospital internal logistics.

**Results:** The mean absolute error was 4.7 °/s (sd 4.1), while the mean forearm absolute velocity was 158.8 °/s (sd 80.2). In the 14 trials of the box-transfer experiment, the range of the 50th and 90th percentiles were 2.1-27.6 and 8.6-41.3 °/s, respectively, the mean EMG 90th percentile was 3.3 and 5.2 %MVE, for the 0.25 and 1-kg boxes. In the field study, 6 of the 7 workers, replied that the system did not disturb their regular work, and that they could use it again (one complained about sensors under gloves).

**Conclusions:** Although further studies are needed, these results indicate a potential of the method to time-efficiently provide results that are easy to compare with the recommended action limit. It may be useful for companies, consultants and occupational health services to easily assess hand/wrist exposure.

## Narrative review of risk assessment methods applied in the agricultural setting for the prevention of musculoskeletal disorders

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**Background:** Agricultural industry comprises strenuous occupations with musculoskeletal disorders (MSDs) being some of the most common health outcomes. Understanding the ergonomic risk for MSDs is fundamental to set up preventive measures.

**Methods:** A narrative review of methods for biomechanical risk assessment applied in the agricultural setting is reported. A research string was launched on PubMed. Studies published in the last 10 years, reporting risk factors assessment other than job title/task and published in English, Italian, Spanish, German and French were included.

**Results:** In the field of crop production, out of the 800 studies identified, we selected 58 studies on the basis of title and abstract. The mainly used risk assessment methods were direct measurements as electromyography and IMU sensors (28%), different types of questionnaires (24%), RULA method (Rapid Upper Limb Assessment) (12%), OWAS method (Ovako Working posture Analysing System) (10%) and experts' opinion (10%). The OCRA Checklist (Occupational Repetitive Actions), the REBA method (Rapid Entire Body Assessment) and the QEC method (Quick Exposure Check) were also commonly used. The design of the selected studies was mostly cross-sectional and we did not find any longitudinal study evaluating the strength of association between exposure level and the health outcome (MSDs). We found five reviews relevant for our purpose, no standard method assessing biomechanical exposures was identified. Asia was the world region from where the majority of the studies came from.

**Conclusions:** Most of the applied methods in agriculture are observational. They have been originally developed for the manufacturing sector, and therefore they may not be directly suitable for the agricultural setting without adjustments and validation within the specific conditions found in this field.

Mattioli S, Gori D, Di Gregori V et al. PubMed search strings for the study of agricultural workers' diseases. *Am J Ind Med.* 2013 Dec;56(12):1473-81

## Ergonomic Risk Assessment and Process Efficiency in the Craft Brewing Industry: A Pilot Study

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**Background:** The craft brewing industry is rapidly growing throughout the U.S. and represents nearly 25% of the \$111.4 billion beer market. Colorado has the second highest number of craft breweries, which produce over 1.5 million barrels of beer and have an economic impact of over three billion dollars. Craft breweries are predominately small businesses that rely heavily on physical labor. The purpose of this study was to determine the feasibility of characterizing the biomechanical risk and process efficiency associated with tasks on a canning line.

**Methods:** The canning process was videotaped from two perspectives while workers wore a Zephyr Bioharness that logged heart rate, breathing rate, estimated core temperature and trunk posture data. Videotaped data was used to associate canning tasks with physiologic variables and to assess process efficiency. The main canning line tasks analyzed were operating, drying, boxing, and palletizing.

**Results:** Six workers were assessed during a 4-hour period while performing at least one of the canning tasks. All workers were male, age range 24-35 years. The task of palletizing was associated with the greatest amount of trunk flexion (mean of 23.8°) for the 4-hour period. Mean trunk flexion was significantly less for drying (6.2°), boxing (3.1°), and operating (1.2°) tasks. Breathing rate and heart rate were higher for the two fast-paced tasks, drying and boxing. During the shift, 5,053 cans were filled and a total of 37 cans were wasted or rejected, resulting in an efficiency of 99.99%. Waste was also detected in worker time and movements while loading empty cans, palletizing at floor level, and drying cans.

**Conclusions:** The combination of data on biomechanical risk and work efficiency provides an effective way to characterize work tasks. The data can be used to develop targeted interventions that reduce biomechanical risk and improve process efficiency.

## Prevalence of musculoskeletal pain in children and youth in rural work and associated factors

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**Objective:** to identify the prevalence of musculoskeletal pain in children and young people working with the family in the rural environment and its associated factors. **Method:** quantitative study, developed in three rural environments, in southern Brazil. The participants were 211 children and young people who assisted the family in the rural work. Data collection was done through a semi-structured questionnaire. Bivariate analysis was performed using t-student and Mann-Whitney and multivariate using Poisson regression.

**Results:** the most common sites of musculoskeletal pain and signs were dorsal (24.6%), legs (10.4%) and arms (10.4%). In the bivariate analysis there was a significant association of the report of musculoskeletal pain related to work with brown skin color and planting cultures as work activity. By means of the regression it was obtained as a prevalence that children and youngsters with brown skin color present an increase in the prevalence of pain in 94% when compared to those of white skin. In addition, those who developed planting activities have a 43% increase in the likelihood of experiencing work-related musculoskeletal pain.

**Discussion:** It converges with data found in the literature(1) to show that musculoskeletal pain, especially in the dorsal region may be associated with skin color, as well as a higher prevalence in the cultivation of this clientele.

**Conclusions:** It is believed that these findings will support the development of health policies, actions in schools and basic health units, with a view to instrumentalising these children and young people to develop their work activities in the rural environment without damage to their musculoskeletal health and education.

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## Manual force assessment using wearable pressure sensors: a case study

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**Background:** Manual force estimation remains one of the elements of more complex acquisition for which several methods have been proposed. The aim of this study, which is part of the Call for Collaborative Research (BRiC-Research Activity Plan 2013-2015), was to develop and test on the field a methodology for measuring the exposure to biomechanical factors during manual handling of loads, focusing on the estimation of hand force.

**Methods:** We measured the distribution of pressure and forces using pressure sensors placed on the hands of the workers (Grip Versatek system; Tekscan®). Devices were used in two exposure scenarios: putting clutches (3.1 kg) and cases (3.0 kg) on shelves in a metalworking company; inserting trays (2.3 kg) with meals in the trolley at different heights in an industrial kitchen. Two workers were tested for each task. Anthropometric characteristics and Maximum Voluntary Contraction (MVC) were collected. Forces were expressed in Newtons and %MCV.

**Results:** The average force exerted by workers in the kitchen task and expressed as %MVC was similar (7% vs 6%). In the metalworking company during the handling of cases 14%MCV and 13%MCV were recorded in the two subjects corresponding to different absolute values of force. A similar scenario was observed when some degrees of freedom due to different heights and couple were introduced: 17, 15 and 12 %MVC and 10, 13, 10 %MVC were recorded respectively to place clutches on different shelves (63, 95 and 125 cm).

**Conclusions:** Despite the limitation due to the small study sample, our results highlight the importance to consider individual characteristics when assessing hand load due to manual handling of objects, together with objective parameters as load, weight and shape as well as spatial and temporal variables.

## Use of Virtual Workplace Models and Predetermined Time Systems for Analysis of Work Loads

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**Background:** Many jobs are unique or performed by a small number of workers. Also, there can be large process, material and tool variations. These factors can make it difficult to obtain accurate and precise assessments using tools such as, RULA, Strain Index, ACGIH, OCRA and Strain Index. Standardization of work methods, materials and tools is used to understand and control these variations so that workers can consistently complete jobs within given time limits.

**Methods:** Predetermined Time Systems (PTSs), such as, MTM and MODAPTS, are used to specify the steps and time required to complete a given task. Distances that a worker must walk or reach to complete a given tasks and the resulting loads on the body can be determined from virtual models of the workplace. CAD tools can be coupled with PTSs to estimate posture and load patterns over time for a given job under normal conditions and anticipate the effects of task variations. We previously described an analysis of force and posture patterns for a case packing job to demonstrate the use of time-based force and posture analysis (Armstrong et al. 2003). We have subsequently performed an analysis of the job using MODAPTS based on the work layout and materials.

**Results:** Close agreement was observed between the MODAPTS and observed times. Force estimates were assigned to elements that involved a "Move" followed by "Put" for computation of duty cycle and average force as specified by the ACGIH TLV for localized fatigue. The job was found to be near the ACGIH limit for hand-forearm fatigue.

**Conclusions:** It can be shown that irregular or abnormal tasks that interrupt the primary packing task can increase the duty cycle and cause the ACGIH limit to be exceeded.

## Telehealth with Extended Care to promote the quality of life of office workers: a cluster randomized controlled trial

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**Background:** Telehealth programs in the workplace have been adopted to promote health and quality of life among workers. To evaluate the effect of an e-learning health education program supported by tutors compared to those who received only audiovisuals.

**Methods:** This is a cluster randomized controlled trial, 2-arm parallel, double blinded. A total of 326 office workers (18 clusters) were randomly allocated to the two groups: Telehealth and Telehealth with Extended Care. Nine audiovisual following topics: musculoskeletal health (walking program, back school, muscle relaxation techniques and work-related musculoskeletal diseases), healthy diet (three eating and commensality, ultra-processed food, and food labeling and oils and fats) and mental health (burnout syndrome and meaning of work) were addressed to participants every 20 days. The Telehealth with Extended Care group had the support of online tutors to ask questions and discuss health issues related to audiovisuals. The primary (quality of life by Whoqol-bref) and secondary (lifestyle by IPAQ-questionnaire) outcomes were performed by a blinded evaluator at the baseline, in the 6-month, and 2-months after the end of the intervention (8-month). An intention-to-treat analysis principle was used. Linear mixed model was applied using SPSS 21.0 (The level of significance was set at 5% ( $p < 0.05$ )).

**Results:** There was no statistically significant difference between the two groups for quality of life (-0.1 [-1.6 to 1.4]); Physical domain (0.4 [-1.3 to 2.0]); Psychological domain (-0.6 [-2.4 to 1.2]), Social domain (1.2 [-1.5 to 4.0]) and Environmental domain (-1.2 [-3.2 to 0.9]). For the within-group comparisons to intervention group the quality of life values were statistically significant between the baseline and the sixth month ( $p < 0.05$ ). There was no statistically significant of lifestyle ( $p > 0.05$ ).

**Conclusions:** Telehealth program tutored it was not better than e-learning to promote quality of life to office workers. Financing: Universidade do Estado da Bahia (01/2015 DCV/UNEB). CNPq - Support: 129550/2017-5, FAPESP - Support: 2017/16544-0.

## Adherence of office workers to active and passive pauses at workplace

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**Background:** Pauses have been recommended at workplace to occupational health management strategies. Objective: To evaluate the adherence on the office workers to passive and active pauses at work. To associate of adherence programs with musculoskeletal symptoms.

**Methods:** This is a secondary analysis of a cluster randomized controlled trial study. A total of 212 office workers were randomized into groups: active (N=132) or passive (N=80) pauses. The active pauses group performed supervised physical exercises program at workplace, including: warm up, stretching and resistance exercises training. The passive pauses group received chair massage program focus on neck, upper limb, and vertebral column (upper and low back). Both interventions occurred for 15-20 minutes, twice a week, during 12 weeks (42 sessions – 100%). All workers received ergonomics training and orientation to take of 10-minute rest breaks for every hour worked. Sociodemographic characteristics, rate of adherence per group, intensity of musculoskeletal symptoms were analyzed.

**Results:** The sociodemographic characteristics of the participants were similar except for the gender, chair massage group were more women (80%), exercise group men (66.7%). The mean adherence to active pauses was 30.7% (SD 22.5) of the sessions for passive pauses was 34.4% (SD 28.5) Passive pauses had no more adherence than active pauses among workers ( $P>0.05$ ). There are no significance differences of musculoskeletal symptoms between groups considering the adherence programs ( $p=0.395$ ).

**Conclusions:** There was a similarity for adherence rate between groups. The musculoskeletal symptoms are not associate group's adherence. This showed that both active and passive pause may be recommended for use as a preventive strategy of musculoskeletal symptoms. Financing: This study was financed in party by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001

## Design of a return-to-work program to improve productivity and reduce recurrence: Back Pain Case

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**Background:** Work absence due to low back pain (LBP) is one of the most frequently and expensive events on the industry (Johnston et al., 2013). Although recommendations exist to prevent recurrences, they frequently are suited to specific workplaces and imply moving workers to processes where they are not required (Waddell G, 2006).

**Methods:** A model was designed to assign LBP-related absent workers to tasks or processes based on workers' health status, work demands of the tasks where they could return, and informal requirements of workforce needs at a large retail company. To develop the model we: 1) assessed work return processes using a business process management (BPM) methodology; 2) quantified and qualified work absences; 3) estimated workforce requirements in different areas of the company using an online survey; 4) evaluated occupational risk factors associated with the task or processes requiring additional workforce, considering physical and psychosocial aspects; and 5) developed an allocation optimization model (VBA algorithm) to assign affected workers to tasks with workforce requirements, taking into account the duration of the work absence, injury mechanism and skills of the worker. The model was evaluated considering acceptance, costs and implementation feasibility.

**Results:** Jobs with the highest rates of work absence due to LBP were, "Administrative support", "Sales aid", "logistics operator" and "distribution aid". Thirty-five jobs with potential to accommodate affected workers were found. We revised and proposed changes to processes related to communications, tasks' evaluation, workers' task assignment, and workers' performance monitoring. The return-to-work model was evaluated with simulations that resulted in three out of five optimal assignments. Focus groups analysis in the company yielded positive results.

**Conclusions:** The developed model is feasible and allows for good solutions under general industry constraints. The model can be extended to other occupational health conditions.

## Reducing MSD risk in the aged care sector using multi-factorial evidence-based interventions

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**Background:** The prevalence and associated costs of work-related musculoskeletal disorders (MSDs) are high in the aged care sector. Current workplace risk management procedures fail to take account of strong research evidence that the risk of MSDs is affected by a large and diverse range of both physical and psychosocial hazards whose effects often interact. This project implemented a participative hazard identification and risk management (APHIRM) toolkit designed to (a) assess risk from all relevant MSD hazards, both physical and psychosocial; (b) identify the subset that are having the greatest impact on MSD risk; and (c) guide the development, implementation and evaluation of interventions to reduce this risk.

**Methods:** On the basis of their high injury rates five residential aged care organisations agreed to implement the APHIRM toolkit. There was a nominated intervention site and matched control site for each organisation. Risk Management Teams (RMT) were established in the intervention sites, and they were responsible for implementing the toolkit. An action plan, based on identified hazards, was developed by the RMT, in consultation with staff, and implementation was monitored monthly. Process evaluation was undertaken which included observational and interview data.

**Results:** Only one organisation was able to fully implement APHIRM and complete their participation in the project. This organisation demonstrated a reduction in the pain/discomfort scores of staff (although due to low survey return rates, this was not statistically significant). Multiple barriers and facilitators to implementation of the toolkit were identified.

**Conclusions:** Notwithstanding the barriers, the results support the need for a high level of management and organisational support for successful implementation of the APHIRM toolkit. Results from this intervention study were used to inform modifications of the toolkit to improve usability.

## A Cochrane Review about the effectiveness of work breaks for preventing musculoskeletal symptoms

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**Background:** The aim is to assess and compare the effectiveness of different work-break schedules for preventing or decreasing work-related musculoskeletal symptoms in workers

**Methods:** The literature was searched for randomized, quasi-randomized, and cluster-randomized studies evaluating a work-break intervention among healthy, adult workers. From an initial 10,642 records, only seven full-texts were selected for inclusion. Comparisons were derived from the included studies, which were assessed for risk of bias using the criteria outlined in the Cochrane Handbook for Systematic Reviews of Interventions and assessed for quality of the evidence using the five GRADE considerations.

**Results:** The seven records included six randomized controlled trials (373 workers) that used a parallel or cross-over design and assessed different work-break interventions including work-break frequency (amount) and work-break type (passive, active). In all six studies a high risk of bias was found on all outcomes. From the six studies, eleven comparisons were derived, all of which were judged to have very low-quality evidence. We found very low-quality evidence that supplementary breaks have no effect on musculoskeletal pain, discomfort or fatigue. We found very low-quality evidence that 30-s supplementary passive breaks at 20-min and 40-min intervals have a positive effect on productivity (mean difference of 501 and 584 words typed per 3 hours, respectively). We found very low-quality evidence that different types of work-breaks have no effect on musculoskeletal pain, discomfort or fatigue and on productivity or work performance.

**Conclusions:** Considering the marginal effect of work-break interventions on the outcomes we selected, further high-quality studies are urgently needed to determine the effectiveness of frequency, duration and type of work-break interventions among workers, if possible, with much higher sample sizes than the studies included in the current review. In addition, work-break interventions should be rethought considering the target group and specific type of work.

## Do high adherence to job rotation results in positive effects on the musculoskeletal symptoms, occupational risk factors perception and job satisfaction?

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**Background:** Organizational culture, tasks characteristics, job satisfaction and worker training has been described as crucial elements for successful job rotation. This study aimed to evaluate the adherence to job rotation and its influences on the prevalence of musculoskeletal symptoms, occupational exposure and job satisfaction.

**Methods:** It was conducted in five departments of an automotive industry, that performed job rotation in order to optimize the production schedules. A total of 149 male blue-collar workers self-rated the job rotation performance, musculoskeletal symptoms, occupational exposure and job satisfaction. An ergonomic analysis was performed. Quick Exposure Check (QEC) method was used to rating the biomechanical exposures at work. For statistical analyzes, the departments were divided into high (>50% workers) or low (≤50% workers) adherence rate to job rotation.

**Results:** Ergonomics analysis showed that the work organization, productive layout and tasks characteristics had influence on decision to implement the job rotation. Decision-making by the department's coordinator also influenced on this. The number of tasks to be alternated by each worker depended on their ability to perform them. However, the job rotation was usually done between three tasks at 2-hour intervals. Three serial layouts departments presented high adherence rate to job rotation (n=52). Biomechanical exposures ranged between low to moderate scores for both department groups ( $P>0.05$ ). Musculoskeletal symptoms were more prevalent in workers from departments with high adherence to job rotation (32.4%). In contrast, higher job satisfaction and lower level of stress was found in the departments with low adherence ( $P<0.05$ ).

**Conclusions:** High adherence to job rotation was influenced by the organizational culture and tasks characteristics. However, it had no positive effects on the musculoskeletal symptoms, occupational exposure and job satisfaction.

**Key words:** Job Rotation; Ergonomics; Manufacturing Industry.

**Financing:** This study was financed in party by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001

## Impact of Secondary Intervention on Musculoskeletal Disorder Development, Systemic Inflammation and Sensorimotor Behavioral Declines in A Rat Model

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Musculoskeletal Disorders are the result of prolonged repetitive or forceful movements, in combination with other potential risk factors. It was previously shown that performance of highly repetitive tasks is associated with increased serum cytokines, and reach performance and sensorimotor behavior declines. This study investigated effects of flat treadmill running and resting in attenuating systemic inflammatory responses and sensory motor behavioral declines. Fifty-four young adult female Sprague-Dawley rats were trained to a high repetition, high force (HRHF) reaching and lever pulling task at a rate of 12 reaches/min with 60% maximum pulling force. This task was performed for 2 hrs/day, in four 30 min sessions, 3 days/week, for 10 weeks. Rats were randomly assigned to food restricted control: "FRC", trained only: "TRHF", trained then rested for 10 weeks: "TRHF+Rest", trained then rested for 4 weeks then ran on treadmill for 6 weeks: "TRHF+Rest+TM", trained then performed 10 weeks of HRHF task: "10wk HRHF", and trained then performed 10 weeks of HRHF task while running on treadmill for the last 6 weeks: "10wk HRHF+TM" groups. Rats that were assigned to treadmill regimen ran at 20m/s for 1hr/day, 5 days/week. Task performance outcomes, grip strength, and voluntary reach performance outcomes including reach rate, success rate, grasp force and grasp time were assessed for each of the above groups. Serum cytokines, IL-1a, IL-1b, IL6, rIL10, MIP2 and TNF-alpha, were assessed using multiplex ELISA. Flexor digitorum tendons were harvested from both limbs and scored using the semi-quantitative method, Bonar scale. In conclusion, the HRHF reaching task had a significant adverse effect on systemic inflammation, task performance and sensory motor behavior. The above-mentioned adverse effects were evident even in rats who only underwent HRHF training. Rest attenuated systemic inflammation and improved sensory motor behavior, but did not improve task performance. Treadmill intervention attenuated systemic inflammation, but did not improve task performance or sensory motor behavior.

## Which workers in France are at high risk of long-term work absence due to work-related musculoskeletal disorders?

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**Background:** The purpose was to identify groups of workers at high risk of long-term work absence (>90 days) due to non-traumatic musculoskeletal disorders compensated as an occupational disease or an accident (MSD-ODA).

**Methods:** National data of the French social insurance compensation system for ODAs of salaried employees were used. Cases of non-traumatic MSD-ODAs reported or occurring in 2008 with at least one day off work were included (inclusion criteria were discussed with the Québec Institute of Public Health). The total duration of sick leave for each MSD-ODA was calculated for the 2008-2011 period. The proportion of MSD-ODA cases with long-term work absence on all included MSD-ODA cases was calculated separately in men and women, by body region and 2008 NAF industry sectors with at least 100 cases.

**Results:** We observed 160 508 MSD-ODAs (122 975 accidents, 37 533 diseases) in 2008. A higher proportion of occupational diseases cases had long-term work absences (60.4% vs. 13.2% among accident claims). Women, who represented approximately one third of cases, had a higher proportion of long-term work absences than men (32.1% vs. 19.7% for men,  $p < 0,0001$ ). Upper-extremity MSD cases had also higher proportions of long-term work absences ( $p < 0,0001$ ; 44.6% for women and 29.7% for men). Among women, the three sectors with the highest proportions of long-term work absences were manufacture of distribution and electrical control equipment (60.8%), manufacture of other rubber items (56.7%) and retail laundry and dry-cleaning services (55.6%); among men: manufacture and retreading of tires (35.0%), meat processing and preservation (33.9%) and road and highway construction (33.9%).

**Conclusions:** Determinants of long-term work absences in the identified sectors should be studied. Interventions to facilitate return to work of those off work for a MSD-ODA should give priority to women with upper-extremity MSD working in specific manufacturing activities and laundry and dry-cleaning services.

## Individual Placement and Support as a model of vocational rehabilitation for patients unemployed with chronic pain: A feasibility programme

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**Background:** Chronic pain is common and causes substantial work loss. 50-60% of those with chronic pain have musculoskeletal conditions. Individual Placement and Support (IPS) has proved successful at enabling work rehabilitation amongst people with severe mental health conditions. Therefore, we investigated the feasibility of doing a trial of IPS for people unemployed with chronic pain.

**Methods:** This was a mixed-methods programme. Methodological issues including recruitment of chronic pain patients, retention, intervention development, and outcomes important to assess were explored through qualitative research with all stakeholders. Subsequently, a pilot randomised controlled trial was carried out, trying a range of methods of recruitment. Participants in the active and control arms were followed up at 3-, 6- and 12-months to explore retention and outcomes.

**Results:** People with chronic pain and their care providers were enthusiastic about this trial and thought that employment was vitally important as a health outcome. Recruitment was challenging in primary care as employment status is not routinely collected in the UK. However, we recruited 50 patients over 12 months. Retention in both arms has been excellent (78% at 3-month follow-up). Some participants have reported remarkable results from the IPS. Employment support workers have identified some training needs when first working with chronic pain patients. The important outcomes from IPS are broader than in work/not in work and include health/wellbeing and quality of life as well as confidence and self-efficacy.

**Discussion:** Being able to work is important for people with chronic pain. Existing health records fail to capture employment status although it is an important "outcome". A trial of IPS would be feasible and the outcomes for patients of this intervention are broader than employment.

## Effects of an early multidisciplinary intervention on sickness absence in patients with persistent low back pain - a randomized controlled trial

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**Background:** Musculoskeletal disorders, especially LBP are the leading cause of disability in the western world and account for one third of the long-term absenteeism in Denmark.

This study had the purpose to investigate the effect of a 12-week multidisciplinary vocational rehabilitation programme on the number of days off work, pain and disability during follow-up in patients already sick-listed, or at the risk of being sick-listed, because of persistent LBP.

**Methods:** This study was a randomized controlled trial including 770 working age adults with persistent low back pain comparing a multidisciplinary vocational rehabilitation programme with usual treatment.

The primary outcome was number of days off work due to back pain. The secondary outcomes were disability, health-related quality of life, pain, psychological distress and fear avoidance behaviour.

Data was collected at baseline, end of treatment, and at 6 and 12 months after inclusion. Analyses were carried out according to the "intention-to-treat" principles.

**Results:** A significant decrease in the number of days off work were found in both treatment groups at the end of treatment and at 6 and 12 months follow-up. Also disability, pain, health related quality of life, psychological distress, and fear avoidance beliefs improved in both groups. However, no statistically significant differences were found between the groups on neither outcome.

**Conclusions:** The coordinated multidisciplinary intervention had no additional effect on sickness absence, disability, pain, or health related quality of life compared to usual care. A significant improvement of days off work, disability, pain and health related quality of life were found in both treatment groups. The improvements were sustained at 12 months follow-up.

## Prevalence of sickness absenteeism and presenteeism due to musculoskeletal disease in manufacturing workers

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**Background:** This study aimed to evaluate the prevalence of sickness absenteeism and presenteeism due to musculoskeletal disease in manufacturing workers.

**Methods:** This is a secondary analysis of baseline from a cluster randomized controlled trial study. The sample was 484 blue-collar workers from a textile industry. The absence from work due to musculoskeletal disease (M Group International Classification of Diseases, ICD-10) was assessed by records of medical certificates during the last 3 months. Presenteeism refers to going to work despite illness. It was assessed by the prevalence of musculoskeletal disease using the Nordic Questionnaire. All participants were asked about perceived performance at work (10-point Likert Scale) and occupational risk factors (JFQ).

**Results:** Workers consisted of 479 women and 100 men, mean age of 30.2 years (SD=8.6), mean working time of 4.4 years (SD=3.6). Absenteeism due to musculoskeletal disease rate was 27.8%, with average duration of 3.3 days (SD=3.4). The most prevalent ICD-10 (M Group) was dorsopathies (M50-M54= 99 records) and synovitis and tenosynovitis (M65= 48 records). Presenteeism was reported by 84.1% of workers, whose musculoskeletal complaints are mainly related to shoulders (66%), neck (52%) and back (45.6%). Performance at work was reported as usual (8.3±1.6 points; P>0.05). The perceived risk factor was moderate and the most critical was "continue to work when injured" (6.8±3.5 points), mainly for the workers presenteeism p<0.05).

**Conclusions:** There was a high prevalence of absenteeism and presenteeism due to musculoskeletal diseases in manufacturing workers. Despite this, workers reported high performance at work. This finding may be related to economic reasons and worry about being laid off.

**Key-Words:** Absenteeism; Presenteeism; Work-related musculoskeletal disorders; Manufacturing industries.

**Financing:** This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001

## Prevalence of musculoskeletal complaints in minimal invasive surgery

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**Background:** Minimal invasive surgery is characterized by sustained statistic muscular loading, awkward body postures, and prolonged standing associated with the prevalence of musculoskeletal complaints. However, it is unclear whether prevalence ratios are higher than for other occupational groups e.g. office workers. Furthermore people from different professions are involved in minimal invasive surgery (e.g. surgeons or surgical nurses) and little is known which of them have the highest prevalence levels of musculoskeletal complaints.

**Methods:** Musculoskeletal complaints of 360 subjects will be assessed by the Nordic Questionnaire (180 surgeons, assistants, surgical nurses and 180 office workers). In addition aspects of working conditions like musculoskeletal stress during work will be evaluated by self developed items. Subjects involved in minimal invasive surgery will be recruited in the field of gynaecology from tertiary and secondary hospitals. Office workers will be recruited from a local city administration and the administration of a local university hospital.

**Results:** Preliminary results of 49 subjects involved in minimal invasive surgery indicate a higher 12-month prevalence of musculoskeletal complaints in the lower back and the shoulder region than office workers (n = 68). Both groups indicated high 12-month prevalence levels of musculoskeletal complaints in the neck region. Subjects involved in minimal invasive surgery reported more frequently that musculoskeletal complaints led to impairments at work than in office workers.

**Discussion:** Based on preliminary findings musculoskeletal complaints in subjects involved in minimal invasive surgery seem to be increased compared to office workers. Although office workers also reported musculoskeletal complaints e.g. in the neck, those complaints may be associated with less impairments at work. Subsequently, interventions to promote musculoskeletal health in minimal invasive surgery are highly required. After recruiting more subjects potential differences in musculoskeletal complaints between e.g. surgeons and surgical nurses will be evaluated.

## Future work ability is not regularly discussed with their general practitioner by patients suffering from musculoskeletal disorders – results of a survey among patients of a German population-based integrated healthcare model

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**Background:** In Germany, "integrated care" (IC) was designed to improve healthcare by better inter- and multidisciplinary cooperation. The "Gesundes Kinzigtal Integrated Care" (GKIC) is one population-based IC and is regarded as best-practice example in Germany. It has a strong emphasis on prevention. In 2017, within the third survey on patient satisfaction, the current and future ability to work were assessed for the first time.

**Objectives:** The following questions were explored: How many GKIC patients discuss their future work ability with their general practitioner (GP)? Do musculoskeletal disorders (MSD) make the difference compared to other chronic diseases?

**Methods:** A standardized questionnaire was sent to 3221 randomly selected GKIC patients by mail. Four questions from the Work Ability Index were asked to assess the patient's ability to work. Finally, we asked whether the future work ability was discussed with the GP.

**Results :** 1168 pseudonymized questionnaires could be evaluated. 497 (42.6%) respondents were employed (average age 50.6 years; women 54.6%). Nearly one fifth (19.6%) of them stated that they had already discussed their future work ability with their GP. Among others, the estimated work ability in two years (Spearman's  $r=0.19$ ) and presence of a chronic disease (0.17) showed a significant association. Among those with a chronic disease and estimating their future work ability as unsafe or unlikely ( $n=119$ ), patients with MSD ( $n=36$ ) indicated more often (16/36) the discussion of the future work ability with their GP than participants with another chronic condition (20/83) ( $\text{Chi}^2=4.927, p<0.05$ ).

**Conclusions:** Even in an IC with emphasis on prevention, the future work ability of patients seems to be too rarely discussed in consultations with the GPs. The proportion was relatively high (44%) in patients with MSD and self-estimated poor future work ability. This observation should be further analyzed to find ways to enable patients and GPs to improve current and future work ability despite chronic (musculoskeletal) disorders.

## Definition of work disability from shoulder pain in a large French population

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**Background:** This study aimed to describe several work disability indicators for shoulder pain in a French population.

**Methods:** Data were retrieved from the Household Section of the 2008 Disability Health Survey ("Handicap santé - volet ménages"). Participants with shoulder joint discomfort, of working age, who have or had ever worked, were included. The selected work disability indicators were: global activity limitation indicator (GALI), recipient of a disability pension, qualified worker with disability and work limitations. The latter variable was not collected for subjects who did not have currently a job, and who were not searching for one, thus, they were considered as having no limitations. They were excluded in an additional sensitivity analysis. Statistical analyses were weighted to represent the general population.

**Results:** Among the 29930 of the survey, 1723 individuals were included, from whom 53.0% had unilateral shoulder discomfort. There were 62.4% of women, 55.1% of workers and average age was 51 years old. Subjects had respectively limitations at work in 27.7% of cases, and according to the GALI in 67.6% of cases. They were pensioners in 12.9% of cases and were qualified workers with disability for 8.0%. The latter condition was simultaneously found with pensioners in 2.1% of cases, with GALI in 7.7% and with limitations at work in 23.6%. Data concerning work limitations were available for 796 individuals, from whom 60.3% had limitations according to the GALI, 44.5% reported work limitations, 6.5% were pensioners, and 9.4% were qualified workers with disability.

**Conclusions:** This study shows the plurality and the complexity of work disability definition. Heterogeneous results were found depending on the functional or administrative indicator used. They emphasize the limit of a single question to address such a complex concept. The construction of standardized composite indicators shared worldwide seems to be crucial.

## Musculoskeletal disorders in children due to overuse of electronic devices: Risk factors and clinical features

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Musculoskeletal disorders (MSD) due to the use of electronic devices are common in children. The aim of this study was to find out the risk factors, clinical features and outcome of treatment of MSD due to electronic devices among children. 110 children, aged 5-18 years, underwent rehabilitation for 2 to 4 weeks using a sequenced protocol. 52.7% (n=58) of the participants were male, with a median age of 14 years. The MSD was attributed to cell phone (79%), tablet (68%), laptop (55%), electronic games (54%), desktop computer (30%), portable music players (5%), and electronic book readers (2%). The commonest risk factors were lack of rest breaks (84%), static loading (74%), hazardous body positions (68%), excessive load (36%), deficiency in the design of tools/furniture or poor ergonomics (36%) and repetition (26%). Right upper limb musculoskeletal symptoms (85%) were predominant. Myofascial Pain Syndrome (MPS) was the most commonly diagnosed clinical condition in 100% followed by Thoracic Outlet Syndrome (32%), and tendinopathies of the elbow, wrist or hand (20%). After the rehabilitation, the VAS scale showed a significant reduction in pain levels ( $p<0.01$ ). Reducing the duration of electronic device use, training in ergonomics and body mechanics, including rest breaks, is recommended.

## Lifestyle risk factors in the incidence and prognosis of chronic pain

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**Objective:** To estimate the effects of lifestyle factors on the incidence and prognosis of chronic pain.

**Methods:** This study is part of the Finnish Helsinki Health Study. In the current analysis, we included three cohorts of employees of the City of Helsinki (2000/2002-2007 [N=7000], 2007-2012 [N=5973] and 2012-2017 [N=5589], altogether 18562 observations). We defined chronic pain as having pain in any part of the body longer than 3 months at follow-up in participants without chronic pain at baseline (N=13029 observations) and defined recurrent or persistent chronic pain as having pain longer than 3 months at both baseline and follow-up (N=5533 observations). We used generalized estimating equation for logistic regression.

**Results:** Of the participants without chronic pain at baseline, 20.5% had chronic pain during a 5-year follow-up and of the participants with chronic pain at baseline 55% experienced recurrent or persistent chronic pain during the follow-up. Overweight increased the incidence of chronic pain in women (adjusted odds ratio (OR)=1.21, 95% CI 1.08-1.36), whereas obesity increased the incidence of chronic pain in both men (OR=1.47, 95% CI 1.06-2.04) and women (OR=1.68, CI 1.46-1.94). Moreover, overweight (OR=1.19, 95% CI 1.04-1.37) and obesity (OR=1.52, 95% CI 1.28-1.81) increased the risk of recurrent/persistent chronic pain in women only. Smoking weakly increased the risk of incident chronic pain in women only. Strenuous leisure-time physical activity reduced the incidence of chronic pain (OR=0.85, CI 0.75-0.96). Furthermore, overweight or obesity modified the effect of leisure-time physical activity on incident chronic pain. Both moderate (OR=0.85, CI 0.74-0.98) and strenuous (OR=0.71, CI 0.61-0.84) leisure-time physical activity reduced the incidence of chronic pain in overweight or obese participants, but not in normal weight participants.

**Conclusions:** Obesity not only increases the risk of developing chronic pain, but also increases its recurrence/persistence rate, while leisure time physical activity protects against the development of chronic pain.

## Time-use composition of physical behaviors at work and sick leave trajectories due to musculoskeletal pain

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**Background:** There is limited knowledge on the influence of physical behaviors at work such as sitting, standing, low- (LIPA) and moderate-to-vigorous physical activity (MVPA) on sick leave due to pain. Studies addressing this relationship using valid objective measures of physical behaviors are scarce. The aim was to determine the prospective association between time-use compositions of physical behavior at work with sick leave trajectories due to musculoskeletal pain.

**Methods:** Data on 981 workers were analyzed in the DPHACTO cohort (2012-2014). Physical behaviors at work were assessed objectively at baseline using accelerometers, and the resulting time-line of exposure at work was classified as sitting, standing, low- (LIPA) and moderate-to-vigorous physical activity (MVPA). The number of days on sick leave due to musculoskeletal pain was reported using text messages at 4-week intervals across 1 year (14 waves in total). Latent class growth analysis was used to distinguish sub-groups with different trajectories of sick leave. Associations between time-use in physical behaviors and sick leave trajectories were determined using multinomial regression analysis with adjustment for age and gender. Compositional data analysis was used to account for the co-dependency of different behaviors.

**Results:** We identified four distinct trajectories of sick leave due to pain over one year as follows: no days (prevalence 76%), few days-increasing (19%), some days-decreasing (3%), and some days-increasing (2%). Spending more time in sitting relative to the other behaviors was associated with a reduced likelihood of few days-increasing sick leave ( $p < 0.001$ ), while time in LIPA was associated with an increased likelihood of some days-increasing sick leave ( $p = 0.001$ ).

**Conclusions:** We found that the time-use composition of physical behaviors at work was associated with sick leave trajectories due to pain over 1 year. Reducing time in occupational physical activities in favor of sitting may be useful for preventing sick leave due to musculoskeletal pain.

## Predictive equations for initial horizontal hand forces when pushing or pulling trolleys based on trolley weight

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**Background:** Pushing and/or pulling of trolleys is common to many workplaces, which can present a significant risk of low back and shoulder injuries. Psychophysical data on maximum acceptable hand forces is frequently used to provide preventive guidelines for pushing or pulling tasks (e.g. Snook & Ciriello, 1991). However, measuring hand forces in the workplace is often difficult. This study investigated whether a formula-based approach can be used to determine horizontal push/pull forces based on trolley weights.

**Methods:** In a field study horizontal push/pull forces were measured for six different trolley types, that varied in trolley shape and size and wheel characteristics, and two types of floor surface, smooth and carpeted. Trolley weights varied between 31 and 434 kg. The peak initial force to set the trolley in motion was measured using a unidirectional force dynamometer (Chatillon, USA). Linear and non-linear regression analysis was used to determine the relationship between trolley weight and initial push/pull forces.

**Results:** 764 data points were collected for all trolley types and conditions. Initial horizontal hand forces followed an exponentially relationship with increases in trolley weight and provided the best fit to the data. Wheel and flooring characteristics significantly influenced hand forces.

**Conclusions:** Predictive equations were developed for initial horizontal hand forces when pushing or pulling trolleys based on trolley weight. The exponential relationship between hand force and trolley weight is most likely due to normal physical and behavioural responses when faced with increasing trolley weights, e.g. reduced acceleration. The ability to estimate initial hand forces from trolley weight provides occupational practitioners with a simple method to determine musculoskeletal injury risk associated with pushing and pulling tasks in the field.

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## Improved Planning for Active Pauses during Computer Work via Ocular Biofeedback

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**Introduction:** Prolonged computer work may associate with work-related disorders. Active pauses are taken regularly as a strategy to overcome adverse health effects of computer work. An open question is how the pauses could be timely planned to avoid early fatigue while maintaining an acceptable level of performance. This study provides a biofeedback solution to optimize time-planning of pauses.

**Methods:** Twenty young participants (10 females and 10 males, aged 26±3 years) performed a cyclic computer task (~31-35 min) while their eye movements were recorded over two counterbalanced sessions. Each cycle involved memorization and replication of random patterns for ~10 s. Following a segment (20 cycles), the task was interrupted to obtain the level of perceived fatigue. This interruption was extendable by a 25-s active pause, where the participant performed mindful breathing and seated shoulder rotations using an elastic band. Perceived workload was obtained from the participants following the task termination. In non-biofeedback sessions, the pauses were triggered at the participants' discretion. In the other sessions (biofeedback), the pauses were triggered by a probabilistic model associating vectors of five ocular features to fatigue levels of each segment. The ocular features contained information from fixations, saccades, blinks, and pupillary responses. The model was an ensemble of decision trees, which was developed using an ocular dataset from 38 participants who indicated their fatigue level in a same computer task performed for 40 min.

**Results:** The model detected fatigue with ~70% of accuracy across participants in the biofeedback sessions. The perceived workload was lower in the biofeedback sessions than in the non-biofeedback sessions ( $p=0.01$  Cohen's  $d_z=0.89$ ). A ~10-min delay in fatigue perception was also observed in the biofeedback sessions compared with the non-biofeedback sessions ( $p<0.05$ ).

**Conclusions:** The results suggest the utilization of ocular biofeedback to improve the timing plan of active pauses during computer work.

## Concordance between exposure to physical factors in the Italian and the US O\*NET database

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**Background:** Job exposure matrix (JEM) can provide data for epidemiological studies that lack data. Cross-national JEMs may provide direct comparison of results, particularly if created by the same items. The purpose of the study was to evaluate concordance between O\*NET job exposure matrix (JEM) created by data from Italian and from U.S. general workers.

**Methods:** We selected 21 physical exposures related to forceful exertions, awkward postures, repetitive work, handling objects, and vibration. The Italian O\*NET JEM was created from interviews of ~20 workers for each of 800 job codes. The U.S. O\*NET JEM was created by worker survey responses or occupational analyst ratings of 967 job codes. U.S. and Italian job codes were linked by crosswalks through the ISCO-08 4-digit job codes, limiting jobs to 586 in Italy and 684 in the U.S. Statistical analyses used multilevel random effect models with national job codes (Italy or U.S.) nested within ISCO codes, weighted by the number of workers interviewed in each national job. Concordance was estimated through the Intraclass Correlation Coefficient (ICC).

**Results:** ICCs showed good agreement of 0.75 or higher for the following exposures: static and dynamic strength, standing, bending the trunk, time spent using hands. ICCs showed moderate agreement above 0.60 for all other physical exposures with the exception of computer use (ICC=0.25) and repeating same tasks (ICC=0.42).

**Conclusions:** These results show strong agreement for most physical exposures compared between the two JEMs. Limited agreement may be due to misclassification in job code assignments and differences in job exposures between countries. Further exploration of the data will elucidate these problems. These findings show excellent promise for using JEMs cross-nationally for studies of epidemiological exposures if no other source data is available.

## How does heavy physical workload effect the progression of musculoskeletal pain? A cohort study of Swedish workers with pre-existing occasional pain

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**Background:** The prevalence of musculoskeletal disorders (MSDs) among employees is high and an important determinant of labour market exit. However, as the majority of studies focus on MSDs' incidence, factors affecting prognosis for employees with existing disorders remain unclear. This study aims to explore the impact of physical workload on aggravated musculoskeletal pain among employees with pre-existing pain.

**Methods:** This cohort study employs data from the Stockholm Public Health Cohort (SPHC) to follow a sample of workers with pre-existing pain over a 4-year period. The SPHC is a randomly selected sample of residents in Stockholm County who responded to repeated questionnaires. Of 34,707 respondents to a baseline questionnaire in 2006, 25,167 answered a follow-up questionnaire in 2010. For the purpose of this study, the sample was restricted to employees under the age of 60-year and with occasional pain at baseline. Occasional pain was determined via self-reported single site pain in the neck, shoulders, arms or lower back no more and no less than a couple of days per month (n=940). A question on physical exertion at work at baseline measured the participants' exposure to heavy physical workload. The outcome was self-reported pain at any location a couple of days per week or more often at follow-up. Logistic regressions estimated odds ratios adjusting for age, long-term health condition and completed level of education.

**Results:** Women with single site monthly pain and self-reported heavy physical workload, compared to sedentary or light work, had a higher risk (OR 3,20 95% CI: 1,16-8,87) of developing weekly pain. For men the risk was close to significant (OR 2,20 95% CI: 0,99-4,88). The increased risks remained after adjusting for age, long-term health condition and completed level of education.

**Conclusions:** The results suggest an association between heavy physical workload and increased pain frequency among employees with pre-existing occasional musculoskeletal pain.

## Prevalence and risk factors for musculoskeletal disorders in South African workers

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**Background:** Musculoskeletal disorders have been associated with risk factors at the workplace. Information regarding these risk factors is scanty in South African workers.

**Objectives:** To determine the 12-month prevalence and identify risk factors for musculoskeletal disorders in South African workers.

**Methods:** The study was cross-sectional and conducted among 488 South African workers (252 nurses and 236 bank workers). A modified Cultural and Psychological Influences on Disability questionnaire was administered at interview. Information about demographic characteristics, potential musculoskeletal disorder risk factors and musculoskeletal disorders was collected. Binary logistic regression was used to identify possible risk factors associated with musculoskeletal disorders.

**Results:** The 12-month prevalence of musculoskeletal disorders was 80.5% with low back pain being the most prevalent (56.9%) and elbow pain the least prevalent (14.3%). Somatising tendency was associated with pain in all body sites. The associations with pain in "any" body site ORs (95% CI) 2.23 (1.15-4.31); 3.52 (1.84-6.72) and low back 1.81 (1.07-3.03); 2.72 (1.69-4.40), demonstrated increasing trends when the effect of one and two distressing somatic symptoms was compared to no symptoms, respectively.

"Women" was associated with shoulder pain 1.83 (1.04-3.37); and wrists or hand pain 2.28 (1.09-4.74); compared to men. Age groups (40-49 and  $\geq 50$  years) demonstrated increasing trends with shoulder pain 2.23 (1.27-3.90); 2.40 (1.21-4.79) and knee pain 2.18 (1.16-4.09); 2.50 (1.16-5.38), respectively.

Occupational group (bank workers) was associated with pain in the neck 1.66 (1.04-2.67) compared to nurses.

**Conclusions:** Musculoskeletal disorders are prevalent in the South African workers studied with low back pain being the most prevalent. Most of the risk factors emerging from this study belong to the non-work dimension of risk factors. This may signal their importance in the development of these disorders. Furthermore, they may need to be considered in any effort to address musculoskeletal disorders in the workers studied.

## Ergonomic risk assessment for work related musculoskeletal disorders in an orthopedic surgery team

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**Background:** An orthopedic surgery team (OST) specialising in Single Event Multi-Level Surgeries (SEMLS) for children with Cerebral Palsy (CP) had reported work related musculoskeletal disorders (WRMSD). However, existing ergonomic risk assessment tools fail to appropriately evaluate the nature of task, variable postures involved and the duration of exposure that can predict the risk of an OST developing WRMSD. The objective of this study was to use the Time-based Assessment Computerised Strategy (TACOS) method to evaluate the risk of WRMSD among the OST.

**Methodology:** A prospective experimental study was conducted among the OST working in a rehabilitation hospital performing an average of 5 SEMLS per month. The OST (n=10) comprising of a Chief Orthopedic Surgeon, Assistant Surgeon, Scrub Nurse, Circulating Nurse, X-ray Technician and OT Assistant, were evaluated with the TACOS tool based on video analysis of the tasks performed. The SEMLS surgeries involved bony and soft tissue procedures lasting for a minimum of 2 to a maximum of 4 hours per surgery (without breaks) depending on the type of surgery and the severity of the child with CP to be operated.

**Results:** All the members of OST (n=10) had a high risk of "spine in standing position". The predominant posture causing high risk was "standing posture with lumbar spine slight bending". The high-risk job tasks were found to be "seated not supported with trunk twist" by the Chief Orthopedic Surgeon and Assistant Surgeons, followed by "back in extension with upper limbs over the height of the head", performed frequently by the X-ray technician controlling the C-Arm.

**Conclusions:** Members of OST are exposed to a high risk of WRMSD. Appropriate handling techniques and postural advice must be emphasised to the OST.

## Working in cold environments and chronic pain lasting $\geq 3$ months, a cross-sectional study from The Tromsø Study 6

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**Background:** Workers exposed to a cold environment, outdoors or in cold buildings, report higher prevalence of musculoskeletal pain from different sites. The aim of the study was to investigate if exposure to a cold environment  $\geq 25\%$  of the time at work was associated with chronic musculoskeletal pain or pain in other tissues, lasting  $\geq 3$  months.

**Methods:** We used data from the sixth survey (2007-2008) of The Tromsø Study. The study population included 6600 men and women, aged 30-67 who were not retired, on disability benefits or had any missing values. Participants were asked if they had persistent pain lasting three months or more (Yes/No) and if yes, where the pain was situated. There were 15 different sites. The association was examined with logistic regression and adjusted for sex, age, BMI, insomnia, physical work, education, smoking and leisure time physical activity.

**Results:** 846 participants reported to work in a cold environment  $\geq 25\%$  of their working time. The exposed were mostly men, were younger, had higher BMI, physical demanding work, less education, and were more frequently current or former smokers compared to the rest of the working population. In the fully adjusted model, working  $\geq 25\%$  of the time in a cold environment was significantly associated with pain from 3+ sites (OR 1.54 95% CI 1.21-1.96), but not with pain from 1-2 sites (OR .91 95% CI 0.70-1.18). When using specific sites as outcomes, those working  $\geq 25\%$  of the time in a cold environment had significantly higher odds for pain from neck (OR 1.44 95% CI 1.13-1.84), shoulder (OR 1.35 95% CI 1.06-1.72), and leg (OR 1.34 95% CI 1.01-1.78)

**Conclusions:** Working in a cold environment  $\geq 25\%$  of the time was significantly associated with chronic pain. The observed association was strongest for pain at musculoskeletal sites.

## Non-explicit observational method is reproducible and valid for the analysis of occupational biomechanical exposure of workers

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**Background:** Non-explicit observational methods to evaluate occupational biomechanical exposure based on the experience and knowledge of professionals has been used to replace explicit observational methods.

**Objective:** To evaluate the reliability, agreement, and internal consistency of non-explicit observational method and the REBA method and to establish the concurrent validity between a non-explicit method, the REBA method, and self-reporting of workers' perception of exposure.

**Methods:** The sample was of 50 video tasks from different job and biomechanical demands (i.e., repetitive movement, vibration, physical effort, and work postures). The workers self-reported their perception of occupational biomechanical exposure in different body regions. Two independent evaluators were trained to use the non-explicit and the REBA methods. A retest was performed seven days after the first evaluation of video tasks.

**Results:** The non-explicit method presented intra- and inter-rater reliability, varying from moderate to high (CCI2.1 = 0.45 to 0.87) except for the neck region, which had poor inter-rater reliability (CCI2.1 = -0.40). The agreement was acceptable (EPM = 0.60 to 3.35). REBA presented moderate to excellent intra-rater reliability (CCI2.1 = 0.50 to 1.00) except for the wrist region, which ranged from poor to excellent (CCI2.1 = 0.33 to 0.98). The inter-rater reliability for REBA varied from poor to high (CCI2.1 = -0.17 to 0.83), poor to moderate inter- and inter-rater agreement (EPM = 0.00 to 0.74). The internal consistency was positive for the non-explicit method ( $\alpha = 0.88$ ) and for self-reporting ( $\alpha = 0.82$ ) and low for REBA ( $\alpha = 0.68$ ). Finally, the concurrent validity had low to good correlation between the non-explicit and REBA methods. The correlation between non-explicit method and REBA with the self-reporting was low.

**Conclusions:** Non-explicit observational method is reproducible and valid as the REBA method.

**Financing:** Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001

## Direct assessment of net spinal moments in subjects wearing a passive exoskeleton for trunk support in stooped working pose.

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Recently a method for direct estimation of 3D net moment around L5/S1 intervertebral body during actual work [2002, 2007, 2009] has been further developed by authors. Net spinal moments are estimated by an artificial neural network (ANN), driven by trunk EMG and 3D kinematics (movement sensors) and trained applying a biomechanical linked segment model. A unique feature of the method is its insensitivity to the distribution of external forces acting on the body, making it suited for direct spinal moments estimation while wearing an exoskeleton.

One series of experiments was done under laboratory conditions to test hardware and software, one in a hospital setting with five nurses as subjects and one in an industrial environment with four metal workers as subjects (total 30 sessions). For each subject a series of recordings was done comprising calibration movements, a series of simulated working tasks with the Laevo prototype not active, plus a series of the same tasks with the prototype actively supporting the subject's trunk.

Direct comparison of the net spinal moments estimates against a reference method using a linked segment model driven by lower body kinematics and ground reaction forces delivered showed  $r^2 = 0.87 \pm 0.05$  and  $RMSE = 26 \pm 11$  Nm for straight, fast straight and oblique lifting in the sagittal plane over 6 subjects (no significant effect of subject). In the other 2 planes the RMSE values were similar but the  $r^2$  values dropped to  $\pm 0.25$ . Typically consistently observed effects of the exoskeleton (with back stop) were a decrease in spinal net moment of up to  $90\% \pm 5\%$ , depending on back angle, representing, and consistent with, the amount of support the subject was seeking.

This method appears to hold a promise for large scale quantitative estimation of sagittal plane back load exposure during work. More work is required for enhancing accuracy in other planes.

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## Dose-response relationship between cumulative physical workload and osteoarthritis of the hip – a meta-analysis applying an external reference population for exposure assignment

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**Background:** Many studies find an association between occupational handling of heavy loads and the diagnosis of hip osteoarthritis. However, due to the heterogeneity of exposure estimates considered in single studies, a dose-response relationship between cumulative physical workload and hip osteoarthritis could not be determined so far.

**Methods:** We aimed to analyze the dose-response relationship between cumulative physical workload and hip osteoarthritis by replacing the exposure categories of the included studies with cumulative exposure values of an external reference population. Our meta-regression analysis was based on a systematic review (Bergmann et al. 2017) which was updated till March 2017. The population control subjects of a German multicenter case-control study (Seidler et al. 2009) served as the reference population. Based on the sex-specific cumulative exposure percentiles of the reference population, we assigned exposure values to each category of the included studies (6 case-control studies for men) using three different cumulative exposure parameters. There was no linear association between physical workload and the risk of hip osteoarthritis in women.

**Results:** In men, the risk of hip osteoarthritis was increased by an OR of 2.08 (95% CI 1.22–3.53) per 10,000 tons handled >10 times per day and 8.64 (95% CI 1.87–39.91) per 1 million operations. We were able to calculate the amount of cumulative physical workload required to double the risk of hip osteoarthritis („doubling dosages“) by applying meta-regression analyses.

**Conclusions:** Even in case of high heterogeneities of exposure assessment in the available studies, the use of an external reference population might allow for the derivation of an exposure-response relationship.

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Acknowledgements: The authors thank the BAuA for funding.

## Opioids prescribed to manage musculoskeletal pain often lead to opioid use disorder among construction workers

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**Background:** Construction workers often experience pain caused by the physical demands of work, and have among the highest opioid prescription and overdose fatality rates of any occupational group. We explored the relationship between opioids prescribed for chronic musculoskeletal disorders (MSD) and other health conditions and their relationship to development of chronic opioid use and opioid use disorder (OUD).

**Methods:** From a sample of 19,909 workers, we identified chronic MSD, acute injuries, musculoskeletal surgery, and other conditions linked within 3 days to opioid prescription fills from January 2015 through June 2018. We examined predictors of high doses ( $\geq$  50 morphine mg equivalents/d), large supply ( $>$  7 days in one fill) and chronic opioids ( $\geq$  60 days supply in  $<$  3 months) by diagnoses, and odds of OUD associated with MSDs, opioid dose, supply, and chronic opioid prescriptions.

**Results:** Many workers (42.8%) suffered from chronic MSDs and/or recurring acute injuries in a single year, of whom 24.1% received at least one prescription of opioids and 6.3% received chronic opioid prescriptions ( $\geq$  60 days supply/quarter). Those diagnosed with chronic MSD had the highest risk of OUD (OR 4.71) followed by musculoskeletal surgery (OR 1.89) and acute musculoskeletal injury (OR 1.53). During follow up, workers with chronic opioid prescriptions were 9.95 times more likely to be diagnosed with OUD and/or receive medication-assisted treatment (e.g. buprenorphine).

**Conclusions:** Opioids are commonly prescribed for pain relief among construction workers through their personal health insurance. Among those with chronic MSDs, 6.3% became chronic opioid users, and these chronic users had a 10-fold risk of developing opioid use disorder. Opioids should be prescribed more judiciously, with strong consideration for alternative pain management treatments. Reducing musculoskeletal disorders among construction workers could help to prevent their strikingly high morbidity and mortality due to opioids.

## Patterns in concurrent low back and neck/shoulder pain among eldercare workers - A one-year longitudinal study with 4-weeks measurements

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**Objective:** To examine patterns of concurrent low back and neck/shoulder pain (LBP+NSP) over time and to investigate characteristics of those having constant pain.

**Methods:** One year follow-up with measurements of self-reported musculoskeletal LBP+NSP via text message every 4-weeks among 275 eldercare workers. Patterns of pain over time was categorized as constant pain free, repeated pain free, improving, worsening, repeated pain, and constant pain. Selected characteristics of constant LBP+NSP population versus constant pain-free population was analyzed as odds ratios for belonging to the constant LBP+NSP population with adjustments for age and sex.

**Results:** The study population mostly consisted of women (94 %), average age was 47 years, most participants (83 %) were born in Denmark and 28 % reported no LBP+NSP in the 3 months before the text message survey. The average LBP and NSP intensity was 4 and 3 (on a scale from 0 to 10), respectively. The 4-weeks prevalence of LBP+NSP varied between 49% and 56 % with a one-year prevalence of 79%. Monthly fluctuations in pain status on an individual level was seen for the categories with improvement or worsening, while 24% reported LBP+NSP every 4-week period throughout the year. Compared to the constant pain-free population, these 24%, reported a significantly higher physical exertion during work (odds ratio of 1.32 (CI:1.08-1.62)). Also ethnicity other than Danish, increased the risk of having constant LBP+NSP.

**Conclusions:** A high proportion of eldercare workers reported multisite pain in terms of low back and neck/shoulder pain constantly over the one year follow up. The high 4-weeks prevalence of LBP+NSP additionally covered a pattern of frequent individual fluctuations between improvement and worsening. The association of LBP+NSP with higher physical exertion during work indicates a need for work site prevention targeting both the low back and neck/shoulder body sites.

## The profile of people working in the social care sector in a cohort of 50-64 year-olds: results from the Health and Employment After Fifty (HEAF) study

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**Background:** Previous research has shown that social care workers in the UK are under severe pressure, reporting higher level of stress, poorer health and worse financial circumstances than other professions. We described the characteristics of people working in social care using HEAF, a cohort study of 8,134 men and women aged 50-64, recruited in 2013-2014 through 24 English general practices.

**Methods:** Data came from HEAF baseline and were restricted to participants in paid employment at the time (n=5,518). Social care workers were identified through the Standard Occupational Classification 2010 (n=176) and were compared to workers in any other sector. Socio-demographic variables, finances, feelings about work and self-reported health measures were ascertained by postal questionnaire. Associations were analysed by logistic regression, with adjustment for age and sex.

**Results:** Social care workers were predominantly women (84%), poorly educated, and struggling to manage financially. They were also more likely to be dissatisfied with their pay (OR=2.5, 95%CI 1.8 to 3.4) and to have difficulties coping with their job's physical (OR=2.2, 95%CI 1.7 to 3.0) or mental demands (OR=1.8, 95%CI 1.3 to 2.4). These results were robust to further adjustment for finances. Furthermore, social care workers showed worse health (self-rated, depression, sleep problems, and chronic musculoskeletal pain at either back, shoulder or legs) than participants in other professions.

**Conclusions:** Our data suggest that social care workers have a disadvantaged health, financial and psychosocial work profile. Further research is needed to identify how older workers in the social care sector can be better supported.

## Work-Related Musculoskeletal Disorders among Older Construction Workers in the United States

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**Background:** Work-related musculoskeletal disorders (WMSDs) are common among construction workers because of their job exposures. With the aging workforce, more and more older workers are employed in construction. Safety and health issues vary by age. To provide insights to workplace interventions, this study examines trends and patterns of WMSDs among U.S. construction workers from 1992 through 2017, with an emphasis on older workers.

**Methods:** WMSDs were identified from the Survey of Occupational Injuries and Illnesses conducted by the U.S Bureau of Labor Statistics (BLS). Risk of WMSD was measured by number of WMSDs per 10,000 full-time equivalent workers (1 FTE= 2,000 hours). FTEs were calculated from the Current Population Survey, a BLS household survey. Stratified and trend analyses were performed to examine differences in age groups over time. Chi-Square and Cochran–Armitage tests were applied to test statistical significance at the  $\alpha = 0.05$  level. SAS version 9.4 was used for all data analyses.

**Results:** Both number and rate of WMSDs have significantly dropped since 1992 following the overall injury trends in construction, but the share of WMSDs among workers aged 55+ nearly tripled. From 2011 to 2017, the percentage of WMSDs for workers aged 55+ increased from 13% to 19%, a 46% increase within seven years. Moreover, the median days away from work due to WMSDs was about 10 days or less among workers under 35 years old, but was one month or more among workers aged 55 years and older. By body part affected by WMSD, the back ranked at the top for all age groups. Overexertion was the major cause of WMSDs in construction.

**Discussion:** Older construction workers face a higher risk of WMSDs and difficulties to recover after injury. Ergonomic solutions to reduce overexertion should be adopted extensively on construction sites, particularly for workers at high risk.

# Poster Presentations



## 1. A multidisciplinary team to manage ergonomic hazard: case report of a storekeeper with hand strain

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**Background:** Upper limb musculoskeletal disorders is a significant health condition among working population. This case report aims to describe the investigation and management of an employee in the hospital pharmacy store with right hand pain for one week.

**Methods:** We adopted a multidisciplinary approach to assess the risk factors using socioecological model and understand the interactive effects between personal and environmental factors. Data was collected through history taking, physical examination, interviewing supervisors and joint walkthrough survey with an Occupational Therapist and Occupational Physician (OP).

**Results:** A 50-year-old lady working as a pharmacy storekeeper was reviewed the Occupational Health (OH) clinic for right thenar muscle strain. At an individual level, her age and gender put her at risk of musculoskeletal injuries. At the departmental level, there was prolonged repetitive work with insufficient rest breaks. Her work involved pasting labels on medication packaging, sealing the medication zip lock bags and cutting blister packs with scissors. These activities involved repetitive abduction of the right thumb, pinch grip and pressure on right thumb. She was referred to an Occupational Therapist (OT) who also assumed the role as the Return-to-Work Coordinator. OT and OP jointly recommended strategies to mitigate the risks using hierarchy of control which was discussed with the department. The Pharmacy department planned to automate manual work processes. In the meantime, the OT taught the employee and supervisors simple hand stretching exercises which were then taught to other staff. The department also implemented microbreaks during work, recommended to review risk assessment documents and encourage early reporting of musculoskeletal complaints.

**Conclusion:** There are risk factors for upper limb musculoskeletal disorders from personal demographics, work organization and work processes factors. A multidisciplinary team ensures a holistic approach to investigate and manage musculoskeletal disorders among employees.

## 2. Designing and making smart class board into automatic height adjustable and determine the effect on user body posture

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**Introduction:** The aim of this study is designing and making smart class board into automatic height adjustable and determine the effect on posture of users.

**Methods:** This study is before-after interventional study that evaluates the effect of smart board on users posture. First users posture assessment is done based on REBA method using non-smart board and then this evaluating is done when using the smart board.the study population is Isfahan university of medical sciences professors and students.entry criteria to this study are classs professors and students who use non-smart boards.analysis of data is done by using spss20 software,and Pvalue<0.05 is considered meaningful.

**Results:** Results showed that at the upper part of non-smart board 54.5% of samples required a necessary corrective action (whatever sooner) which were at the level 3 of prioritizing corrective action. Posture assessment in middle part of board showed that in non-smart board 90.9% of samples are at the level 2 of prioritizing corrective action,while in smart board 4.5% of samples are at this level.also posture assessment was done in lower part,results showed that 18.2% of samples are at the level 2 of prioritizing corrective action,while in smart board there was no need for corrective action.

**Conclusion:** The results of posture assessment by REBA method in this study indicate a high level of risk in the use of non-smart boards.so according to the results of smart board,it is suggested that this new technology be used to prevent musculoskeletal disorders.

### 3. The relationship between status ergonomic construction jobs and musculoskeletal disorders construction workers using check list NIOSH-CPWR

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**Introduction:** Musculoskeletal disorders are the second highest damage of construction workers. The purpose of this study was to evaluate the ergonomic construction jobs with the check list CPWR- NIOSH and Nordic.

**Methods:** This study is cross-sectional and it was carried out for 106 construction workers in Ahvaz. The research instruments in this study were the Nordic questionnaire and check list CPWR – NIOSH ergonomic. Check list CPWR – NIOSH ergonomic is included 11 specific sections. Nordic questionnaire was completed for 106 construction workers. Data analyzed by SPSS statistical software for statistical analysis.

**Results:** Shoulder disorders (3/61%), back (4/59%) and knee (7/54%) had the highest percentage prevalence of musculoskeletal disorders in the subjects. 5/74% of jobs had repetitive movements and 9/68% duty had more than an hour a day on their knees. 5/75% of workers have to bending and twisting of their bodies during operation. The most construction sites surfaces were rough and tough for walking and working.

**Conclusion:** According to research conducted musculoskeletal disorders Occurs among construction workers shortly after they began their work. The use of tools and equipment designed according to ergonomic principles, management controls and training instructions and compliance with the relevant standards by managements and systems monitoring construction activity and health workers necessary application health monitoring workplace.

#### 4. Musculoskeletal disorders, ageing and overweight in the workforce - a prospective cohort study

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**Background:** In Denmark, initiatives to keep workforce at the labour market has resulted in a higher average retirement age. This will likely lead to an increased incidence of musculoskeletal disorders, but whether that would be due to more degenerative changes or to longer durations of occupational exposure is not clear. Also, an escalating global epidemic of overweight and obesity may contribute to increased load at work. By establishment of a cohort, we aim to describe work exposure and age-related changes in physical capacity among a working population and evaluate the impact of occupational workload and lifestyle on degenerative changes.

**Methods:** This longitudinal, epidemiological study, comprises a web-based questionnaire on condition at work, workload, workability, and general health, sent to all residents (50-65 years of age) in the municipality of Esbjerg, Denmark (n=23,700). A randomly selected group corresponding to 10% of the study population will early summer 2019 be invited to participate in interviews on work exposure and clinical examination. A similar data collection will be performed in 2023-2024.

**Results:** At present, a total of 8,914 participants have responded to the questionnaire (female:4694/male:4220). The mean(SD) age was 59(4) years. Most of the subjects (f/m) were either normal weight (BMI $\leq$ 24.9): 45%/29% or overweight (25 $\leq$ BMI $\leq$ 29.9): 32%/48%. The workability (score 0-100) was 77.3 (27.0) (75.2 $\pm$ 28.4/79.6 $\pm$ 25.3). Nineteen percent had physically demanding jobs, 46% mentally demanding jobs, and 35% reported jobs with equal mental and physical demands. The participants rated their physical capacity with respect to their current job as 'very bad' (3%), 'bad' (6%), 'moderate' (20%), 'good' (52%) and 'very good' (19%).

**Conclusion:** This prospective cohort study is in its initial phase. Promising response rate of 37,6% and good dispersion regarding work load provides good conditions for achieving new knowledge on age-related degenerative changes and the importance of work exposure and lifestyle in relation to higher retirement age.

## 5. Relationship between depression and musculoskeletal disorders

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**Background:** A number of Japanese workers have been acknowledged for work-related mental disorders since 1990s until today. It is also known serious cases of work-related musculoskeletal disorders (WRMSDs) concur with depression, insomnia, autonomic imbalance, etc.

The aim of this study is to test if patients suffering from various types of long lasting musculoskeletal pain are also suffering from depression than healthy people.

### **Methods:**

**1.Subjects;** Seventy patients visiting the rehabilitation medicine department at the Kanazawa Medical University (KMU) hospital for treatment of chronic musculoskeletal pain were assigned as the patients group for the present study. The control group was recruited from healthy students of KMU. Thus 41 students joined to this study.

**2.Examination;** Each subject was examined for tender muscle points and pressure-pain threshold (PPT). Altogether 58 tender muscle points were examined, including 18 specified points for fibromyalgia by the American college of Rheumatology (ACR) criteria. PPT of 22 body regions were recorded using a strain-gauge sensor. Subjective assessment of depression was measured by using Zung's Self-rating Depression Scales (SDS).

**Results:** The mean values of tender points for male and female patients were respectively 53 and 56, and for male and female students were respectively 38 and 42. The mean PPTs of the right trapezius for male and female patients were respectively 1.9kgf and 1.2 kgf, and for students 2.5kgf and 1.7 kgf. The mean scores of SDS for male and female patients respectively were 46 and 52, and for students 38 and 41.

**Conclusion:** It revealed most of these patients were suffering from both musculoskeletal pain and depression. However, with commencement of treatment SDS scores improved earlier than musculoskeletal problems. It may suggest that depressive states are induced by the long lasting serious musculoskeletal pain. The findings encourage further studies on relationship between MSDs and mental disorders in a broad perspective.

## 6. Comparison of musculoskeletal symptoms in blue-collar and white-collar workers in the previous seven days - analysis stratified by age

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**Background:** There is a global trend toward an increase in the number of older workers in the labor market. The aim of the present study was to compare the prevalence of musculoskeletal symptoms among blue-collar and white-collar workers in an analysis stratified by age.

**Methods:** A cross-sectional study was developed in Brazil using data from the BRAZilian eValuation of Occupational health (BRAVO database). This study was conducted in accordance with international ethical standards. The sample consisted of 900 blue-collar and white-collar workers distributed in two age groups: <50 years (309 blue/429 white) and ≥50 years (81 blue/81 white). Workers under the age of 18 and those with less than 12 months in the current position were excluded. Musculoskeletal symptoms in the previous seven days were investigated using the Brazilian version of the Nordic Musculoskeletal Questionnaire. Blue-collar and white-collar workers were compared using the chi-squared association test ( $\alpha=5\%$ ) in analyses stratified by age (<50 and ≥50 years).

**Results:** In the younger group (<50 years), the prevalence of symptoms in the shoulder (22% vs. 15%), upper back (23% vs. 16%), lower back (30% vs. 19%), knee (13% vs. 8%), ankle/foot (17% vs. 10%) was significantly higher among blue-collar workers compared to white-collar workers. In the older group (≥50 years), the prevalence of symptoms in the elbow was significantly higher among the white-collar workers compared to the blue-collar workers (10% vs. 3%).

**Conclusion:** Blue-collar workers younger than 50 years of age had more musculoskeletal symptoms, possibly due to the healthy worker effect (sick and older workers do not remain active in the labor market). Another explanation would be the job accommodation process, in which older workers are reallocated to sectors with lower physical demands, placing an overload on younger workers. Organizational strategies and effort reduction can contribute to the reduction of musculoskeletal symptoms, especially among younger blue-collar workers.

## 7. Influence of low and high cognitive loading on task precision during a 30-min tracking task in younger and older subjects

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**Background:** Little is known about the application of combined cognitive and physical loading, which induces muscular fatigue, on task precision. Furthermore, a potential influence of age also remains unclear. Therefore, this study aims to investigate the influence of an n-back test on the task precision during a tracking task inducing muscular fatigue in two age groups.

**Methods:** Forty-eight subjects from two age groups will be recruited (group I: 18-27 years; group II: 50-67 years). Each subject has to perform a 30-min working memory task (n-back test) at a low (0-back) and a high (2-back) cognitive level. Meanwhile, subjects have to handle a tracking task (intermittent isometric contraction of the dorsal extensor of the wrist at an average of 10 % of the individual maximum voluntary force) inducing low levels of muscular fatigue. Task precision will be calculated as the deviation of the applied force to the target force as given by the tracking task. Muscular fatigue is measured by changes in isometric maximum voluntary force. In addition, subjects will assess their cognitive and muscular effort on an 11-point Likert scale.

**Results:** A preliminary evaluation of 19 younger adults (10 male / 9 female; mean age 22.5 years) showed an influence of cognitive load ( $p = 0.027$ ) and muscular fatigue ( $p < .001$ ) on task precision. However, no interaction between cognitive load and muscular fatigue was observed ( $p = 0.448$ ). Results of the older subjects (group II) will be presented at the conference, since the recruitment of this group is not completed yet.

**Conclusion:** The results indicate a decrease in task precision due to higher cognitive loading at the state of no muscular fatigue and during muscular fatigue in young adults. With regard to real working conditions, the cognitive load levels and muscular fatigue are important determinants of workplaces with high requirements on task precision.

## 8. The Swedish Work Environment Authority introduces medical checks for hand-intensive work

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Hand-intensive work, involving high repetition combined with power development, is common in a variety of industries in the Swedish labor market. In addition to traditionally male-dominated professions, such as cutting carcasses, hand-intensive work is also common in, for example, food processing industry, manufacturing industry, and among cleaners. In these professions, many women work. Statistics indicates that more women than men are suffering from WRMSD's from hand-intensive work.

Provisions on ergonomics for prevention of MSDs (AFS 2012:2): 7 § "The employer shall ensure that there is normally no work that is repetitive, closely controlled or restricted. If, nevertheless, an employee must perform such work on account of particular circumstances, the employer shall prevent the risks of ill-health or accidents as a consequence of health-endangering or unnecessarily fatiguing loads..."

It's important that symptoms of WRMSD's are detected early. Then rehabilitation can start early and the problems do not become chronic. SWEA regulates currently by provisions (AFS 2005: 06) on medical controls in working life prescribing that medical check-ups must be carried out if a risk is detected in the OSH management system that cannot be eliminated nor handed in another way. Experience says that risk assessments for WRMSD's from hand-intensive work are not made to a sufficient extent, and it can be difficult for employers to understand when medical checks for hand-intensive work are to be ordered.

SWEA introduces a new section on hand-intensive work in the provisions (AFS 2012:2) and in the new provisions on medical controls. They should clarify to employers when they are obliged to offer their employees medical control for hand-intensive work. SWEA's Director General will decide on the new rules in 2019. The presentation will focus on the changes to the provisions on ergonomics for prevention of MSDs (AFS 2012:2) and the new provisions on medical control for hand-intensive work and how it should be applied.

## 9. The U.S. National Occupational Research Agenda for Musculoskeletal Health

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**Background:** The National Occupational Research Agenda (NORA) is a research framework that prioritizes research for the U.S. and the National Institute for Occupational Safety and Health (NIOSH). Research priorities for the next decade are targeted toward 10 major industrial sectors of the US economy and 7 health areas that cross industrial sectors, including musculoskeletal health (<https://www.cdc.gov/nora/councils/default.html>). Separate NORA councils on these 17 issues were created to develop updated national research agendas. Each NORA council is a coalition of volunteers from U.S. universities, businesses, professional societies, worker organizations and government agencies. This presentation illustrates the NORA research agenda for the prevention of work-related musculoskeletal disorders (WMSDs).

**Methods:** In 2017, 32 Musculoskeletal Health Council members reviewed injury statistics and relevant literature to identify areas where research is most needed. The process involved a consensus approach with the exchange of research papers and draft proposals. A draft agenda was created by the council in the summer 2017. In February 2018, the draft agenda was published in the federal register for public comments. These comments were addressed in the final agenda published in October 2018 (<https://www.cdc.gov/nora/councils/mus/researchagenda.html>).

**Results:** Gaps in five research areas were identified and addressed in the agenda: (1) defining the incidence and impact of WMSDs; (2) understanding the risk factors for WMSDs; (3) describing the underlying mechanism of MSDs; (4) developing and evaluating interventions to prevent WMSDs and limit disability due to WMSDs; and (5) disseminating and implementing interventions to prevent WMSDs and limit disability.

**Conclusion:** Research in all five areas is recommended in the agenda. Evaluations of intervention effectiveness using robust study designs, such as randomized controlled trials, are of particular importance for providing evidence-based solutions. U.S. stakeholders for the prevention of WMSDs are encouraged to collaborate with the NORA Musculoskeletal Health Council on addressing this agenda over the next decade.

## 10. Effectiveness of workplace interventions in the rehabilitation of musculoskeletal disorders among workers with physical employment: Systematic review

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**Background:** Although there has been a major focus on the rehabilitation of musculoskeletal disorders (MSDs) and preventing its consequences, MSDs remain a significant problem especially among employees with physically demanding work. This systematic review evaluates the effectiveness of workplace-based interventions to reduce MSDs and its consequences among adult workers with physical work tasks.

**Methods:** Randomized controlled trials (RCTs) are considered the most powerful experimental design in clinical trials, but solely including these may be too restrictive to understand effective workplace-based interventions where randomized and carefully controlled trials are not always possible. In order to maximize practical relevance, the selection process, therefore, include both RCTs and non-RCTs and the quality assessment and evidence synthesis conform to the Institute for Work and Health (IWH) guidelines focusing on developing practical guidelines for stakeholders. Studies are eligible for inclusion if 1) participants are adult physical workers with any MSD (both specific and non-specific and including musculoskeletal pain), 2) interventions are aiming at rehabilitating pain symptoms of MSDs or preventing its consequences, 3) interventions are carried out at the workplace, and 4) reported in English. The following bibliographic databases were searched: PubMed and Web of Science. The review is registered in PROSPERO (CRD42018116752).

**Results:** The bibliographic searches identified 15,556 references, 6,778 from Web of Science and 8,778 from PubMed. After removal of 3,091 duplicates, 12,465 titles and abstracts were screened. 12,117 records were excluded based on title/abstract. Screening of the remaining 348 full-text records is ongoing. The results of the review will be presented at PREMUS 2019.

**Conclusion:** This systematic review will form the basis for evidence-based recommendations on effective workplace-based interventions for rehabilitation of MSDs and its consequences that will later be operationalized into concrete and user-friendly practical tools for workplaces.

## 11. The impact of office ergonomics intervention: a case study in 18 companies across Singapore

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**Background:** Musculoskeletal disorders (MSD) have become a major concern in companies because of the negative impact on the health and productivity of employees. The office ergonomics intervention was conducted to assess the part of the body of the participants affected by aches and pain.

**Methods:** The intervention was conducted for 18 Companies with 688 participants. The execution for the "Office Ergonomics Intervention" was comprised of the logistic and the actual intervention (by providing back rest, document holder, keyboard gel pad, mouse gel pad, wireless keyboard and mouse, footrest). Participants reported the intensity of pain on various body parts before and after intervention. The intervention form used the 7-point scale with 0 as "no pain" and 7 as "worst pain". The intervention was deemed to be successful if participant reported improvement in at least one body part.

**Results:** There were 595 (86.98%) participants with complaint of body aches and pain before intervention. This condition improved 2-weeks after intervention with 476 (80%) participants reported improvement in at least one body part.

**Conclusion:** The study showed the impact of office ergonomics intervention to improve the complaint of musculoskeletal disorders (MSD) among workers.

## 12. Sit-stand tables in overweight and obese computer workers: investigation of a comfortable pre-set time

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**Background:** Sit-stand tables became an important intervention to decrease sitting time at work, as well as to reduce musculoskeletal discomfort<sup>1</sup>. However, little is known about a comfortable pre-set time for sit-stand table usage, particularly for overweight/obese population. The aim was to identify a comfortable pre-set time for use of the table in sitting and standing position by an overweight/obese population.

**Methods:** This pilot study included 15 computer workers divided into two groups: overweight/obese degree 1 group (OG; n = 8), BMI 27.6 (SD 1.8) kg/m<sup>2</sup> and normal weight group (NWG; n = 7), BMI 22.6 (SD 1.25) kg/m<sup>2</sup>. The study was conducted for three hours per day for five days, and participants performed their regular working tasks at a sit-stand table. The first day was entirely in sitting position and, during the following days, four pre-set schedules were randomized for each participant as follow (sit/stand): A: 50/10 min; B: 40/20 min; C: 30/30 min; D: 20/40 min. Participants evaluated the pleasantness of each schedule through a Likert scale of five points and the Nordic Musculoskeletal Questionnaire was applied every day to identify any discomfort.

**Results:** Participants chose schedule A as the most pleasant [median 5 (4.0–5.0)], followed by schedule B [median 4 (4.0–5.0)], and schedule C [median 4 (3.7–4.2)]. At the baseline, the NWG reported more symptoms than the OG. This behaviour has reversed during the protocols, when OG reported more symptoms than NWG. Both groups reported more symptoms in schedule D.

**Conclusion:** A schedule of ten minutes standing for each 50 minutes sitting was demonstrated to be a good pre-set schedule for the OG, considering both comfort and musculoskeletal symptoms. More studies are necessary as this is the first pilot study to investigate a comfortable schedule of sitting versus standing for this population.

### 13. Evaluation of the Current Advise for Return to Activities and Work after Total Knee Arthroplasty

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**Background:** Recommendations concerning return to activities (RTA) and return to work (RTW) after total knee arthroplasty (TKA) are scattered. Evidence is limited, and recommendations are therefore often based on expert opinions of health care professionals. Considering that well-defined and mutual advise for post-surgical recommendations could improve shared decision making and perioperative care, we aimed to evaluate the current recommendations with regard to RTA and RTW provided by hospitals to patients after TKA.

**Methods:** We summarized and compared current advice and recommendations regarding RTA and RTW after TKA surgery. Scientific literature and guidelines of various healthcare professions were identified. Moreover, advice and recommendations were searched on websites, brochures and flyers from Dutch hospitals. Additionally, after request, three Dutch hospitals provided us with a frequently used mobile phone application with advise and recommendations they provide to TKA patients.

**Results:** A total of 23 recommendations were evaluated and the advice for 14 activities was summarized. Our results showed that recommendations regarding RTA and RTW were often missing, and postoperative advise was mostly focussed on pain relief and wound healing. Furthermore, advice concerning RTA and RTW varied greatly between Dutch hospitals. For example, the advice for resuming heavy chores after TKA varied from 6 weeks to 3 months, recommendations for resuming cycling varied from 4 to 12 weeks and advice for returning to work varied from 3 to 9 weeks.

**Conclusion:** Recommendations for RTA and RTW after TKA are often lacking in usual care and vary considerably in Dutch guidelines and between hospitals. To improve shared decision making and perioperative care for TKA, consensus about guidelines and recommendations for postoperative rehabilitation is needed. Therefore, our next step will be to conduct a Delphi Study to yield such consensus among health professionals involved in TKA care.

## 14. Supervisor's roles and responsibilities in preventing prolonged disability in workers with musculoskeletal disorders

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**Background:** Even if the role of supervisors in the process of return to work (RTW) after work-related musculoskeletal disorders (WMSD) is mentioned by many studies, very few of them detail supervisors' precise responsibilities in the workplace. The objective of this paper is to provide an overview of supervisors' roles and responsibilities in the workplace.

**Methods:** A systematic review of the literature was performed. Documents between 1995 and 2018 were searched from three occupational scientific databases and INTERNET websites with different terms related to three concepts by a specialist librarian. Studies' selection criteria were: focus on the supervisor; considering the role of supervisor in the RTW process; at least one group of workers absent from work because of work-related musculoskeletal injuries, quality. An inter-judge agreement procedure was used. Descriptive and thematic content analyses were performed.

**Results:** From the 788 references retrieved, nineteen publications were included. Twenty-two precise actions and interactions were identified and grouped according to eight essential activities and two organizational and individual challenges. The essential activities referred to actions accomplished at different moments of the RTW process and favorable circumstances contributing to improve RTW in the workplace. The challenges were essentially related to a need for clarifications regarding supervisors' expected actions, distinguishing them from other involved actors' responsibilities, as well as to a need for adopting measures allowing for the creation of facilitative strategies – such as communication and collaboration between actors involved, and the coordination of their actions with the actions of rehabilitation professionals.

**Conclusion:** For helping the supervisors playing their supporting role of the worker and accomplish sustainable RTW, the organisations need to recognize the importance of the role of the supervisors in the RTW, explicitly state supervisors' responsibilities, offer them adequate support, such as decisional latitude to implant adjustments and accommodations, and appropriate training to develop better attitudes and experience.

## 15. Review of research, policy and practice on prevention of work-related musculoskeletal disorders (MSDs)

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**Background:** The aim of the project is to seek answer to the question why work-related MSDs remain a major concern despite a substantial body of research and decades of efforts invested in prevention at all levels, and to provide recommendations for new approaches to tackle work-related MSDs.

### **Methods:**

The project consists of

- desk research comprising an exploratory literature review and an overview of policies aimed at tackling MSDs in selected European countries;
- qualitative research encompassing focus groups and interviews in six countries to investigate risk assessment practices and prevention strategies in relation to MSDs and the effectiveness of policy implementation;
- an expert workshop to discuss and validate the results.

**Results:** Preliminary findings suggest: significant diversity between Member States regarding the extent to which they are addressing the MSDs problem and the approaches they apply; a lack of evaluation of policy initiatives; legal requirements appear to be an important determinant of action at workplace level; risk assessment often appears to be an end in itself, whereas it should be the starting point; general risk assessment is not sufficient for MSDs prevention; training on manual handling and job rotation are the most commonly used measures.

**Conclusion:** A combination of various factors appears to contribute to the persistent high prevalence of MSDs. This includes the ageing of the workforce, the still high exposure to 'traditional' risk factors, new risk factors related to new technologies and new forms of work, but also lifestyle related risk factors. To tackle MSDs successfully, all these areas need to be addressed. There seems to be a gap between research evidence and workplace practice and between policies and practice. A systematic approach combining various policy instruments, including legislation, more effective policy implementation and cross-policy action are needed, including with public health, education and social security.

## 16. An unobtrusive wrist orthotic for carpal tunnel syndrome intervention

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**Background:** Carpal tunnel syndrome (CTS), the most common upper peripheral entrapment neuropathy, leads to lost wages for the employee and reduced productivity and expense for the employer. A wrist orthotic was developed to treat symptoms of CTS by non-invasively decompressing the median nerve. The CTS wrist orthotic was successfully tested in a pilot clinical study to investigate the safety and efficacy of the device as a treatment for CTS and biomechanics experiments were performed to understand the mechanism.

**Methods:** In the pilot study, 11 adults with nerve conduction study-confirmed CTS were enrolled. Participants wore the device for 8-10 hours daily for 4 weeks. Follow-up occurred fortnightly during treatment with one post-treatment follow-up 8 weeks later. The main outcome measure was the Boston Carpal Tunnel Questionnaire (BCTQ) Symptom Severity Score (SSS, 1-5 Likert scale). In a cadaveric study, pressure reduction on the median nerve was measured on 10 cadaver forearms using PPS Tactile Sensors. Baseline pressure was elevated to 100 mmHg to mimic higher carpal tunnel pressures in patients with CTS. Changes in pressure on the median nerve were then measured in response to cyclic (20x), controlled lifting of the volar wrist tissue by the wrist orthotic.

**Results:** After 4 weeks of daily wear, patients with unilateral CTS experienced the greatest reduction in SSS:  $-0.9 \pm 0.5$  points at 4 weeks and  $-1.2 \pm 0.5$  points 8-week post-treatment. In the cadaver study, a small lifting distance of 3 mm was enough to result in a significant reduction in carpal tunnel pressure and pressures decreased on average 25 mmHg with 6 mm lifting distance.

**Conclusion:** The CTS wrist orthotic has been shown to reduce pressure on the median nerve and reduce CTS symptoms. Randomized placebo controlled multi-center clinical trial is ongoing as well as efforts to be integrated into worker safety programs to prevent the onset of CTS.

## 17. Comparison of municipal bus driver whole-body vibration exposures when operating a bus with an active, passive and static suspension bus seat

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**Background:** Municipal bus drivers have a high rate of work-related musculoskeletal disorders (WMSDs) and Whole Body Vibration (WBV) has been shown to be a risk factor associated with WMSDs. Recently, active suspension seats have become commercially available for use in municipal buses in North America. A recent randomized controlled trial with semitruck drivers demonstrated that the active suspension seats reduced WBV exposures by 50% and self-reported back pain by up to 30% when compared to truck drivers that used industry-standard, passive air suspension seats.

**Methods:** This study compared WBV exposures while bus drivers operated a municipal bus over a standardized test route using three different types of seats: 1) an active (electromechanical) suspension bus seat, 2) a passive (air) suspension bus seat, and 3) a static (suspension-less) bus seat. Tri-axial WBV exposures were collected from the bus seat and floor and were compared across the three seats.

**Results:** During the evaluation of the three seats, the buses were operated at roughly the same speeds and there were significant differences in the WBV exposures measured across the three seats ( $p$ 's  $< 0.0001$ ). On city streets and freeways that comprised the standardized route, the active suspension seat reduced the WBV exposures by 40 to 60% compared to the other two seat types.

**Conclusion:** For the first time an active suspension seat was evaluated in a municipal bus and the results demonstrated that the active suspension seat substantially reduced WBV exposures relative to the other types of commercially available bus driver seats. A recent Cost Utility Analysis demonstrated that the return on investment on the active suspension seat, resulting from less severe and reduced workers compensation claims, will be much greater than the incremental cost. Bus manufacturers and bus municipality procurement specialists need to be trained on the hidden value associated with the incremental cost of the active suspension seat.

## 18. Implementing preventive interventions for work-related upper extremity disorders in agriculture: facilitators and barriers

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**Background:** To identify facilitators and barriers for employers and workers for implementing interventions to reduce work-related risk factors associated with upper extremity musculoskeletal disorders (UEMSDs) in the agricultural sector.

**Methods:** An expert panel of health and safety consultants was used as a qualitative research method aimed at identifying facilitators and barriers for employers and workers for implementing interventions to reduce work-related risk factors associated with the following UEMSDs: carpal tunnel syndrome, medial and lateral epicondylitis and soft tissue shoulder disorders. The facilitators and barriers were asked to health and safety consultants who worked for the agricultural sector (n=9) during an one hour audio recorded session. The audio recording was transcribed verbatim and structured using MAXQDA 12. Possible facilitators or barriers were identified and classified into thematic categories for employer and worker.

**Results:** Facilitators and barriers for employers and workers were categorized in the following themes: knowledge, skills, attitude, culture, costs, loss of income, facilitation and employability. There were no differences in facilitators and barriers between the different diagnoses of UEMSDs. Most facilitators and barriers for implementation of preventive interventions for employers and workers were reported in the theme of attitude. An open attitude and continued attention to preventive interventions enhance the opportunity for implementation of preventive interventions for UEMSDs. Incorrect assumption of the employer regarding job changes and little willingness by the employer if there is no work disability are reported barriers regarding attitude which reduce the chance of preventive interventions being implemented. Other frequently reported facilitators and barriers were in the themes of knowledge and culture.

**Conclusion:** Facilitators and barriers for implementing preventive interventions in agriculture were on organizational level, like diversity in choice of preventive devices, and personal level such as willingness if there is no urgency like work disability.

## 19. Physical Exercise intervention to reduce musculoskeletal disorders and improve work performance – a systematic literature search

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**Background:** During the last decade a number of RCT's implementing physical exercise training (PET) at the worksite have been conducted to reduce musculoskeletal disorders and improve productivity and workability. The present study aimed to summarize the literature based on a systematic literature search.

**Method:** Studies were identified by a Scoping Search and according to the PRISMA checklist in the databases Medline and Embase. Eligibility criteria for selecting studies: Only RCT's published 2013-01-01 to 2018-11-15. A Boolean-search strategy was used with the operators "AND" and "OR" as well as "free-text-words" and defined keywords related to (worker OR workplace OR workforce) AND (physical activity OR physical exercise OR physical training) AND (fitness OR endurance OR strength) AND pain AND work performance.

**Results:** Overall, 1962 references were identified - 1598 without duplicates. Screening of titles identified 161 papers and reading of abstracts etc. resulted in 65 relevant papers on PET representing 38 studies. In total ~7000 workers were involved, ~2000 seated workers, ~4500 standing/walking, and ~450 with heavy physical work. In 15 studies mainly strength training was implemented, in 8 aerobic training, and in 15 combinations of these together with e.g. functional and/or cognitive training. Reduction of pain in neck/shoulder was evidenced in 25 studies mainly due to strength training among seated workers. Low-back was addressed in 11 and effective in 9 studies. In 13 studies measures related to work performance were reported and 11 reported positive effects. Finally, health risk indicators were improved in 26 studies. Only one study reported no such positive effect and no studies reported negative effects on these outcomes.

**Conclusion:** In jobs including office and computer work, dentists, technicians, musicians, health care workers, cleaning personnel, chicken farmers, pilots, construction work, and firefighters PET proved effective to reduce pain, improve work performance and/or reduce health risk indicators.

## 20. A Participatory Ergonomics Research Model for Development Of Interventions and Identification of Cultural Norms

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**Background:** A recent study on US lobstermen (Fulmer et al 2016, 2017) estimated a total annual occupational exposure of 5,847 FTE, where injuries receiving treatment occurred at a rate of 17.5/100 FTE and where 50% of lobstermen reported experiencing pain or discomfort in the low back in the previous 3 months. This burden of suffering called for research into effective means for reducing risk.

**Methods:** The current investigation utilized a participatory ergonomic research design to develop and evaluate interventions as a response to exposure to occupational risks for musculoskeletal disorders. The research design included a training in ergonomics principles to orient the research subjects and a structured series of meetings that focused on problem identification, intervention, evaluation, and dissemination of findings. Qualitative and quantitative data on exposure pre- and post-intervention were collected in accordance with the research subjects' input and prioritization for evaluation to measure efficacy and effectiveness.

**Results:** Six crews have engaged in the research. A single, predominant concept for reducing risk was not found. Interventions included: new equipment to reduce shoulder flexion and forceful exertion at back and upper extremity, new equipment to reduce awkward posture at hand/wrist during various activities associated with material handling; an informational video meant to develop dissemination of information about a work method to reduce forceful exertion during an irregular high exposure task of disentangling trap lines; and a 3" horizontal relocation of a block to reduce exposure to awkward posture. Not all these interventions resulted in statistically significant changes, and some were not quantifiable.

**Conclusion:** The greater value given to property ownership over preventive changes, and a propensity toward do-it-yourself adaptation of any changes introduced have been observed to be cultural norms that affect intervention effectiveness. Dissemination mechanisms and forum for ergonomic idea exchange are critically absent norms in the industry.

## 21. Gender differences on work-related musculoskeletal disorders among workers who perform their activities on sitting posture

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**Background:** Several factors contribute to gender differences that could potentially justify the higher prevalence of work-related musculoskeletal disorders (WRMD) among women. Nevertheless, there is no consensus regarding gender difference when male and female workers are performing the same occupational activity.

**Aim:** To evaluate, through a systematic review, whether there is difference in the prevalence of WRMD among men and women performing the same occupational activity.

**Methods:** PRISMA and Cochrane Collaboration recommendations were followed. Electronic search was performed on PubMed, MEDLINE, Embase, Cochrane, Web of Science and CINAHAL. Two independent reviewers selected the studies. Cross-sectional studies that compared the prevalence of musculoskeletal symptoms between men and women performing the same occupational activity were included. Methodological quality was assessed through the JBI for cross-sectional studies checklist. Results were initially analyzed descriptively. Further the evidence will be synthesized through meta-analysis.

**Results:** Up to October 2018 a total of 1,533 references were retrieved and 27 studies were included; of them 21 were classified as high methodological quality. A total of 12,921 workers were evaluated (7,883 men and 5,038 women). Those studies which assessed works performed in the sitting posture were considered for this report. It was possible to identify a high prevalence of musculoskeletal symptoms for men and women for all the body regions analyzed. In general women presented a higher prevalence of pain in the neck, shoulder and low back regions when compared to men. Nevertheless, these differences were higher for the neck region (men: 19-60% and women: 27-85%), when compared to shoulder and low back. Prevalence of shoulder pain varied between 45-76% for male and, 44-90% for female workers. LBP prevalence ranged 56-78% for male: and 44-75% for female workers:

**Conclusion:** Workers who perform activities in the sitting posture present very high prevalence of musculoskeletal symptoms regardless gender. Women are slightly more predisposed to neck symptoms than men.

## 22. If sternocleidomastoid muscle activation increased in women during the simulation of repetitive tasks could it predict greater risks of disorders?

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**Background:** Work-related musculoskeletal disorders (WRMSD) in the neck region mainly affect economically active women. Muscle activation has been studied to investigate sex differences in the neuromuscular fatigue process – this may explain the highest prevalence of WRMSD in women. The aim of this study was to evaluate the activation of the sternocleidomastoid muscle (SCM) after muscle fatigue induced by a simulated repetitive industrial task.

**Methods:** Twenty males and twenty females (18-35 years, no pain/discomfort in the neck/shoulder) were evaluated. We simulated a simple repetitive assembly task based on reaching and manipulating objects, choosing, fitting and discarding parts. The task was performed at/above shoulder level, until mechanical failure. Surface electromyography (sEMG) was recorded bilaterally from SCM along the task. The first and the last minute of the task were processed to obtain the RMS (root-mean square), which was normalized by maximum voluntary contraction (%MVC), and MF (median frequency). These values were considered as pre- (first minute) and post-fatigue (last minute). Two-way mixed ANOVA was applied (sex X time). As the behavior on the right side was the same as on the left side, only the right side data is reported.

**Results:** We have found neither interaction nor sex effect. Time effect was found for RMS: at post-fatigue, RMS from SCM was significantly greater than the pre-fatigue for both sexes ( $P < 0.05$ ).

**Conclusion:** These findings provide new insight on the repetitive task altered the activation of ECM, without difference between men and women. Even though we have not found sex differences, fatigue of ECM may call attention for neck stabilizers – they might also be overloaded in repetitive tasks. These muscles should also be addressed besides the shoulder movers and stabilizers.

## 23. Gender differences in the prevalence and intensity of neck, back and shoulder pain in austrian bank headquarter workers - a secondary analysis of an observational study

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**Background:** Musculoskeletal pain especially in the neck, back and shoulder regions is a health issue in modern societies. The aim of this analysis was to evaluate gender differences in prevalence and intensity of musculoskeletal pain in an Austrian cohort with sedentary behaviour.

**Method:** Four hundred twenty-seven people from an Austrian bank headquarter participated in this observational field study via an online survey (response: 36%). Allocation was done via email, with data collection during February and March 2019. Prevalence and intensity of neck, back and shoulder pain was determined with the Nordic Musculoskeletal Questionnaire and Visual Analogue Scales (0 mm - no pain, 100 mm - heavy pain), respectively.

**Results:** Three hundred twenty-eight participants (age:  $41.4 \pm 11.1$  years, female: 61.9%) were analyzed. The overall 12 month and 7 day prevalence of neck, back and shoulder pain ranged between 17.9% - 73.3% (men) and 32.0% - 83.1% (women), with intensities between 21.3 - 29.7 (men) and 33.6 - 39.4 (women). Women and men experienced comparable back pain (64.8%,  $p=0.87$ ) over 12 months, but more back pain in prior week (36.2 vs 27.6%,  $p=0.01$ ) and more neck and shoulder pain in both prior year and prior week ( $p \leq 0.04$ ). Pain among women was generally more intense ( $p < 0.06$ ). Outside of work accident rates were comparable for shoulder injuries ( $p=0.83$ ), but 3.5-4.5 times greater among women for back and neck ( $p < 0.10$ ). Men were more highly educated, worked more hours, spent more occupational time sitting, and earned more income ( $p < 0.08$ ). Women spent more leisure time sitting ( $p=0.04$ ) and tended to smoke more ( $p=0.12$ ).

**Conclusion:** Differences in prevalence and intensity of musculoskeletal pain exist between men and women in this study. Accident history, personal background, and outside of work activities might explain these differences. Further research is needed to understand gender-related musculoskeletal pain differences in sedentary occupational environments.

Trial registration: This study was prospectively registered (ClinicalTrials.gov Identifier: NCT03845803).

## 24. Investigation of morningness and eveningness and it's related of factors caused by shift working in hospital nurses.

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**Introduction:** The workload of nurses in the care of patients incur, if morningness and eveningness type were not be identified, they might be vulnerable to the adverse effects of shift work. The purpose of this paper is to determine the type of rhythm and its relationship with risk factors of shift working.

**Materials and Methods:** This cross-sectional study was done on 174 nurses in Al-zahra hospital in Isfahan on 2017-18. Morningness and eveningness were identifying with morningness- eveningness questionnaire (MEQ) and shift working disorder was identifying with survey of shift working questionnaire(sos).

**Results:** The highest prevalence disorder were related to its effects on social life, uncomfortable side effects, familial and personal effects, and gastrointestinal disorders that respectively contained, 90.8, 90.3, 89.1, 88.6 and 76.9 percent. More of them were middle type. Chi-square test showed a significant association between job satisfaction with morningness and eveningness ( $P < 0.001$ ). There was no difference between men and women in their type. ( $P > 0.05$ ).

**Conclusion:** Health, social and individual life disorders, in this group of people are high. With shortening the night shift, rotating shift work, regular staff training, regulation of shift working, as much as possible to prevent this problem. According to the vital job in functioning and tending to patient, identify the type of morningness and eveningness is important.

## 25. Presenteeism and Work-Related Musculoskeletal Disorders in Brazilian Nursing Workers

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The Work-Related Musculoskeletal Disorders (WRMD) have been described as one of the main causes of the nursing workers illness, carrying effects in the capacity to work, and consequently in the quality of the health care, due to presenteeism. Objective: to analyze the association between WRMD and presenteeism in brazilian nursing workers of a university hospital. Method: Epidemiological, cross-sectional study, by Stanford Domain Scale (SPS-6). It was using the Chi-Square association test for the categorical variables. For the quantitative variables, after the test of homogeneity of the Levene variances ( $p > 0.05$ ), the ANOVA test was applied. Results: The population was predominantly female (87.3%), The mean age was 41.6 years (SD = 9.2 years), ranging from 23.0 to 65.0 years, with the mean age of 14.0 years (SD = 8.6 years) the institution. The weekly workload was 38.5 hours on average, in proportions of use in the three work shifts. It was observed that the present average score was 19.9 points (SD = 4.9), ranging from 6.0 to 30.0 points and a median of 20.0 points. The physical dimension presented a mean of 12.3 points, ranging from 3.0 to 15.0 points and a median of 13.0 points. The psychological dimension (avoided distraction) presented a mean of 7.5 points ranging from 3.0 to 15.0 points, with an average of 7.0 points. Musculoskeletal disorders, headaches and migraines, and gastrointestinal disorders, with prevalent prevalences of 60.9, 13.9%, and 12.6%. Conclusions: The quantitative data showed the WRMD impact on presenteeism, however, they noticed the workers' efforts to remain productive due to their greater commitment to the nursing profession.

## 26. Factors of success and of failure in the process of returning to work after surgery for a work-related degenerative shoulder injury: description of the sample

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**Background:** Operated-on work-related shoulder injuries expose patients to serious difficulties when they go back to work. Therefore, a foresight study in 5 stages, from the pre-operative stage to one year after going back to work is currently in progress. The aim is to identify the prognostic factors of return to work. This work presents the data gathered at inclusion.

**Methods:** 110 people who had undergone rotator cuff operations were included. The data gathered were: sex, age, time off sick, general health (SF-12 survey); musculoskeletal health (Nordic Questionnaire (NQ), DASH, Constant Score (CS)); psychosocial health (HADS, Karasek Questionnaire (KQ)), and kinesiophobia (Tampa Questionnaire (TQ)); perceptions about work ability (WAI) and about returning to work (RRTWS).

**Results:** 88% of the included subjects were aged from 40 to 59 years. 58% were women. 56% of the patients had been off sick, on average, for 5 months (SD of 5 months). The physical and mental health scores from the SF-12 survey were respectively 32 (10) and 45 (9). 100% of the people had felt shoulder symptoms over the last 7 days. The mean intensity of discomfort/pain (NQ) was 6(2); the mean work DASH score was 80 (27). The CSs were 40 (22) on the operated-on side and 93 (20) on the non-operated-on side. The HADS scores were 26% for anxiety and 16% for depression. 69% of the people were kinesiophobic (TQ) and 46% showed exposure to job strain (KQ). Perceived ability to work was poor (63% of cases); 31% doubted being able to do their work within 2 years (WAI); 65% were situated in the pre-contemplation and contemplation dimensions the farthest away from return to work (RRTWS).

**Conclusion:** Next, the influence of these different variables on the length of time off sick and on the outcome of return to work will be studied.

## 27. The experience of nursing workers without work related musculoskeletal disorders on a sick team

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**Background:** The work context in health has been the cause of several illness processes, causing concern for researchers, managers and users, since often, illness can generate physical and / or mental restrictions on workers, compromising their capacity for work.

**Methods:** A qualitative study from the social phenomenology of Alfred Schütz, developed in a University Hospital, with nursing workers who did not present restrictions to the work, being the phenomenon unveiled with subjects. The speeches were transcribed in full for further analysis.

**Results:** The analysis resulted in the elucidation of two categories, the first one related to Why, "Context of Adversities in Nursing Work" encompassing fear of disability to the future, conflicts over work overload, and empathy. The second category, was called "Unrestricted Workers' Expectations", which included: the improvement of human resources management and the need for individual commitment.

**Conclusion:** The subjects evaluate and judge the work activities performed by the incapacitated colleagues. They recognize that they are overburdened, project themselves with the same disabilities in the future, express a sense of empathy, and rely on this tool to re-signify the participation of the disabled colleague and his own in their work processes.

## 28. Work ability and self-rated health of workers with chronic musculoskeletal diseases: a prospective cohort study

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**Background:** Chronic work-related musculoskeletal disorders (WRMDs) contribute to long term sick leave. Objective: To identify factors associate of work ability and workers' health perception with chronic musculoskeletal diseases.

**Methods:** This is a prospective cohort study. A total of 273 individuals diagnosed with chronic musculoskeletal disease that were attended at the occupational public health services of Unified Health System (SUS), SP, Brazil from 2015 to 2017. Individual were contacted by telephone to participate a 12-month follow-up (2018). A total of 126 individual agreed to participate but 118 responded to a structured questionnaire sociodemographic data, self-rated health, occupational characteristics, daily living habits, pain intensity and treatments.

**Results:** The mean age was 48.8 ( $\pm$  9.7) years, working time 9.6 ( $\pm$  10.4) years, blue-collar workers (37.3%), service sectors (29.7%), women (62.7%) and married (62.7%). The most frequent diagnoses were disorders in low back (46.6%) and upper limbs (45.8%). At baseline data showed the current work ability (Mean 6.1; SD 2.9 points), future work ability (mean 5.6; SD 3.2 points), physical and mental work demand (53.4%), health perceived (mean 6.0; SD 2.2 points). The job satisfaction was mean 7.4 (SD 2.8) points, pain intensity 6.4 (SD 2.7) and emotional condition (mean 6.0; SD 2.7) points. The linear regression analysis showed that the current work ability is explained (50%;  $p < 0.05$ ) by predictors of future capacity for work and physical activity. The current self-rated health has as predictors (70%,  $p < 0.05$ ) the emotional condition, the current occupational situation (to be or not to working) and job satisfaction.

**Conclusion:** Individuals with chronic musculoskeletal diseases presented poor work ability and self-rated health influenced by physical activity performance, occupational situation, job satisfaction.

Keywords: WRMSD; Work ability; Occupational health.

Financing: This study was financed in party by CNPq - Junior Scientific Initiation - Support: 129550/2017-5, The São Paulo Research Foundation (FAPESP) - Support: 2017/16544-0.

## 29. A multiprofessional care program to chronic work-related musculoskeletal diseases individual: a cohort prospective study

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**Background:** Work-related musculoskeletal disorders (WMSDs) rehabilitation involves physical treatment, behavioral, psychological and counseling on how to deal with pain and disability. Objective: To follow-up the general health perceived, pain intensity and work ability of individual with chronic WMSDs

**Methods:** This is a cohort study design. Participants were 88 individual with medical diagnosis chronic WMSDs attended at the occupational public health services of Unified Health System (SUS), SP, Brazil. All individuals after medical diagnosis are referred to a multiprofessional care group program (medical, physiotherapist, psychologist, social worker, nurse). From 2017 to 2018 six groups were happened with duration of 4 months (16 to 21 meetings; 10 to 19 participants per group). Sociodemographic, occupational characteristics, general health, pain intensity and work ability were evaluated in three times. The general health perceived, current and future work ability were collected through a Likert scale from 0 ("very bad") to 10 ("great"). Pain intensity was measured using the Numerical Pain Scale (11 points) monthly.

**Results:** The mean age was 49 (8.2) years, women (66%), married (62.5%), elementary education (51.1%). Time in job was 12.8 (SD 9.5) years, working with cleaning services (23.9%), blue-collar workers (22.7%), and service sectors (22.7%). The most frequent musculoskeletal diagnoses were disorders in upper limbs (55.7%) and low back (28.4%). Health perceived improved 1.2 points ( $p < 0.001$ ) and the current work ability 1.0 points at baseline to after 2 months at the end of group program ( $p < 0.05$ ), and 1.6 points after end of the program ( $p < 0.001$ ). There was no significant improvement in future work ability and the pain intensity ( $p > 0.05$ ).

**Conclusion:** Follow-up of individual with chronic WMSDs showed that there was a significant improvement in health perceived and current work ability.

Keywords: WRMSD; Work disability; Rehabilitation; Occupational health.

### 30. The independent Association Between Number of Pain Sites and Return to Work. An Explanatory, Prospective Cohort Study

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**Purpose:** Persons with musculoskeletal pain often suffer from pain in multiple locations. Multi-site pain has been shown to influence work ability and sickness absence, but the influence of number of pain sites (NPS) on return to work has yet to be clarified. The aim of this study was to measure the independent association between number of pain sites (NPS) and return to work (RTW) in adults absent from work due to musculoskeletal pain in the upper body (MSP).

**Method:** We conducted a phase 2 explanatory prognosis investigation of 122 citizens absent from work for less than nine weeks due to MSP. Participants were recruited from Sønderborg Municipality (public compensation agent) for an 11-month, two-arm RCT on physical activity. No between-group differences were seen in the RCT, and the groups were combined to form the cohort. The exposure was self-reported NPS at baseline based on a modified Nordic Musculoskeletal Questionnaire. The outcome was working status as registered by The Department of Financial Security in Sønderborg Municipality at 11-month follow-up. The independent association between NPS and RTW when adjusted for confounders relating to both outcome and exposure was evaluated using logistic regression analysis.

**Results:** At baseline, the mean NPS was 4.3 (2.36 SD). At 11 months, 71 (58.2%) had returned to work. A significant association was found between NPS and RTW in both the unadjusted model OR=1.31 [95% CI=1.11-1.55] and adjusted model OR=1.22 [95% CI=1.01-1.47] when adjusted for gender, age, body mass index  $\geq 25$ , educational level, physical and mental health.

**Conclusion:** NPS was found to be an independent predictor of RTW in citizens absent from work due to MSP. The results from this study highlight the importance of assessing NPS when assisting persons with MSP in the RTW process.

## 31. Development and measurement properties of a firefighter-specific work limitations scale

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**Background:** Previous validation of the Work Limitations Questionnaire in firefighters indicated problems with floor effects, likely arising from the unique and challenging nature of firefighting work.

**Methods:** We used a mixed methods approach to developing a firefighter specific work limitations questionnaire. Item generation included a series of interviews Fifty-two firefighters (42 males, 10 females) from fire services across Canada (Alberta, Atlantic Canada, British Columbia, Nunavut, Ontario, Quebec) were interviewed using a semi-structured guide to assess areas of work limitation. The phone interviews were recorded and transcribed verbatim into. Content analysis identified themes physical, social/interpersonal, cognitive, emotional, routines/time management. In addition, we conducted two nominal group exercises and firefighter conferences or firefighters nominated activities within these themes that could be affected by physical or mental health injuries /problems. Items were refined by expert panels, then piloted on a series of 40 firefighters.

**Results:** A beta version of the firefighter specific work limitations questionnaire was developed with five subscales, each subscale containing 3 to 6 items. Test-retest reliability of the items/subscales was high ( ICCs > 0.90). Firefighter endorsed the new measure as relevant to their work.

**Conclusion:** A firefighter specific work limitations questionnaire was developed and will provide a mechanism for more accurate assessment of work limitations in mental and physical health injury; and identifying early concerns with job abilities or be useful in planning return to work

## 32. Perceptions of facilitating factors and barriers when implementing activity based workplaces before and after implementation

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Activity-based workplaces (ABW) are implemented in many organizations, with implications for physical and psychosocial working conditions and individual work ability. Successful implementation requires certain prerequisites, but little is known about the perception of these factors by the involved users. The purpose of the study was to explore employee and managers' perceptions about facilitating factors and barriers for implementing ABW, before and after the transition from traditional work offices.

This prospective study was conducted at two regional offices site of a large governmental agency in Sweden. Qualitative and quantitative data were collected using questionnaires administered before (n=455, response rate 59%) and three months after (n=409) the transition from traditional offices to ABWs. Some group interviews were also conducted before (n=9) and after (n=7). Data were collected about health, physical and psychosocial work environment, and implementation process. Content analysis was used to analysed open questions and interviews regarding facilitating factors, barriers to implementation, and perceptions of the process.

Factors that facilitated ABW implementation were e.g. attitudes toward work and colleagues and level of worker involvement in the implementation process. Barriers to implementation were for example lack of knowledge about the reasons for ABW, uncertainty about roles working in ABWs, and the new workplace design. Employees participating in preparatory activities such as workshops had a better comprehensibility of the reasons for the ABW implementation. Before the transition, there was a perceived risk of not being able to concentrate at work. Changes in employee collaborations within the ABWs were addressed by the respondents in interviews before and after the transition.

**Conclusion:** Factors among workers and managers such as knowledge and understanding of the ABW, persons that facilitate and contextual factors make the transition manageable, comprehensive and meaningful and thereby contribute to successful implementation of ABW.

### 33. Correlation between exposure to work-related musculoskeletal risk factors and self-reported musculoskeletal lower back and neck/upper limb symptoms: A cross-sectional study based on the fourth Korean Working Conditions Survey

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**Background:** Work-related musculoskeletal disorder is an important health issue, accounting for the majority of work-related disorders in many countries. We aimed to investigate the correlation between the degree of exposure to work-related musculoskeletal risk factors and self-reported musculoskeletal symptoms based on the fourth Korean Working Conditions Survey (KWCS).

**Methods:** The fourth KWCS (2014) was used for this study. Chi-square tests and logistic regression were used to assess correlations between 5 work-related musculoskeletal risk factors and self-reported musculoskeletal lower back and neck/upper limb symptoms. In addition, we analyzed the correlation between exposure to 2 work-related risk factors and musculoskeletal symptoms.

**Results:** All 5 work-related musculoskeletal risk factors (fatigue-inducing and painful posture; lifting or moving people; dragging, pushing, or moving heavy objects; standing posture; and repetitive hand or arm movements) were significantly correlated with musculoskeletal lower back and neck/upper limb symptoms in the high exposure group (odds ratios: 5.13/6.75, 2.01/1.83, 2.13/2.71, 1.82/2.13, 2.06/3.27, respectively). When exposed to 2 risk factors simultaneously, the correlation between exposure and lower back musculoskeletal symptoms was not greater than exposure to only 1 risk factor. However, the correlation between exposure and neck/upper limb musculoskeletal symptoms increased when exposed to 2 risk factors.

**Conclusion:** There was a strong correlation between exposure to each work-related musculoskeletal risk factor and lower back and neck/upper limb symptoms when the exposure was classified as severe. When exposed to 2 work-related risk factors simultaneously, the correlation between exposure and neck/upper limb symptoms was stronger than when exposed to only 1 risk factor. Future studies should continue to investigate the correlation between exposure to a combination of work-related risk factors and the development of musculoskeletal symptoms.

**Keywords:** Self-reported lower back and neck/upper limb musculoskeletal symptoms, work-related musculoskeletal risk factors, fourth Korean Working Conditions Survey (KWCS)

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## 34. Consensus on testing and evaluation of occupational exoskeletons in the workplace, for a better integration

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**Background:** There is a broad consensus about the impact of work activities on the occurrence of musculoskeletal disorders (MSD). To address the prevalence of these pathologies in physically demanding tasks, ergonomic researchers are paying increasing attention to new technologies such as exoskeletons in the workplace. The potential for exoskeletons to attenuate muscular strains appears fairly promising in laboratory. Nevertheless, it is difficult to determine the actual value attached to the proposition of an exoskeleton in the workplace because of the variety of methods and metrics used, the disparity of work situations, and the protean character of these technologies. The aim of this communication is to present a standard framework for the assessment of human-exoskeleton interaction in the workplace.

**Methods:** A structured methodology was developed on the basis of consultation with French market participants (Designers, Integrators, and Dealers), users (Companies, Ergonomists) and research institutes.

**Results:** This method consists of three phases. The first one lists the objective criteria to be included in an assessment of the assistance needs associated to the work situation, to select an exoskeleton adapted. The second one consists in the evaluation of the human-exoskeleton interaction after a exoskeleton's use familiarization's period. This includes a selection of assessment criteria and the designing of a structured protocol. This step allows the integration of the exoskeleton into production to be validated or not. Finally, the third phase involves assessing the use of the exoskeleton in the short, medium and long terms.

**Conclusion:** This methodology better enables companies to assess a system's potential and risks, specifically in the work situations that concerns them. This methodological consensus also allowed sharing the results of the assessment of different exoskeletons in different work situations, with the hope to improve the integration of these technologies and to guide their future development.

## 35. Patient Transfers and Risk of Back Injury: An Electromyographic Evaluation of Assistive Devices

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**Background:** Previous studies indicate that frequent patient transfer is associated with increased risk of low back pain- and injuries among healthcare workers. This study quantified the erector spinae muscle activity during patient transfers using various assistive devices.

**Methods:** This study utilized a cross-sectional design in order to perform measurements of muscle activity (surface electromyography) and body positions (actigraphy) during a normal workday at Danish hospitals. A total of 52 female healthcare workers from 16 different departments volunteered to participate in the study. The normalized RMS values, presented here as 95% percentiles, were statistically analyzed using linear mixed models controlling for patient characteristics (body mass and level of self-reliance) and number of personnel assigned to the task.

**Results:** Compared with no assistive device, the use of intelligent beds ( $p=0.0004$ ) and ceiling-lifts ( $p=0.0028$ ) resulted in significantly lower erector spinae muscle activity, across all types of patient transfers. Conversely, the use of bed sheets ( $p=0.0063$ ), sliding sheets ( $p=0.0240$ ) and sliding boards ( $p=0.0004$ ) led to higher levels of erector spinae muscle activity. Furthermore, the use of ceiling-lifts and intelligent beds was associated with less upper-body flexion ( $p=0.0128$  and  $p=0.0154$ , respectively).

**Conclusion:** The use of various assistive devices during patient transfer contributes to varying degrees of muscle activity. The implementation of ceiling-lifts and intelligent beds is likely to decrease the level of upper-body flexion and muscular load of the erector spinae. However, caution is needed when generalizing these findings as different types of patient transfer scenarios will affect the level of muscle activity associated with each assistive device.

## 36. Developing RAMP 2.0 - For enhanced applicability

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**Background:**The RAMP package (Rose et al., 2018) consists of RAMP (Risk Assessment and Management tool for manual handling Proactively), a website (ramp.proj.kth.se) and a Professional Certificate Program consisting of three MOOCs (massive open online courses) on musculoskeletal disorders (MSDs) and the RAMP use. RAMP, developed for managing risks in manual handling work, was launched 2017 and has been disseminated to over 70 countries. In October 2018 the “RAMP 2.0” project started to meet requests from industries to i) expand the tools application range, ii) include key performance indicators (KPIs), and iii) provide a database version of the ‘RAMP 2.0’. Here the current state of the project is presented.

**Methods:**The project, using a participative, iterative methodology, is carried out in seven steps ranging from a needs analysis and specification of requirements on the new tool to development and dissemination of a “RAMP 2.0”. The project is led by KTH and carried out in cooperation between researchers and practitioners at companies.

**Results:**This far eight organisations from five industrial branches (Manufacturing, Food, Dental Care Occupational Safety & Health, and Technical Installation industries) participated in a needs analysis, resulting in:

- i) a wish-list with additionally 20 types of work tasks to be included in the RAMP 2.0, e.g. electricians cable stripping and dentists’ drilling work,
- ii) suggestions of 16 KPIs, e.g. trends of Number of high risks, compared to Number of low risks over several years and
- iii) 15 characteristics considered important in the database-design and user interface, e.g. security and flexibility in results presentation.

**Conclusion:** In conclusion, requirements on the RAMP 2.0 have been identified and will be used as a basis in the development process.

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## 37. The Upper limb neurodynamic test 1 in the clinical diagnosis of carpal tunnel syndrome

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The aim of this study was to compare the diagnostic accuracy of the Neural test 1 with nerve conduction test for the assessment of patients with clinical diagnosis of Carpal Tunnel Syndrome (CTS). Materials and methods: This validation study was carried out in 117 subjects -234 hands - with CTS. The nerve conduction test was used as the reference test. Results: A sensitivity of 93 % and specificity of 6.67 % was found for Upper limb neurodynamic test 1. The positive likelihood ratio was 1.04 and the negative likelihood ratio was 1.00. The positive predictive value was 86.9 % and the negative predictive value 12.5%. Discussion: Due to its high sensitivity and positive predictive value but low specificity, this research suggests the application of neural test 1 just as a screening test for CTS followed by more specific tests. New studies with participation of subjects with no clinical diagnosis of CTS are strongly recommended.

**Keywords:** Occupational epidemiology, musculoskeletal disorders, occupational health, sensitivity, specificity, occupational illness, carpal tunnel syndrome, manual therapy.

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### 38. Worker's strategies analysis to prevent musculoskeletal disorders: the case of deburrers in the foundry sector

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**Background:** In order to prevent musculoskeletal disorders (MSDs), a company in the foundry sector explored a cobotic solution to deburring activity. To provide a frame of reference when analyzing situations with cobot, a first step, subject of this paper, focused on worker's strategies analysis during manual deburring (without cobot). This analysis, for MSDs prevention, will help to understand the diversity of workers strategies to analyze their evolution in the situation with the cobot.

**Methods:** The activity of seven deburrers was observed during five and a half days. Two deburrers participated to an interview (auto-confrontation) of 1h15. Different parameters of the activity could be identified in order to inform worker's strategies. These strategies were formalized by content analysis of interviews.

**Results:** Worker's strategies were characterized according to the deburrer location relative to workpiece (3 operational modes), the use of the grinder (2), the direction of the grinder movement (8) and the orientation of the grinder relative to the deburrer (4). Intra and interindividual diversity of deburrers strategies was identified. These strategies can involve either same operational mode to achieve different purposes (for example, during cutting-off, the two operators are placed outside the workpiece: one to get a better visibility, the other to get secure) or different operational modes to achieve the same goal (for example, when grinding the ribs, deburrers have oriented their grinder differently to both save time). The analysis of these worker's strategies helps to better understand how this diversity is expressed into the manual deburring activity.

**Conclusion:** In order to prevent MSDs, this strategies diversity will have to be questioned within the framework of evolution of work situations including a cobot.

## 39. Occupational Injuries in Craft Beer Brewing Industry

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**Background:** Occupational tasks that have been associated with musculoskeletal disorders and acute injuries are common in the rapidly growing craft brewing industry in the US. Craft breweries are small businesses that do not have the resources for robotic or mechanized equipment. Thus, most craft brewing operations involve a high percentage of physical labor for brewing and packaging (kegging, canning, and/or bottling). The purpose of this study was to use workers' compensation data to characterize the cause, nature, distribution, and cost of injuries in the craft brewing industry.

**Methods:** Five years (2013–2018) of Colorado workers' compensation data (571 claims) were included in the study. The cause, nature, anatomical distribution of injuries, and costs of claims were analyzed to characterize occupational injuries among workers in the craft brewing industry.

**Results:** The mean age of workers at the time of claim was 32,4 years and 80% were male. Over 60% of injuries occurred within the first year of employment with a median claim cost of \$297 USD among the newly hired workers. The median claim cost among more experienced workers (> 1-year employment) was \$416 USD. The top three injury types were cuts and burns (26,4%), lifting (23,1%) and struck or caught by (20,3%). The anatomical areas most frequently involved were hands (20,1% of claims), low back (12,8%), and knees (8,8%).

**Conclusion:** Although it was not possible to assess rates of occupational injuries among craft brewing workers, the dataset does provide valuable information on where to target interventions efforts. Training interventions related to safe work methods should be focused on newly hired workers. Additionally, engineering interventions should be targeted at tasks involving the hands (e.g., folding cardboard, handling cans and bottles) and low back (manual materials handling).

## 40. Parsonage-Turner Syndrome: differential diagnosis of painful shoulder in a bus driver

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**Background:** Parsonage-Turner Syndrome is believed to be an immune-mediated condition with the possible influence of genetic, infectious, and autoimmune factors. The most common presentation is characterized by sudden onset of intense pain in the shoulder girdle, usually unilateral, with evolution to paresis and muscular atrophy in a brachial plexus distribution. Treatment is based on pain control and rehabilitation. Recovery is variable and may require months to years.

**Methods:** This study is a case report that describes the semiological approach that allowed the removal of the causal connection between the painful shoulder in a bus driver and his work.

**Results:** A 35-year-old male bus driver has been suffering from left shoulder pain for 4 weeks, followed by progressive limitation to left shoulder abduction and external rotation. On examination there was hypotrophy of the left deltoid, supraespal and infraespal muscles associated with pain and, especially, weakness for abduction and external rotation of the shoulder. There was no restriction on passive movements. Laboratory tests were unremarkable and electromyography examination corroborated with the clinical hypothesis of Parsonage-Turner Syndrome.

**Conclusion:** It is known that professional drivers correspond to a risk group for work-related musculoskeletal disorders. Therefore, a detailed clinical evaluation and a careful musculoskeletal physical examination are necessary to put away its nexus with work, as described in the present case.

This abstract contains material that has been previously presented at the XXXIV Brazilian Congress of Rheumatology and published as abstract in Revista Brasileira de Reumatologia, Supl 1. v57. p.305-306.

## 41. Raynaud's phenomenon in the occupational context

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**Background:** Raynaud's phenomenon (RP) is characterized by exaggerated vasospastic response at the level of the digital arteries and cutaneous arterioles. The episodes are evidenced by the well marked alteration of the coloration of the fingers, which may be accompanied by paresthesias and pain. Localized vibrations, vinyl chloride and working in low temperatures are considered occupational risk factors for RP. The objective of this study was to review the articles that evaluated the prevalence of RP of occupational origin.

**Methods:** The search for articles was carried out in Medline databases (via PubMed), Embase, Web of Science, Scientific Electronic Library Online (SciELO) and Latin America and Caribbean Health Sciences Literature (Lilacs). The search strategy for Medline/PubMed considered the combination of the following descriptors: "raynaud disease", "epidemiology", "prevalence", "occupational exposure", "occupational diseases", "occupational injuries", "cold temperature", "vibration", and "vinyl chloride". This strategy was adapted to other databases. Articles published since 1998 in English, Spanish or Portuguese were searched.

**Results:** 64 articles were obtained from the electronic search; 18 articles met the eligibility criteria and were included in the review. All studies discussed about the exposure to vibrations in upper limbs. In 6 of them, the thermal issue was directly or indirectly addressed. No studies have addressed exposure to vinyl chloride.

**Conclusion:** In general, it was found a higher prevalence of Raynaud's phenomenon among vibratory tool operators compared to non-exposed workers, with an increase in the number of cases the higher the level of vibration and the time of exposure. Cold is a triggering and aggravating factor of the Raynaud's phenomenon and seems to play an important role in the emergence of the vascular manifestations of the hand-arm vibration syndrome.

## 42. Prevalence of and factors associated with nonspecific lower back pain in warehouse workers

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**Background:** To analyze the factors associated with symptoms of low back pain in warehouse workers.

**Methods:** This cross-sectional study included 204 warehouse workers employed in a company of motorcycle parts. The workers' jobs involved the stocking, transportation, separation, inspection, and packing of motorcycle parts. The study subjects were asked to score their lower back pain symptoms on an 11-point visual analog scale of pain. Muscle strength of the trunk was evaluated by a lumbar dynamometer using an average of three repetitions of maximum force, with a 5-minute pause between tests. Flexibility was tested by an electrogoniometer placed unilaterally on the trunk of the study subject to determine the degrees of inclination. Other variables collected were age, body mass index (BMI), body movement, and pause time. Workers had 1-hour breaks for meal and rest. Statistical analysis was performed using SPSS software version 23.0, and data were analyzed using the chi-square and Fisher's exact tests ( $P < 0.05$ ).

**Results:** All workers were male, with a mean age of 27.8 (SD, 6.8) years. There were 97 (47.5%) stockists, 57 (27.9%), separators, 26 (12.7%) checkers, and 24 (11.8%) packers. There was no job rotation among workers. There are a smaller amount of checkers and packer. In the study, 84 (41.2%) of the stockists reported low back pain, and 70 (34.3%) were overweight. The results showed a positive and moderate association of low back pain with BMI ( $r = 0.370$ ,  $P < 0.05$ ), flexibility ( $r = 0.666$ ,  $P < 0.05$ ), trunk strength ( $r = 0.426$ ,  $P < 0.05$ ), and age ( $r = 0.495$ ;  $P < 0.05$ ).

**Conclusion:** Chronic nonspecific low back pain was evident among the young warehouse workers included in this study. The BMI, trunk flexibility, trunk strength, and age were moderately associated with lower back pain.

Keywords: Ergonomics; Occupational health; Low back pain

### 43. Prevalence of musculoskeletal pain and evaluation of postural risk among administrative workers at the Costa Rica Institute Technology

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**Objective:** To determine musculoskeletal pain prevalence and postural risk among administrative workers at the Costa Rica Institute Technology (main campus).

**Methods:** A representative sample of participants (36) were randomly selected from payroll records. Information on musculoskeletal pain was collected using the Nordic Questionnaire. The Rapid Office Strain Assessment (ROSA) gathered postural risk information. Computer workstations were assessed before and after adjustments. The statistical analysis was completed using minitab and SPSS.

**Results:** The results from the Nordic Questionnaire showed that most people have some type of pain (83.3%), only 16.7% have no pain in any part of the body. The highest prevalence of pain were right wrist-hand (18%), low back (16%), neck (14%), left shoulder (10%), and right shoulder (7%). According to ROSA assessments of postural risk, all individuals studied obtained a score equal or greater than 5, which indicates that they are at risk and immediate intervention is needed. After workstation adjustments (monitor height, mouse and keyboard height, and chair height adjustments), ROSA assessments were reduced from risk (>5) to no risk (<5) in almost all cases (83%).

**Conclusion:** We concluded that workstation adjustments showed statistically significant changes in the magnitude of the risk changing from risk to no risk in 83% of participants by just adjusting the existing furniture and accessories. In addition, adjustments might reduce pain experienced by 83.3% of the sample. Based on this preliminary study, we can develop an intervention program of workstations' assessments and adjustments that will reduce risk and might reduce development of musculoskeletal injuries among administrative workers.

#### 44. Online dashboard for surveillance of ergonomic-related workers' compensation claims by industry and diagnosis category

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**Background:** This project demonstrates how workers' compensation (WC) claims data from Ohio, USA have been used for surveillance of ergonomic-related (ERGO) musculoskeletal disorders by industry and diagnosis category through the application of interactive data visualization.

**Methods:** This study analyzed WC claims data from 2001–2011 for privately owned employers in Ohio insured by the Ohio Bureau of Workers' Compensation (OHBWC). Claim rates were calculated per 100 estimated full-time equivalent employees (FTE)s by industry. Each claim was assigned to a diagnosis category based on the most severe diagnosis code. To identify ERGO claims, Artificial Intelligence methods were used to auto-code claims into three intervention categories: ERGO, slips/trips/falls, or other event/exposure. Interactive charts were created to present user-friendly analysis by industry, claim type (medical only, 0-7 lost workdays (MO); lost time, 8+ lost workdays (LT)), and diagnosis category.

**Results:** Among over 1.2 million WC claims, 257,368 WC claims were coded as ERGO, (21% of total claims (MO+LT), 35% of LT claims). Among the six largest industry sectors, Manufacturing had the most ERGO WC claims (68,232, 27% total claims, 28% LT claims), and the highest total rate; however the Transportation Warehousing and Utilities sector had the highest rate for LT ERGO claims. Based on the average of claim count and rate ranks for > 200 industry groups, Skilled Nursing Facilities was ranked highest for LT ERGO claims. The most common ERGO diagnosis categories were back sprains (MO=47%, LT=28%) and upper extremity sprains (MO=28%, LT=18%). Carpal tunnel syndrome accounted for 5% of LT ERGO claims and 2% of all LT claims. The results are available as an interactive, online dashboard to improve access and encourage further exploration.

**Conclusion:** These findings are being used to prioritize ergonomic prevention and research to a greater degree of precision, which can maximize impact, especially in Ohio.

## 45. Difference between experts' and novices' footstep patterns during a palletizing task

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**Background:** Expert handlers handle boxes differently than novices. Their foot motions during transfer allow them to efficiently use box momentum, improving their balance (Authier et al. 1996). However, differences in footstep patterns among novices and experts are often neglected in ergonomic studies as they are rarely the main focus. This study adapts the classification taxonomy developed by Wagner et al. (2009) to compare novice and expert handlers' foot motions during a palletizing task.

**Methods:** Fifteen experts and 15 novices transferred 24 15-kg boxes (4 boxes high, 3 wide, 2 deep) from one pallet to another 1.5 m away, without foot placement restrictions. Footstep patterns were observed at five points: first contact with the box, pickup, first step following pickup (transfer), last step prior to deposit, and deposit. A taxonomy similar to another study (Wagner et al., 2009) was used to assess foot positions and movements in each phase. Mann-Whitney U-tests were performed to evaluate differences between the frequency of occurrence of footstep patterns in novices and experts ( $\alpha < 0.05$ ).

**Results:** During the lifting phase, experts maintained a static posture of the feet 58.6% and novices 41.3% of the time ( $p < 0.001$ ). A "split stance" during lifting was observed more frequently in novices ( $\Delta = +11.3\%$ ,  $p = 0.02$ ). Pivot motion of the rear foot during lifting was observed more frequently in novices than experts ( $\Delta = +9.4\%$ ,  $p = 0.006$ ).

**Conclusion:** Differences in experts' and novices' footstep patterns occur only during the lifting phase. Generally, experts stand still while lifting the box, and then move toward the pallet. During lifting, novices' rear foot motions may represent a time-efficiency strategy, whereas experts' static foot positioning may ensure symmetry of movements to minimize joint loading at L5/S1.

## 46. Work-related musculoskeletal injuries among health care workers handling patients - Brief statistical analysis

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**Background:** Health care workers (HCW) are susceptible to work-related musculoskeletal injuries (MSI) due to patient-handling accidents. This study aimed to analyse work accidents (WA) caused by physical strain.

**Methods:** A dataset related to WA occurred in a Portuguese hospital between 2014 and 2018 was analysed. Demographics, job related variables, WA type and injury location were documented. WA were categorized as "excessive strain" and "others" (which included aggressions, falls and sprains, needlesticks and cuts, direct trauma by objects, commuting). Chi-square test was used for significance testing of associations between categorical variables (statistical significance was set at  $p < 0.05$ ).

**Results:** A total of 633 WA occurred resulting in 6992 of lost work days (LWD). Overall, mean age was 44 years old (minimum 22 years; maximum 66 years) and 84.5% of the injuries occurred in females. The most injured professionals were nurses (37.8%) and aides (37.4%). 14.5% of all injuries were related to excessive strain during patient-handling (mainly affecting back (53.4%), upper limbs (19.8%) and neck (12.9%)), with 66.3% of those resulting in LWD. It wasn't found a statistically significant association between type of accident, age and gender. Total number of working years was related with strain accidents. Medical and surgical wards were associated with higher amount of excessive strain WA. Professional category was statistically associated with excessive strain accidents, with aides being more exposed to these WA, while nurses had more heterogeneous causes. Overweight and obese HCW were more prone to sick leave due to strain accidents, while normal body mass index HCW could keep working, even with some kind of MSI. HCW with previous MSI who suffered excessive strain accidents, apparently, had more LWD, but no statistically significant association was found.

**Conclusion:** Different work organization, better ratio between nurses, aides and patients, improvement of equipment provision, and specific patient-handling training could decrease MSI and LWD among HCW.

## 47. Evaluation of resilience in nursing workers in a teaching hospital

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**Background:** The resilience, as a human construction tool, seeks to emphasize the strengths of the worker, to find a point of balance for coping with labor adversities. Measure the level of resilience and to verify the factors associated with the resilience of nursing workers in a teaching hospital

**Methods:** The sample was composed of 375 nursing workers. To perform the data collection, a Sociodemographic and Professional Characterization Questionnaire and the Resilience Scale (RE) developed by Wagnild and Young (1993) and validated for the Portuguese. Initially, univariate analysis was performed to identify the factors associated with resilience. For the analysis of the correlations between the quantitative variables and the Resilience Scale score, we used the Spearman correlation coefficient. To compare the means of the RE according to the categories of the qualitative variables with constant variance, the ANOVA Test was used.

**Results:** The mean score of the Resilience Scale of the 375 participants was 138.7 points (SD = 18.3), ranging from 36.0 to 174.0 points and a median of 142.0 points. The highest proportion of workers reported moderately low / moderate (45.3%, 170), followed by moderately high / high (39.5%, 148).

**Conclusion:** Resilience was positively associated with age, working time at the institution and working time in the profession.

## 48. Evaluation of a passive back exoskeleton in simulated industrial tasks

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**Background:** Low back pain is known as one of the most common work-related musculoskeletal disorders. This study aimed to assess the potential biomechanical-physiological effect of wearing Laevo® (Laevo, Delft, the Netherlands), a passive exoskeleton that was designed to support the back musculature, in industrial tasks.

**Methods:** Thirty-six healthy, male subjects performed three typical industrial tasks arranged in a circuit: (1) screwing in a static posture in trunk flexion; (2) lifting and replacing boxes and (3) lifting boxes from behind a grid box. The circuit was absolved four times with and without using the Laevo® exoskeleton. Muscle activity of selected muscles (erector spinae, trapezius descendens, rectus abdominis, vastus lateralis, biceps femoris and gastrocnemius medialis) was recorded using bipolar surface electromyography and root-mean-square values were calculated. Posture sensors placed on the spine and legs were used to calculate the thoracic kyphosis, lumbar lordosis and knee flexion angle. Perceived task difficulty was assessed by a visual analog scale.

**Results:** The preliminary results of eight subjects are analyzed and show a tendency for a decreased activity of erector spinae and biceps femoris muscles during all tasks of the circuit when wearing the exoskeleton. The thoracic kyphosis tended to decrease in the lifting and replacing as well as in the static task. A smaller knee flexion angle was observed in all tasks when wearing the Laevo®. No differences were noted in the perception of task difficulty between performing the course with and without exoskeleton, so far.

**Conclusion:** The Laevo® exoskeleton might support the erector spinae and biceps femoris muscles and tends to influence thoracic kyphosis and knee angles in simulated industrial tasks. Future evaluation of the additional 28 subjects will follow and allow a more specific, reliable assessment of the exoskeleton's potential by a quantitative analysis including a statistical analysis

## 49. Creating Awareness Amongst Community and Office Employees on Safer Use of Computing Technology Equipment (Laptops, Desktops and Hand-Held Devices)

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**Background:** Computers and Handheld devices (HHD) combine advanced computing capability, like internet communication, information retrieval, video, e-commerce, etc. that makes the device a necessity for modern day lifestyle, as currently not only IT industry, but modern day office-goers, our family members & school children, students in colleges are using these devices, experiencing discomfort and even serious injuries necessitating physiotherapy, pain management and surgeries.

There is an urgency to create awareness on safer use of Computers and HHD in maximum individuals in shortest possible time, develop trainers who can train family members or colleagues to become trainers (TTT). In this way awareness on ergonomics can be achieved widely.

**Methods:** Hence solution lies in educating individuals and groups on safer use of Computers and HHD by conducting training sessions emphasizing that all individuals using computer hardware and accessories should arrange their work space to their respective body dimensions for avoidance of slouched posture, protecting eyes by lubrication, avoiding glare, taking rest breaks, performing desk stretches and engaging in aerobic activities. A KAP study was carried out in 12 different sessions, town-hall lectures, small groups of participants, social community gatherings like rotary club meetings and their respective office employees (total n=2117) from 2017 - 2018. Feedback was collected in prescribed format and a mouse pad summarizing prevention precautions was handed over to participants.

**Results:** Effective awareness on working safely with computers and HHDs was organized in different groups in twelve sessions. Participants ranged from 26-40 years (40.34%) followed by 20-25 years (33.54%). When successfully implemented, 95% participants reported these awareness sessions were extremely practical and useful, however opining that session duration could be shortened.

**Conclusion:** All physicians and community health workers today share a responsibility to educate community on safer use of computing technology devices, based on ergonomics principles.

**Keywords:** Musculoskeletal Disorders, Computers, Smartphone, Safe Use, Education Responsibility

## 50. Implementation of short passive and active breaks during simulated laparoscopic work

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**Background:** Minimally invasive surgeons have a prevalence of work-related musculoskeletal complaints of up to 86% (Tijam 2014) due to exposures to static loading, awkward postures, work pressure, and responsibility for patient's wellbeing (Riditid 2015). A way to counteract the prevalence of musculoskeletal complaints is to implement work-breaks during surgery, which showed promising results including no increased surgery duration (Hallbeck 2017). We aim to investigate the effect of no breaks, 2.5-min passive and 2.5-min active breaks on back and upper extremity muscular activity, back curvature, feelings of discomfort, and work performance.

**Methods:** Twenty-three surgeons will participate in the study and perform tasks in the Szabo Pelvic Trainer® (ID Trust Medical), including hot-wiring, peg-transferring, picking-and-placing, picking-and-tightening, threading, and pulling-and-sticking. The active break intervention consists of eight exercises that will be performed while standing with the feet hip-width apart, including mobilization and extension in the lower-back and shoulder-neck area. Muscular activity will be continuously recorded using bipolar surface electromyography of the erector spinae, trapezius descendens, deltoid medialis, extensor digitorum and flexor carpi radialis muscles. Heart rate will be continuously recorded using electrocardiography, and back curvature will be assessed by continuous recordings of position sensors at the levels of vertebrae T1, T10, L1, and L5. Discomfort will be assessed before and after each condition using a 11-point Likert scale. Performance will be assessed as time-to-completion and amount of errors per time. Following a balanced, randomized, cross-over design, differences between the three conditions (active, passive, no break) will be analyzed applying a repeated-measures ANOVA.

**Results:** The study design will be presented as well as some preliminary results.

**Conclusion:** Based on the high prevalence of musculoskeletal complaints in surgeons, research allowing the development of workplace interventions such as active or passive micro-breaks during laparoscopic procedures is important. Improving surgeons' musculoskeletal health may also have a positive influence on patients' wellbeing.

## 51. Effect of telehealth program to office workers on knowledge, skills and on behavior: a secondary analysis of a cluster randomized controlled trial

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**Background:** The e-learning technology and the active and collaborative methodologies of health education have shown great effectiveness. Objective: To evaluate the effect of audiovisual content of health education in the increment of knowledge, skills and attitudes of office workers.

**Methods:** This is a secondary analysis of the randomized controlled trial by cluster. The study implemented an online program to promote health in the workplace for two groups (Telehealth and Telehealth with Extended care). In this study were included 100 workers (45 telehealth and 55 telehealth with Extended care) who received the content of nine audiovisual into three themes: musculoskeletal health, healthy diet and mental health available to participants through Moodle software. The outcomes knowledge, skills and attitudes were evaluated per six specific affirmative sentences were created for each audiovisual, being two sentences for each construct. The answers were graded on a Likert scale of 11 points (0-10 points). All statistical analyzes were performed with a significance set up of 5% by SPSS 22.0 program.

**Results:** There was a significant increment in the knowledge, skills and attitude at baseline to the end of the program (8-months) ( $p < 0.05$ ). The exception occurred for the knowledge obtained with two audiovisuais healthy diet: ultra-processed food and food labeling, Oil and fat. There was significant difference between groups in favor of telehealth with extended care in the knowledge, skills and attitudes for the Walking program ( $p < 0.05$ ), for knowledge about Eating and commensality ( $p < 0.05$ ), for skills and attitudes for audiovisual Oil and fat.

**Conclusion:** The telehealth program was effective in developing skills, abilities and attitudes for office workers.

**Financing:** This study was financed in part by research unit of the Life Sciences Department of the Universidade do Estado da Bahia (grant number - n° 01/2015 DCV/UNEB). CNPq - Junior Scientific Initiation, The São Paulo Research Foundation (FAPESP) - Support: 2017/16544-0.

## 52. The Workers Applied More for the Sick Days Secondary to Musculoskeletal Disorders in the Year of a Major Downsizing: An Observed Case Report at a Korean manufacturing company

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Applying for the sick days and disability due to musculoskeletal disorders (MSD) is not as common in South Korea as in other developed countries. There can be several potential discouraging factors to explain this trend in South Korea: individual, organizational and cultural. This is a case report of a single company in South Korea, which has two completely different product divisions (Division A and B). The department of health management of the company provided their internal data from 2012 to 2016 including the sick days to the research team for an external consultation to improve the workers' health promotion program. In 2015, only Division B had a major downsizing, more than 40% (from 14348 to 8438) of employees were laid off, while Division A had a little increase in the number of employees (from 38227 to 38683). The total number of employees who applied the sick days for whatever reason did not increase much in both divisions from 2012 to 2016. The percent of employees who used sick day secondary to the MSD almost triple increased from 0.5% of total number of employees in 2014 to 1.4% in 2015 only in Division B while it was 0.5% in Division A during the same period. The mean duration of MSD related sick days also increased from 43.6 days in 2014 to 47.2 days in 2015 and 56.2 in 2016 in Division B and it was 31.1, 31.0 and 30.3 in Division A. These findings are very unusual in South Korea and thought provoking. The possible interaction among the influencing factors was discussed and the suggestions for improving the workers' compensation and disability system were made.

### 53. Lumbar disc surgery: is it only a sentinel event of spinal disease?

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**Background:** Lumbar disc-related disorders are a major cause of work-related osteo-articular morbidity. Lumbar disc surgery (LDS) was chosen as the sentinel event to implement a system for the epidemiological surveillance of these disorders. The aim of this study was to describe the variations in the incidence of LDS and the influence of socioeconomic factors and of factors related to healthcare provision on this incidence.

**Methods:** LDS was identified in the hospital database of the Pays-de-la-Loire region. A total of 16,267 LDS cases was detected from 7 codes for surgical acts in 2007-2010. A main component analysis, followed by a hierarchical bottom-up classification, was carried out on the basis of socioeconomic factors and of factors related to healthcare provision, in order to characterize the 137 regional areas (RA).

**Results:** The mean incidence rate of LDS was 1.6‰ (standard deviation = 0.3) and varied widely according to RA. There were three types of RA: 1) large regional cities and coastal RAs, with a rich supply of healthcare, a high proportion of managers and higher intellectual professions, but also a higher unemployment rate, coupled with a high incidence of LDS; 2) the RAs located around the large cities, with a large proportion of young and active population, associated with a low incidence of LDS; 3) and finally the RAs located at the periphery of the administrative limits of the 5 departments of the region marked by a weak supply of healthcare and a higher proportion of manual workers and agriculture and associated with an intermediate impact of LDS.

**Conclusion:** This study suggests a link between the incidence of LDS and criteria other than strictly medical. Thus, the LDS indicator would be a health tracer that would also reflect the provision of healthcare and the socio-economic fabric that could be useful for the implementation of policies to combat social and health territorial inequalities.

## 54. The relationship between sustained inflammation and work-related upper limb disorders - preparation of a cohort study

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**Background:** From epidemiological studies we know that optimal design of workplaces may improve performance. But beneficial effects in preventing work-related musculoskeletal disorders (wrMSDs) seem to be small. To better understand the generation of chronic (wrMSDs), we propose to shift the focus from high levels of workload to the role of insufficient time for recovery.

In studies with rats it was shown that persisting exposure to repetitive limb movements leads to chronic inflammation of all the tissues (muscle, tendon, bone, nerves, spinal motor neurons) involved in the execution of the task. Indicators of inflammation were present in the circulating blood and the observed behavior of the female rats was significantly changed.

The findings of these animal studies shall be ascertained by an exploratory field study.

**Methods:** Seven male and female workers with highly demanding tasks (upholstery work) with a work history between two and five years will be recruited and will be followed over ten weeks. The personal workload will be monitored based on the OCRA method. Medical records will be analyzed for the occurrence of disorders in the forearm muscle. Musculoskeletal discomfort will be assessed at the beginning and end of each week. In each week a blood sample will be taken and analyzed for indicators of inflammation (C-reactive protein, interleukin 1 beta (IL-1b), IL-6, and tumor necrosis factor alpha (TNFa)).

**Expected results:** The course of indicators of inflammation will be described and relationships between acute and chronic musculoskeletal disorders will be tested. Intra-class correlations between the repeated measures will be of use to determine the optimal testing interval in a following cohort study.

**Conclusion:** Although there is strong support for the hypothesis that chronic local inflammation is an important factor in chronic wrMSDs there is a lack of studies and preparatory efforts are needed to prepare high-quality longitudinal studies.

## 55. Associations of objectively measured forward bending at work with low-back pain intensity: a 2-year follow-up study of construction and healthcare workers

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**Background:** Research has indicated that time spent in forward bent position is linked to the development of low-back pain. Still, the research on this topic is inconclusive and there is limited evidence from high quality studies investigating this hypothesis. Most of the studies on the topic are based on self-reported data, which may have reduced validity.

**Objective:** From a group of 594 construction and healthcare workers responding to a baseline questionnaire, we objectively measured forward bending in 125 workers continuously for 3-4 days. Duration of  $\geq 30^\circ$  and  $\geq 60^\circ$  forward bending at work (FBW) in minutes was assessed using two accelerometers (Actigraph GT3X+). Low-back pain intensity (LBPi) for the previous four weeks was self-reported as no pain (0), mild pain (1), moderate pain (2) or severe pain (3) and collected at baseline, 6, 12, 18, and 24 months follow-up. Association between FBW and LBPi was investigated with Linear mixed models.

**Results:** The duration of  $\geq 30^\circ$  and  $\geq 60^\circ$  FBW in minutes was not associated with average LBPi during follow-up, neither for the total sample nor stratified on work sector. Furthermore, analyses on all workers and on construction workers only, found no significant association between  $\geq 30^\circ$  or  $\geq 60^\circ$  FBW and change in LBPi over the 2-year follow-up. However, there was a consistent significant association between the duration of  $\geq 30^\circ$  FBW at baseline and the change in LBPi for healthcare workers during follow-up, indicating increased LBPi with increasing duration of FBW.

**Conclusion:** This study suggests that objectively measured duration of FBW in minutes is not associated with average levels of, or change in LBPi in construction workers over a 2-year period. In healthcare workers, exposure to FBW is associated with a change towards increased LBP intensity. This may indicate that the associations between FBW and LBP may vary depending on sector.

## 56. Sitting dynamics are age-dependent during computer work

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**Introduction:** Sitting is often related to work-related disorders located in the low back and neck-shoulder region. The study aimed to characterize the dynamics of sitting during a sustained computer task in both younger and older computer users.

**Methods:** Twenty asymptomatic younger (nine females, 11 males aged 23+/-3 years) and 18 older computer users (11 females, seven males aged 58+/-7 years) volunteered to participate. A task consisting of a sequence of cyclic computer operations including memorization, washout and replication was designed. The task was performed for 40-min divided in 12x20 cycles separated by 5-s pauses. The perceived level of mental fatigue before and after the task completion as well as the overall performance during the task were acquired. A force and torque transducer was mounted on an office chair. We computed the displacement of the center of pressure (CoP) in anterior-posterior (AP) and medial-lateral (ML) direction. The average displacement (AVG), standard deviation (SD) and sample entropy (SaEn) values were extracted from the CoP signals in the AP and ML direction. Standard deviation and sample entropy were used as metrics of variability.

**Results:** Mental fatigue ratings increased from before to after computer task ( $p < 0.001$ ). Mental fatigue and overall performance were respectively higher and lower in the older than in the younger computer users ( $p < 0.001$  for both). The AVG of the CoP was larger in the ML in the older than in the younger computer users ( $P < 0.001$ ). In the AP and ML direction, the SD of the CoP were larger in the older than in the younger computer users while the SaEn were lower ( $P < 0.01$  for all).

**Conclusion:** The present study showed that the sitting dynamics are age-dependent. These new findings suggest that office chairs companies should consider sitting dynamics when designing office chairs.

## 57. Change of Musculoskeletal symptoms and working condition in a car part assembling factory during 2004 ~ 2016

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**Background:** Because work related musculoskeletal disorders (WMSDs) are related with aging process as well as micro and macro working conditions, longitudinal study is important to reveal the changes and contributions of the risk factors.

**Methods:** Workers in a car part assembling factory had been followed from 2004 to 2016 with 5 times in risk assessment program of WMSDs of Korea. Structured questionnaire was composed of ANSI-365, ACGIH TLV for hand activity, labor intensity, Korean Occupational Stress Scale (KOSS) and WMSDs symptoms of each body parts.

**Results:** Numbers of responder in 2004, 2007, 2010, 2013, and 2016 were 162, 191, 187, 195, and 197 respectively. Overall WMSDs symptom prevalence were 21.1%, 34.9%, 31.7%, 24.4%, and 29.8% respectively. Symptom prevalence in each body parts showed different patterns by year. In year 2007 WMSDs symptom prevalence was highest. Those of WMSDs of back were 11.3%, 18.9%, 12.2%, 9.9%, and 12.6% respectively, which showed decreased trend after 2010. Among 8 sub-dimensions of KOSS physical work load were related with WMSDs symptoms in 2013 and 2016. Job demand were related with it in 2007, 2013, and 2016. Job control were related with it in 2007, 2013, and 2016. Relation conflict were related with it in 2013. Job insecurity were related with it in 2007, 2010, 2013, and 2016. New working methods to improve productivity which causes increased labor intensity was introduced in year 2006. Lifting equipment to reduce manual material handing was widely adapted in 2010. Change of working hours and working patterns had different effects on each body parts.

**Conclusion:** Aging process might be different effects by body parts. Improved working conditions could reduce WMSDs symptoms. General increase of labor intensity increase job stress and WMSDs in various routs. Interactions between aging and various working conditions including physical and psychosocial factors needs careful approach.

## 58. A Mixed Methods Analysis of Farm Machinery Injury: Contributing Factors and Proposed Prevention Strategies

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**Background:** Agriculture is one of the most dangerous occupations in Canada, and many of the injuries are related to farm machinery. Machinery injuries are especially prevalent in the prairie region of Saskatchewan, where commodity crop farming is heavily mechanized including the use of tractors, combines, and various implements. This paper reports on farm machinery injury in the Canadian prairies.

**Methods:** A mixed-methods analysis of farm machinery injury (excluding quad bikes) was performed on postal survey data collected for the Saskatchewan Farm Injury Cohort Study from 2013-2016. Respondents described injury events in terms of severity, cause, situation/task/location in which the injury occurred, and personal reflections on 'what went wrong'. Qualitative content analysis and thematic coding were used to better understand individual, operational, contextual, and environment risk factors associated with farm injury.

**Results:** Of the 2629 farmers that responded, 468 reported farm injuries, 166 of which were identified as machinery-related cases. Machinery-related injury occurred during three main scenarios: 1) operating machinery, 2) working around mobile machinery or powered implements, and 3) performing maintenance and repairs. Farmer-reported incident causes ranged from workplace factors (poor visibility, machinery instability), personal factors (rushing, distraction, body mechanics), to bewilderment ('it all happened so fast'). Farmer-identified opportunities for prevention tended to reside lower on the hierarchy; the 'missing prevention levels' in event descriptions by farm people suggest that attributing injury causes within a human factors framework may be a challenge.

**Conclusion:** Focusing on farmers' understanding of injury occurrence brings insights on contributing factors and potential control strategies, as well as insight into how farmers consider injury causes. Given that prevention strategies high on the hierarchy of controls are generally more effective, reorienting beliefs about cause may predispose farmers towards these higher-level controls and ultimately to injury prevention.

## 59. Musculoskeletal disorders risk factors among Ophthalmologists in the operating theatre

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**Background:** Ophthalmologists perform eye operation which involve static posture looking through microscope for prolonged duration and fine movement of the fingers. This may pose a risk for musculoskeletal disorders (MSD). We aim to assess their risk for MSD during operation and the feasibility of using an ergonomic chair with adjustable tilt. to address the risk

**Methods:** The study team collected the demographics and musculoskeletal complaints through self-administered questionnaire, measured the anthropometric data of the participants in accordance with International Standard Organization guidelines and conducted walkthrough survey.

**Results:** There were 34 participants in this study. Majority of them had neck (81%), shoulder (76%) and upper back (75%) pain. High proportion of Ophthalmologist attribute the pain to repetitive movements (92%), awkward posture (83%) and long working periods (77%). Through the walkthrough survey, we observed that Ophthalmologists had to crane their neck and slouch their back to reach the eye piece of the microscope. The surgeons did not adjust the height of the adjustable chair prior to the surgery. The eye height at sitting ranged from 65.2cm to 81.5cm. The horizontal distance between the surgeons' eyes and the eye pieces of the surgical microscope ranged from 1.2 cm to 17.5 cm. To bridge the distance, the ophthalmologists adopted awkward posture. Using trigonometric calculation, we estimated an ergonomic chair with an adjustable degree of tilt from 5.25° to 11.44° can bridge the distance differences.

**Conclusion:** Awkward posture is a risk factor for musculoskeletal complaints during operation among Ophthalmologists. Ergonomics chair with adjustable angle for forward tilt can help maintain an upright posture while operating with the microscope.

## 60. Reliability of an observation protocol for foot motion assessment in a palletizing task

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**Background:** Foot placement during manual material handling (MMH) activities has been shown to affect posture and motion, and consequently low back loading. A classification taxonomy of foot motions for MMH tasks exists (Wagner et al. 2009) but assumes that a worker's feet always "face" the job and remain motionless during pickup and deposit. Furthermore, certain elements of the observation protocol result in discrepancies among raters, and the limited range of load masses manipulated limits its applicability to situations where the handling of heavy loads may require different foot motions. Consequently, this study presents an adaptation of Wagner et al.'s taxonomy to analyze foot motions during a palletizing task with 15-kg boxes.

**Methods:** The method for qualitatively describing foot motions is based on Wagner et al.'s taxonomy (Wagner et al. 2009). A terminal stance is defined as the relative placement of the feet with regard to the pickup/delivery location in MMH events: first contact with the box, pickup, steps between pickup and the last step before delivery, last step before delivery, and delivery. Terminal stances comprise a postural stance element (Split stance, Even stance, Parallel stance) and a foot motion element (No movement, Pivot, Move, Orient, Counterweight). Terminal stances from video data of box transfers from a previous laboratory study (Plamondon et al. 2014) were analyzed to assess intra-rater and inter-rater reliability. Intra-observer reliability (one rater only) was evaluated by re-observing data on 252 box transfers (1 month between assessments). Inter-rater reliability was assessed by calculating the percentage of agreement between two independent raters.

**Results:** Re-observing 252 transfers, the proportion of intra-observer reliability reached 86.2%. At pickup, reliability equaled 84.1%. Overall inter-observer agreement totaled 76.2% and 82.3% for the pickup.

**Conclusion:** Agreement percentages were adequate (Wagner et al. 2009). This taxonomy uses Wagner et al.'s terminology to analyze foot motions during a palletizing task involving the handling of heavy loads.

## 61. Can productive manufacturing layouts influence of the pauses and worker`s health?

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**Background:** The manufacturing layouts aim to organize the production in order to obtain greater efficiency.

**Objectives:** To evaluate the influence of the serial and cells production layouts in the work cycle, spontaneous pauses and for the health of the workers. **Methods:** This is a cross-sectional study that included 120 workers of the automobile industry. The worker groups were divided by serial and cell layouts after work organization analysis. The work cycle, spontaneous pause time and micro-pause, habitual physical activity level (Baecke), occupational exposure (QEC and JFQ), occupational stress (Job Stress Scale -JSS), the need for recovery scale (NFR) and work ability index (WAI) were evaluated. Statistical analysis by SPSS 17.0 program was set at  $p < 0.05$  (5%).

**Results:** The mean of the work cycle in the serial was  $22.79 \pm 10.67$ s and cells  $69.83 \pm 52.77$ s ( $p < 0.001$ ) layouts. Occupational exposure levels were classified as moderate for both groups. There was no statistically significant difference ( $p > 0.05$ ) between the groups for physical activity level, NFR, JSS, WAI.

**Conclusion:** The serial and cell production layouts influenced the pauses, cycle time of work, but not have influence in the general health of the workers.

**Keywords:** Ergonomics; Lean production; Occupational health; Design of systems.

## 62. Risk factors for work related musculoskeletal disorders in information technology professionals

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**Background:** Work Related Musculoskeletal Disorders (WRMSD) are highly prevalent among Information Technology (IT) professionals. The objective of this study was to evaluate the risk factors that predispose IT professionals to WRMSD.

**Methods:** A prospective analysis of 1400 IT Professionals (age 20 to 60 years, median 32 years, 82% males) was conducted. The employees were evaluated by a detailed questionnaire consisting of demographic data, job details, health status, physical risk factors, short-form Work Style Questionnaire and Nordic Musculoskeletal Pain Questionnaire.

**Results:** 78% of the employees were diagnosed by an experienced occupational health physician to have a WRMSD. 60% of the employees were laptop users, 32% were desktop users and 8% used both. 64% of the employees worked for at least 5-9 hours per day. Most of the male workers complained of low back and radiating pain in upper or lower limbs, compared to female workers who complained predominantly of neck and shoulder pain. 72% had widespread body pain, 68% neck pain, 65% lower back pain and 46% shoulder pain. 87% were diagnosed to have Myofascial Pain Syndrome, followed by Thoracic Outlet Syndrome (32%), Fibromyalgia (30%), Tendinopathies of shoulder, elbow or wrist (24%), Patellofemoral Pain Syndrome (10%) and Type 1 Complex Regional Pain Syndrome (7%). Increasing age, high Body Mass Index, longer working hours, hazardous body postures, static loading, resting elbows and wrists on hard surfaces, and adverse work-style were positively correlated ( $r < 0.01$ ) with the presence of WRMSD. On the other hand, rest breaks during work, regular exercises and formal ergonomics training were negatively correlated ( $r < -0.01$ ) with the presence of WRMSDs, as more frequent breaks, regular exercises and prior ergonomics training showed lower prevalence of WRMSD. Also, the presence of co morbidities like joint hypermobility, diabetes, hypothyroidism, hyperuricemia, low bone mineral density, hypovitaminosis D and B12 had a positive influence on the prevalence of WRMSDs in the study population. Other specific factors like work experience, hand dominance, type of computer used also had an influence on the development of WRMSDs.

**Conclusion:** The risk factor analysis provides data to prioritise areas of ergonomic interventions among IT professionals.

## 63. A holistic approach to a disability management program in Occupational health management

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**Keywords:** Pre-employment medical examination, benefits, process, policies and procedures, impairment.

**Introduction:** A Disability Management Program is a systematic, goal orientated process of actively preventing injury, illness or disease. Minimizing the impact of an impairment/disease, injury on an employee as well as the employer. A disability management program commences with the pre-employment medical examination where the fitness of the employee is measured against the job description, taking exposure and protective equipment into consideration. The law, policies and procedures and rules of procedures must be in place to protect the employee and employer. The last resort and step in a disability management program is the application disability benefit from the insurer due to the inability of an employee to perform his job description due to illness or impairment. The financial impact on an employee, employer and insurer with regards to a disability application can have a negative impact on all the mentioned parties involved. There is also a non-financial for example the psychological impact on an employer.

**Method:** Literature with regards to legislation, standards, journal articles, professional association guidelines, personal work history and experience.

**Results:** Taking into consideration the impact that a disability claim temporary or permanent disability can have on an employee, employer and insurer it will be beneficial for all the parties involved to have a well-planned disability management program in place.

**Conclusion:** A disability management program is implemented the day an employee is employed and ends the day the employee leaves employment. Between employment date and discharge date there must be policies and procedures as well as rules of procedures in place to manage injuries, impairment/diseases and disabilities. A well-organized multidisciplinary team, working together to prevent and/or manage any disability claim, temporary or permanent disability will help to minimize the impact of an injury, impairment/disease or disability on the employer and employee.

## 64. Correct identification of health promotion awareness to facilitate return to work

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**Keywords:** Specific, Effective, Participation

**Background:** Injuries resulting in employees' long term absence from work and disabilities usually necessitate a change in health or work, their lifestyle, habits or behaviour. Correct planning and support of interventions for the rehabilitation, and accommodation of employees needs at the workplace should be addressed at the onset, to facilitate early return to work which will benefit both the employer and employee.

**Method:** Data was collected by utilizing questionnaires, literature reviews, journal articles, sick notes and employee engagement surveys. The focus was on the impact and effectiveness of health awareness and flexibility of reasonable accommodation. Frequent onsite clinic and workplace visits ensured employees were able to adapt willingly and very quickly. Strategies such as scheduled reviews and updates of the multi-disciplinary and community reports were welcomed. The presence of the onsite clinic interventions ensured it was not a desk top exercise but focused on the individual strengths and weakness per employee of their work ability. The initiatives from the employer to assist with ergonomic friendly adaptations at the employees' work stations were supported by the employee. This was viewed as a two way communication between employer and employees. Indicators such as age, gender, level of education and culture were used.

**Results:** Employees acknowledged that management were committed in assisting them and it was evident that the affected employees were positive and confident in returning to work. A sense of belonging was enforced as all interventions were planned and transparent. A successful rehabilitation and adaptability at the workplace resulted in decreased absenteeism. Overall this increased and improved employees' morale, enthusiasm and cooperation.

**Conclusion:** Increased involvement with management, occupational health, employees and trade unions is necessary for the correct process, frameworks and policies to follow for rehabilitation and re-integration. This approach confirms commitment and dedication yielding maximum outputs.

## 65. The my relief project: a european online education programme for older workers with chronic low back pain

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**Background:** Low back pain (LBP) is the main cause of activity limitation and work absenteeism, leading to high economic burden on individuals, families, labour market and society (Lidgren 2003, Kent & Keating 2005, Thelin et al. 2008). Sedentary and strenuous jobs together with other risk factors, such as low educational status, stress, anxiety, depression, job dissatisfaction, low social support in workplace and whole-body vibration, may negatively affect this health problem and lead to severe chronic LBP (Wong et al. 2017). The main goal of the MY-RELIEF project (funded by the EU Erasmus+ Programme) is to enhance the awareness of mature workers (55+ years) about correct ergonomics, pain self-management and healthy behaviour strategies to limit LBP, allowing them to improve their pain control skills.

**Methods:** Five European Countries (Sweden, United Kingdom, Italy, Lithuania and Portugal) will contribute to develop a free motivating education package, including the following outputs:

- MULTIMEDIA TRAINING VIDEOS with workers suffering from LBP and experts, explaining workers' needs, strategies and recommendations for daily life activities;
- HEALTH EDUCATION HANDBOOK with advices on physical exercises and relaxation techniques to improve health status and mental well-being;
- MOBILE-BASED SERIOUS GAME simulating practical daily-life situations experienced by LBP sufferers;
- MASSIVE ONLINE OPEN COURSE (MOOC) including textual and multimedia contents (from previous outputs) and accessible through mobile devices.

**Results:** The training package, available in five EU's official languages (English, Italian, Swedish, Lithuanian and Portuguese) will provide a motivating learning experience for mature workers with LBP.

The project is expected to raise the ability of mature workers to monitor and cope with LBP, improving job satisfaction and the general quality of life.

**Conclusion:** The project is still ongoing and it will develop preventive methods to limit LBP in mature workers.

## 66. Why Workers Hesitate to Report Their Work-Related Musculoskeletal Disorders: A Survey at a Korean manufacturing company

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The purpose of this survey was to figure out how many employees of a large manufacture in South Korea experience the work-related musculoskeletal disorders and what the possible obstacles in reporting to the company are. The survey was done via the company's intranet for thirteen days and total 2,862 respondents out of 24,380 employees anonymously completed the survey (response rate: 11.7%). The 1,580 (55.3%) respondents felt musculoskeletal symptoms during the past year and the 665 of them thought their symptoms are work-related more than 50%. The 776 (27.4%) respondents answered that they did not report their symptoms to the company more than once. The reasons why did not report were because 1) symptoms were not serious (394 respondents); they did not want to make it a big deal (305); 2) they did not know what and how to report (151); 3) they felt some kind of pressure in reporting (132); 4) they did not want to be a burden for their co-workers and supervisor (112); 4) they thought that reporting to company is no use (99); and 5) they worried about potential disadvantages in the future (52). The 444 (16%) respondents answered that they had at least one day off due to musculoskeletal symptom during the past year. However, according to the company's record, only 2-3% of employees use sick days and the mean duration of sick days was  $38.1 \pm 9.2$  days for recent 5 years. Findings of this survey underscores more thorough surveillance system in reporting the work-related musculoskeletal disorders and needs for an education program for the employees and employers to minimize the obstacles in reporting to the company or governmental agency.