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Mohd Hasnun Arif Hassan
Mohd Nadzeri Omar
Nasrul Hadi Johari
Yongmin Zhong *Editors*

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Editors
Mohd Hasnun Arif Hassan
Faculty of Mechanical and Automotive Engineering Technology
Universiti Malaysia Pahang Al-Sultan Abdullah
Pekan, Pahang, Malaysia

Mohd Nadzeri Omar
Faculty of Mechanical and Automotive Engineering Technology
Universiti Malaysia Pahang Al-Sultan Abdullah
Pekan, Pahang, Malaysia

Nasrul Hadi Johari
Faculty of Mechanical and Automotive Engineering Technology
Universiti Malaysia Pahang Al-Sultan Abdullah
Pekan, Pahang, Malaysia

Yongmin Zhong
School of Engineering
RMIT University
Melbourne, VIC, Australia

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Preface

Technological advancements have significantly benefited humans. Technology has led to the development of ergonomic tools and equipment that improve human comfort, reduce strain, and enhance overall productivity. From adjustable office chairs to ergonomic keyboards, these innovations promote proper posture and reduce the risk of musculoskeletal disorders. When it comes to road safety, technology has played a pivotal role in saving lives and preventing accidents. Advanced driver assistance systems (ADAS) equipped with sensors, cameras, and artificial intelligence algorithms help detect potential hazards, warn drivers, and even intervene if necessary. In the realm of sports technology, advancements have revolutionized training methodologies and performance analysis. Athletes now have access to wearable devices that monitor their biometric data, providing insights into their physical condition, performance metrics, and injury prevention. Further, technological advancements have led to sophisticated tools and methods for studying the human body's mechanics and movement. High-speed cameras, force sensors, and motion-tracking systems enable researchers to gain deeper insights into human locomotion, joint mechanics, and muscle activation patterns. These findings help design better prosthetics, rehabilitation programs, and ergonomic solutions tailored to individual needs.

The "Unlocking Human Potential: The Future of Human Engineering" symposium seeks to delve into the cutting-edge field of human engineering, exploring the possibilities of augmenting and optimizing human capabilities through advancements in science, technology, and design. This symposium brings together experts from various disciplines to discuss and showcase innovative approaches, methodologies, and ethical considerations in the realm of human engineering. From neuroenhancement to prosthetics, cognitive augmentation to genetic engineering, this symposium aims to stimulate insightful discussions and inspire the creation of a future where human potential knows no bounds.

Pekan, Malaysia — Mohd Hasnun Arif Hassan

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About the Editors

Dr. Mohd Hasnun Arif Hassan earned his first degree in Mechanical Engineering from the Technische Hochschule Bingen, Germany, in 2010. During the final year of his undergraduate study, he was offered a scholarship by Universiti Malaysia Pahang (UMP) to pursue a Master's degree in Mechanical Engineering at the University of Malaya in Kuala Lumpur, which he graduated with distinction in 2012. After that, he embarked on his Ph.D. journey at UMP where he studied about the head injury sustained by soccer players due to heading manoeuvre. He completed his Ph.D. study in 2016 and then continued to serve UMP as a senior lecturer. His research interests include finite element modelling of the interaction between human and sports equipment, instrumentation of sports equipment, and injury prevention particularly with regards to sports and traffic accidents. His work aims to apply engineering principles in sports not only to enhance the performance of an athlete but also to prevent injuries.

Dr. Mohd Nadzeri Omar received the B.Eng. (Hons) and Ph.D. degrees from RMIT University, Melbourne, Australia, in 2013 and 2017, respectively. He is a senior lecturer with the Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang. He is also attached to the Human Engineering Research Group which focuses on research, development, and innovations in human-centered technology and products. His research interests include soft tissue modelling, sports technology, biomechanical engineering, and mechatronics.

Dr. Nasrul Hadi Johari obtained his Ph.D. in Biofluid Mechanics from Imperial College London, United Kingdom. He is currently a senior lecturer at the Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang. Dr. Johari's research activities include computational modeling of blood flow, tissue mechanics, and mass transport in the cardiovascular system, with applications ranging from evaluating the hemodynamic performance of medical devices to predict the outcome of endovascular interventional procedures. He is also interested in computational and experimental modeling of the interaction between human

and sports equipment particularly in improving training aid systems and injury prevention.

Dr. Yongmin Zhong is currently an Associate Professor with the School of Aerospace, Mechanical and Manufacturing Engineering, at RMIT University, Australia. His research interests include computational engineering, haptics, soft tissue modeling, surgical simulation, aerospace navigation and control, intelligent systems, and robotics.

A Review of Biomechanical and Psychosocial Risk Factors Among Workers

Khairulhafiy Muhammad Ruzairi, Ezrin Hani Sukadarin, Mirta Widia, and A. Alaman

Abstract From the negative biomechanical experiences and psychosocial risk factors may contribute to Musculoskeletal Disorder (MSD) and it has been scientifically shown. In the last few years, there have been many systematic literature reviews on the correlation between risk factors and MSD, as well as several newly published papers but not for exact states combining risk factors. The current work aims to update the knowledge base on combining risk factors associated with MSD specifically. This review is conducted using the terms ergonomics, MSD, biomechanical, and psychosocial risk factors. The databases visited were Scopus, Google Scholar, Springer, CORE, ResearchGate, Elsevier, ScienceDirect, Semantic Scholar, and NIOSH Abstract. Based on the 52 literatures reviewed, White Finger Disorder (38.4%), general MSD (36%), and Lower Back Pain (23%), are the most dominant complaints among workers in various industries. The findings revealed that the biomechanical and psychosocial risk factors have a potential relationship when both can increase the susceptibility to MSD.

Keywords Musculoskeletal disorders · Psychosocial · Biomechanical · Workplace

K. M. Ruzairi · M. Widia (✉)
Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Lebuh Persiaran Tun Khalil Yaakob, 26300 Kuantan, Pahang, Malaysia
e-mail: mirta@umpsa.edu.my

E. H. Sukadarin · A. Alaman
Department of Chemical Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM), Johor, Malaysia

M. Widia
Centre for Advanced Industrial Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26600 Pekan, Pahang, Malaysia

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1 Introduction

Ergonomics is defined as the condition that fits the job to the worker; if there is an improper condition (mismatch) between physical needs and capacity requirements, then it will affect the health condition of the worker. In that case, the problem of Musculoskeletal Disorders may arise. Musculoskeletal Disorders (MSD) are typically characterised by feelings of pain (often persistent) at any part of the musculoskeletal system and may create limitations in mobility and thus reducing people's ability to work and participate in daily life activities. Job demands should not go beyond an employee's capacity. Excessive load can lead to psychosocial stress and physical fatigue which can negatively impact organisational performance. In implementing ergonomics, there are several major areas to consider, such as (1) the understanding of the interactions among humans (as workers) and other elements of a system, and (2) psychological stress faced by the workers, or at least keep them as minimum as possible[1].

Epidemiological studies involve three components of MSD risk factors [2] and to conduct ergonomic risk assessments, the three types of risk factors also need to be considered which are psychosocial, biomechanical, and individual. A combination factor can be stated as more than two or multiple factors that can contribute to the occurrence of MSD [3]. As indicated by previous research, there are also cases where workers experience a combination of risk factors that contribute to higher levels of injury [4]. Therefore, the authors aim to review the existing literature that investigates the relationship between biomechanical and psychosocial risk factors that cause MSD among workers.

2 Material and Method

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) are adopted as guidance for providing information in this study. The keywords used are ergonomics, MSD, biomechanical risk and psychosocial risk factor, combined with "OR" and "AND" Boolean operators. The databases of Scopus, Google Scholar, Springer, CORE, ResearchGate, Elsevier, ScienceDirect, and Semantic Scholar were visited. The screening process using the computerised search must meet the inclusion criteria: journals in English literacy, the outcome must be related to MSD that can be more than one of disease aetiology, research covering at least one risk factor of studies investigation, and emphasis on peer-reviewed report literature.

3 Results and Discussions

In Fig. 1, the outline is illustrated as a review study carried out with 148 articles selected based on inclusion criteria design from 236 articles.

3.1 Ergonomic Risk Factors Evaluation Method

Ergonomic risk factors are situations that exist or unintentional conditions that can or may contribute to results that are contrary to the ergonomic philosophy [3] and may result in MSD [4]. With some training and experience, identifying the ergonomic risk factors on a worksite is easy and should be done for designing work methods to prevent MSD.

Findings concerning the eight generic ergonomic risk factors can be further triggered when workers in an organisation suffer from adverse health effects. Many risk evaluation methods for working conditions were developed and used to meet that purpose [5]. Table 1 shows examples of evaluation methods which are widely used to investigate ergonomic risks at the workplace.

3.2 Ergonomic Risk Factors and MSD

The prevalent reviews on the effects of occupational ergonomic risk factors on musculoskeletal diseases of the neck and elbow [5]; shoulder [13]; hip and knee [14], and psychological stress [15] have identified the eight generic categories of ergonomic risk factors which are of interest in the occupational spectrum: (i) force exertion and heavy lifting; (ii) demanding posture; (iii) repetitiveness or prolonged activities; (iv)

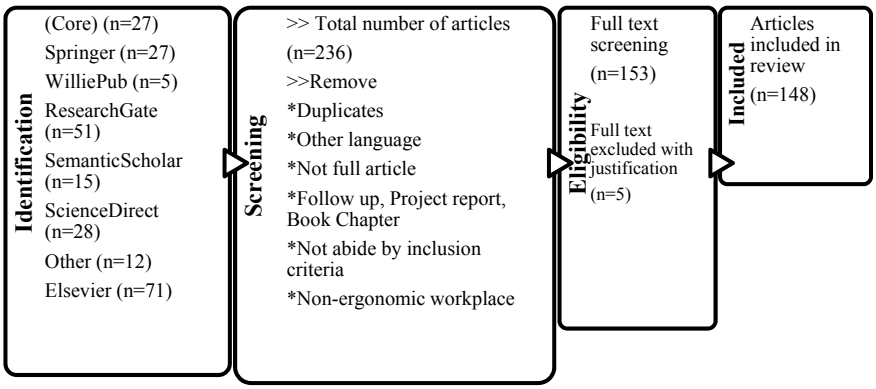

Fig. 1 Flowchart of article search design

Table 1 Ergonomic risk factors evaluation method for working conditions

Risk factor	Method	Sources
Lifting of heavy loads	National Institute for Occupational Safety and Health lifting equation (NIOSH-Eq)	Waters et al. 1993 [6]
Awkward postures	Ovako Working Analysis System (OWAS)	Karhu et al. 1977 [7]
	Rapid Upper Limb Assessment (RULA)	McAtamney and Nigel Corlett 1993 [8]
	Rapid Entire Body Assessment (REBA)	Hignett and McAtamney 2000 [9]
Repetitive work	The Occupational Repetitive Action Tool (OCRA))	Occhipinti 1998 [10]
	European Assembly Worksheet (EAWS)	Schaub et al. 2013 [11]
Noise assessment	Daily Noise Dosage (DND)	Aryanezhad et al. 2009 [12]

whole-body or segmental vibration; (v) temperature extremes; (vi) localised contact stresses; (vi) Hand tools and equipment; and (vii) Personnel Relations.

The ergonomic issue arises when workers are exposed to a risk factor or a combination of risk factors. MSD results from a combination of biomechanical and psychosocial risk factors at the workplace [3, 16]. Workers will be affected by emotional disturbance (Prodanovska-Stojcevska et al. 2016), physical strain and sprains, and muscle stress. These will affect mechanical joint stability and muscle activity (Romaiguere et al. 1993), as well as have some auditory effects [17].

Meanwhile, a previous study also discovered that MSD is a symptom of physical and psychological risk factors at the workplace. Biomechanical risk factors occur when a person accommodates psychosocial demands, which leads to a stress response, which can produce muscle stiffness or static muscle loading or build other biological responses [3]. According to Baek et al. [18], there is a correlation between psychosocial risk factors and MSD, as it can refer to various models of psychosocial factors among those from Bongers [19]. It was mentioned in Bongers et al. [19] that when there is a factor of biomechanical exposure to the human body, such as localised contact pressures, this will directly influence problems by changing posture through stress when there is a psychosocial disorder. Furthermore, Moon and Sauter [20] also identified an uninterrupted pathway between work methods, including ergonomics, organisational systems, and physical work surroundings.

Psychosocial factors are more concerned with the mental response of job dissatisfaction to a working condition that can lead to physical strain. Psychosocial risk factors may affect workers' psychological response to their work and influence the risk of low back disorders. For example, mental workload is associated with the risk of low back pain symptoms.

At the workplace, low social support, hostile behaviour, conflicting demands, and the addition of family problems are among the causes of the negative psychosocial

impact of organisations. This situation may be getting worsen with poor management systems. When the problem with work arises it also will affect worker's lifestyles such as taking unhealthy substances, job satisfaction, and organisational attribute. The important part is that the psychosocial components have been denoted to be significantly associated with MSD. According to Ariëns et al. [21], psychosocial risk factors also seem to play a significant role in the development of neck pain it has emerged that it has a reciprocal influence. Low decision latitude, low social support, and job dissatisfaction are among the significant predictors of neck pain [21].

Bongers et al. [19] considered two paths of action concerning psychosocial factors on the appearance of MSD: (i) the direct effect of these factors on the biomechanical load of the individual as shown in previous research, among which are roofers working with unique work environments (kneeling and awkward postures) and extreme temperature and other cogent arguments. The exposure to vibration can cause a reduction in heart rate variability (ii) the workers evaluate psychosocial factors as being potential threats for which a solution must be found. It has also been proven by Aptel and Cnockaert [22] that when pressure is felt, it will increase in the muscular tonus following the central nervous system (CNS) activation of the reticulate, which increases the biomechanical load, thus resulting in inflammation of the tendons and tissue deformation. Hales and Bernard [23] found that psychosocial demands may be highly correlated with physical demands in certain situations. This suggests that any association between psychosocial risk factors and MSDs may reflect the relationship between physical risk factors and MSDs.

3.3 Musculoskeletal Disorders (MSD) and Its Effects

Based on the literature review, the symptoms of MSD also vary according to the level of risk industrial activity and sociodemographic variables such as age, marital status, level of education, and personal lifestyle [15]. Prolonged exposure may lead to signs and symptoms of the disease until the more severe illness is called a disorder that makes people more vulnerable to injury. Uncontrolled ergonomic risk factors without proper solutions will affect employees and the environment. In addition, the substantial changes in work organisation along with the organisation's need to incur costs for workers' compensation claims will also add to the substantial economic burden.

Emphasis on the development of MSD in this study, the authors indicate various large groups of MSD components. Pramitasari et al. [24] stated that MSD is the single largest category of workplace injuries and disorders that affect the human body's movement or musculoskeletal system with different levels of severity (i.e. muscles, tendons, ligaments, nerves, discs, blood vessels). Predominantly, MSD has been shown to cause drowsiness, economic burden monotonous work [13], and muscle tiredness. These results suggest that lack of recognition and work delays contribute to the stresses that facilitate the emergence of MSDs [25].

Researchers also began to explore psychosocial risk exposure according to age and gender. Collins et al. [26] found notable different effects for neck and shoulder disorders, where males are found to be less affected than females. Another case study over the past year found that prolonged exposure to monotonous, repetitive work with arms outstretched in front of the body or twisted arms was associated with elbow pain in women, but not in men [27]. Elbow pain is also related to biomechanical factors among women subjects because of low support at work and mental resilience [27]. This signifies that women are more likely to suffer from MSD symptoms [26]. However, the emphasis on health aspects such as physical exercise, healthy food intake, and leisure activities proved to contribute to disease prevention. Concerning work related by age, the findings by Collins et al. [26] indicated that with increasing age and prolonged exposure, it is not difficult to understand why this group of elderly people shows significant MSD symptoms.

4 Conclusion

Biomechanical risk factors contribute to MSD. With that, it unsurprisingly arises, when combined with psychosocial factors, that results may worsen. Finally, workers' experience of biomechanical factors and exposure to psychological factors were significantly associated with MSDs and susceptible to their occurrence. Many well-known syndromes from negative biomechanical experience and psychosocial risk factors contributing to MSD have been scientifically shown. High job demands and vibration are the most exposure in most of the studies reviewed. Most of these studies were experimental, but there were also self-reported symptoms from observational studies. As discussed in previous studies, there are concerns about which combinations of risk factors would be most affected by MSD variability outcomes. Previous studies also have been done to prove the biomechanical relationship between neck, shoulder, and upper limb symptoms. Studying this relationship with the symptoms of knee disorder (lower limb) is also necessary. There is a high potential for combining risk factors in longitudinal research studies.

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