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A FUTURE FRAMEWORK FOR MUSCULOSKELETAL DISORDERS SYMPTOMS AMONG COMPUTER OFFICE WORKERS

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ABSTRACT

Background: This review summarizes the evidence regarding the association between musculoskeletal disorders and computer users at work. Past studies had identified that musculoskeletal disorders among computer users are known to be multifactorial in origin. This includes work related and nonwork-related factors.

Methods: Literature search was conducted in various databases such as Pubmed, ScienceDirect, and Scopus. The articles were analyzed based on predetermined objectives and Medical Subject Headings (MeSH) such as computer users, musculoskeletal disorders and risk factors. Almost seventy-seven (77) articles were retrieved and analyzed to understand the occurrence of musculoskeletal disorders among computer users.

Results: Based on the previous articles, a framework of musculoskeletal disorders and computer users was proposed for a better understanding of the occurrence of musculoskeletal disorders among computer users in the workplace. The framework emphasizes the association between work-related (physical, environmental and psychosocial risk factors) and non-work related factors (individual risk factors) among computer users. It was hypothesized that an increase in the muscle activity or increase in the muscle loads were the possible early symptoms of musculoskeletal disorders among computer users at the workplace due the interaction of individual, psychosocial and physical risk factors. Furthermore, the decrease in productivity was shown in the framework as an effect of an increase in musculoskeletal disorders among computer users.

Conclusion: The proposed framework may be used for better prevention and intervention of musculoskeletal disorders among computer users in the workplace.

Keywords: WRMDs, Ergonomic, Computer, Office Workers, Risk Factors, Musculoskeletal disorders.

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INTRODUCTION

In conjunction with the Industry 4.0, the role of human is greatly limited in the companies with a focus on using different types of modern information technologies such as cyber-physical systems and data processing [1]; [2]. The concept of Industry 4.0 assumes a high-efficiency production by creating a computerized and automated production system [1]. In practice, the use of computer plays an important role in achieving the Industries 4.0 solution [2]. According to a report by the National Institute of Safety and Health (NIOSH) of Malaysia, almost 61.4% of the workers in Malaysia is highly dependent on the computers in their workplace [3]. However, the recent technology development in ICT, with the use of computers and different types of pointing devices such as a mouse, touchpads, and keyboards have caused a different type of musculoskeletal injuries and health problems among computer users in the workplace [4].

A study conducted in Germany had revealed that computer office workers suffered from musculoskeletal symptoms in a different type of regions [5]. The study had identified, the prevalence rates for neck, shoulder and forearm/arm complaints were 0.31 (95% CI 0.28–0.37), 0.33 (0.27–0.39) and 0.21 (0.14–0.28) irrespectively [5]. The above study finding is consistent with another study which was conducted among computer users working for the population in China [6]. The study had identified that almost 50% of the working population had musculoskeletal disorders in the lower back region [6]. Similarly, a cross-sectional study among bankers using computers had found a high prevalence rate of musculoskeletal disorders in the neck (71.6%) and shoulder (48.33.%) region during working hours [7].

In Malaysia, there are few published papers which had reported a high incidence of musculoskeletal symptoms among computer users at work. A report from SOCSO (Malaysia) had found that almost 10,000 cases of musculoskeletal injuries were reported among Malaysian workers in every year [3]. Next, another prevalence study had identified that almost 92.8% of workers had musculoskeletal disorder [8]. A cross-sectional study from Malaysia reported computer users at the workplace has 2.0 higher odds ratio of developing of musculoskeletal symptom in the upper limb region [9]. Also, cross-sectional studies among computer users had reported a prevalence rate of musculoskeletal symptoms (10% - 62%) in the shoulder and neck region among computer users [10].

Musculoskeletal symptoms among computer users in the workplace are known to be a multifactorial in origin [4]; [11]. This includes psychosocial risk factors such as decision latitude, psychological demand, social support, job insecurity, etc. [12]; [13]. Furthermore, individual risk factors such as gender, BMI, physical fitness level, previous illness history are known to play a role in the occurrence of musculoskeletal disorders [14]; [15]. Apart from the risk mentioned above factors, most of the research studies on musculoskeletal disorders among computer users in the workplace are focused on work-related physical risk factors such as an awkward body posture, duration of computer users, repetitiveness and work pace [13]; [16]; [17].

Some studies that had looked into risk factors associated with musculoskeletal disorders among computer office workers were identified and presented in Table 1. Despite all the available knowledge on risk factors causing the development of work-related musculoskeletal disorders among computer users, the prevalence rate of musculoskeletal symptoms among computer users is still increasing. Although few studies had incorporated physical, psychosocial and individual risk factors in their studies, however, the level of exposure to risk factors that causes musculoskeletal disorders among computer users in the workplace are very difficult to establish as most of the studies only considered upper limb regions and utilized subjective measurement in their studies [4]; [5] [8]; [10]; [18]; [19] . Therefore, there is a limitation to establish the causality of musculoskeletal disorders among computer users in the workplace.

Table 1: Past studies on WRMDs and risk factors among computer office workers

Studies	Physical Risk Factors	Individual Risk Factors	Psychosocial Risk Factors	Limitations
Ambusam et al., 2015 [20]	/			
Amell & Kumar, 2000 [21]	/	/		
Barbieri, et al., 2012 [22]	/			
Chaiklieng & Krusun, 2015 [23]	/			
Coelho et al., 2015 [24]	/		/	
Collins & O'Sullivan, 2015 [25]	/	/		
Darvishi et al., 2016 [26]		/		
David, 2005 [17]	/			
Devereux et al., 1999 [16]	/			
Eltayeb, et al., 2009 [5]	/	/	/	Considered only the upper limb regions
Eltayeb et al., 2007 [18]	/	/	/	Considered only the upper limb regions
Evans & Johnson, 2000 [27]	/		/	
França et al., 2012 [13]	/		/	
Fagarasanu & Kumar, 2003 [28]	/	/		
Golubovich et al., 2014 [29]			/	
Griffiths et al., 2007 [30]	/		/	
Helland et al., 2008 [31]	/			
Holtermann et al., 2010 [32]			/	

Hsiao & Cho, 2012 [33]	/	/		
IJmker, et al., 2006 [34]	/			
Janwantanakul et al., 2009 [35]	/			
Johnston et al., 2009 [36]			/	
Johnston, et al., 2007 [37]		/	/	
Johnston et al., 2008 [38]	/	/		
Juul & Jensen, 2005 [39]	/	/		
Kaliniene et al., 2013 [40]	/	/	/	
Karasek et al., 1998 [41]			/	
Korhan & Mackieh, 2010 [42]		/	/	
Lassen et al., 2005 [43]	/	/	/	Considered only the upper limb regions
Le & Marras, 2016 [44]	/			
Li & Buckle, 1999 [45]	/			
Lin et al., 2017 [46]	/			
Luttmann et al., 2010 [47]	/	/		
Maakip et al., 2015 [48]		/	/	
Maakip et al., 2016 [49]		/	/	
Maakip et al., 2017 [8]	/	/	/	Includes only the subjective measurement - Validated questionnaire for assessing physical risk factors were not used
Malmberg-Ceder et al., 2017 [50]		/	/	
Matos & Arezes, 2015 [51]	/			
Meijer et al., 2002 [52]			/	
Ming & Zaproudina, 2003 [53]	/	/		
Moom et al., 2015 [19]	/	/	/	Includes only the subjective measurement
Oakman et al., 2018 [54]			/	
Oha et al., 2014 [14]		/	/	
Ortiz-Hernández et al., 2003 [4]	/	/	/	Includes only subjective measurement
Padmanathan et al., 2016 [55]			/	
Paksaichol et al., 2014 [56]	/	/		
Palmer et al., 2007 [57]	/			
Pan & Schleifer, 1996 [58]	/			
Poochada & Chaiklieng, 2015 [59]		/		
Pope et al. 2002 [60]	/			
Portuné, 2012 [61]			/	
Punnett, 2009 [62]			/	
Ranasinghe et al., 2011 [10]	/	/	/	Includes only upper limb regions
Ribeiro et al., 2016 [63]		/		
Riccò et al., 2016 [64]	/	/		
Rodrigues et al.,2017 [65]	/			
Sadeghian et al., 2014 [66]		/	/	
Santos et al., 2016 [67]	/			
Sciences et al., 2009 [12]			/	
Shabbir et al., 2016 [7]	/			
Shahidi et al., 2015 [68]		/	/	
Sharan et al., 2012 [69]	/	/		
Sharan et al., 2011 [70]	/	/	/	No any objective measurement available. Egonomic risk factors were not included.
Sheahan et al., 2016 [71]	/			
Shuval & Donchin, 2005 [72]	/	/		
Straker et al., 2008 [73]	/			
Szeto & Lee, 2002 [74]	/			
Szeto et al., 2005 [75]	/			
Takala & Viikari-Juntura, 1991 [76]		/		
Thorn et al., 2007 [77]		/		
Ustinaviciene et al., 2013 [78]		/		
Van et al., 2006 [79]	/			
Wahlstro, 2017 [11]	/		/	
Wu et al., 2012 [6]	/	/		
Yang & Cho, 2012 [80]	/			
Zakerian & Subramaniam, 2011 [3]			/	
Zemp et al.,2016 [81]	/			

Hence, this paper aims to give a summary of evidence regarding musculoskeletal disorders and computer users in

the workplace and to present a framework that integrated physical, individual and psychosocial risk factors. This framework was built to focus on the multi-factorial origin of musculoskeletal disorders among computer users in the workplace and to assist in the understanding of the complex nature of the interactions between physical, psychosocial and individual risk factors in the development of musculoskeletal. This framework can also be used as a fundamental knowledge for better intervention and prevention of musculoskeletal disorders among computer users working profession.

Overview and risk factors of work-related musculoskeletal disorders among Computer Office Workers

Work-Related Musculoskeletal Disorders (WRMDs) are injuries or dysfunctions affecting muscles, bones, nerves, tendons, ligaments, joints, cartilages and spinal discs due to the exposure at the workplace. The WRMDs includes clinical syndrome, such as tendon inflammations (tenosynovitis, bursitis), nerve compression syndrome (carpal tunnel syndrome, sciatica), and other musculoskeletal injuries such as myalgia and back pain which pathologies are still unknown [82]; [83]. The body regions which are frequently affected due to the WRMDs are the lower back, shoulder, forearm, and lower limb [84]; [85].

Beginning to the 1990s, there has been growing evidence that WRMDs risks among computer users in workplace arose mainly from occupational hazards associated with the physical requirements of work performances that impose biomechanical stress on worker and commonly known as a physical risk factor [10]; [11]. Physical risk factors are the prospects of a job or task that impose biomechanical stress on worker which can contribute to the musculoskeletal hazards [45]. The most frequently associated risk factors on the occurrence of musculoskeletal symptoms among computer office workers are posture, duration of computer users, work pace, force, repetition, number of working days, and computer-related equipment such as a monitor, keyboards, and mouse [13] ;[57]; [75]. Also, a few studies had discussed the effect on environmental factors such as temperature and lighting on the development of musculoskeletal symptoms in computer office workers [31]; [35].

Posture and Repetition

Static posture is an isometric posture which will lead to the static loading of muscles and joint tissues, consequently leading to discomfort and back pain [60]. A few studies had revealed that prolonged sedentary postures had been positively associated with musculoskeletal complaints in the neck, arm, shoulder in computer office workers [15]; [81]. In contrast, awkward posture is known when parts of the body are far from the extreme range of movements which lead to muscle stretching and compression of nerves [81]. A cohort study among Dutch computer office workers had identified that improper neck and body postures are either due to prolonged sitting with a twisted trunk or with the head in a flexed position [5]. A similar prevalence study among computer office workers in Thailand revealed that frequently working in an uncomfortable posture, increased the risk of experiencing head/neck symptoms (adjusted OR=1.81, 95% CI=1.35–2.44) [35]. A review of carpal tunnel syndrome (CTS) had reported that almost 21% of the cases of work-related were due to repetitive typing or data entry [57]. Computer tasks such as mouse clicking, keystroke, data entry and etc. are always led to a combination of risk factors such as an awkward posture of upper limb (ulnar deviation > 241; radial deviation > 151; pronation > 401; supination > 571; abduction > 671; extension > 501 and flexion > 45) and highly repetitive motion (30/40/min) [53]. This cumulative load increases the risk of getting musculoskeletal disorders among computer office workers [53].

Force and Speed

Past research studies had demonstrated a strong relationship between occupational exposures, especially high force and speed in development of WRMDs among computer office workers [75]. Research studies by NIOSH of United State had described a relationship between keyboard usage and development of Cumulative Traumatic Disorders (CTD) [21]. The report specified that typing speed and force required to activate the keys might be the contributing factors for the occurrence of CTD [21]. It has been observed that symptomatic workers with musculoskeletal symptoms type the keyboards with an extra force [21]; [75]. Also, a cross-sectional study conducted among female office workers had identified that workers with neck pain typed the keyboard with an extra force [38]. An increase in the force and speed with prolonged working duration may lead to an increase in muscle fatigue among computer office workers [38].

2.3. Lighting and Temperature

Environmental factors such as temperature and lighting had shown a significant relationship in the development of musculoskeletal disorders [31]; [38]. A cross-sectional study among office workers had found a relationship between neck pain and temperature in the office [38]. Similarly, a review on computer use upper limb related disorders had discussed on the influence of the cold working office environment in the development of hand pain and stiffness [53]. The review also suggested wearing gloves to keep the hands and wrist warm. Also, an intervention study on ergonomically designed office working environment had found a relationship between poor lighting and visual discomfort among computer users [53]. Similarly, few studies had identified that good lighting system in the working environment had decreased EMG activity of Trapezius muscle and pain in the several body regions compared to the control group [31]; [58].

Psychosocial Factors and Work-Related Musculoskeletal Disorders

The World Health Organization (WHO) and the NIOSH had noted that the causes of work-related musculoskeletal disorders among computer office workers are multifactorial including psychosocial risk factors [52]; [86]. Industrial-

ized countries nowadays are undergoing a lot of changes in the working system or working organization which leads to increase of job demands among computer office workers and eventually increases the psychological demands among workers [13]; [62]. The increase in mental health problems due to the presence of psychosocial risk factors in the workplace leads to a high number of absenteeism and loss of productivity [62]. Psychosocial risk factors emerge from the poor working organization, lack of effective management as well as lack of coworker supports which may result in negative health outcomes such as depression, stress and WRMDs [61]. Some examples of psychosocial risk factors present in the working environment of computer users include high psychological job demand, lack of decision latitude, job insecurity and lack of support from the management as well as from working colleagues [11]; [32];[62]. Psychological demand is defined as a perception of an individual on their work intensity with which he or she was required to perform a task in the middle of the existing conflicts in the working environment [55]. Besides, decision latitude is the capacity of the individual to make a decision and develop skills according to the requirement of the authorities [55].

Furthermore, few theories of stress had been linked to the development of the potential links between job stress and work-related musculoskeletal disorders. According to the Karasek Demand-Control theory, the combination of high psychological demand and low decision latitude may lead to different type of job strains such as cardiovascular diseases, mental disorders and musculoskeletal disorders [41]. Next, Smith & Sainfort (1989) had developed a job stress model based on the stress and balance theory [86]. The model explained that any individual who is exposed to prolonged physical, individual and psychosocial risk factors might increase the stress reactions which will eventually lead to the development of the WRMDs [86].

Individual Factors and Work-Related Musculoskeletal Disorders

Individual risk factors such as age, gender, and previous illness history are proven to be some of the risk factors for the development of WRMDs among computer office workers [10]; [63]; [78]. A study on determining the risk factors on the development of work-related complaints of neck, shoulder, and arm in computer office workers had identified that female workers were prone to get musculoskeletal disorders to compare to male workers [10]. Similarly, Maakip et al. (2017) reported the prevalence rate of WRMDs among Malaysian female computer workers (93.4%) were higher compared to male computer workers. Also (Armstrong & Chaffin, 1978) found that the anatomical differences between male and female, regarding bone circumference, size of the bone and joint flexibility increases the risk of getting carpal tunnel syndrome [87]. In almost all scientific research studies of WRMDs, increase in the age was found to be associated with the occurrence of musculoskeletal disorders. In the study by Poochada & Chaiklieng (2015), the most commonly affected workers were in between 41-50 age [59]. Furthermore, Ustinaviciene et al. (2013) found the risk of neck pain increased with age among computer office workers [78]. Similarly, another experimental study identified the age factors influence the motor performance of mouse clicking task among computer users [88].

A review by Ranasinghe et al. (2011b) on the complaint of arm, neck, and shoulder (CANS) among computer office workers reported that the previous history illness was also considered as a potential risk factor for CANS [10]. This report corresponds with findings from Eltayeb et al. (2007) which can differ in severity from mild, periodic symptoms to severe, chronic and debilitating conditions. They are thought to be associated with both physical and psychosocial risk factors. The measurement and identification of the various risk factors for these complaints is an important step towards recognizing (a who found in a longitudinal study that the strongest predictor of incident neck/shoulder pain was the previous history of illness [5]. Although, several other factors such as BMI, education level, physical fitness, anthropometric, experience level, work habits, smoking history, and sleeping quality were found to have a link in WRMDs, very limited studies have been conducted to look into the association between these factors and musculoskeletal symptoms among computer users. Hence, more research integrating the following pre mentioned risk factors need to be conducted to identify the exact cause and effect of musculoskeletal symptoms among computer office workers.

Theoretical Model

A theoretical framework of musculoskeletal symptoms among computer office workers is presented in figure 1. The framework shows that computer office workers have a direct path to work-related factors and non-work related factors. The work-related factors consist of psychosocial risk factors and physical risk factors which includes environmental, job task, and tool/equipment. Meanwhile, the non-work related factors consist of individual risk factors such as gender, age, previous illness history, BMI, education level, smoking /alcohol history, physical fitness level, etc.

3.1 Physical Risk Factors

The direct path from physical factors to job task and the tools/equipment suggest that job task factors such as; the number of working days, working hours, duration of computer use, the type of task, type of position assumed, the number of breaks and different type of computer equipment and tools will increase in the awkward posture, work pace, repetitiveness, and force. The increases in some working days/ hours and duration of computer use cause prolonged in sitting posture, which increases the muscular load and muscle activity around the facet joint which leads to the joint compression which in turn influences the musculoskeletal symptoms [44]; [46]. The same mechanism applies to a different type of position assumed during computer use. The sitting posture causes changes in the intervertebral disc and ligament joints due to excessive flexion

in lumbar and neck region [89].

The extreme flexion position increases the muscle loads and muscle activity, which leads to the compression of anterior and nucleous polpusus and eventually causes musculoskeletal disorders [35]. Next, a decrease in the number of breaks among computer users leads to an increase in muscle fatigue due to an increase in muscle activity and muscle load [63]. The increase in breaks schedules during working hours was also proven to decrease musculoskeletal discomfort among workers [71]. Also, the increase in muscle activity and muscle load may also be aggravated by the use of different type of computer appliances and equipment such as a mouse, keyboard, the position of the monitor, document holder, the design of chair and desk, and workstation design. For example, frequent clicking of mouse and typing of keyboards due to different types of tasks which over time may increase the force and repetition which eventually will increase the muscle activity and muscle load [75].

Moreover, an increase in work pace indicates a strong indication of muscle fatigue due to an increase in muscle activity in the EMG signal [28]; [63]. Also, there is also an indirect path from physical factors to environmental factors such as lighting, temperature, noise and air condition. For instance, poor lighting inside the workstation may cause visual discomfort, in which the body will try to adopt a posture, especially in the neck and shoulder region to improve the vision [31]. This causes an increase in muscle activity and muscle load around the neck and shoulder region[31]. A cold working environment is found to accelerate muscle fatigue and cause higher muscle activity to compare to the warmer working environment [28]. Besides that, the framework also concluded that other environmental factors such as noise and air circulation indirectly increase muscle activity by elevating the mental stress level. The detailed mechanism between muscle activity and mental stress will be explained in the next section of mental stress.

Individual Risk Factors

The current framework hypothesized that any imbalance between work-related factors and individual factors (non-work-related factors) could increase in muscle activity and muscle load. Example, women tends to get musculoskeletal discomfort compared to the men [6]. This may be because generally women are having smaller body stature and weaker muscles compared to the men [6]. Therefore, women might work with higher muscle load and muscle activity when they perform the same job tasks as men, example larger range of motion might be used by women to perform any tasks related to mouse [6]. Next, older computer users apply a higher grip force while performing different tasks due to a loss in capacity in performing fine movements [33]. This increases the muscle activity in EMG due increase in the physical demands [33]. The link between other individual factors and musculoskeletal symptoms as per shown in the frameworks need to be studied in more detail for better understanding of the mechanism of musculoskeletal disorders.

Mental Stress

The framework also shows an indirect path from psychosocial risk factors to mental stress, which might influence the occurrence of musculoskeletal disorders. Studies had identified that the risk of getting musculoskeletal symptoms are higher when workers are exposed to psychosocial risk factors. For example, an experimental study using EMG had identified an increase in trapezius muscle activity in the neck and shoulder region when the workers were exposed to psychosocial risk factors such as time pressure [13]. In another experimental study, Szeto et al., (2005b) had identified that a typing task that requires high speed and relative accuracy create a high demand on a motor control system which causes additional mental stress to the workers [75]. Furthermore, past research had already identified that psychosocial stress could increase the biomechanical loading in joint and increase the muscle activities among workers [29]. Next, although the exact mechanism between the musculoskeletal disorders and environmental factors are not known, perhaps few studies had discussed that increased in the noise level (occupational stressor) might increase the mental stress and eventually increased the muscle tension [12]; [54]. The increase in the noise level also causes post-stressor deficits in task performance and task motivation. Another mechanism that might link the environmental factors and mental stress to musculoskeletal disorders is postural invariance [27]. The increase in mental stress due to noise leads to lack of postural adjustment in workstation furniture (chair, table, etc.) due to narrowing of attention to dominant stimuli (noise) [27]. The lack of postural adjustment might increase the muscle strain among computer office workers [27]. Despite the fact, few studies had included environmental factors such as air quality into looking occurrence of musculoskeletal disorders, yet none of the studies had discussed the exact mechanism between environmental factors and musculoskeletal disorders [54]; [62]. Hence, more research studies need to be conducted in the future to look into the possible association between environmental factors in the development of musculoskeletal disorders.

The new suggested framework hypothesized that increase in the muscle load or muscle activity to be early signs of musculoskeletal symptoms, which also has been observed in numerous research studies among computer office workers [6]; [46]; [63]. Also, an increase in mental stress also increases the muscle load, and muscle activity and this association have also been supported by past research findings [13] ; [62]. Finally, the framework also hypothesized that the rise of musculoskeletal disorders leads to a decrease in the organization productivity. This has been supported in various past studies in musculoskeletal disorders [29]; [54]. For instance, in the USA, it has been estimated that almost 12 % of the computer workers indicate a reduction of productivity in term of medical expenses and absenteeism due to WMSDS which cost almost 45-54 billion dollars annually [64].

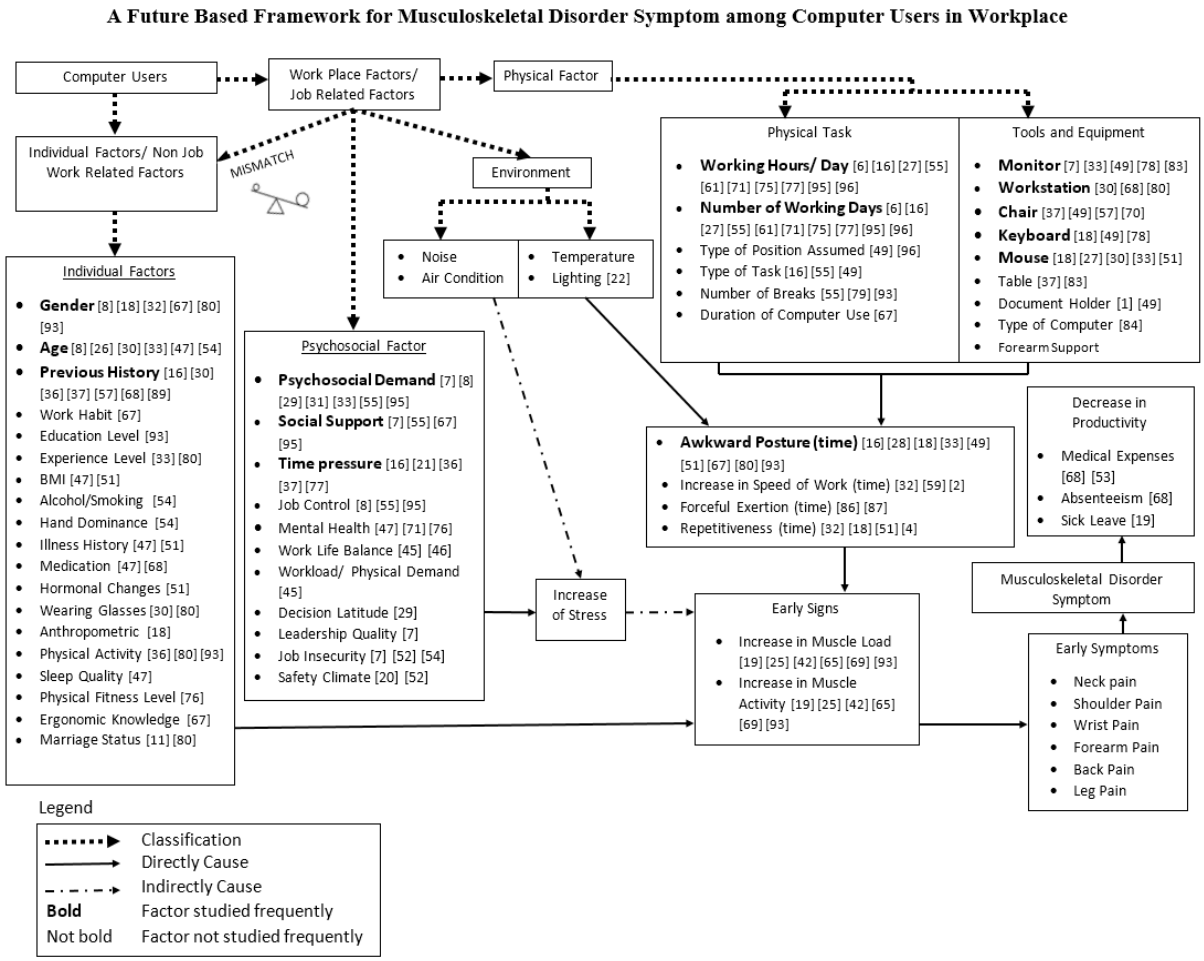

Figure 1: A Future Based Framework for Musculoskeletal Disorder Symptom among Computer Users in the Workplace

CONCLUSION

The proposed framework can be used by practitioners to design effective intervention strategies for preventing WRMDs among office workers. For instance, any intervention strategies to prevent WRMDs among computer office workers must consist of ergonomic training, counseling session (to identify the psychosocial risk factors) and individual training focusing on healthy lifestyle behaviors. Also, the suggested framework can also be used as a fundamental knowledge in developing an expert system or knowledge-based system for the identification of musculoskeletal symptoms among computer office workers.

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