UNIVERSITI PUTRA MALAYSIA

EFFECT OF BREAK-TIME ON THE UPPER EXTREMITY MUSCULOSKELETAL DISORDER DEVELOPMENT AND TASK PERFORMANCE OF COMPUTER USERS

THULASI MANOHARAN

FK 2018 53

EFFECT OF BREAK-TIME ON THE UPPER EXTREMITY MUSCULOSKELETAL DISORDER DEVELOPMENT AND TASK PERFORMANCE OF COMPUTER USERS

By

THULASI A/P MANOHARAN

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

November 2017

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

EFFECT OF BREAK-TIME ON THE UPPER EXTREMITY MUSCULOSKELETAL DISORDER DEVELOPMENT AND TASK PERFORMANCE OF COMPUTER USERS

By

THULASI A/P MANOHARAN

November 2017

Chairman : Rosnah bt Mohd Yusuff, PhD
Faculty : Engineering

Work Related Occupational Musculoskeletal Disorder (WRMSD) developed due to excessive, repetitive and forceful motions of certain parts of the body. Musculoskeletal Disorder (MSD) problems begins initially with a minor discomfort and if no action was taken to overcome this problem it can develop to major injuries and deformation. According to a report from NIOSH Malaysia, there has been an increase in the occurrence of MSDs, especially in work that require continuous computer usage. Office workers who use computer intensively for instance more than 3 hours continuously without sufficient rest break tends to develop MSD problems. Previous studies shown than rest break can allow workers to relax muscles and reduces the possibility of developing physical and mental discomfort. However studies on an effective break time that can improve performance and reduce muscle work load on the upper extremity muscles among office workers in Malaysia are still lacking. A preliminary study was conducted to determine relationship between break time and other risk factors to the development of MSD. The effect of work rest schedule on the muscular load levels, performance and discomfort rate on the upper extremity muscles among computer users was studied. Hundred twenty questionnaires survey which was designed based on the Nordic Questionnaire and Body Discomfort Chart (BDC) were distributed to office workers in a company. The questionnaires were analyzed to determine various risk factors such as individual, physical and job characteristics that contribute to the development of MSD. Bivariate analysis using SPSS software showed that age have a significant positive correlation with discomfort that was 0.308 at (p=0.01); frequency of work rest showed higher negative correlation whilst working hour showed positive correlation to the presence of MSD discomfort. These findings suggests that more work rest with less persistent working hour can reduce the development of MSD problems. The effect of break time on performance was

conducted using three different work rest schedules. Three thirty minutes of typing tasks was given to 15 respondents where one with no break, second with 1 min break and third with 30 seconds' break. The muscle load, performance and discomfort level were measured. The result showed that 30 seconds micro-break at every 10 minutes interval reduces muscle load where EMG recorded lowest mean average- EMG (AEMG) which was 0.0350 ± 0.012 (mV) for flexor carpi ulnaris and radialis muscles and typing performance improved by 13.5% compared to 1 minute break and 20.14% compared to schedule with no breaks. At the end of the experiment, 71% of respondents recorded minimal discomfort for 30 seconds micro-break. As a conclusion 30 seconds micro-break is effective for office workers to practice during their continuous typing activity as it can reduce muscle load and improve their performance by reducing muscle discomfort on the upper extremity muscle. The limitation of this study was that computer users from different working background was not covered. In future work, the scope of study can be focused on the people who spend greater amount of time in computer gaming.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN WAKTU REHAT DALAM PEMBANGUNAN GANGGUAN MUSKULOSKELETAL DAN PRESTASI TUGAS PENGGUNA KOMPUTER

Oleh

THULASI A/P MANOHARAN

November 2017

Pengerusi : Rosnah bt Mohd Yusuff, PhD
Fakulti : Kejuruteraan

Kerja yang berlebihan dan berulang boleh melesukan bahagian-bahagian badan yang tertentu yang dikenali sebagai gangguan rangka otot (Musculoskeletal Disorder/MSD). Pada awalnya MSD bermula dengan ketidakselesaan kecil dan jika tiada tindakan diambil untuk mengatasi masalah ini, gangguan ini boleh menyebabkan kecederaan utama dan ubah rupa bentuk anggota badan. Menurut laporan dari (NIOSH) Malaysia, terdapat peningkatan dalam masalah MSD, terutamanya dalam kerja yang memerlukan penggunaan komputer yang berterusan. Pekerja pejabat yang menggunakan komputer secara intensif misalnya lebih daripada 3 jam secara berterusan tanpa rehat yang mencukupi, boleh terdedah kepada MSD. Kajian terdahulu menunjukkan rehat yang mencukupi membolehkan pekerja untuk melonggarkan otot dan mengurangkan kemungkinan mengalami ketidakselesaan fizikal dan mental. Walaubagaimanapun, kajian mengenai masa rehat yang berkesan yang boleh meningkatkan prestasi dan mengurangkan beban kerja pada otot hujung atas di kalangan pekerja pejabat di Malaysia masih kurang. Oleh itu, kajian awal dijalankan untuk menentukan hubungan antara masa rehat dan faktor risiko lain kepada perkembangan MSD. Kesan jadual istirahat kerja pada tahap beban otot, prestasi dan kadar ketidakselesaan pada otot hujung atas dalam kalangan pengguna komputer telah dikaji. Kajian sebanyak seratus dua puluh soal selidik yang dibuat berdasarkan soal selidik Nordic dan Carta Gangguan Otot (Body Discomfort Chart) telah diedarkan kepada pekerja-pekerja pejabat di sebuah syarikat. Analisis bivariat menggunakan perisian SPSS menunjukkan usia mempunyai hubungan positif yang signifikan dengan ketidakselesaan iaitu 0.308 pada ($p = 0.01$); kekerapan masa rehat menunjukkan korelasi negatif yang lebih tinggi manakala jam kerja menunjukkan hubungan positif dengan masalah MSD. Penemuan ini menunjukkan bahawa lebih banyak kerja berehat dengan jam kerja yang kurang dapat mengurangkan perkembangan masalah MSD. Kesan masa rehat terhadap prestasi dijalankan menggunakan tiga jadual rehat

yang berbeza. Tiga puluh minit tugasan menaip diberikan kepada 15 responden dengan 3 jenis jadual rehat yang berbeza. Jadual pertama tanpa masa rehat; jadual kedua dengan 1 minit rehat dan ketiga dengan 30 saat rehat. Kadar beban otot, prestasi dan ketidakselesaan diukur. Hasilnya menunjukkan bahawa 30 saat rehat pada setiap 10 minit jarak waktu mengurangkan beban otot di mana EMG mencatatkan minimal purata EMG (AEMG) iaitu 0.0350 ± 0.012 (mV) untuk otot flexor carpi ulnaris dan otot radialis. Prestasi menaip juga menaik sebanyak 13.5% berbanding dengan 1 minit rehat dan 20.14% berbanding dengan jadual tanpa rehat. Pada akhir eksperimen, 71% responden mencatatkan ketidakselesaan yang minimum untuk jadual waktu dengan 30 saat rehat. Sebagai kesimpulan, micro-rehat sebanyak 30 saat berkesan untuk pekerja pejabat untuk berlatih semasa aktiviti menaip yang berterusan kerana mereka dapat mengurangkan beban otot dan meningkatkan prestasi dengan mengurangkan ketidakselesaan pada rangka-otot hujung atas. Batasan kajian ini adalah bahawa pengguna komputer dari latar belakang kerja yang berbeza tidak dipelajari. Pada masa akan datang, skop pengajaran dapat difokuskan kepada orang-orang yang menggunakan lebih banyak masa dalam permainan komputer.

ACKNOWLEDGEMENTS

First and most of all, I would like express my sincere gratitude to my supervisor, Prof. Dr. Rosnah bt Mohd Yusuff for her expertise, guidance and assistance throughout the process of writing this thesis. I thank you so much for the knowledge you have passed on and I am grateful for having the opportunity to study under you. Without your help and guidance, this thesis would not have been possible. I would like to thank my supervisory committee members Associate Prof Dr. Norzima Zulkifli and Dr. Enoch Kumar Perimal for their support suggestions and encouragement. Dr. Enoch`s guidance and his supervision in conducting experimental design with electromyography (EMG) has been essential in this research.

I also thank the Universiti Putra Malaysia for providing the required facilities and equipment which helped me a lot to carry out my data collection and analysis. In addition, I also thank to the company for granting me permission to conduct questionnaire survey among their office workers. Last but not least, I also take this opportunity to dedicate my gratitude to my family and friends for their support and motivation for not letting me give up and helps me to survive all the stress throughout this master journey. I also owe a great debt of gratitude to my senior Mr. Azizul for sharing his experience and guiding me throughout my master.

I certify that a Thesis Examination Committee has met on 27 November 2017 to conduct the final examination of Thulasi a/p Manoharan on her thesis entitled "Effect of Break-Time on the Upper Extremity Musculoskeletal Disorder Development and Task Performance of Computer Users" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Nuraini binti Abdul Aziz, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Siti Anom binti Ahmad, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Siti Zawiah Md Dawal, PhD
Senior Lecturer
University of Malaya
Malaysia
(External Examiner)

NOR AINI AB. SHUKOR, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 27 February 2018

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Rosnah bt Mohd Yusuff, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Norzima bt Zulkifli, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Enoch Kumar Perimal, PhD
Senior Lecturer
Faculty of Medicine and Health Science
Universiti Putra Malaysia
(Member)

ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: Thulasi a/p Manoharan, GS43769

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Professor Dr. Rosnah bt Mohd Yusuff

Signature: _____
Name of Member of Supervisory Committee: Associate Professor Dr. Norzima bt Zulkifli

Signature: _____
Name of Member of Supervisory Committee: Dr. Enoch Kumar Perimal

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CTD	Cumulative trauma disorder
MSD	musculoskeletal disorder
WRMSD	work related musculoskeletal disorder
EMG	electromyogram
MUAP	motor unit action potential
LBP	low back pain
MVC	maximum voluntary contraction
CTS	cumulative trauma disorder
ANOVA	analysis of variance
BDC	body discomfort chart
RSI	repetitive strain injuries
ERF	ergonomic risk factor
BMI	body mass index
OD	odds ratio
VDU	video terminal unit
CES	Cervical erector spinae
UT	upper trapezius
SPSS	statistical package service and solution
WPM	word per minute
NIOSH	National Institute of Occupational Safety and Health

CHAPTER 1

INTRODUCTION

Cumulative Trauma Disorder which is an umbrella term used for musculoskeletal disorder (MSD) or repetitive strain injuries that effect workers performance due to muscle fatigue which lead to permanent injury or disability on certain body parts. MSD symptoms are referred to pain in one or more regions of the body. Minor injuries that accumulates from repeated long-term work-related load were known as the main cause of MSD problems. Many occupations today require workers to use computer to complete their daily office task due to the advancement of technology. The amount of time spent using computers today has also increased significantly compared to the year it was first introduced (Aziz et al., 2015). Studies that show the effect of computer use on musculoskeletal disorder indicate that many video display terminal (VDT) operators spend as much as 75% of their work time at a computer work (Haynes, 2009).

According to a report from the National Institute of Occupational Safety and Health (NIOSH), Malaysia, numerous office workers were severely affected by musculoskeletal symptoms since 61.4% of the workforce in Malaysia were highly dependent on computers (Zein et al., 2015). Serina & Rempel, (2015), indicated that prevalence of upper limb symptoms among Malaysian office workers were associated with computer use by 34%. Many of the intensive computer work required more than 3 hours of continued computer work routinely without a sufficient break (Haynes, 2009).

WMSDs are a painful disorders which affects many body parts such as muscles, tendons, and nerves which can significantly reduce the performance of computer users. Symptoms that frequently develops due to musculoskeletal disorders includes pain, numbness and tingling sensation during computer use. These symptoms were caused by “inflammation of the muscle-tendon unit, neural compression and vascular alteration”. The frequency of MSD symptoms varies with the consistency and level of force implied by computer users and for severe cases, the symptoms will be continuous. (Donoghue & Walsh, 2013) and (Onyebeke et al., 2014) stated that risk of MSD such as cumulative trauma disorders (CTD) are due to several aspects of computer usage such as fingertip loading, mouse usage and wrist posture. Danuta (2013) has investigated the relationship between musculoskeletal load in terms of posture, force and time sequence that leads to the development of MSD problems. A suitable work load can minimize the risk of developing MSD problems (Roman-Liu, 2014).

Other factors that result to the escalation of MSD problems due to prolonged usage of computer among office workers include individual factors (age, gender

and BMI), physical factors (keyboard condition, postures and keyboard angle) and job characteristics (working hour, work rest and work flexibility). Periodic rest break has been identified as one of the way to reduce the prevalence of MSD problems among office workers. However many workers fear to take frequent breaks throughout the working day as it will affect their performance level and cause bad perception from the managers. According to Hongjai (2016) microbreaks can even be practiced using smartphones throughout the day that can help office workers to feel relax and can also improve their work performance (Rhee & Kim, 2016). Frequent rest breaks are practical and easy to be followed since it does not make extensive and costly changes in the workplace. Workers productivity and well-being can be enhanced by applying short and frequent breaks from continuous computer-mediated work.

1.1 Problem Statement

Musculoskeletal disorders (MSD) has become a major occupational problem all over the world by affecting general well-being of working adults. Despite many years of ergonomic study, work related MSDs is the most expensive category of occupational health problem that still remains as a major problems for individuals, companies and societies. There has been many studies investigated various risk factors which contribute to the development of MSD among office workers and take action to prevent them. One of the risk factors which were usually not given higher priority by intensive office workers was interval break time. Intensive office workers are those who spend more than 4 hours a day and 5 days a week to complete their work (Zakerian & Subramaniam, 2015).

Most of the office workers in Malaysia use computers intensively where they work for more than four hours daily with insufficient interval breaks. They usually do not give high priority in practicing work rest as they are fearful that taking frequent microbreaks during heavy continuous typing work will affect their performance and can cause bad perception from their manager. Generally workers have the attitude of practicing rest break once they have diagnosed by cumulative trauma disorder (CTD) such as trigger finger or carpal tunnel syndrome whereas short rest breaks earlier in the workplace can prevent such problems from occurring.

A number of work rest schedules has been experimented previously that have shown some benefits to the office workers. For an example, Roseni et al (2015) studied that, rest interval can alleviate physical and mental discomfort. Gallagher et al (2014) proposed that 3-5 minutes breaks after every hour allow workers to relax muscles and reduce possibility of fatigue. Rhee & Kim, (2016) conducted empirical study to show that taking break with a smart phones are more popular and give better result compared to conventional breaks such as lunch time and tea time.

Although, many studies has been done related to various risk factors and interventions associated with MSD problems, study on the effect of break time on Malaysia office workers` performance is still lacking. Thereby, this study can help to fill the gap by evaluating effect of work rest schedule on the performance, discomfort and muscular load levels of computer users in Malaysia. In addition, a questionnaire survey among intensive office workers in order to determine various risk factors can be used to highlight the significance of work rest break to the development of MSD in Malaysia.

1.2 Significant of Studies

Ergonomic risk factors such as prolonged working hour associated with the development of musculoskeletal disorder among highly repetitive and forceful hand-arm work such as keyboard typing. Continuous typing work without sufficient break will bring tiredness and numbness sensation especially around wrist and forearm part. Hence this study highlight the significance of work rest break and other contributing risk factors to the development of MSD among office workers in Malaysia.

In addition, an appropriate work rest schedule that is practical and easy to follow without affecting work was determined. Computer users require a number of interval breaks throughout the typing activity in order to regain sufficient recovery for the finger muscles and tendons to act optimally. Hence an experimental design was conducted to determine the effect of an appropriate work rest schedules on the discomfort level, performance and muscle activity on 15 respondents.

1.3 Objectives

1. To determine the relationship between break time and other risk factors to the development of CTD among intensive computer users
2. To analyse the effect of break-time on the upper extremity musculoskeletal disorder development and task performance of computer users.

In the end of the study, some recommendations with regards to the appropriate work rest schedules for intensive computer workers are explained.

1.4 Scope

This study focused on the Malaysian office workers from manufacturing companies who use computers for more than four hours daily. Office workers who have high intensity of work and insufficient interval breaks were selected as a sample of study in this research.

Epidemiological studies was conducted on the office workers to evaluate various ergonomic risk factors that contribute to the prevalence of upper extremity problems. Office workers also identified the severity level and frequency of exposure to muscle pain or discomfort on their body parts based on the Body Discomfort Chart.

As an intervention program, work rest schedules were investigated to determine the most effective break time which can help to improve work performance in terms of speed and accuracy and also can help to reduce muscle fatigue and discomfort level.

1.5 Thesis Organization

There are five chapters used to conduct this research. In chapter 2 journals and articles are reviewed to determine the area of research. The topic of the research, problem statement, aim and scope were selected in this research. In the literature review previous literatures, researches, journals, books, websites and studies related to the topics are reviewed. In chapter 3, a set of questionnaire survey were distributed among office workers who work on computers for more than 5 hours daily. The questionnaire was prepared based on the Nordic Questionnaire and Body Discomfort Chart (BDC) to gather information regarding frequency and severity of discomfort felt on various body regions by intense computer workers. The questionnaire also carried questions about demographic data such as age, gender and BMI, physical risk factors and job characteristics.

In chapter 4 the questionnaire was analysed to determine the significant level of various contributing factors including individual, physical and job characteristics to high body discomfort level through correlational studies and one-way ANOVA. The questionnaire was also analysed to determine the severity and frequency of discomfort level and its interference with work.

An experimental design is then set up to determine the optimal work rest schedule which can help to reduce the risk of CTD and improve the work quality in terms of speed and accuracy. Electromyogram (EMG) test was conducted on

the respondents to determine optimal interval break duration based on its Average EMG work performance in terms of speed and typing accuracy and discomfort level. In chapter 5, conclusions and recommendations were written based on the results and achievements of research`s objectives.

REFERENCES

Ahmad, N., Taha, Z., & Eu, P. L. (2006). Energetic requirement , muscle fatigue , and musculoskeletal risk of prolonged standing on female Malaysian operators in the electronic industries : influence of age, *1*(2), 47–58.

Amell, T. K., & Kumar, S. (2000). Cumulative trauma disorders and keyboarding work. *International Journal of Industrial Ergonomics*, *25*(1), 69–78. http://doi.org/10.1016/S0169-8141(98)00099-7

Aziz, R. A., Adeyemi, A. J., Kadir, A. Z. A., Rohani, J. M., & Rani, M. R. A. (2015). Effect of Working Posture on Back Pain Occurrence among Electronic Workers in Malaysia. *Procedia Manufacturing*, *2*(February), 296–300. http://doi.org/10.1016/j.promfg.2015.07.052

Balci, R., & Aghazadeh, F. (2004). Effects of exercise breaks on performance, muscular load, and perceived discomfort in data entry and cognitive tasks. *Computers and Industrial Engineering*, *46*(3), 399–411. http://doi.org/10.1016/j.cie.2004.01.003

Brewer, S., Eerd, D. Van, Amick, B. C., Irvin, E., Daum, K. M., Gerr, F., … Rempel, D. (2006). Workplace interventions to prevent musculoskeletal and visual symptoms and disorders among computer users: A systematic review. *Journal of Occupational Rehabilitation*, *16*(3), 325–358. http://doi.org/10.1007/s10926-006-9031-6

Chen, J. D., Falkmer, T., Parsons, R., Buzzard, J., & Ciccarelli, M. (2014). Impact of experience when using the Rapid Upper Limb Assessment to assess postural risk in children using information and communication technologies. *Applied Ergonomics*, *45*(3), 398–405. http://doi.org/10.1016/j.apergo.2013.05.004

Chiasson, M.-È., Imbeau, D., Aubry, K., & Delisle, A. (2012). Comparing the results of eight methods used to evaluate risk factors associated with musculoskeletal disorders. *International Journal of Industrial Ergonomics*, *42*(5), 478–488. http://doi.org/10.1016/j.ergon.2012.07.003

Cho, C.-Y., Hwang, Y.-S., & Cherng, R.-J. (2012). Musculoskeletal Symptoms and Associated Risk Factors Among Office Workers With High Workload Computer Use. *Journal of Manipulative and Physiological Therapeutics*, *35*(7), 534–540. http://doi.org/10.1016/j.jmpt.2012.07.004

Chowdhury, R. H., Reaz, M. B. I., Ali, M. A. B. M., Bakar, A. A. A., Chellappan, K., & Chang, T. G. (2013). Surface electromyography signal processing and classification techniques. *Sensors (Basel, Switzerland)*, *13*(9), 12431–12466. http://doi.org/10.3390/s130912431

Collins, J. D., & O'Sullivan, L. W. (2015). Musculoskeletal disorder prevalence and psychosocial risk exposures by age and gender in a cohort of office based employees in two academic institutions. *International Journal of Industrial Ergonomics*, *46*, 85–97. http://doi.org/10.1016/j.ergon.2014.12.013

Cook, C. J., & Kothiyal, K. (1998). Influence of mouse position on muscular activity in the neck, shoulder and arm in computer users. *Applied Ergonomics*, *29*(6), 439–443. http://doi.org/10.1016/S0003-6870(98)00008-8

del Pozo-Cruz, B., Gusi, N., Adsuar, J. C., del Pozo-Cruz, J., Parraca, J. A., & Hernandez-Mocholí, M. (2013). Musculoskeletal fitness and health-related quality of life characteristics among sedentary office workers affected by sub-acute, non-specific low back pain: A cross-sectional study. *Physiotherapy (United Kingdom)*, *99*(3), 194–200. http://doi.org/10.1016/j.physio.2012.06.006

Descatha, A., Roquelaure, Y., Chastang, J. F., Evanoff, B., Cyr, D., & Leclerc, A. (2009). Description of Outcomes of Upper-Extremity Musculoskeletal Disorders in Workers Highly Exposed to Repetitive Work. *Journal of Hand Surgery*, *34*(5), 890–895. http://doi.org/10.1016/j.jhsa.2009.02.012

Dianat, I., Kord, M., Yahyazade, P., Karimi, M. A., & Stedmon, A. W. (2015). Association of individual and work-related risk factors with musculoskeletal symptoms among Iranian sewing machine operators. *Applied Ergonomics*, *51*, 180–188. http://doi.org/10.1016/j.apergo.2015.04.017

Donoghue, M. F., O'Reilly, D. S., & Walsh, M. T. (2013). Wrist postures in the general population of computer users during a computer task. *Applied Ergonomics*, *44*(1), 42–7. http://doi.org/10.1016/j.apergo.2012.04.009

Douwes, M., & de Kraker, H. (2014). Development of a non-expert risk assessment method for hand-arm related tasks (HARM). *International Journal of Industrial Ergonomics*, *44*(2), 316–327. http://doi.org/10.1016/j.ergon.2013.09.002

Evans, O., & Patterson, K. (2000). Predictors of neck and shoulder pain in non-secretarial computer users. *International Journal of Industrial Ergonomics*, *26*(3), 357–365. http://doi.org/10.1016/S0169-8141(00)00011-1

Filiatrault, J., Parisien, M., Sullivan, A., Richard, L., & Pinard, C. (2015). International Handbook of Occupational Therapy Interventions. *International Handbook of Occupational Therapy Interventions, Second Edition*, 837–848. http://doi.org/10.1007/978-3-319-08141-0

Gerard, M. J., Armstrong, T. J., Rempel, D. A., & Woolley, C. (2002). Short term and long term effects of enhanced auditory feedback on typing force, EMG, and comfort while typing. *Applied Ergonomics*, *33*(2), 129–138. http://doi.org/10.1016/S0003-6870(01)00062-X

Gerr, F., Marcus, M., & Monteilh, C. (2004). Epidemiology of musculoskeletal disorders among computer users: Lesson learned from the role of posture and keyboard use. *Journal of Electromyography and Kinesiology*, *14*(1), 25–31. http://doi.org/10.1016/j.jelekin.2003.09.014

Gold, J. E., Driban, J. B., Yingling, V. R., & Komaroff, E. (2012). Characterization of posture and comfort in laptop users in non-desk settings. *Applied Ergonomics*, *43*(2), 392–9. http://doi.org/10.1016/j.apergo.2011.06.014

Gonzalez, I., & Morer, P. (2016). Ergonomics for the inclusion of older workers in the knowledge workforce and a guidance tool for designers. *Applied Ergonomics*, *53*, 131–142. http://doi.org/10.1016/j.apergo.2015.09.002

Halaki, M., & Ginn, K. a. (2012). Normalization of EMG Signals: To Normalize or Not to Normalize and What to Normalize to? *Computational Intelligence in Electromyography Analysis - A Perspective on Current Applications and Future Challenges*, 175–194. http://doi.org/40113

Hallbeck, M. S. (1994). Flexion and extension forces generated by wrist-dedicated muscles over the range of motion. *Applied Ergonomics*, *25*(6), 379–385. http://doi.org/10.1016/0003-6870(94)90057-4

Harris, C., & Straker, L. (2000). Survey of physical ergonomics issues associated with school childrens ' use of laptop computers, *26*.

Haynes, S. (2009). Effects of positioning optimization in an alternative computer workstation for people with and without low back pain. *International Journal of Industrial Ergonomics*, *39*(5), 719–727. http://doi.org/10.1016/j.ergon.2009.05.001

Hsiao, L.-P., & Cho, C.-Y. (2012). The effect of aging on muscle activation and postural control pattern for young and older computer users. *Applied Ergonomics*, *43*(5), 926–32. http://doi.org/10.1016/j.apergo.2011.12.014

Johnston, V., Souvlis, T., Jimmieson, N. L., & Jull, G. (2008). Associations between individual and workplace risk factors for self-reported neck pain and disability among female office workers. *Applied Ergonomics*, *39*(2), 171–182. http://doi.org/10.1016/j.apergo.2007.05.011

Keyserling, W. M., Brouwer, M., & Silverstein, B. A. (1992). A checklist for evaluating ergonomic risk factors resulting from awkward postures of the legs, trunk and neck. *International Journal of Industrial Ergonomics*, *9*(4), 283–301. http://doi.org/10.1016/0169-8141(92)90062-5

Korhonen, T., Ketola, R., Toivonen, R., Luukkonen, R., Häkkänen, M., & Viikari-Juntura, E. (2003). Work related and individual predictors for incident neck pain among office employees working with video display units. *Occupational and Environmental Medicine*, *60*(7), 475–482. http://doi.org/10.1136/oem.60.7.475

Liu, C.-W., Chen, C.-H., Lee, C.-L., Huang, M.-H., Chen, T.-W., & Wang, M.-C. (2003). Relationship Between Carpal Tunnel Syndrome and Wrist Angle in Computer Workers. *The Kaohsiung Journal of Medical Sciences*, *19*(12), 617–622. http://doi.org/10.1016/S1607-551X(09)70515-7

Luca, C. J. De. (2002). S Urface E Lectromyography : D Etection and R Ecording. *DelSys Incorporated*, *10*(2), 1–10. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:SURFACE+ELECTROMYOGRAPHY+:+DETECTION+AND+RECORDING#0

Lueder, R. (2004). E RGONOMICS R EVIEW Ergonomics of seated movement A review of the scientific literature Considerations relevant to the Sum ™ chair, (818).

Marcus, M., Gerr, F., Monteilh, C., Ortiz, D. J., Gentry, E., Cohen, S., … Kleinbaum, D. (2002). A prospective study of computer users: II. Postural risk factors for musculoskeletal symptoms and disorders. *American Journal of Industrial Medicine*, *41*(4), 236–249. http://doi.org/10.1002/ajim.10067

Ming, Z., Närhi, M., & Siivola, J. (2004). Neck and shoulder pain related to computer use. *Pathophysiology*, *11*(1), 51–56. http://doi.org/10.1016/j.pathophys.2004.03.001

Nevala-Puranen, N., Pakarinen, K., & Louhevaara, V. (2003). Ergonomic intervention on neck, shoulder and arm symptoms of newspaper employees in work with visual display units. *International Journal of Industrial Ergonomics*, *31*(1), 1–10. http://doi.org/10.1016/S0169-8141(02)00102-6

Onyebeke, L. C., Young, J. G., Trudeau, M. B., & Dennerlein, J. T. (2014). Effects of forearm and palm supports on the upper extremity during computer mouse use. *Applied Ergonomics*, *45*(3), 564–70. http://doi.org/10.1016/j.apergo.2013.07.016

Pan, C. S., & Schleifer, L. M. (1996). An exploratory study of the relationship between biomechanical factors and right-arm musculoskeletal discomfort and fatigue in a VDT data-entry task. *Applied Ergonomics*, *27*(3), 195–200. http://doi.org/10.1016/0003-6870(95)00075-5

Pillastrini, P., Mugnai, R., Bertozzi, L., Costi, S., Curti, S., Guccione, A., … Violante, F. S. (2010). Effectiveness of an ergonomic intervention on work-related posture and low back pain in video display terminal

operators: A 3 year cross-over trial. *Applied Ergonomics*, *41*(3), 436–443. http://doi.org/10.1016/j.apergo.2009.09.008

Pinheiro, C. F., Santos, M. F. dos, & Chaves, T. C. (2016). Flexion-relaxation ratio in computer workers with and without chronic neck pain. *Journal of Electromyography and Kinesiology*, *26*, 8–17. http://doi.org/10.1016/j.jelekin.2015.12.011

Povlsen, B., & Rose, R.-L. (2008). Managing Type II Work-related Upper Limb Disorders in Keyboard and Mouse Users Who Remain at Work: A Case Series Report. *Journal of Hand Therapy*, *21*(1), 69–79. http://doi.org/10.1197/j.jht.2007.09.004

Rahman, N. A. A., Marican, A. M. A., Davies, A. M., Kadir, M. Z. A. A., & Abdullah, N. (2011). A practical method for optimised earth electrode designs at transmission towers exposed to lightning. *2011 7th Asia-Pacific International Conference on Lightning, APL2011*, 131–134. http://doi.org/10.1109/APL.2011.6111088

Rainoldi, a, Gazzoni, M., & Casale, R. (2008). Surface EMG signal alterations in Carpal Tunnel syndrome: a pilot study. *European Journal of Applied Physiology*, *103*(2), 233–242. http://doi.org/10.1007/s00421-008-0694-x

Reaz, M. B. I., Hussain, M. S., & Mohd-Yasin, F. (2006). Techniques of EMG signal analysis: detection, processing, classification and applications (Correction). *Biological Procedures Online*, *8*(1), 163. http://doi.org/10.1251/bpo115

Rempel, D., Barr, A., Brafman, D., & Young, E. (2007). The effect of six keyboard designs on wrist and forearm postures. *Applied Ergonomics*, *38*(3), 293–298. http://doi.org/10.1016/j.apergo.2006.05.001

Rhee, H., & Kim, S. (2016). Computers in Human Behavior Effects of breaks on regaining vitality at work : An empirical comparison of " conventional " and " smart phone " breaks. *Computers in Human Behavior*, *57*, 160–167. http://doi.org/10.1016/j.chb.2015.11.056

Rojects, C. O. P. (2013). E RGONOMICS P RINCIPLES AND UTILIZING IT AS A R EMEDY FOR P ROBABLE W ORK R ELATED I NJURIES IN, *6*(1), 232–245.

Roman-Liu, D. (2014). Comparison of concepts in easy-to-use methods for MSD risk assessment. *Applied Ergonomics*, *45*(3), 420–427. http://doi.org/10.1016/j.apergo.2013.05.010

Serina, E. R., Tal, R. O. N., & Rempel, D. (2015). Wrist and forearm postures and motions during typing, *139*(December). http://doi.org/10.1080/001401399185225

Seth, V., Weston, R. L., & Freivalds, A. (1999). Development of a cumulative trauma disorder risk assessment model for the upper extremities, *23*.

Sheahan, P. J., Diesbourg, T. L., & Fischer, S. L. (2016). The effect of rest break schedule on acute low back pain development in pain and non-pain developers during seated work. *Applied Ergonomics*, *53*, 64–70. http://doi.org/10.1016/j.apergo.2015.08.013

Silva, C., Barros, C., Cunha, L., Carnide, F., & Santos, M. (2014). Prevalence of back pain problems in relation to occupational group. *International Journal of Industrial Ergonomics*, *52*, 52–58. http://doi.org/10.1016/j.ergon.2015.08.005

Simoneau, G. G., Marklin, R. W., & Joseph, E. (2003). Research Report Effect of Computer Keyboard Slope on Wrist Position and Forearm Electromyography of Typists Without Musculoskeletal Disorders, *83*(9), 816–830.

Staal, J. B., de Bie, R. a., & Hendriks, E. J. M. (2007). Aetiology and management of work-related upper extremity disorders. *Best Practice and Research: Clinical Rheumatology*, *21*(1), 123–133. http://doi.org/10.1016/j.berh.2006.09.001

Szeto, G. P. Y., Straker, L. M., & O'Sullivan, P. B. (2005). A comparison of symptomatic and asymptomatic office workers performing monotonous keyboard work--1: neck and shoulder muscle recruitment patterns. *Manual Therapy*, *10*(4), 270–80. http://doi.org/10.1016/j.math.2005.01.004

Tepper, M., Hermens, H. J., & Baten, C. T. M. (2003). The effect of an ergonomic computer device on muscle activity of the upper trapezius muscle during typing, *34*, 125–130.

Toosi, K. K., Hogaboom, N. S., Oyster, M. L., & Boninger, M. L. (2014). Computer keyboarding biomechanics and acute changes in median nerve indicative of carpal tunnel syndrome. *Clinical Biomechanics*, *30*(6), 546–550. http://doi.org/10.1016/j.clinbiomech.2015.04.008

Toosi, K. K., Hogaboom, N. S., Oyster, M. L., & Boninger, M. L. (2015). Clinical Biomechanics Computer keyboarding biomechanics and acute changes in median nerve indicative of carpal tunnel syndrome. *JCLB*, *30*(6), 546–550. http://doi.org/10.1016/j.clinbiomech.2015.04.008

Van Niekerk, S. M., Fourie, S. M., & Louw, Q. A. (2015). Postural dynamism during computer mouse and keyboard use: A pilot study. *Applied Ergonomics*, *50*, 170–176. http://doi.org/10.1016/j.apergo.2015.03.009

Vezina, N., Tierney, D., & Messing, K. (1992). When is light work heavy? Components of the physical workload of sewing machine operators working at piecework rates. *Applied Ergonomics*, *23*(4), 268–276.

http://doi.org/10.1016/0003-6870(92)90155-O

Visacro, S., Alipio, R., Murta Vale, M. H., & Pereira, C. (2011). The response of grounding electrodes to lightning currents: The effect of frequency-dependent soil resistivity and permittivity. *IEEE Transactions on Electromagnetic Compatibility*, *53*(2), 401–406. http://doi.org/10.1109/TEMC.2011.2106790

Werner, R. A., & Andary, M. (2002). Carpal tunnel syndrome: pathophysiology and clinical neurophysiology. *Clinical Neurophysiology*, *113*(9), 1373–1381. http://doi.org/10.1016/S1388-2457(02)00169-4

Wilson, J. R. (2014). Fundamentals of systems ergonomics / human factors. *Applied Ergonomics*, *45*(1), 5–13. http://doi.org/10.1016/j.apergo.2013.03.021

Won, E. J., Johnson, P. W., Punnett, L., & Dennerlein, J. T. (2009). Upper extremity biomechanics in computer tasks differ by gender. *Journal of Electromyography and Kinesiology*, *19*(3), 428–436. http://doi.org/10.1016/j.jelekin.2007.11.012

Workineh, S. a., & Yamaura, H. (2015). Effects of Multiple Working Positions on User Comfort: A Study on Multi-position Ergonomic Computer Workstation. *Procedia Manufacturing*, *3*(Ahfe), 4792–4799. http://doi.org/10.1016/j.promfg.2015.07.585

Yang, J., & Cho, C. (2012). Comparison of posture and muscle control pattern between male and female computer users with musculoskeletal symptoms. *Applied Ergonomics*, *43*(4), 785–791. http://doi.org/10.1016/j.apergo.2011.11.013

Zakerian, S. A., & Subramaniam, I. D. (2015). The Relationship Between Psychosocial Work Factors , Work Stress and Computer-Related Musculoskeletal Discomforts Among Computer Users in Malaysia The Relationship Between Psychosocial Work Factors , Work Stress and Computer- Related Musculoskeletal Disco, *3548*(September). http://doi.org/10.1080/10803548.2009.11076822

Zein, R. M., Halim, I., Azis, N. A., Saptari, A., & Kamat, S. R. (2015). A Survey on Working Postures among Malaysian Industrial Workers. *Procedia Manufacturing*, *2*(February), 450–459. http://doi.org/10.1016/j.promfg.2015.07.078

Zennaro, D., Läubli, T., Federal, S., & Zurich, T. (2004). Trapezius Muscle Motor Unit Activity in Symptomatic Participants During Finger Tapping Using Properly and Improperly Adjusted Desks, *46*(2), 252–266.

UNIVERSITI PUTRA MALAYSIA

STATUS CONFIRMATION FOR THESIS / PROJECT REPORT AND COPYRIGHT

ACADEMIC SESSION : _____

TITLE OF THESIS / PROJECT REPORT :

EFFECT OF BREAK-TIME ON THE UPPER EXTREMITY MUSCULOSKELETAL DISORDER DEVELOPMENT AND TASK PERFORMANCE OF COMPUTER USERS

NAME OF STUDENT: THULASI A/P MANOHARAN

I acknowledge that the copyright and other intellectual property in the thesis/project report belonged to Universiti Putra Malaysia and I agree to allow this thesis/project report to be placed at the library under the following terms:

1. This thesis/project report is the property of Universiti Putra Malaysia.
2. The library of Universiti Putra Malaysia has the right to make copies for educational purposes only.
3. The library of Universiti Putra Malaysia is allowed to make copies of this thesis for academic exchange.

I declare that this thesis is classified as :

*Please tick (√)

☐	**CONFIDENTIAL**	(Contain confidential information under Official Secret Act 1972).
☐	**RESTRICTED**	(Contains restricted information as specified by the organization/institution where research was done).
☐	**OPEN ACCESS**	I agree that my thesis/project report to be published as hard copy or online open access.

This thesis is submitted for :

☐ **PATENT** Embargo from _____ (date) until _____ (date)

Approved by:

_____
(Signature of Student)
New IC No/ Passport No.:

Date :

_____
(Signature of Chairman of Supervisory Committee)
Name:

Date :

[Note : If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization/institution with period and reasons for confidentially or restricted.]