



**INVESTIGATING THE EFFECT OF COMPUTER  
WORKSTATION SETUPS ON MUSCULOSKELETAL  
SYMPTOMS, OXYGEN SATURATION, AND  
PERCEIVED FATIGUE**



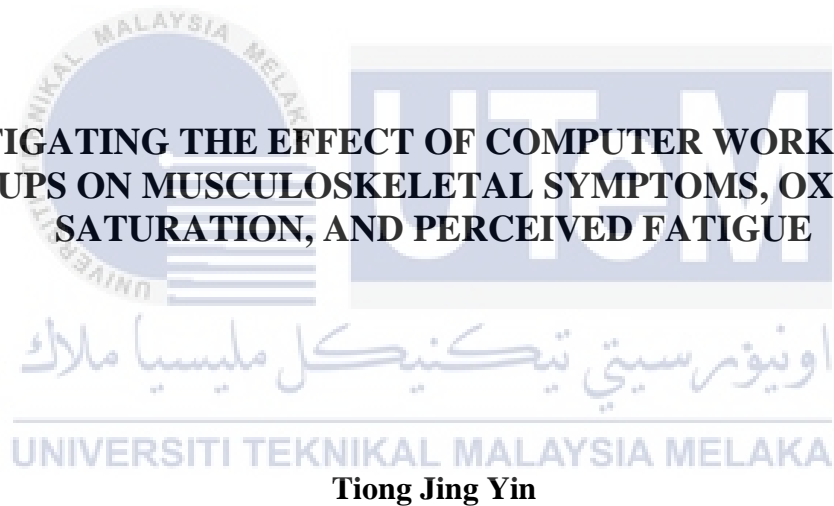
**MASTER OF SCIENCE IN  
MANUFACTURING ENGINEERING**

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**Faculty of Manufacturing Engineering**

**INVESTIGATING THE EFFECT OF COMPUTER WORKSTATION  
SETUPS ON MUSCULOSKELETAL SYMPTOMS, OXYGEN  
SATURATION, AND PERCEIVED FATIGUE**



**Tiong Jing Yin**

**Master of Science in Manufacturing Engineering**

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PERCEIVED FATIGUE**

**TIONG JING YIN**



**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2023**

## DECLARATION

I declare that this thesis entitled “Investigating the Effect of Computer Workstation Setups on Musculoskeletal Symptoms, Oxygen Saturation, and Perceived Fatigue” **is the result of my own research except as cited in the references.** The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



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## APPROVAL

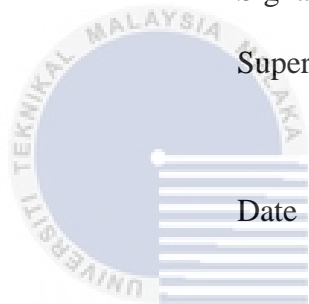
I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

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Date : 6/8/22 .....



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## DEDICATION

Special dedication to my beloved parents and siblings  
for giving me support, encouragement and guidance throughout this education journey.

Thank You So Much



## ABSTRACT

Symptoms of musculoskeletal disorders are common among office workers worldwide. Several studies have documented self-reported data on musculoskeletal disorder symptoms among office workers, though there are limited published studies focusing on summarisation of assessment results by ergonomics practitioners. In addition, the relationship between the effect of upper limbs posture and office workstation set-ups to muscle oxygen saturation among office workers is unclear. The main objective of this study is to compare the percentage of muscle oxygen saturation and perceived fatigue ratings between four different experimental conditions among representative computer users. The prevalence rates of musculoskeletal disorder symptoms, ergonomics risk factor exposure patterns, and root causes of these exposures among office workers in Malaysia was investigated. The study also aimed to compile lists of common recommendations by ergonomists to control the exposures. The methodology was segregated into two phases to achieve each objective. Phase 1 includes a review of 399 ergonomics assessment reports which obtained from consulting ergonomic company. In phase 2, a repeated measure experiment was conducted among 15 subjects with four experimental conditions through the use of Moxy Muscle Oxygen Monitor device and perceived fatigue rating scale. The findings from phase 1 showed high MSD symptoms prevalence of varying degrees (87%) among sample population. Body parts that were mostly affected among sample population include shoulder (42%), lower back (38%) and neck (32%). Common ergonomics risk factors among office workers include poor postures (97%), static loading (90%), and contact stress (74%), in which the root causes of these risk factors can be traced back to substandard furniture designs as well as poor work habits. Most common recommendations by ergonomists were related to proper adjustments of chair and monitor, as well as improvement of sitting postures and technique of using mouse. Data analysis from phase 2 showed statistically significant trends ( $P \leq 0.05$ ) of muscle oxygen saturation level in different workstation setups. In addition, the findings revealed that the perceived fatigue ratings on shoulder, upper arm and lower arm are lowest ( $P \leq 0.05$ ) in workstation condition where subject can adopt neutral postures. In conclusion, this study provides insight on patterns and root causes of exposure to ergonomics risk factors among Malaysian office workers from ergonomists point of view. Besides, the findings also provide guidance for organization, management and office workers focus on improving their office workstation setups, especially for workers who are spending most of the working time on the computer.

# **KAJIAN MENGENAI KESAN SUSUN ATUR STESEN KERJA KOMPUTER TERHADAP SIMPTOM MUSKULOSKELETAL, KETEPUAN OKSIGEN DAN TANGGAPAN KELESUAN**

## **ABSTRAK**

*Penyakit muskuloskeletal adalah penyakit pekerjaan yang biasa di kalangan pekerja pejabat di seluruh dunia. Walaupun kajian telah dijalankan mengenai simptom penyakit ini di kalangan pekerja pejabat, namun kajian yang diterbitkan adalah terhad kepada laporan sendiri dan tidak memfokuskan pada penilaian oleh pengamal ergonomik. Hubungan antara kesan postur bahagian anggota badan-atas dan susun atur stesen kerja pejabat keatas tahap ketepuan oksigen otot di kalangan pekerja pejabat juga masih tidak jelas. Objektif utama kajian adalah untuk mengkaji perbezaan tahap ketepuan oksigen otot dan tanggapan kelesuan di antara empat jenis susun atur stesen kerja pejabat menerusi eksperimen. Kelaziman simptom penyakit muskuloskeletal, corak pendedahan faktor risiko ergonomik dan punca pendedahan di kalangan pekerja pejabat di Malaysia telah diselidik. Kajian juga mengumpulkan senarai cadangan oleh pengamal ergonomik untuk mengawal pendedahan tersebut. Metodologi kajian dipisahkan kepada dua fasa, setiap satunya untuk mencapai setiap objektif. Fasa 1 adalah kajian terhadap 399 laporan penilaian ergonomik yang diperoleh daripada pengamal ergonomik menerusi sebuah syarikat perundingan ergonomik. Pada fasa 2, eksperimen 'pengukuran-ulang' dijalankan di antara 15 subjek, dimana 4 susun atur stesen kerja diuji menggunakan peranti 'Moxxy Muscle Oxygen Monitor' dan skala penilaian kelesuan. Hasil kajian dari fasa 1 menunjukkan peratusan tinggi (87%) terhadap kelaziman simptom penyakit muskuloskeletal di kalangan populasi kajian. Bahagian badan terjejas termasuk bahu (42%), bawah belakang (38%) dan leher (32%). Faktor risiko ergonomik yang lazim di kalangan pekerja pejabat termasuk postur badan yang buruk (97%), postur statik (90%), dan tekanan setempat (74%). Punca risiko adalah rekabentuk perabot yang kurang ergonomik dan tabiat kerja yang buruk di tempat kerja. Penyesuaian kerusi dan monitor, serta cara duduk dan penggunaan tetikus yang betul adalah diantara cadangan pengawalan disarankan oleh pengamal ergonomik. Analisis data dari fasa 2 menunjukkan corak yang signifikan secara statistik ( $P \leq 0.05$ ) didalam tahap ketepuan oksigen otot antara empat susun atur stesen kerja komputer. Hasil kajian juga menunjukkan bahawa skala kelesuan yang dirasakan oleh subjek pada bahu, lengan atas dan lengan bawah adalah paling rendah ( $P \leq 0.05$ ) apabila bekerja didalam keadaan postur badan yang neutral. Kajian ini memberikan gambaran mengenai corak dan punca pendedahan faktor risiko ergonomik di kalangan pekerja pejabat dari sudut pandang pengamal ergonomik. Selain itu, kajian ini juga memberikan panduan kepada organisasi, pihak pengurusan dan pekerja pejabat untuk menambahbaik tempat kerja di pejabat.*

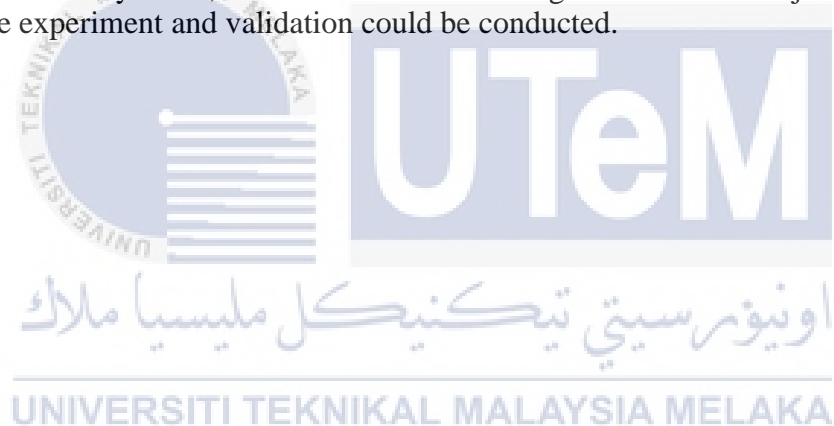


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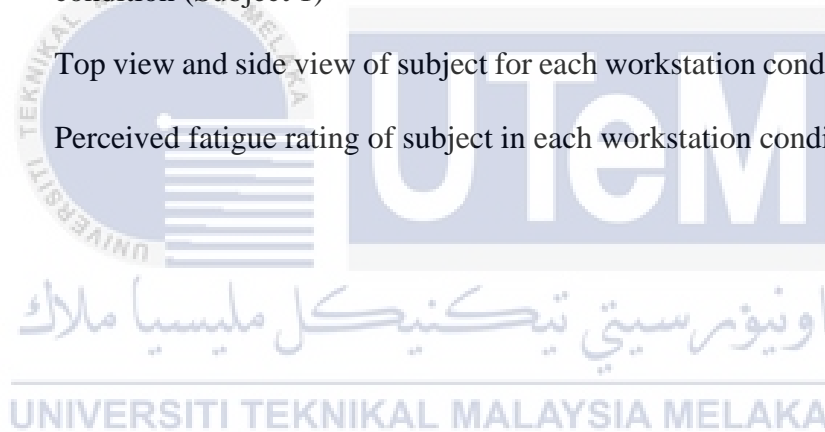


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## LIST OF ABBREVIATIONS

ANOVA	–	Analysis of Variance
CCOHS	–	Canadian Centre for Occupational Health and Safety
CHQ	–	Chinese Health Questionnaire
DOSH	–	Department of Occupational Safety and Health
DOSM	–	Department of Statistic Malaysia
EHS	–	Environmental Health and Safety
EMG	–	Electromyographic
FDM	–	Fuzzy Delphi Method
HSE	–	Health and Safety Executive
MSDs	–	Musculoskeletal Disorders
MUEQ	–	Maastricht Upper Extremity Questionnaire
NIOSH	–	National Institute for Occupational Safety and Health
NIRS	–	Near Infrared Spectroscopy Device
OSHA	–	Occupational Safety and Health Administration
ROSA	–	Rapid Office Strain Assessment
RULA	–	Rapid Upper Limb Assessment
SMEG	–	Surface Electromyography
SOCSSO	–	Social Security Organisation
UiTMP	–	University Technology of MARA
UTM	–	Universiti Teknologi Malaysia

VAS	–	Visual Analog Scale
VDT	–	Video Display Terminal
WRMSDs	–	Work-related Musculoskeletal Disorders



## LIST OF SYMBOLS

$SmO_2$  – Muscle Oxygen Saturation



# CHAPTER 1

## INTRODUCTION

### 1.1 Background of study

Musculoskeletal disorders (MSDs) are common occupational health problems in the workplace worldwide (Luan et al., 2018). MSDs are defined as damage or disease of the muscles, tendons, joints, cartilage, veins and bones (Wang et al., 2015; Centers for Disease Control and Prevention, 2020). Common example of MSDs reported among workers include carpal tunnel syndrome, de Quervain's disease, tendonitis, slipped disc, and epicondylitis (Smith et al., 2009; Harris et al., 2010; Le Manac'h et al., 2011; Newington et al., 2015; Mukhtar et al., 2018). MSDs are generally categorized into 2: 1) work-related MSDs, and 2) non-work-related MSDs. Work-related Musculoskeletal Disorders (WRMSDs) is defined as disorders resulting from the exposures while completing work duties (Ling, 2020). Till date, the number of work-related musculoskeletal disorders and ergonomics compensation cases in Malaysia has been rising steadily. The number of reported MSDs cases is seen to be on the sharp rise in Malaysia from 10 cases in year 2005 to 1354 cases in the year 2017 as shown in Figure 1.1 (Social Security Organisation (SOCSO), 2018). This represents 100-fold increase in reported work-related MSDs cases in 13 years from 2005 to 2017. These statistics shown that ergonomic hazards in workplaces must be seriously addressed and relevant parties should take prompt actions to reduce work-related MSDs from continuing increasing in Malaysia.

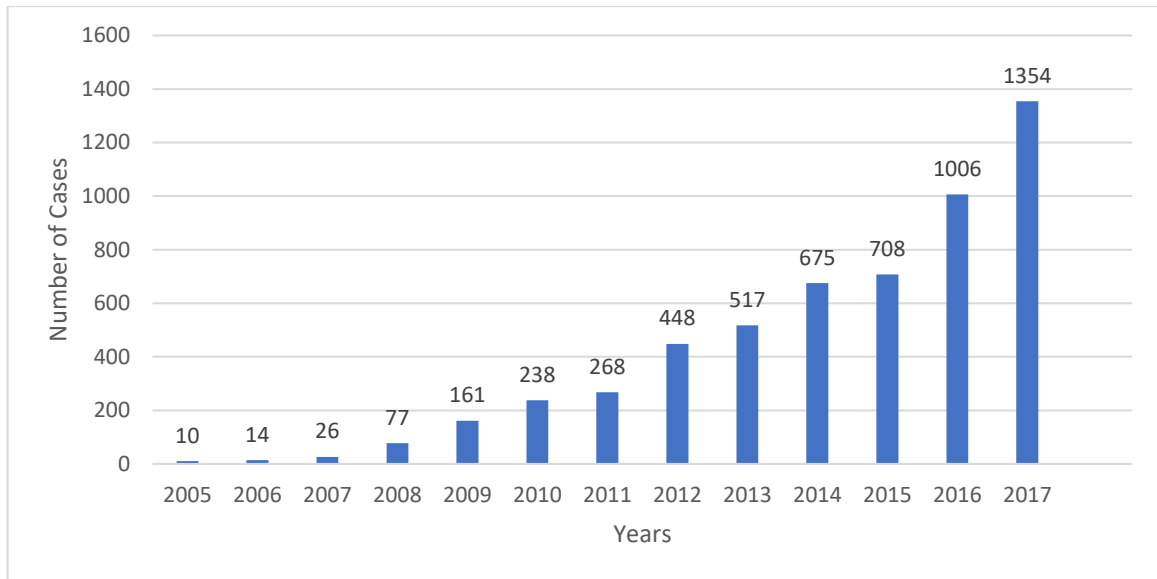


Figure 1.1: Number of reported MSDs cases in Malaysia from year 2005-2017 (Adapted from SOCSO, 2018).

The causes of work-related MSDs are usually multifactorial including physical factor and psychosocial factor (European Agency for Safety and Health at Work, 2010). Examples of physical causes include workload, sustained repetitive activity, duration of working without a break, design of office work and computer workstation design. Work-related MSDs mostly affect workplace sectors that involves direct human interactions such as individual workstations setups (Occupational Health and Safety, 2020). This includes office since work exposure in office settings also involves interactions between computer, monitor, chairs, work surface, input devices such as keyboard and mouse.

Computer are the popular corporate device across industries (Stamford, 2016). The introduction of computers into workplace can aid productivity in some ways, but they also brought negative issue on health problems including the incidence of work-related MSDs (Oha et al., 2014; Khan et al., 2017; Borhany et al., 2018). There were extensive evidences that MSDs symptoms are common among the general population of office workers in different countries including Malaysia, New Zealand, and Netherlands (Harcombe et al., 2010; Campos-Fumero et al., 2016; Maakip et al., 2016; Maakip et al., 2017). The increase

in the number of workers working with computer in the workplace is corresponding with the increase of work-related musculoskeletal disorders among office workers (Korhan and Onsorodi, 2011). In office settings, ergonomic risks are influenced by workplace factors such as inappropriate workstation setups which increased the occurrence of WRMSDs symptoms. (Matos and Arezes, 2015). Ardahan and Simsek (2016) in a cross-sectional study indicated that cumulative years of computer work, long-term daily use of computers and prolonged sitting are associated with the development of MSDs. Office workers involves sedentary duties that requires sitting for prolonged period of time are linked to risk of developing MSDs in working conditions. Pandey et al. (2020) in a cross-sectional observational study among 1193 office workers found large portion of office workers (72%) spend more than 8 hours per day on computer with less than 30 minutes break duration. Job tasks of office workers include data processing, emailing, filing documents, typing correspondence and reports which mainly using computer mouse and keyboard typing. The job task of office workers may be associated with prolonged static postures, improper hand positioning, improper lower arm support and sustained non-neutral postures during work. These constant activities for long period may restrict the blood circulation on the body parts and supply oxygen to the muscles are also reduced. In this respect, there is less demand on the circulatory system due to the limited mobility during sitting (Canadian Centre for Occupational Health and Safety (CCOHS), 2016). As a result, the heart may not be able to pump sufficient blood quickly to deliver oxygen to muscles for proper oxygenation, which may lead to increase the rate of muscle fatigue and tissue damage (Hepple, 2002; Amann and Calbet, 2008). Inadequate recovery time can leave insufficient time for tissue repair and MSDs symptoms start to emerge (U.S Department of Labor Occupational Safety and Health Administration, 2000). The symptoms of pain, body ache and fatigue over time making workers more vulnerable to developing MSDs (Yazuli et al., 2019).