REVIEW ARTICLE

A Literature Review on Work-related Musculoskeletal Disorders (WMSDs) and its Ergonomic Implementation Among Industrial Workers in Workstation Design

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ABSTRACT

Work related musculoskeletal disorders (WMSDs) are relatively common among industrial workers. Repetitively lifting, standing, bending, pulling and pushing are the major causes to WMSDs. This paper presents a literature review of studies that have been carried out on the ergonomic workstation design of industrial workers to overcome WMSDs. The objective is to provide information on WMSDs among workers and discusses the implementation of ergonomics to prevent WMSDs among industrial workers through workstation design. The results indicate that many workers in different sectors are exposed to ergonomic risk factors such as repetitive movement, prolonged standing, and awkward posture. Various ergonomic interventions have also been studied to prevent WMSDs. To conclude, it is recommended for future studies to assess these risk factors and its ergonomic implementation to mitigate WMSD risks among industrial workers.
Malaysian Journal of Medicine and Health Sciences (2025) 21(5): 397-408. doi:10.47836/mjmhs.21.5.43

Keywords: Literature review, Ergonomics, Workstation design, WMSDs, Industrial workers

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INTRODUCTION

Ergonomics is the study of people's efficiency in their working environment, which considers their capabilities, limitations, safety, and health that can affect a company's productivity. The objective of an ergonomics program is to provide comfort to workers in their workplace to fulfil the goals of the organization. The primary aim of ergonomic implementation is to enhance the quality and productivity of workers' performance by fitting the job to the workers rather than the workers to the job. Hence, the ergonomist considers the worker, workplace, and job design to evaluate the fit between the worker and their work task. Adverse working conditions encompass noise, high or cold temperatures, inadequate lighting, poor workstation design, improper machines, and tool designs among others. In addition, job design can also have a great impact, such as shifts, breaks, and meal schedules.

Work-related musculoskeletal disorders (WMSD) are conditions in which the work environment and performance of work contribute significantly to the condition. Nowadays, the problems of WMSDs in industrial work are getting wider attention. WMSDs often occur in conditions where the environment and performance of work contribute significantly to the condition and/or the condition is made worse or persists longer due to work conditions. WMSDs continue to present a challenge in virtually every occupational sector (1,2). The Bureau of Labor Statistics in United States reveal that musculoskeletal disorders (MSDs) account for the primary source of illness and injury and accounts for 31.8% of all illnesses and injuries (3). WMSDs affect body structures such as muscles, tendons, ligaments, joints, nerves, bones, and blood circulation systems (4–6). There is also significant risk of WMSDs involved in manual activities related to consumption of manpower (7). Examples of work conditions which can lead to WMSDs include lifting heavy objects, body vibrations, the neck being in a chronic flexion position, repetitive forceful tasks, and overhead work (8–12). In other words, MSDs often correlate to injuries to the neck, shoulder, elbow, back, hand and wrist (13–16), which are mainly caused by inappropriate postures and awkward positions.

Adverse working conditions can result in injuries or problems that relate to the tendons, muscles, or nerves, which can develop into MSDs. MSDs concern injuries or disorders of the muscles, nerves, tendons, joints, cartilage, and spinal discs. Non-ergonomic working stations setup or tools will affect industrial workers' productivity, leading to poor quality of work, health, and safety (17–19). Workers performing tasks in non-

ergonomic environments in long periods are also likely to confront pain and discomfort, leading to chronic MSDs. In addition, long working hours daily may further contribute to MSDs negatively impacting workers' health among workers (20). Lack of rest during work can also further worsen the problem, affecting the back and the lower extremities of the worker's body (17).

A worker's productivity depends largely on the ergonomic design of the workplace. This review discusses MSDs and its relation to work conditions as well as literature on the implementation of ergonomics on WMSDs in industrial workstations.

Defining Ergonomics

The word "ergonomic" is derived from a Greek word that carries two meanings, which are Ergo, referring to work, and Nomos, which refers to natural laws (21–23). As clarified by the International Ergonomics Association (24), ergonomics is the scientific discipline that relates to understanding interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods in design to optimize human well-being and overall system performance.

Ergonomics relates to human biology and engineering science that is connected to workers and the work environment. In other words, it is the connection between humans and the design of the product and work environment. Reviews from numerous research of ergonomics have used a variety of definitions to describe the concept of ergonomics. According to Boatca and Cirjaliu (2015), ergonomics, which is also known as human factors, is a key science that focuses on ensuring the work environment can adapt to human being's talents, abilities, skills, and limits (25). Ergonomics practitioners, who are called ergonomists, must contribute to the design and evaluation of jobs, tasks, products, environments, and systems to make it compatible with the needs, abilities, and limitations of humans.

Ergonomic Workplace Design

The workplace is an area where work of a particular nature is carried out. It is a specific location that encompasses the office table to an assembly line. Work plays a special role in life since it is an important factor in the development and organization of human life. According to Lis, Nowacki, & Łakomy (2018), an adult spends two thirds of their life on their occupation (26). Hence, the condition of the workstation for every person has a fundamental impact not only on their effectiveness in working, but also on their physical and mental health. Ergonomics is the science and practice of designing tools, equipment, workstations, and environments to suit human capabilities and limitations. Over the past few centuries, the effectiveness of manual tools such as hammers, axes, and plows have been improved by ancient practices. This shows that the principle of ergonomics has continued to develop from long ago between humans and the work environment. As mentioned by Pandve (2017), the selection and creation of tools, machines, and work processes need to evolve continuously to ensure that work becomes more worker-friendly (27).

Each company that hires workers regardless of position needs to apply the principle of ergonomics in their organizational culture, as it can enhance the work capability of their workers (28). Moreover, ergonomics gives an organization the ability to reduce cost by increasing staff satisfaction and productivity of workers, leading to enhanced quality of products. Ergonomics helps harmonize things that interact with workers as it considers their needs, abilities, and limitations. Therefore, employees should be given early exposure to the benefits of ergonomics in the workplace.

Musculoskeletal disorders

MSDs are a combination of two different systems which are the muscle system and skeletal system. Both systems work together to support body weight and movement. MSDs are health problems that are related to the locomotor apparatus such as muscles, tendons, the skeleton, cartilage, ligaments, and nerves (29,30). It can affect soft tissues such as the bone, tendon, joint, and ligament, which can cause difficulties, limitations, and pain in movement that could negatively affect the activities in work and life. As mentioned by the World Health Organization (WHO), the International Classification of Diseases has listed more than 150 diagnoses on musculoskeletal conditions that could affect the locomotor system such as the muscles, bones, joints, and tissues including ligaments and tendons (31). The causes of MSDs vary. Daily activities that involve wear and tear may lead to damage of muscle tissue. Trauma to an area can also cause musculoskeletal pain, such as awkward movements, repetitive movement, falls, dislocations, accidents, fractures, prolonged immobilization, and more. In nutshell, MSDs are injuries that tend to result from overuse or misuse of certain body parts. Neglecting the symptoms of MSDs such as pain, discomfort, swelling, stiffness, tingling and numbness for long periods can also lead to temporary or permanent injuries.

MATERIAL AND METHODS

In this literature review, several databases were used to search for journals and articles related to WMSDs. The articles and journals were found on online databases such as Science Direct, Google Scholar, PubMed and Scopus. The selected papers were those written in English that had been published from 2010 to 2020. The papers found were then sorted according to the criteria described below. Figure 1 shows the process of flow of the methodology.

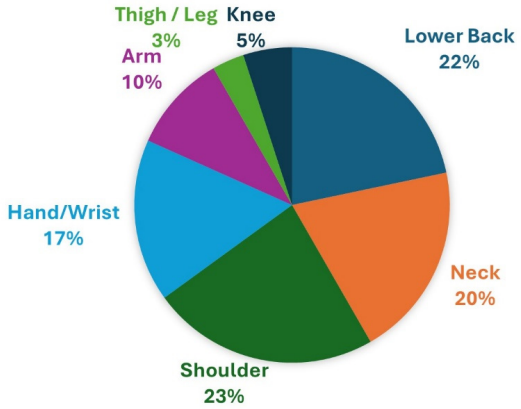

Figure 1: Frequency of WMSDs among industry workers in the literature from 2010–2020.

The process of selecting the journals and articles was based on two selection criteria. The first criteria was that the journals and articles must be published between 2010 and 2020. Second, the scope of the papers is limited to WMSDs among health, construction, manufacturing, agriculture, and services workers. Journals and articles which do not meet these two criteria were excluded.

Initially, there were 18,100 journals and articles found via the online database. Since this study only focuses on publications between 2010 and 2020, papers that published before 2010 as well as those that did not focus on occupational MSD industries, were excluded. This amounted to about 18,056 papers. After sorting all the papers, 44 journals and articles remained that fulfilled the criteria and were suitable to be analyzed for this study.

RESULTS

Based on the literature published between 2010–2020, it can be observed that MSDs are common among workers. Table I lists some of the WMSDs and their risk factors that have been reported among industries workers from 2010 to 2020.

Based on Table I, many workers became exposed to MSDs due to their job tasks. The risk factors associated with WMSDs include awkward posture, prolonged standing and sitting, repetitively lifting heavy weights, and having poor tools and workstations. As depicted in Figure 1, shoulder pain is the most highly reported MSD among industries workers, following by pain in the lower back and neck.

Table I: List of industries impacted by WMSDs that have been reported in the literature from 2010–2019

Industries	Author	Title	Job description	MSDs reported	Risk factor	Recommendation	References
Healthcare	Heidari M, Borujeni MG, Rezaei P, Abyaneh SK.	Work-related musculoskeletal disorders and their associated factors in nurses: A cross-sectional study in iran	Nurse	Lower back pain	Lifting and carrying weights, and standing for long periods	Improve quality of care by nurses should design necessary plans to manage physical strains, improve working conditions, and reduce working hours	37
Healthcare	Amin NA, Fatt QK, Oxley J, Abu IF, Noah RM, Nordin R.	Predictors of work-related musculoskeletal disorders of neck and shoulders among nurses	Nurse	Neck and shoulders pain	Psychological job demand and physical demands	An intervention programme includes design components to reduce the physical and psychological job demand	38
Healthcare	Mirmohammadi S, Yazdani J, Etemadinejad S, Asgarinejad H. A	A Cross-sectional Study on Work-related Musculoskeletal Disorders and Associated Risk Factors Among Hospital Health Cares	Health Cares	Lower back and neck pain	Patients handling/ transferring and relocating are a high-risk task	A periodic educational program as well as back school practice can play a main role in prevention and reducing the musculoskeletal disorders resulted.	39
Dentists	Ohlendorf D, Naser A, Haas Y, Haenel J, Fraeulin L, Holzgreve F, et al.	Prevalence of musculoskeletal disorders among dentists and dental students in Germany	Dentist	Lower back, neck and shoulders pain	Repetitive movements, prolonged static postures, and excessive contraction of short muscles while handling patients	The design of job-related strength training, or the therapy of MSDs	40
Construction	Lop NS, Kamar IFM, Aziz MNA, Abdullah L, Akhir NM.	Work-related to musculoskeletal disorder amongst Malaysian construction trade workers: Bricklayers	Contrustion workers	Shoulders, hands, wrists, lower back, thighs and knees pain	Bending down to lift bricks, straightening up, and turning to lay bricks	Designing a suitable tools, solving the problems of manual handling and provide scaffolding and platform	41

CONTINUE

Table I: List of industries impacted by WMSDs that have been reported in the literature from 2010–2019 (CONT.)

Industries	Author	Title	Job description	MSDs reported	Risk factor	Recommendation	References
Agriculture	Syazwani N, Nawi M, Deros B, Nizam M, Rahman A, Sukadarin EH	WMSDs complaints among Palm Oil Plantation Workers: Impact of the use machines technology	Palm oil plantation	Neck, shoulders, and lower arm pain	Awkward posture	None	42
Agriculture	Razak S, Karuppiah K, Tamrin SBM.	Musculoskeletal disorder: The prevalence among workers in selected palm oil mills in Malaysia	Palm oil harvesters	Neck, shoulders, and lower arm pain	Awkward positions	Corrective measures seem essential to prevent possible elevating MSD prevalence in the future.	43
Agriculture	Nawi NSM, Md Deros B, Norani N.	Assessment of Oil Palm Fresh Fruit Bunches Harvesters Working Postures Using REBA	Oil palm plantation	Left- and right-hand side pain	Awkward posture, pulling/pushing long-armed, prolonged working without rest	Need to conduct ergonomic training and assessment to identify and control ergonomics risk factors	44
Agriculture	Ng YG, Tamrin SBM, Yusoff ISM, Hashim Z, Deros BMD, Bakar SA, et al.	Risk factors of musculoskeletal disorders among oil palm fruit harvesters during early harvesting stage	Oil palm fruit harvesters	Neck and shoulders pain	Awkward posture	Inverse relationship of MSDs with daily working and resting duration of work	45
Agriculture	Ng YG, Bahri MTS, Irwan Syah MYI, Mori I, Hashim Z	Ergonomics observation: Harvesting tasks at oil palm plantation	Oil palm fruit harvesters	Lower back, upper back, hands and arms pain	Awkward postures and stooping	The strategy and design of effective intervention related to agriculture's ergonomics	46
Agriculture	Sukadarin EH, Md Deros B, Ghani JA, Ismail AR, Mokhtar MM, Mohamad D.	Investigation of Ergonomics Risk Factors for Musculoskeletal Disorders among Oil Palm Workers Using Quick Exposure Check (QEC)	Oil palm fruit harvesters	Arm and shoulders pain	Loading from ground to truck activity. High exposure level for wrist / and in loading (ground to truck), for loading (truck to lorry) affected	Limited knowledge in ergonomics – workers must have training in ergonomics	47
Agriculture	Salleha NFM, Sukadarina EH.	Job Hazard Analyses (JHA) for Ergonomics Risk Factors in Malaysian Pineapple Plantation.	Pineapple plantation	Lower limbs, wrist pain	Prolonged exposure to standing, squatting, stooping and kneeling	Educating and training the pineapple workers to perform their task with strong consideration of occupational safety and health.	48
Video display terminal (VDT)	Erna Faryza, Mohd Suleiman Murad, Syamsul Anwar.	A Study of Work-Related Complaints of Arm, Neck and Shoulder (Cans) Among Office Workers in Selangor and Kuala Lumpur	Office	Arms, neck and shoulders pain	Poor work station, body posture, rest time, social support, working duration and levels of ergonomic knowledge	None	49
Video display terminal (VDT)	KALINKARA V, SARI İ, İhsan Ö.	Work-Related Musculoskeletal Disorders and Ergonomic Risk Factors in VDT Workers.	Computer operators	Neck, back, wrist, forearm pain	Heads bent whereas, humped or slanted position,	Optimum hardware design – designing a suitable workstation	50
Video display terminal (VDT)	Daruis DDI, Ramli S.	Investigation on Ergonomics Awareness among Video Display Unit Users - A Case Study among Office Workers in UPNM.	Office	Lower back pain	Prolonged standing, bent over, sitting	Educate through educational tools and expert talks.	51
Video display terminal (VDT)	Che Mansor CH, Zakaria SE, Md Dawal SZ.	Investigation on Working Postures and Musculoskeletal Disorders among Office Workers in Putrajaya	Office	Lower back pain	Awkward postures, unsuitable workstation and lack of ergonomics knowledge	None	52

CONTINUE

Table I: List of industries impacted by WMSDs that have been reported in the literature from 2010–2019 (CONT.)

Industries	Author	Title	Job description	MSDs reported	Risk factor	Recommendation	References
Video display terminal (VDT)	Widanarko B, Legg S, Devereux J, Stevenson M	The combined effect of physical, psychosocial/organisational and/or environmental risk factors on the presence of work-related musculoskeletal symptoms and its consequences		Neck and shoulders pain	Awkward grip and hand movements and working with prolonged standing	Improving physical conditions as well as the psychosocial/organisational and environmental aspects of the working environment.	53
Transportations	Aini N, Huda B.	Prevalence of Musculoskeletal Symptoms and Its Associated Risk Factors Among Bus Drivers	Driver	Lower back, knee, leg and neck pain	prolonged driving duration, working experience, and shift work	Periodical training and improvement of work factors and working condition	54
Transportations	Mad Isa NS, Razali MM, Sahani M	Musculoskeletal discomfort and its associated risk factors among train drivers	Driver	Lower back, upper back, knee and neck pain	Poor workstation design, vibration.	None	55
Printing	Saleh HM, Fasiha N, Yusof M, Hussain MN.	Prevalence of Wrist MSD Risk amongst Silk Screen Printing Workers in Johor Bahru: A Preliminary Result	Printing Workers	Wrist pain	Awkward posture	None	56
Canting	Yusof N, Yusof R, Ahmat Basri FMF, Soin N	Ergonomic Evaluation of Postural Assessment among "Canting" Batik Workers	"Canting" Batik Workers	Shoulders pain	Prolonged standing, repetitive movement and poor workstation design	Designing an ergonomic workstation	57
Footwear	Vieira ER, Buckeridge Serra MVG, Brentini de Almeida L, Vieira Villela W, Domingos Scalon J, Veiga Quemelo PR.	Symptoms and risks for musculoskeletal disorders among male and female footwear industry workers.	General worker	Wrists/hands/finger pain	Awkward posture, prolonged sitting and standing	Implementation of intervention programs for optimum outcomes	58
Printing	M.L M, G.S D.	An Ergonomic Approach to Design Hand Tool for Screen Textile Printing	Printing Workers	Lower back, hand/wrist, shoulders pain	Poor hand tools	Redesign hand tool based on anthropometric dimensions and ergonomic principles	59
Manufacturing	Nur NM, Dawal SZ, Dahari M	The Prevalence of Work-Related Musculoskeletal Disorders Among Workers Performing Industrial Repetitive Tasks in the Automotive Manufacturing Companies.	automotive manufacturing	Neck, hand and wrist, shoulder, and lower back pain	repetitive tasks	None	60
Manufacturing	Zare M, Black N, Sagot JC, Hunault G, Roquelaure Y.	Ergonomics interventions to reduce musculoskeletal risk factors in a truck manufacturing plant	truck assembly	Neck, shoulder, hand and wrist and lower back pain	Lifting and carrying, manual material handlings, and repetitions	Ergonomically balancing and redesigning of the workstations	61
Manufacturing	Khan M, Pope-Ford R.	Improving and Modifying the Design of Workstations within a Manufacturing Environment	assembly worker	Shoulders and hand/wrists pain	Short cycle time and high production volume	Improve the workstations design	62

DISCUSSION

Work-Related Musculoskeletal Disorders (WMSDs) Among Workers

WMSDs can lead to extensive economic consequences among workers, employers, and the society through medical care, medical leave, and early retirement pension. There are various WMSD risks factors such as repetitive movements, bending and twisting, heavy lifting, uncomfortable working conditions, working with too much force, working for long periods without breaks, and psychosocial factors (32,33). Other risk factors include the workstation design, age, body mass index (BMI), and smoking habit. In the industrial sector, three main factors were identified as possible contributors to WMSDs, which are repetitive movement, force, and sustained awkward posture (34). In addition, the most common types of WMSDs complaints involve the upper limb, lower back, and lower limb. Upper limbs may affect certain body parts such as the neck, shoulders, arms, forearms, hands, and wrists. The most common upper limb syndromes are the neck syndrome and cervical spine syndrome for the neck, shoulder tendinitis and shoulder bursitis for the shoulder, epicondylitis and radial syndrome for the elbow, and trigger finger, hand-arm syndrome and carpal tunnel syndrome for the hands or wrists. Furthermore, the lower back is mostly affected by spinal disc problems and muscle and soft tissues injuries. This disorder occurs regularly for heavy physical work that involves awkward postures, static postures, repetitive movements, and vibrations in the entire body. Finally, the lower limbs include effects on the hips, knees, and leg. These disorders affect those who work in standing or kneeling positions over long periods. It also poses a risk to workers who kneel and squat repetitively, as well as those who frequently jump from heights.

Current trends in industries worldwide including Malaysia show that WMSDs and compensation costs are increasing. SOCSO also reported an increasing trend of employees' compensation for occupation-related diseases (permanent and temporary benefit) from RM2.65 million in 2009 to RM14.05 million in 2014 (35). Moreover, compensation due to MSDs showed an overall increasing trend from 2009 to 2014 (36). The increasing trend in employees' compensation for occupation-related diseases requires the consideration of ergonomic intervention.

WMSDs can occur among workers from management to construction. Table I listed the industries impacted by WMSDs that have been reported in the literature from 2010–2019. Many researchers have conducted studies on ergonomics in the workplace. For instance, in the healthcare sector, nursing or healthcare is considered a high-risk occupation for developing diseases. These are due to inappropriate postures during work activities, as well as long-term and constant muscle and repeated body movements. Healthcare workers are also involved in providing psychological and physical care such as lifting a patient's body, carrying weights, and standing for long periods, that lead to lower back, neck, and shoulder disorders (37–39). One study also revealed that dentists experience lower back, neck and shoulder MSDs that relate to repetitive movements, prolonged static postures, and excessive contraction of short muscles while handling patients (40).

In a study conducted on WMSDs for construction workers, activities that result in bending the body and twisting the body such as bending down to lift bricks, straightening up, and turning to lay bricks, which involve awkward and repetitive positions, are the main causes of MSDs in the shoulders, hands, wrists, back, thighs and knees (41). In addition, WMSDs also occur in the agriculture field. In the study by Syazwani et al. (2015), a survey on WMSDs revealed complaints among palm oil plantation workers such as pain in the neck, shoulder, and lower arm (42). A similar study found that the awkward positions of palm oil harvesters may contribute to MSDs (43–47). A study by Salleha and Sukadarina (2018) in the pineapple plantation identified that farmers are exposed to prolonged standing, squatting, stooping and kneeling positions, as well as highly repetitive motions of the lower limbs such as deviation, twisting of wrist, and heavy lifting, leading to MSDs (48). The video display terminal (VDT) that is widely used in workplaces can also lead to various ergonomic-related problems associated with workstation, body posture, rest time, social support, working duration and levels of ergonomic knowledge. This condition may result in ergonomic risk involving the arms, neck and shoulders (49–52).

WMSDs can occur in any condition of work. Widanarko, Legg, Devereux, and Stevenson (2014) reported that the combination of physical, psychosocial, and environmental exposure can increase MSD symptoms (MSS) (53). Accordingly, a modified version of the Nordic Musculoskeletal Questionnaire was used to obtain information on MSS by considering current occupational exposures, workplace practices, and occupational illnesses at the Electoral Roll in New Zealand. People who work with transportations were also found to be exposed to MSS. A study in public transport indicated that prolonged driving duration, working experience, and shift work associated with the wrist, shoulder, and thigh discomfort can lead to lower back pain (54,55). Many researchers have conducted studies on the symptoms and risk of MSDs in various scopes of work that cause poor symptoms including in textiles, footwear and printing (56–59).

The manufacturing industry has also grown rapidly over past few years, as reflected by the increasing number of researchers who have conducted research on the safety and health of manufacturing workers to reduce diseases

and disorders. A study by Nur, Dawal, and Dahari (2014) on workers within the automotive manufacturing industry found that the prevalence of WMSDs was highest in the neck, followed by the hand and wrist, shoulder, and lower back (60). A similar study among truck assembly workers found that the prevalence of WMSDs was highest in the neck, shoulder, hand and wrist, and lower back (61). The prevalence of WMSDs in the shoulders and hand/wrists was due to the short cycle time and high production volume (62).

Table I provides some recommendations to each task. Based on the findings, many workers need more intervention programs to increase their knowledge on safety while performing their task. It is evidence that there is low ergonomic risk awareness among industrial workers (63). In addition, there are few factors that are associated with above problem. Some workers perceive ergonomics as relatively less important compared to safety issues. In addition, there is still a lack of understanding between the management and workers regarding ergonomic awareness. This is due to their perceptions that ergonomic programs are unimportant (64). In fact, ergonomic awareness is highly important in ergonomic implementation as all companies need to develop their own ergonomic guidelines as suggested by the Occupational Safety and Health Administration (OSHA). Based on a study on the furniture industry in USA, awareness should include worker's attitude and behavior only. However, attitude is more challenging to address compared to knowledge. The development of attitude and behavior is highly affected by personal traits, education, working experience, age group and training received. In related to ergonomic tools design or workstation design, some studies also suggested changes in workstation design. As indicated in Table 1, physical jobs require adequate space to cater for movements such as assembling and handling materials. It also requires a visual display terminal.

Workplace design is the process of planning and arranging a work environment to optimize operations, promote staff wellbeing and enhance quality and productivity of workers, as workers often spend a lot of time performing the same and repetitive operations. In order to design a good workplace environment and tools, better ergonomic planning can be incorporated. Workplaces and tools should be designed safely and effectively to fit work into human needs. Therefore, in designing workplaces, there are certain criteria that should be taken into consideration such as anthropometric factors, reaches, capability of muscle strength and visual impact (65). Similar to tools and equipment design, the major ergonomic concerns of a tool design include anthropometric factors, weight, shape and materials and texture of design (66). WMSDs in workplace could be reduced by improving MSDs prevention practices and ergonomic interventions in all industrial sectors. This would then increase productivity, leading to high returns on investment by reducing production costs and cycle time, and increasing product quality, flexibility, and innovativeness. As a result, lost work time, sick leave, human and system errors, injury costs and a drops in labor turnover could be reduced.

The literature reviewed in this study indicated that most workers experience WMSDs. There is a high prevalence of MSD symptoms among workers with high proportion of MSDs in the shoulder, lower back and neck. In addition, from the point of view of the risk factors, the prevalence of MSDs is higher among workers who perform repetitive movements, stand for prolonged periods, have awkward posture, and work long working hours. This may be caused by certain reasons such as neglect in ergonomic awareness, poor workstation design, and lack of rest while handling work. Many studies worldwide have been conducted to understand, identify, and reduce WMSDs among workers. However, accidents still occur in the workplace. Hence, extra caution needs to be taken when considering the activity of work by implementing ergonomics in workstation design.

Implementation of Ergonomics on WMSDs in Industrial Workstation

Ergonomics plays an important role in improving occupational health and work productivity in most industries in Malaysia. Globally, many researchers have proposed ideas to reduce MSDs among workers. Daria Battini, Calzavara, Otto, and Sgarbossa (2017) proposed the idea of preventing ergonomic risks through integrated planning (67). In their study, a mixed-integer model was proposed and compared to common hierarchical planning. The study found that workplaces that have a high risk of ergonomics should avoid static and awkward postures, which can emerge in production that involves handling and low weight work pieces. The research also showed that the proposed integrated approach can enhance productivity and remove excessive ergonomic risk. A study was also conducted to identify issues related to the ergonomics of an industrial control panel (68). The researcher proposed redesigning the layout and elements to improve the usability of the industrial control panel. Through this study, the researcher concluded that computer modeling can reduce the possibility of accidents by considering the misperception or mental burden experienced by operators and improving the design of panels to reduce inappropriate task allocation. Khan and Pope-Ford (2015) conducted a detailed study to improve and modify the design of workstations within a manufacturing plant (62). They suggested several approaches in lifting activities such as the turntable on load-leveler, a lifting device, and a portable hoist or crane. These were claimed by the researchers to be able to reduce stress, back disabilities, and other shoulder injuries among workers.

Senderská, K., Mare , A., and Ongyik (2016) discussed the workstation design, which can be supported

by ergonomics software tools (69). In the study, the application of an analyzed system proved to be advantageous in the design of the workstation as it could help eliminate problems related to ergonomics even before the buildup of the workplace. Hence, it will help improve working conditions and increase quality, productivity, and cost benefits. Lin, Chen, and Cho (2012) conducted a study on the influence of floor conditions on discomfort during prolonged standing (70). Their analytical findings suggest that ergonomic interventions such as modifying the flooring on which workers stand can relieve leg edema for workers who stand for four-hour shifts. Nevertheless, they also stressed that prolonged standing for more than an hour while working should be avoided.

Many designs have been proposed that uses technology or manual methods to prevent or reduce WMSDs. A wearable equipment that enables self-prevention of WMSDs is one such technology (71). In the study, real-time motion warning in personal protective equipment (PPE) automatically alerts workers of hazards through a smartphone application as soon as dangerous operational patterns are detected. In another study, a multi-position ergonomic computer workstation design was found to potentially increase the comfort of employees (72). In the study, the researchers presented a new design of a computer workstation that could increase the comfort of users while working for long periods. This study resulted in increasing comfort by supporting the body's balance, where users could freely stretch and feel more comfortable in different working positions. As a result, they could work for a longer time without strain, which leads to higher productivity. Lin and Chan (2007) also suggested certain workstation designs to reduce MSD risk factors for semiconductor workers (73). The study suggested using an appropriate height of the keyboard shelf to reduce shoulder flexion and abduction angles for workers.

MSDs typically occur when workers perform work in inappropriate postures, including awkward positions. It also occurs with repetitive movements, carrying or lifting using force, becoming exposed to vibrations, and many more. The findings in this review showed that industrial workers are often exposed to repetitive movements, awkward postures, force, and several other physical activities that can result in MSDs. For the industrial worker, WMSDs often affect the upper limbs such as the neck, shoulder, hand/wrist, and lower back. These cases typically occur as the industrial worker needs to carry, lift, and switch loads.

Many researchers have suggested preventative actions to reduce WMSDs. Yet, accidents still occur in the working field. From creating the product to planning the work design station layout, WMSDs can be prevented through developments in design. The improvement of work design could also provide a better working environment through ergonomic intervention. Organizations need to play an active role to increase the awareness of WMSDs among workers, as poor and improper ergonomic work design in any workplace system can generate a large amounts of medical leaves, especially due to MSDs (74–77). Therefore, it is necessary to have an efficient workplace design system to provide better work-related satisfaction in human operations. According to Mali and Vyavahare (2015), the benefit of creating an ergonomic workplace is to ensure the workplace is free from hazards (78).

The advantages of implementing an ergonomic workstation include lowering injuries of WMSDs, increasing productivity of workers by making it easier for them to execute their jobs, and improving product quality due to fewer errors made by unhealthy workers. Hence, through an ergonomic approach on WMSDs, this could lower the rate of injury and lead to increased productivity of workers, increased quality of product, less physical effort, reduced absences, enhanced safety, comfort, and morale, reduced fatigue, and better organization. Ultimately, it can also increase the country's economic success. In designing a workstation and tools for workers, the designer must understand the risk exposure factors and its effects on the muscle. The anthropometry data of workers, the work environment condition, and product characteristics must be managed well in advance to mitigate WMSDs among industrial workers.

CONCLUSION

This paper reviewed studies related to WMSDs and its ergonomic implementation among industrial workers. The review found that many workers in different sectors face ergonomics risk factors such as repetitive movement, prolonged standing, and awkward posture. As a result, various ergonomic interventions had been studied to prevent WMSDs. Hence, to further understand the risk factors of musculoskeletal symptoms among industrial workers, it is recommended that future studies be conducted to assess these risk factors. This is important to identify the current ergonomic design of tools and workstations in various sectors. Many ideas, designs and formulas have been explored and developed by researchers to minimize the risk of WMSDs. Therefore, this review could help designers and ergonomists understand the current situation of WMSDs among workers and develop ergonomic workstations to ensure efficiency and productivity of industrial workers.

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