THE RELATIONSHIP BETWEEN NECK MUSCLE STRENGTH AND DURATION OF COMPUTER WORK AMONG WOMEN EMPLOYEES

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FACULTY OF ENGINEERING

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THE RELATIONSHIP BETWEEN NECK MUSCLE STRENGTH AND DURATION OF COMPUTER WORK AMONG WOMEN EMPLOYEES

ABSTRACT

The usage of computers is common among workforce around the globe. The employees are necessitated to use the computer intensively to help the organizations to increase work quality, and efficiency to go through rapid development era. However, prolonged use of computer is often associated to neck disorder, which could reduce work productivity and may bring a socio-economic impact. Hence, an exploratory study is required to investigate the risk factors and problems of neck pain among computer workers.

This study has three specific objectives. The first objective was to identify the individual, physical and psychosocial influence to neck pain among women in office environment. The second objective was to determine the relationship between the duration on computer task with the neck muscle strength and perceived neck pain. The last objective was to build a generic pattern of changes in neck muscle strength and perceived neck pain with time spent on computer task.

Fifty-one women employees who used computer to perform main task have completed a set of questionnaire to obtain demographic, workstation design and task demand information. Sixteen selected participants were involved in the second phase of data collection. In this phase, neck muscle strength measurement and perceived neck pain rating were taken periodically throughout the computer work experiment in order to observe the pattern of changes in neck muscle strength and perceived neck pain over time.

The results from questionnaire reported the significant risk factors associated with higher neck pain severity were not using vision correction, using a few fingers during typing, using none adjustable backrest chair, using telephone and keyboard concurrently for at least 8 times/day and sitting at workstation for at least 2 hours before taking a break. This result suggests that using keyboard in improper manner may lead to neck pain and higher severity.

The results taken from measurements during the experiment showed that neck muscle strength in extension and flexion decreased significantly after 40 minutes of typing, while the perceived neck pain rating increased significantly after 20 minutes of typing. Overall, these results suggest that the workers may perceive significant neck pain even with slight reduction of neck muscle strength. In general, these findings may give an insight to the organization to take action in proper job scheduling especially in computer working duration to reduce the incidence of unwanted injuries.

Keywords: Neck muscle strength, Neck pain, Computer User, Musculoskeletal disorder, Female employee

HUBUNGAN ANTARA KEKUATAN OTOT LEHER DAN TEMPOH PENGGUNAAN KOMPUTER DI KALANGAN PEKERJA WANITA

ABSTRAK

Penggunaan komputer adalah perkara biasa di kalangan pekerja di seluruh dunia. Para pekerja diperlukan untuk menggunakan komputer secara intensif untuk membantu organisasi meningkatkan kualiti dan keberkesanan kerja dalam mengharungi era pembangunan yang semakin pesat. Walaubagaimanapun, penggunaan komputer yang berpanjangan sering dikaitkankan dengan gangguan pada bahagian leher, di mana ia boleh mengurangkan produktiviti kerja dan boleh memberi impak sosio-ekonomi. Oleh itu, kajian tinjuan diperlukan untuk menyelidik faktor-faktor risiko dan masalah pada kesakitan leher di kalangan pekerja-pekerja yang menggunakan komputer.

Kajian ini mempunyai tiga objektif yang spesifik. Objektif pertama adalah untuk mengenalpasti pengaruh individu, fizikal dan psikososial terhadap kesakitan leher di kalangan wanita dalam suasana pejabat. Objektif kedua adalah untuk menentukan hubungan antara tempoh penggunaan komputer dengan kekuatan otot leher dan kesakitan leher teranggar. Objektif terakhir adalah untuk membina corak generik pada perubahan kekuatan otot leher dan kesakitan leher teranggar dengan tempoh dalam menjalankan tugasan berkomputer.

Lima puluh satu pekerja wanita yang menggunakan komputer dalam menjalankan tugas utama telah melengkapkan satu set borang soal selidik untuk mendapatkan maklumat demografi, reka bentuk stesen kerja dan tuntutan kerja. Enam belas peserta yang terpilih terlibat dalam fasa kedua pengumpulan data. Dalam fasa ini, pengukuran kekuatan otot leher dan pengkadaran kesakitan leher teranggar diambil secara berkala sepanjang eksperimen kerja berkomputer untuk memerhatikan corak perubahan pada parameter-parameter ini.

Hasil daripada borang soal selidik melaporkan faktor-faktor risiko penting yang berkaitan dengan keterukan kesakitan leher yang lebih tinggi adalah tidak menggunakan alat membetulkan penglihatan, menggunakan beberapa jari semasa menaip, tidak menggunakan kerusi dengan sandaran boleh laras, menggunakan telefon dan papan kekunci pada masa yang sama untuk paling kurang 8 kali/sehari dan duduk di stesen kerja untuk paling kurang 2 jam sebelum mengambil rehat. Hasil ini mencadangkan bahawa penggunaan papan kekunci dengan cara yang tidak betul boleh menjurus kepada kesakitan leher.

Hasil daripada pengukuran semasa eksperimen menunjukkan bahawa kekuatan otot leher pada arah mendongak dan menunduk telah menurun dengan ketara selepas menaip selama 40 minit, manakala pengkadaran kesakitan leher teranggar pula meningkat dengan ketara selepas menaip selama 20 minit. Pada keseluruhannya, hasil-hasil ini mencadangkan pekerja-pekerja boleh menganggap kesakitan leher yang ketara walaupun dengan penurunan kekuatan otot leher yang sedikit. Secara umumnya, dapatan-dapatan ini boleh memberikan pencerahan kepada organisasi untuk mengambil tindakan dalam penjadualan kerja yang baik terutamanya pada tempoh bekerja dengan komputer untuk mengurangkan berlakunya kecederaan-kecederaan yang tidak diingini.

Kata kunci: Kekuatan otot leher, Kesakitan leher, Pengguna computer, Gangguan sistem rangka otot, Pekerja wanita

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MSD	: Musculoskeletal disorders
SOCSO	: Social Security Organisation
WRMD	: Work-related musculoskeletal disorders
SCM	: Sternocleidomastoid
FHP	: Forward head posture
UT	: Upper trapezius
SC	: Splenius capitis
MMT	: Manual muscle testing
HHD	: Hand-held dynamometer
SD	: Standard deviation
SPSS	: Statistical Package for Social Sciences
ANOVA	: Analysis of variance

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CHAPTER 1

INTRODUCTION

1.1 Ergonomics and Computer Work

The advancement of technology has promoted higher usage of computer in daily lives, especially for education and work purposes since over four decades ago. The utilization of computer has become an essential means in industry in various countries around the world, including Japan, Kuwait, Taiwan, Australia, United States, Nepal and Greece (Babski-Reeves et al., 2005; Fereig et al., 1989; Fogleman & Lewis, 2002; Hou, 2012; Shrestha et al., 2011; Vlahos & Ferratt, 1995; Yoshitani, 1980; Zeffane & Cheek, 1993). This rapid development era demanded employees to use the computer intensively (Evans & Patterson, 2000) to help the organizations in raising work quality, productivity and efficiency (Culpan, 1995). Nevertheless, it was reported to cause negative effect in terms of health and safety of the workers (Evans & Patterson, 2000; Skilling et al, 2005).

Musculoskeletal disorders (MSD) have become a common issue among workers who frequently use computer in performing their job tasks (Evans & Patterson, 2000; Patrick et al., 2002; Korhan & Mackieh, 2010; Szeto et al., 2009; Zennaro et al., 2003). The neck and shoulder pain was frequently reported with prevalence rates of at least 30% in Netherland and 40% in Belgium (Buckle & Devereux, 2002). Not surprisingly, women was revealed to be affected by this disorders the most (Vogt et al., 2003).

Computer users are acknowledged to be exposed to neck-shoulder symptoms (Ming et al., 2004) which was mainly caused by repetitive and/or continuous work (Ming et al., 2004). An individual who experiences neck pain usually has limited range of motion and a subjective feeling of stiffness. The symptoms worsen with sustained neck postures and neck movement (Hoving et al., 2002). This occurrence may affect a large number of computer workers and subsequently may bring a socio-economic impact (Evans et al., 2002) due to higher usage on medical consultation and sick leave (Ylinen et al., 2004). Hence, it is very important for researchers to focus on studying this phenomenon as the occurrence of neck pain has become a vital issue, especially for women work force.

1.2 Problem Statement

Malaysia is moving towards a technology-driven and high-tech production-based pattern of development (Lai & Yap, 2004). To keep abreast with this rapid growth, the Malaysian industry also encourages the intensive use of computer to promote better productivity and efficiency (Idrus et al., 2008). Concerning this issue, Social Security Organisation (SOCSO) has presented the data of increased number of work-related musculoskeletal disorders (WRMD) among Malaysian employees reported to the organization. The statistics showed an incline, with 161 cases in 2009; 238 cases in 2010; 268 cases in 2011 and 449 cases in 2012 (Boon, 2013). The statistic is illustrated in Figure 1.1.

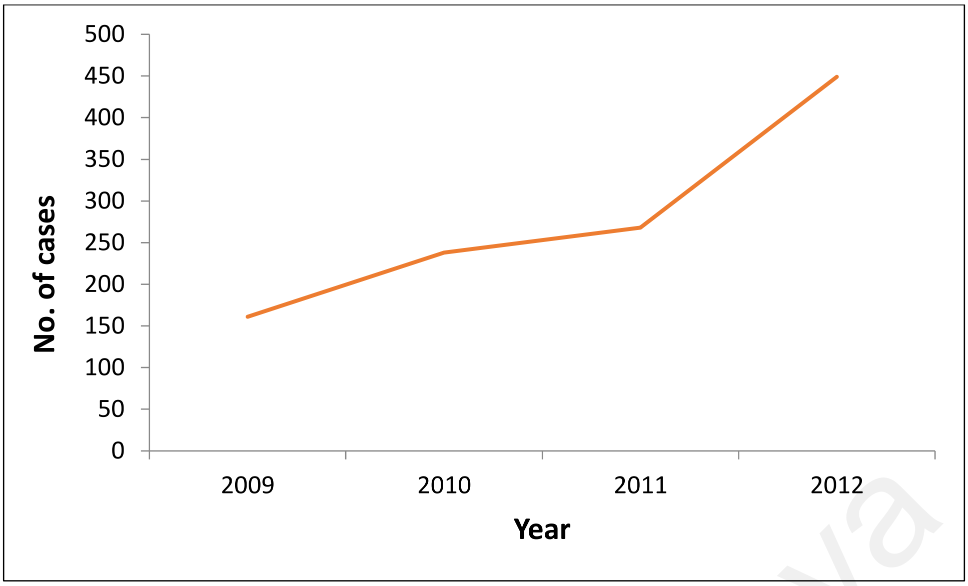

Figure1.1: The inclination of number of WRMD cases by years in Malaysia.

The rise of incidence rate of WRMD was believed due to a number of contributing factors, such as work demand, tough work schedules and poor workstation set-up (Chung & Choi, 1997; Eatough et al., 2012; Long, Johnston, & Bogossian, 2012). This occurrence has brought a significant impact in terms of financial aspect. Researchers have reported to SOCSO the compensation for permanent and temporary disablement benefit for WRMD cases in Klang Valley area, which was RM5,016 in 2008, compared to the average for other cases which was RM4,422 (Boon, 2013). This phenomenon also has brought more awareness of ergonomic aspects that are associated with the physical characteristics of task such as anthropometric, physiological and bio-mechanical characteristics as they closely related to physical activity, workstation design, task analysis and ergonomics risk assessment. In order to improve this situation, a specific study on working condition has to be done.

Association between the intensive computer usage and the increased risk of upper extremities (Blatter & Bongers, 2002; Jensen et al., 2002; Korhan & Mackieh, 2010; Ming & Zaproudina, 2003; Yang & Cho, 2012) has been observed through previous researches, including neck pain. There are several risk factors which caused the neck pain among the computer users. The computer users who worked with time pressure and high quantitative job demand frequently experienced neck pain (Strøm et al., 2009). Prolonged use of computer demands a static posture of the upper limbs. Consequently, the neck muscles will be overloaded and become fatigue and finally injured (Ming et al., 2004).

Muscle fatigue in holding the head to keep static posture is caused by the muscular weakness, as proven by Ylinen (2004), who showed a decrease of neck strength in all directions examined in neck pain patients compared to healthy subjects in control. The finding was also supported by the studies done by Barton and Hayes (1996), Cagnie et al. (2007) and Rezasoltani et al. (2010). This occurrence explains the frequent occurrence of chronic neck pain among women (Cagnie et al., 2007; Chiu et al., 2002; Korhonen et al., 2003). It was reported that women have lower muscle strength than men (Vasavada et al., 2008).

Therefore, an in-depth study is required to identify the contributing factors and problems of neck pain among workers in Malaysia. The study of these contributing factors; such as the setting of the workstation and working hours; is very crucial to prevent the occurrence of the disorder. Lack of intervention into this phenomenon may lead to body disability in the long run. It also may cause depression on the workers and bring new pain-related illness.

The aim of this study was to determine the effect of time spent in computer work on neck flexor and extensor muscle strength among women employees. It was hypothesized that neck muscle strength would significantly decrease as the duration of computer usage is getting longer.

1.3 Objectives of Study

The objectives of this research were:

1. To identify the individual, physical and psychosocial contribution to neck pain among women in office environment.

2. To determine the relationship between the time spent on computer task with the neck muscle strength and perceived neck pain.

3. To predict a generic pattern of changes in neck muscle strength and perceived neck pain with time spent on computer task.

1.4 Scopes and Limitations

In the experiment procedure, only keyboard was involved as an input device by the subjects and does not cover the usage of mouse or any other computer task. This is in order to standardize the definition of computer work in this present study. Typing task also was used in previous study to investigate the muscle behavior during computer work (Szeto et al., 2005). This study was focused on typing task performed by female administrative staffs in University of Malaya as a subject for the experiment. It only focused on female subjects due to higher risk of neck and shoulder disorders in woman then man according to previous study (Brandt et al., 2014; Hogg-Johnson et al., 2008).

The participants in this study must use the computer for at least 3 hours per day based on previous study regarding prolonged computer usage (Cho et al., 2012).

This study involved a small sample size, which may cause the results to be less generalizable to the whole population. However, this small but focused sample allows a more emphasis of the research aim, which was to obtain a better insight of the muscle strength behavior with the usage of computer.

The lack of prior research requires a development of a new research methodology. This present study was aimed to provide a basis for further research into neck pain assessment and the association with neck muscle strength characteristic in office workers. Therefore, this study was a cutting edge in the area of WRMD.

1.5 Contribution of the Study

The occurrence of neck pain among office workers is very common. If this condition is not treated well, it will affect the productivity of the organization as a whole and reduce the quality of life of the people who is influenced by the symptoms. This issue can be tackled by investigating the physiological changes on the people affected. In this study, the changes in neck muscle strength of the workers during computer work are to be investigated. The findings from this study can be utilized to give some information to the employers about the effect of high job demand towards the incidence of the injury, and hence a better job scheduling can be organized to promote a better well-being in the workers to serve the organization in higher efficiency. It also can contribute towards ergonomic job design that may reduce or eliminate the risk factors for musculoskeletal disorders.

1.6 Organization of the Study

This study consists of five chapters. Chapter 1 presents the introduction to this study. In this chapter, the background of study and problem statements are described. This chapter also states the objectives and the significance of this study. The scope and limitations of this study also is described towards the end of this chapter.

In chapter 2, the literature reviews the occurrence of neck pain, as one type of musculoskeletal disorder, and the relation with computer workers. The possible risk factors influencing the injury occurrence were explained in the chapter. The relationship between neck muscle strength and the occurrence of neck pain was also presented. Previous works related to this topic were reviewed. The techniques and applications used to achieve the objectives were also explored in this chapter.

Chapter 3 contains the descriptions of the method to achieve the objectives of the study. This chapter covers a detailed explanation of the survey questions and experimental design. It includes the criteria of the participants, the equipment used and the procedure. The details on statistical analyses performed in this study also was elaborated in this chapter.

Chapter 4 presents and discusses all the results from data collection. This chapter begins with the details of survey results which provide the background information of the participants as well as their perceptions towards work environment and demand. The results from the experiments also were explained in this chapter. The relationship between investigated variables were stated based on statistical analyses performed. The content relates the findings in this present study and those from previous studies. The relationship between variables were discussed thoroughly for deeper understanding of the study.

Chapter 5 is the conclusion of the whole study. It outlined the brief descriptions of the key findings of the research. The suggestions for future study were also provided for further understanding of this topic.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

This chapter presents to review the literature and similar studies that have been done previously on neck pain among computer users and the relationship with neck muscle strength. This literature is elaborated under five sections. The first section summarized the prevalence of musculaskeletal disorders and neck pain among computer workers. Secondly, the factors associated with the occurrence of neck pain is emphasized. In the third section, the mechanisms of neck pain are studied. The fourth setion compares and contrasts different types of neck muscle strength measurement. The chapter is concluded with a suggestion of future research related to neck pain issues.

2.2. Musculoskeletal Disorders and Computer Work

In this modern era, with the rapid development in information technology, the usage of computers is frequent among workforce around the globe (Foye et al., 2002; Ho & Lee, 2001; Johnston et al., 2008). Research has shown the increase usage of computer by 1970s in North America (Skilling et al., 2005). According to Australian Bureau of Statistics Report in 2001, 66% adults among Australian population access a computer either at home or at work while in Sweden about 65% of working population uses a visual display unit at work (Johnston et al., 2008).

As the usage of computer may assist in improving work productivity (Evans & Patterson, 2000), the frequent and prolonged use might also give a negative impact to the users. The awareness of adverse effects from the excessive use of computer has led to extensive studies on relationship between the usage of computer and the occurrence of MSD (Blatter & Bongers, 2002; Hakala et al., 2006; Ortiz-Hernández et al., 2003).

MSD describe the abnormalities in the soft tissues associated with the bones and joints in the upper limbs, lower limbs, and spine. MSD include a range of conditions such as low back pain, carpal tunnel syndrome, knee bursitis, etc. The term 'disorder' covers acute and chronic injuries whose anatomic and/or pathophysiological basis is not necessarily known. Thus, these disorders usually are described as symptoms reported by the patient, and may be diagnosed by investigating the signs and symptoms as well as the functional and structural anomaly (Aptel et al., 2002).

MSD are associated with physical activities which may lead to stress on the musculoskeletal system (Aptel et al., 2002). These disorders were commonly known as the main causes of severe long-term pain and physical disability, risking world population and have become a big threat to contemporary workforces due to the absenteeism from health problem caused as well as the economic and social cost, although an intervention of ergonomic approach has been widely studied (Aptel et al., 2002; Glover et al., 2005).

Strong evidence of an association between MSD and work-related factors have been shown in previous research (Vern Putz-Anderson et al., 1997). The pain in the neck region is a common issue with overall prevalence in the general population has been reported to be ranged from 0.4% to 86.8% (mean: 23.1%); the point prevalence from 0.4% to 41.5% (mean: 14.4%); and the 1-year prevalence from 4.8% to 79.5% (mean: 25.8%) (Hoy et al., 2010). Due to this high prevalence, it is essential to discover the causes of the disorders. By identifying the risk factors, some modifications can be done in order to prevent or minimize the incidence.

2.2.1 *Work-Related Musculoskeletal Disorder (WRMD)*

WRMD is defined as multi-factorial conditions involving occupational element (Aptel et al., 2002). The employers who are suffering from WRMD will have the conditions of inflammatory and degenerative disorders which lead to pain and functional impairment, involving tendons, muscles, joints, nerves and blood vessels (Aptel et al., 2002).

WRMD of the upper limbs were defined as a multi-factorial syndrome affecting the neck and upper extremities, causing pain or functional loss (Aptel et al., 2002). 60% of cases of MSD among employees involved repetitive trauma affecting upper limbs (Foye et al., 2002). It is likely that the pain is caused by working at sustained high static load, ischemia and hypoxia which lead to energy crisis of muscles and tendon (Strøm et al., 2009). The untreated or inadequately treated of this disorder will not only worsen the function of that particular body part, but also affect the other body regions, despite the body is at rest (Foye et al., 2002).

A relation between MSD and sedentary work in writers and clerks has been studied since 13th century (Aptel et al., 2002). WRMD usually occurs among office workers, especially those who used computer intensively (Cagnie et al., 2007; Szeto et al., 2005; van den Heuvel et al., 2006).

2.2.2 Computer-Related Injuries

Survey has reported 70% to 75% from the computer user among employees have health problems, which mostly includes the symptoms of eyestrain, headaches, and blurred vision. Disorders in computer users usually affect different kind of tissues, including muscles (Foye et al., 2002). The growth of reliance on computer usage is proportionate with the medical consultation taken by employees (Skilling et al., 2005).

The neck region as viewed in Figure 2.1 has a significant amount of motion and to support the weight of the head. Since it is less protected than the rest of the spine, the neck can be at a higher risk to injury and disorders that produce pain and restrict motion. Supporting this statement, Straker et al. (2008) has stated the higher prevalence of discomfort due to intensive computer usage in neck-shoulder region, compared to other regions. Computer users are stated to be at higher risk of catching neck-shoulder symptoms (Ming et al., 2004) than those who work at low-exposure of office and industrial tasks (Johnston et al., 2008). Strøm et al. (2009) have shown in the literature that neck pain frequently occur during work involving very low levels of muscle activity, such as office work with computers. This incidence was mainly caused by working with computer in repetitive manner and/or continuously (Ming et al., 2004). The neck pain related to computer use is usually work-related and chronic.

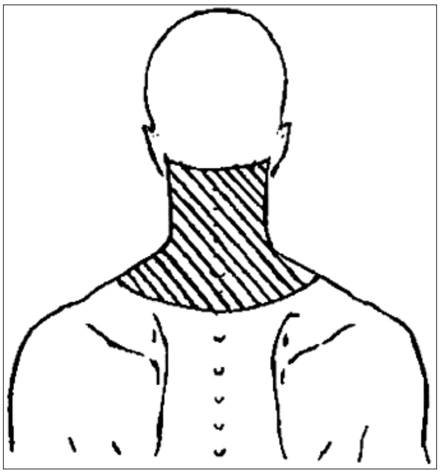

Figure 2.1: Neck pain region

Working in a long period will require a static posture of the upper body, which will overload the muscles of the neck, shoulder and upper limbs, which consequently, leads to injuries. Poor postures due to inadequate conditioning of workstation will shorten the soft tissues, and may cause tension, weakness and fatigue to the muscle (Ming et al., 2004). Poor positioning of monitor screen also may cause eye strain that will increase the tendency for the head to lean forward (Keller et al., 1998). This awkward posture will cause soreness at the neck region (Yan et al., 2008).

The requirement of higher productivity demands the workers to use computers for longer periods daily that bring transformations in an organization. Hence, the workers are obliged to adjust with these changes physically and mentally. It is commonly established that the etiology of neck disorders is complex which is related with groups of risk factors (Cagnie et al., 2007).

Using a computer in a prolonged duration of time may cause neck and upper extremity disorders (Waersted et al., 2010). Therefore, it is important to reduce the risks with proper workstation design, better posture and restricting time spent on the computer.

2.3. Neck Pain in Computer Users and Associated Risk Factors

Contributing risk factors to neck pain caused by the usage of visual display unit can be divided into three main groups which are (i) individual factors (e.g., age, gender, physical activity, etc.); (ii) physical factors (e.g., exposure to workstation design and task demands); and (iii) psychosocial factors of the workplace (Johnston et al., 2008). These factors are as discussed in following subtopics.

2.3.1 Individual Factors for Neck Pain in Computer Users

Gender difference has an important role in contribution to neck pain. Female was reported to have higher incidence rate of neck pain compared to male (Glover et al., 2005; Murphy et al., 2007). This trend could be explained from various biomechanical differences, in terms of anatomy, muscle strength, passive tissue mechanics, etc. (Vasavada et al., 2008). Anatomically, Vasavada et al. (2008) found that female had significantly smaller external neck and lower neck strength than male. For a given head size, female also had more slender necks and smaller cross-section area of the neck, hence, the muscle.

Age was significantly related to the starting of the injury, as stated by Glover et al. (2005). Previous research findings stated that a higher number of subjects were aged 30 years or under when they experienced their most serious work-related musculoskeletal injury compared with those who were aged over 30 years (Glover et al., 2005). Johnston et al. (2008) found an association between risk of neck pain and disability and increasing age. However, Croft et al. (2001) have presented a different result when the relationship between age and the risk of neck pain was ambiguous.

A number of researches have shown a strong relationship between marital status and the incidence of neck pain. The data obtained from population-based study of neck and chest pain (Fejer et al., 2005) shows significantly higher percentage of married individual reported neck pain within the past 2 weeks than single individual. This finding is supported by a research done by Nolet et al. (2005), in which 78.1% of the married respondents had work-related neck pain.

A lot of individual factors have been related to the incidence of neck pain. However, the relationship between these factors and the neck muscle strength has not yet been explored extensively.

2.3.2 Physical Factors for Neck Pain in Computer Users

Neck pain could be developed through the risk of workplace design and the positioning of computer equipment (Babski-Reeves et al., 2005) such as the position of monitor, type and use of input device (Foye et al., 2002; Johnston et al., 2008). The placement of monitor takes into account the visual requirement as well as the comfort musculoskeletal systems equipment (Babski-Reeves et al., 2005). Poor positioning of computer devices may cause the worker to be in awkward static posture (Johnston et al., 2008). High positioning of computer monitor requires the worker to extend the neck to look up at the screen that is higher than his/her line of sight. Pain also can occur due to prolonged cervical rotation, caused by the position of the monitor that is not located in front of the employee (Foye et al., 2002).

Keyboard usage in non-neutral hand placement has been related with neck-shoulder discomfort (Johnston et al., 2008). This might be caused by the failure of the worker to position the arm parallel to the floor while typing, due to poor positioning of the keyboard. Another issues regarding keyboard were the ergonomic aids such as ‘wrist rests'; and the layout of the keyboard itself such as the QWERTY layout (Amell & Kumar, 2000).

In order to prevent the occurrence of this injury, the ergonomic arrangements of the workstation should be adjustable, so that the workers may pose various anatomic proportions (Foye et al., 2002). Adjustable features at workstation have been shown to bring positive impact to the workers physiologically. However, the adjustable ergonomic chairs developed from previous study were ranging in price from less than $100 to several thousand dollars. It was hypothesized that higher price of a workstation component gives better quality of the design that top off the benefits over a lower cost components (Babski-Reeves et al., 2005).

2.3.3 Psychosocial Factors for Neck Pain in Computer Users

Psychosocial factors are defined as two aspects of conditions which are the psychological and social. The psychological aspect included cognitive and affective, while social aspect includes interacting with people and engaging in daily activities. These factors may have the control on the perception of pain. Likewise, the presence of pain may influence the social involvement and psychological interest (Backman, 2006). The examples of psychosocial risk factors are such as lack of quality of leadership, high work demands, low social support and high psychological demands (Munir et al., 2011).

Psychosocial work characteristics could result to adverse change in the physical exposure and may increase the stress symptoms (van den Heuvel et al., 2005). The psychological stress may influence the function of four body systems, namely, central nervous system, autonomic nervous system, endocrine system, and immune system. Continuous stress at workplace may cause an increase in muscle tone, which subsequently increases the biomechanical loads exerted on the muscles and tendons. Stress may also contribute to muscle fatigue as a result from a decrease in microcirculation (Aptel et al., 2002).

Work-related psychosocial factors were known to be related with neck-shoulder pain since decades ago (Larsson et al., 2007). In studying neck and upper limbs symptoms, high job demands and low job control have been discovered as one of the contributing factors (Johnston et al., 2007; van den Heuvel et al., 2005). Larsson et al. (2007) also proposed time constraint as one of confounding factor to these symptoms. Walker-Bone et al. (2003) also have pointed out the significant association between work-related stress and high demands, and disorders in the neck and upper limb.

From the literature, it is certain that in order to prevent the incidence of neck pain in office workers, the recognition of risk factors associated with the disorder is vital.

2.4. The Physiology of Neck Muscle Related To Computer Task

Neck carries many functions for the whole body. One of them is to support the head that weighs approximately 4 kg (Yoganandan et al, 2009). Together with muscles, joints, ligaments and tendons, the vertebral bodies give support, structure and stabilization to the neck. Furthermore, the neck provides tolerance for the head movement, including rotational and bending motions (Ullrich, 2009). The movement of the head through the joint will cause change in the length of the related muscles (Ylinen et al., 2003). The neck muscles are as shown in Figure 2.2.

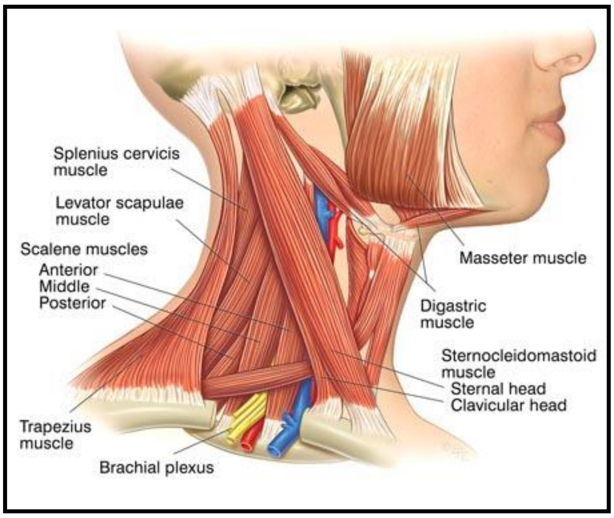

Figure 2.2: The neck muscles (Source: Diseases Pictures, 2012)

Muscles are composed of many muscle fibers. Skeletal muscles are the most substantial soft tissue in human being that are attached to bones by tendons in carrying out body movement (Hill & Olson, 2012). In flexion and extension movement of the neck, the neck flexor and extensor muscles will contract and shorten the length of connective tissue elements of the muscles in order to generate a pulling force (Jones & Round, 1990). Muscles work in pair, which when one muscle (agonist) contracts, the counterpart (antagonist) relaxes. This simultaneous action generates voluntary movement of particular human body part (DeStefano et al, 2009). Computer work usually involves the contraction of neck flexor and extensor muscles.

2.4.1 Neck Flexor Muscles

The neck flexors contract when flexion occurs against a resistance, such as the weight of the head (Clarkson, 2000). The main muscles that is responsible for flexion movement of the neck is the sternocleidomastoid (SCM) muscle (eToims® Medical Technology, 2007). The location of this muscle is as shown in Figure 2.3. The SCM contracting bilaterally flex the cervical spine relative to the thoracic spine, flex the head (Clarkson, 2000). This movement also is known as forward head posture (FHP).

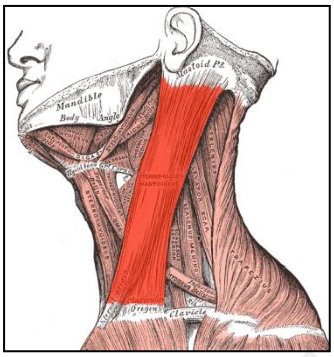

Figure 2.3: Sternocleidomastoid muscle (Source: Wikipedia)

Habitual FHP has been associated in causing neck pain due to increased tension in the muscle regions as well as compressive forces on the cervical spine (Barbara Cagnie et al., 2008). Kang et al. (2012) found that participants who worked with computer for more than 6 hours per day were prone to have greater FHP. They also implied that the occurrence of FHP during computer task may contribute to imbalance of health to an individual.

2.4.2 Neck Extensor Muscles

Neck extensor muscles include upper trapezius (UT) and splenius capitis (SC). The SC and UT acts to extend the head and neck. Besides allowing neck extension, UT also works to draw the scapula (shoulder blade) toward the body (Clarkson, 2000).

Extensor muscles work at various conditions. Contraction of neck extensor muscles occur when the activities were carried out overhead, such as reaching a book at top shelf. The neck extensor muscles also contract in a work to control neck flexion and when the head is inclined forward such as in typing and writing. In sum, the neck extensor muscles contract in the activities requiring less than full neck flexion (Clarkson, 2000) as shown in Figure 2.4.

Figure 2.4: Typing as an activity that requires less than full neck flexion (Source: www.shutterstock.com)

2.5. Relationship between Time Duration, Neck Muscle Strength and Neck Pain

Prolonged use of computer was frequently associated with the incidence of neck pain (Babski-Reeves et al., 2005; Burgess-Limerick et al., 1999; Szeto & Sham, 2008). The prolonged static posture may be sustained by continuous muscle contractions that may produce lactic acid as a result of insufficient oxygen supplied to the muscles. As a result, muscles will experience fatigue and pain (Keyserling et al., 1992).

The functional disorder of the neck usually is related to pain and muscular fatigue (Cagnie et al., 2007). For example, neck muscle weakness has been mentioned as one of the features of pain and muscle discomfort (Barton & Hayes, 1996). It is commonly acknowledged that disorder exists in the musculature function in the presence of pain due to reflex inhibition. It has been reported that reduced muscle strength and adapting an awkward posture may be one of the most important factors contributing to neck pain among office workers (Rezasoltani et al., 2010).

It has been shown that office workers have the high tendency to increase their forward neck flexion when performing a computer task, compared to their relaxed sitting postures (Szeto et al., 2005). This occurrence was more frequent among the symptomatic group (Yang & Cho, 2012). Neck and head flexion also may occur during keying task. Yang and Cho (2012) have found greater head flexion angle towards the end of the 8-min typing task experiment. This occurrence was considered to be as a result of increased tension of the head and neck muscles. Figure 2.5 shows the difference between two cervical movements.

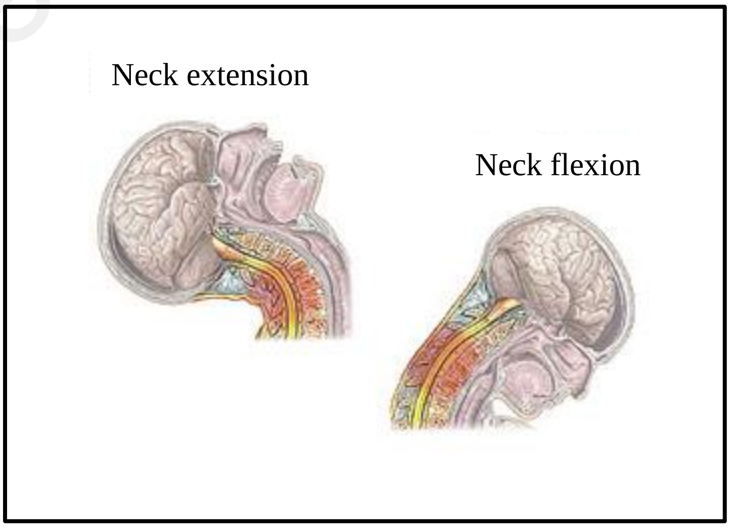

Figure 2.5: The direction of cervical movement (Source: Prince Crossing Family Chiropractic)

Sustained period of neck flexion was cited to have a significant relationship with the incidence of musculoskeletal injury (Kilbom & Persson, 1987). Evans and Patterson (2000) have reported that 65% of the respondents, who have worked for 28.3 hours per week on computer, have had neck or shoulder pain during the past month. This phenomenon is due to the increase in flexor moment caused by the mass of the head, and the head and neck, about axes of rotation at the level of atlanto-occipital joint and the cervical spine. Consequently, the musculature has to produce higher tension for maintaining the static equilibrium (Burgess-Limerick et al., 1998).

Women are revealed to experience neck pain more frequent than man (Vogt et al., 2003). Croft et al. (2001) has reported the majority (64.3%) of the respondents who complaint to have neck pain was among female. It is believed that the occurrence of neck pain is related to the size of the muscle. It is also well known that male has greater cross-sectional area of muscles compared to female although there was no significant difference when the muscle size was normalized for body mass (Rankin et al., 2005). In order to further support the former statement, Rezasoltani et al. (2010) shows a significantly smaller size of semispinalis capitis muscle in patients compared to healthy subjects. The research also found a significantly smaller muscle at the painful side compared to the non-painful side. These findings have given a significant insight on the possible factor of high rate of occurrence of neck pain among women.

A significant decrease of muscle strength in both flexor and extensor muscles has been seen in women with chronic non-specific neck pain (Ylinen et al., 2004). Rezasoltani et al. (2010) shows 42% of strength reduction in neck extensor and 26% in neck flexor in the group of patients, compared to healthy subjects. Similar results have been found in many previous researches (Cagnie et al., 2007; Häkkinen et al., 2004; Lindstrøm et al., 2011). These findings prove a significant decrease of muscle function as a consequence of prolonged neck pain experienced (Falla et al., 2006). A strong relationship between muscle strength and the occurrence of neck pain also can be seen in the study done by Ylinen et al. (2003), which displays the effectiveness of strength training in decreasing pain and disability in women with chronic, non-specific neck pain.

2.6. Researches on Neck Pain and Neck Muscle Strength among Computer Users

Some prior research studies about neck pain and neck muscle strength are summarized in Table 2.1.

Table 2.1: Previous studies about computer users and neck pain

Title: Association of manual muscle tests and mechanical neck pain: Results from a prospective pilot study			
Author (Year)	**Objective**	**Methodology**	**Results**
Scott C. Cuthbert, , Anthony L. Rosner, Donald McDowall (2011)	To determine whether there was a statistical difference for manual muscle test (MMT) findings for cervical muscles in subjects with and without mechanical neck pain (MNP)	Standardized MMT assessments of the strength of the sternocleidomastoid, anterior scalene, upper trapezius, and cervical extensor muscles bilaterally were performed on all subjects in groups 1 (with MNP) and 2 (without MNP).	There was a significant difference between the two groups of patients.
Title: Association of neck pain, disability and neck pain during maximal effort with neck muscle strength and range of movement in women with chronic non-specific neck pain.			
Author (Year)	**Objective**	**Methodology**	**Results**

Jari Ylinen, Esa-Pekka Takala, Hannu Kautiainen, Matti Nyk€anen, Arja H€akkinen, Timo Pohjolainen, Sirkka-Liisa Karppi, Olavi Airaksinen (2004)	To evaluate the association between the severity of neck pain and disability with neck strength and range of movement in women suffering from chronic neck pain.	179 female office workers with chronic neck pain were selected to the study. The outcome was assessed by the self-rating questionnaires on neck pain (visual analogue scale, Vernon's disability index, Neck pain and disability index) and by measures of the passive range of movement (ROM) and maximal isometric neck muscle strength.	- No statistically significant correlation was found between perceived neck pain and the disability indices and the maximal isometric neck strength and ROM measures. - The pain values reported during the strength tests were inversely correlated with the results of strength tests - About two-thirds of the patients felt pain during test efforts.
Title: Associations between individual and workplace risk factors for self-reported neck pain and disability among female office workers			
Author (Year)	**Objective**	**Methodology**	**Results**
Venerina Johnston, Tina Souvlis, Nerina L. Jimmieson, Gwendolen Jull (2008)	1) To determine the level of neck pain and disability 2) To explore the relationship between individual and workplace risk factors with the NDI score and the presence of pain.	A cross-sectional survey of female office workers was undertaken. Neck Disability Index was used to determine level of neck pain and disability	- Workers reported nil (32%), mild (53%), moderate (14%) and severe (1%) neck pain. - The presence of neck pain was associated with a history of neck trauma, using a graduated lens, and negative affectivity in the multiple regression model. - Factors associated with higher NDI score were

			using the computer mouse for more than 6 hours per day, higher negative affectivity, older age and an uncomfortable workstation.
Title: Cervical strength of young adults in sagittal, coronal, and intermediate planes			
Author (Year)	**Objective**	**Methodology**	**Results**
Shrawan Kumar, Yogesh Narayan, Tyler Amell (2001)	To measure the cervical isometric force generation capacity of men and women reliably while seated in upright neutral posture.	40 young subject exerted their maximal voluntary isometric contraction in flexion, extension, lateral flexion, anterolateral flexion, and posterolateral extension bilaterally.	- There was significant difference between male and female strengths. - There was a significant difference in strength values in different directions.
Title: Computer Use Increases the Risk of Musculoskeletal Disorders Among Newspaper Office Workers			
Author (Year)	**Objective**	**Methodology**	**Results**
Luis Ortiz-Hernandez, Silvia Tamez-Gonzalez, Susana Martinez-Alcantara, Ignacio Mendez-Ramirez (2003)	1) To estimate prevalence of MSD among office workers at a newspaper in Mexico City. 2) To analyze the relationship between MSD and use of the personal computer and associated ergonomic factors in the aforementioned population	Information was collected by a questionnaire completed by 218 office workers at a newspaper. Prevalence ratios adjusted for potential confounders (sex, age, educational level, and marital status) were estimated.	- Risk of MSDs was greater among workers at the newspaper who used computers, those involved in editing work, and those who adopted uncomfortable positions. - Among workers without social support, increase in number of postures and rotation/inclination of the neck was associated with substantial risk increase.

	3) To analyze the modifying effect that psychosocial factors have on the relationship between ergonomic factors and MSDs and extant jobs at the newspaper		
Title: Decreased Isometric Neck Strength in Women With Chronic Neck Pain and the Repeatability of Neck Strength Measurements			
Author (Year)	**Objective**	**Methodology**	**Results**
Jari Ylinen, Petri Salo, Matti Nykanen, Hannu Kautiainen, Arja Hakkinen (2004)	1) To evaluate neck flexion, extension, and rotation strength in women with chronic neck pain compared with healthy controls 2) To evaluate the repeatability of peak isometric neck strength measurements in patients with neck pain.	21 women with chronic neck pain and healthy controls matched for sex, age, anthropometric measures, and occupation were selected. Peak isometric strength of the cervical muscles was tested in rotation, flexion, and extension	- Significantly lower flexion, extension and rotation forces were produced by the chronic neck pain group compared with controls. - Intratester repeatability of the neck muscle strength measurements was good in all the 4 directions tested in the chronic neck pain group
Title: Decreased Neck Muscle Strength Is Highly Associated With Pain in Cervical Dystonia Patients Treated With Botulinum Toxin Injections			
Author (Year)	**Objective**	**Methodology**	**Results**
Arja Hakkinen, Jari Ylinen, Mira Rinta-Keturi, Ulla Talvitie, Hannu Kautiainen,	1) To compare the isometric neck muscle strength of cervical dystonia patients treated with botulinum toxin injections	23 patients with cervical dystonia with botulinum toxin–treated neck muscles and 23 healthy control subjects participated	- Cervical dystonia patients with botulinum toxin–treated neck muscles showed significantly lower maximal neck strength than healthy controls.

Aimo Rissanen (2004)	with that of healthy control subjects 2) To evaluate the association between neck strength, neck pain, and disability in these patients.	Isometric neck strength was measured by a special neck strength measurement system. Disability was measured by the Neck Disability Index, and pain and symptoms of cervical dystonia by a visual analog scale.	- The patients also had a statistically significant difference between sides in neck rotation strength.
Title: Differences in Isometric Neck Muscle Strength Between Healthy Controls and Women With Chronic Neck Pain: The Use of a Reliable Measurement			
Author (Year)	**Objective**	**Methodology**	**Results**
Barbara Cagnie, Ann Cools, Veerle De Loose, Dirk Cambier, Lieven Danneels (2007)	1) To determine the intra- and interrater reliability of the Biodex isokinetic dynamometer to measure the maximal isometric strength of the cervical flexors and extensors 2) To develop an age- and sex-based normative database in a healthy population 3) To evaluate the differences in neck strength between women with	96 healthy volunteers and 30 women with chronic neck pain participated. Peak isometric strength of the cervical muscles was tested for flexion and extension by using the Biodex isokinetic dynamometer. The intra- and interrater reliability of the protocol was	- High degree of intra- and interrater reliability in measuring isometric neck muscle strength when using the Biodex isokinetic dynamometer. - Women with chronic neck pain have lower neck muscle strength in extension than the healthy female group.

	chronic neck pain and healthy controls.	evaluated in 12 volunteers.	
Title: Duration of computer use and mouse use in relation to musculoskeletal disorders of neck or upper limb			
Author (Year)	**Objective**	**Methodology**	**Results**
B.M. Blatter, P.M. Bongers (2002)	1) To examine the association between work-related upper limb disorders (WRULDs) and duration of computer and mouse use 2) To investigate differences in these associations between men and women 3) To examine whether a possible relationship between duration of computer use and WRULDs was explained by physical or psychosocial risk factors.	5400 office employees had filled out a questionnaire on job characteristics, job content, physical workload, psychosocial workload and musculoskeletal symptoms.	- Working with a computer during more than 6 h/day was associated with WRULDs in all body regions. - The strength of the associations differed between men and women. - In men, only moderate associations were seen for computer use more than 6 h/day. - In women, moderately increased ORs were observed for a duration of computer use of more than 4 h/day and strongly increased risks for a computer use during more than 6 h/ day. - Frequent computer users who often used a mouse did not report more WRULDs or neck or shoulder disorders than frequent computer users who did not use a mouse.
Title: Factors associated with self-reported musculoskeletal discomfort in video display terminal (VDT) users			

Author (Year)	Objective	Methodology	Results
Maxwell Fogleman, R. Jeffrey Lewis (2002)	To identify risk factors associated with the self-reported musculoskeletal discomfort in a population of video display terminal (VDT) operators.	292 persons who use a VDT at a corporate office site were asked to report on symptoms for six body regions, as well as job requirement information, demographic information, and a question regarding non-occupational hobbies. Descriptive information on these data was obtained through exploratory factor analysis, while logistic regression was used to estimate risk.	- Statistically significant increased risk of discomfort as the number of hours of keyboard use increases. - Improper monitor and keyboard position were also significantly associated with head/eye and shoulder/back discomfort, respectively.
Title: Head and neck anthropometry, vertebral geometry and neck strength in height-matched men and women			
Author (Year)	**Objective**	**Methodology**	**Results**
Anita N. Vasavada, Jonathan Danaraj, Gunter P. Siegmund (2008)	To quantify differences in head and neck geometry and neck strength in pairs of male and female subjects matched for standing height and neck length.	Ninety subjects (35 males, 55 females) participated in the initial phase of anthropometric measurements. Anthropometry, radiography and neck strength	- Most head and neck anthropometric parameters were significantly smaller in females compared to males. - Gender differences in a number of neck anthropometry parameters were larger

		measurements were taken	than differences in head anthropometry parameters. - Female necks were also significantly weaker than male necks and these strength differences corresponded well to those predicted solely from the observed geometric differences.
Title: Individual and work related risk factors for neck pain among office workers: a cross sectional study			
Author (Year)	**Objective**	**Methodology**	**Results**
B. Cagnie, L. Danneels, D. Van Tiggelen, V. De Loose, D. Cambier (2007)	1) To estimate the one-year prevalence of neck pain among office workers 2) To determine which physical, psychological and individual factors are associated with these prevalences.	Information was collected from 512 office workers by an online questionnaire. Self-reported neck pain during the preceding 12 months was regarded as a dependent variable, whereas different individual, work-related physical and psychosocial factors were studied as independent variables.	- The 12 month prevalences of neck pain in office workers was 45.5%. - Women had an almost two-fold risk compared with men - Persons older than 30 years have 2.61 times more chance of having neck pain than younger individuals. - Being physically active decreases the likelihood of having neck pain - Significant associations were found between neck pain and often holding the

			neck in a forward bent posture for a prolonged time, often sitting for a prolonged time and often making the same movements per minute. - Mental tiredness at the end of the workday and shortage of personnel are significantly associated with neck pain.
Title: Interaction of psychosocial risk factors explain increased neck problems among female office workers			
Author (Year)	**Objective**	**Methodology**	**Results**
Venerina Johnston, Nerina L. Jimmieson, Tina Souvlis, Gwendolen Jull (2007)	To investigate the relationship between psychosocial risk factors and (1) neck symptoms and (2) neck pain and disability as measured by the neck disability index (NDI).	Data were collected from 333 female office workers employed in local private and public organizations on various risk factors including age, negative affectivity, history of previous neck trauma, physical work environment, and task demands.	- 61% of the sample reported neck symptoms lasting greater than 8 days in the last 12 months. - The mean NDI of the sample indicated mild neck pain and disability. - Low supervisor support was the only psychosocial risk factor identified with the presence of neck symptoms. - Low supervisor support was the only factor associated with the score on the NDI. - The interaction of job demands, decision

			authority, and supervisor support was significantly associated with the NDI. - As job demands increased, high decision authority had an increasing effect on the NDI when supervisor support was low.
Title: Maximal muscle strength and EMG activity of the shoulder/neck muscles in females with work-related neck muscle pain			
Author (Year)	**Objective**	**Methodology**	**Results**
Lars L. Andersen, Michael Kjær, Karen Søgaard, Gisela Sjøgaard (2007)	To evaluate maximal torque during concentric and eccentric isokinetic and isometric shoulder abduction in females with trapezius myalgia compared to females without pain	42 employed females with trapezius myalgia (MYA) and 20 females without symptoms (CON) participated. Maximal muscle strength was determined during isometric and isokinetic contractions. The subjects were instructed to contract their muscles as forcefully as possible.	Muscle strength was significantly lower in MYA compared to CON during slow concentric and eccentric contraction - During isometric and fast concentric contraction there was no significant difference between the two groups.
Title: Musculoskeletal symptoms and duration of computer and mouse use			
Author (Year)	**Objective**	**Methodology**	**Results**
Chris Jensen, Lotte Finsen,	To study associations	3475 employees in Danish companies	- Working almost the whole working day with a

Karen Sogaard, Hanne Christensen (2002)	between duration of computer and mouse use and musculoskeletal symptoms among computer users.	answered a questionnaire.	computer was associated with neck symptoms and shoulder symptoms among women and hand symptoms among men. - Call center and data entry workers experienced the lowest possibilities for development at work. - All work tasks involving computer use, except computer maintenance, were characterised by a higher frequency of movements than desk work without using a computer.
Title: Neck pain and work-related factors among administrative and academic staff of the Islamic University of Gaza			
Author (Year)	**Objective**	**Methodology**	**Results**
Alia El Keshawi (2008)(2008)(2008)(2008)(2008)(2008)(2008)(2008)(2008)(2008)(2008)(2008)(2008)	To investigate neck pain and its work-related factors among administrative and academic staff in Islamic University of Gaza.	102 academic and administrative employees who suffer from neck pain participated. Data was collected using face to face structured questionnaire. Collected data was entered and analyzed using	- There was no relation between age and neck pain but there was a relationship between neck pain and gender - The majority of those who suffer from neck pain do administrative job. - Muscle spasm was the most dominant type of pain located around neck and both shoulders.

		SPSS.	- There was a relation between stress and neck pain. - Also 94% of all participants use computer during their work. - The employees seem to have insufficient knowledge about the correct sitting position on their desks. - Most of the employees agree that furniture in their offices is suitable and they had good desks and computers.
Title: Pain induced by a single simulated office-work session: Time course and association with muscle blood flux and muscle activity			
Author (Year)	**Objective**	**Methodology**	**Results**
Vegard Strøm, Stein Knardahl, Johan K. Stanghelle, Cecilie Røe (2009)	To assess the development of pain during computer work with high precision demand and time pressure	28 healthy subjects performed a 90-min standardized task of correcting a text on a word-processor. Monetary reward was given according to productivity in order to induce time pressure.	- Pain, tension, and eye strain increased considerably during the computer session with different time course for pain and tension.

		Pain intensity, general tension, and eye strain were reported on visual analogue scales before, during and after the computer session.	
Title: Perceived muscular tension, job strain, physical exposure, and associations with neck pain among VDU users; a prospective cohort study			
Author (Year)	**Objective**	**Methodology**	**Results**
J Wahlstrom, M Hagberg, A Toomingas, E Wigaeus Tornqvist (2004)	To determine whether perceived muscular tension, job strain, or physical exposure are associated with increased risk of developing neck pain among VDU users.	A baseline questionnaire was answered by 1283 respondents, of whom 671 were free from neck pain at baseline. Perceived muscular tension, job strain, and physical exposure were assessed at baseline. Information about newly developed neck pain was collected in 10 follow up questionnaires and the case definition was the first report of such pain in any of the follow up questionnaires.	- Both men and women who perceived muscular tension at least a few times per week, compared to those who had not perceived muscular tension the preceding month, had an incidence rate ratio of for developing neck pain, when stratifying for sex. - High perceived muscular tension was associated with an increased risk, even when controlling for job strain, physical exposure, and age in the model stratified by sex.

		Median follow up time was 10.9 months.	
Title: Preliminary study of neck muscle size and strength measurements in females with chronic non-specific neck pain and healthy control subjects			
Author (Year)	**Objective**	**Methodology**	**Results**
Asghar Rezasoltani, Ahmadipor Ali-Reza, Khademi-Kalantari Khosro, Rahimi Abbass (2010)	To compare the strength of the neck extensor and flexor muscles and the size of the semispinalis capitis muscle (SECM) in patients with chronic non-specific neck pain (CNNP) and healthy subjects.	20 female office workers (10 patients with CNNP and 10 healthy subjects) participated in this study. The strength of the neck extensor and flexor muscles was measured by an isometric device and the SECM size was measured by ultrasonography.	Neck muscle strength, size of the SECM and the ratios of neck strength to body weight, neck extensor strength to SECM size, SECM size to body weight and neck flexor to extensor strength were all significantly lower in patients compared to controls
Title: Prevalence and occupational associations of neck pain in the British population			
Author (Year)	**Objective**	**Methodology**	**Results**
Palmer KT, Walker-Bone K, Griffin MJ, Syddall H, Pannett B, Coggon D, Cooper C (2001)	To determine the prevalence of neck pain and its relation to occupation and occupational activities in the general population.	Information was collected on occupation, workplace physical activities, neck pain in the past week and year, headaches, and feelings of tiredness or stress.	- Among 12907 respondents, 4348 and 2528 reported neck pain in past year and week, respectively. - Symptoms were the most prevalent among male construction workers, followed by nurses, armed services

		Associations were explored by logistic regression, the resultant odds ratios being converted to prevalence ratios.	members, and the unemployed. - The age-standardized prevalence of neck pain varied little by occupation. - Stronger neck-pain associations were found with frequent headaches and frequent tiredness or stress than with occupational activities.
Title: Psychosocial work characteristics in relation to neck and upper limb symptoms			
Author (Year)	**Objective**	**Methodology**	**Results**
Swenne G. van den Heuvel, Allard J. van der Beekb, Birgitte M. Blattera, Wilhelmina E. Hoogendoorn, Paulien M. Bongers (2005)	1) To investigate the relationship between psychosocial work characteristics and neck and upper limb symptoms 2) To examine to what extent this relationship could be explained by other risk factors.	Data were used from a prospective cohort study in a working population, with a follow-up period of 3 years.	- The 3-year cumulative incidence rates of neck or upper limb symptoms and neck/shoulder symptoms 32 and 24%, respectively. - After adjustment for potential confounders high job demands was identified as a risk factor for neck/shoulder.
Title: Reliability of Isometric Strength Measurements in Trunk and Neck Region: Patients With Chronic Neck Pain Compared With Pain-Free Persons			
Author (Year)	**Objective**	**Methodology**	**Results**
Raphael Scheuer, Martin Friedrich (2010)	1) To evaluate reliability of isometric strength measurements in	Patients with neck pain and pain-free persons participated.	- Reliability in both groups ranged from substantial to almost perfect

	the neck and trunk region 2) To compare these measurements between patients with chronic neck pain and pain-free subjects.	Strength of flexion, extension, and lateral flexion in the neck and trunk were measured. Each participant underwent 2 measurement passes on each of 2 examination days; 3 were performed by the same investigator, 1 by a second.	- The patients' strength in the neck and trunk was significantly below that of the control group.
Title: The prevalence of neck and upper extremity musculoskeletal symptoms in computer mouse users			
Author (Year)	**Objective**	**Methodology**	**Results**
Catherine Cook, Robin Burgess-Limerick, Sungwon Chang (2000)	To determine whether a relationship existed between computer mouse use and musculoskeletal symptoms in a sample of computer mouse users.	Factors demonstrating a significant association with symptoms were entered into a step-wise multiple logistic regression, adjusting for age and sex and controlling for potential interdependence between variables	- No relationship was found between hours of mouse use per day and reported symptoms. - A relationship was found between the variable of arm abduction which is specific to mouse use and symptoms in the neck. - Relationships were found between non-mouse-specific risk factors such as stress, screen height and shoulder elevation.

2.7. Comparison of Neck Muscle Strength Measurements

Strength can be defined as the maximum amount of force that can be exerted in a specified movement pattern at its specified velocity (Stoppani, 1968) or against a resistance (Guy et al., 1996). The most common techniques of muscle strength measurement are isotonic, isometric, and isokinetic. The isotonic technique usually requires lifting maximum weight possible through a full range of motion. The isometric technique requires the individual exert maximal pushing or pulling against a measurement device in static position. The isokinetic technique controls the speed of movement during maximal contraction while measuring force application (Guy et al., 1996).

In assessing the functional ability of neck, isometric technique has been implemented in many previous researches (Häkkinen et al., 2004; Ylinen et al., 2003) in various directions. There are also a number of methods that can be applied in order to measure maximal strength isometrically. They are manual muscle testing (MST), isokinetic dynamometer and hand-held dynamometer (HHD) (May et al., 1997).

2.6.1 Manual Muscle Testing

Figure 2.6: Manual muscle testing posture (Source: Peolsson et al., 2010)

Manual muscle testing (MMT) was widely used to assess the muscle performance. This technique is rather subjective, especially at higher muscle test grade (Reinking et al., 1996). MMT assess the capability of the nervous system to adapt the muscle to endure the varying forces applied by examiner. The procedure in performing MMT requires the examiner to be trained in the anatomy, physiology, and neurology of muscle function. In order to attain accurate results, muscle testing has to be executed according to a precise testing procedure (Cuthbert et al., 2011). The technique of MMT is as shown in Figure 2.6.

The ordinary subjective MMT technique was known to have less accuracy than hand-held dynamometer (HHD) in learning the fluctuation of muscle strength in patients with spinal cord injury and chronic neuromuscular disorders (May et al., 1997). Since this technique is subjective, it may not detect the deficits in muscle performance (Reinking et al., 1996).

2.6.2 Isokinetic Dynamometer

Figure 2.7: System 3 isokinetic dynamometer (Source: Cagnie et al., 2007)

Isokinetic dynamometer is an electromechanical instrument controlled by a microcomputer, which offers the possibility of objectively and quantitatively evaluating physical parameters of the muscle function such as strength, power, and resistance in different joints during different angular velocities (Cagnie et al., 2007). It may perform a wide range of strength assessments. This is as shown in Figure 2.7 above. However, isokinetic testing might not be available and are not very practical due to its high expense and lack of portability (May et al., 1997). It also requires extensive training to conduct the testing and occupies a large space (Reinking et al., 1996).

2.6.3 Hand-Held Dynamometer

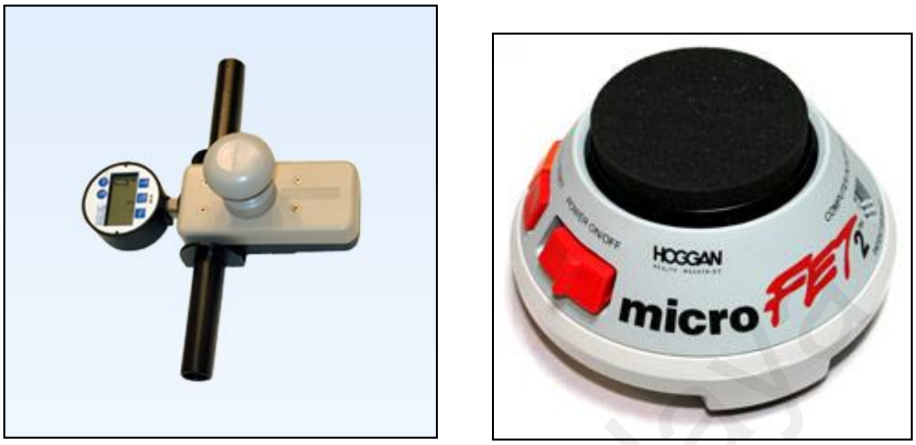

Figure 2.8: Different types of hand-held dynamometer

HHD is used to measure isometric measurement. It is a more practical technique to be applied for it is commercially available (May et al., 1997), easy to conduct, cheaper and minimal training requirement (Reinking et al., 1996). Both intrarater and interrater reliability test have been established for HHD in healthy and neurological impaired populations for a variety of muscle groups (May et al., 1997), make it a reliable device to measure the muscle strength. The use of HHD is sufficiently reliable, comparable and correlated with the result gained by isokinetic dynamometer to be used for achieving the same objective (May et al., 1997; Reinking et al., 1996). Figure 2.8 shows different types of HHD.

There are mainly two techniques of muscle testing by using HHD, which are ‘make’ and ‘break’ tests. In ‘make’ test, the examiner holds the dynamometer stationary while the subject exerts a maximal force against it. The ‘break’ test requires the examiner to put a pressure against the tested body part of the subject until the subject's maximal muscular effort is surpassed. The reliability analyses in patient populations have shown good results for both ‘make’ and ‘break’ test techniques (May et al., 1997).

The advantage and disadvantage of the muscle strength measurement techniques are summarized in Table 3.1.

Table 3.1: Summary of advantage and disadvantage of muscle strength measurement techniques.

Muscle Strength Measurement Technique	Advantage	Disadvantage
Manual Muscle Testing	• Cheap	• The examiner needs extensive knowledge • Less accuracy • May not detect the deficits in muscle performance
Isokinetic Dynamometer	• Offers objective and qualitative evaluation of physical parameters • May perform wide range of strength assessment	• Not very practical • Expensive • Lack of portability • Examiner needs extensive training • Requires large space
Hand-Held Dynamometer	• Practical technique • Cheap • Easy to conduct • Requires minimal training • Reliable	• Only one person allowed to take measurement for the whole sample

Based on Table 3.1, it is shown that HHD is the most practical technique to measure neck muscle strength in extension and flexion direction for experimental purposes. It is because it needs minimal training, relatively cheap and easy to conduct. This technique also is shown to be reliable in previous research in taking neck muscle strength measurement with the average reliability of 0.88 (Vasavada et al., 2008).

2.8. Future Research

Several literatures have specifically studied the work-related risk factors and the role of muscle strength for the development of neck pain among office workers. It is known that prolonged computer usage may cause fatigue, discomfort and pain at neck region, that caused by reduced muscle strength. Literatures prove that static loading on neck muscle is an important risk factor for the development of neck pain.

However, the relation between the time duration of computer usage behind the changes in neck muscle strength in reference to precipitate neck pain symptoms is still ambiguous. Future research in this area should be proposed in objective measurement as it has been observed to be more promosing and accurate.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the processes and methods applied in this research. The selected methods and the explanations behind the selection of these methods are demonstrated in this part. This chapter includes the explanation on the criteria of subjects' selection, the instrument used for measurement and the experimental procedure.

3.2 Research Approach

This research implemented deductive approach to accomplish the objective. This approach was chosen because the literature review done for this research has given an overview about the association between parameters that are to be investigated. Pathirage et al. (2009) describes deductive research approach as a research which is started from a hypothesis established from a general idea or theory. The hypothesis of this study is there is a relationship between neck muscle strength, perceived neck pain and the duration of computer work. Some data or measurements are collected to test the validity of this hypothesis.

Both subjective and objective measurements were applied in this research. Objective measurement offers more direct measure and not biased, provided that the measurement was taken in control environment and conditions. Subjective measurement involves the perception or influence of the test subjects. The subjective measurement approach may help to give more significant insights and supports the outcome of the objective measurement (Kirvesoja, 2001)

3.3 Participants

The sample was taken from University of Malaya, Malaysia, as one of the higher learning institutes in the country, at which work quality is a necessity. 51 females from administrative sector have answered the questionnaire in the first phase of this research who were in the age range of 23-56 years old (mean: 33.3, SD: 8.46). This data is sufficient since a sample size of 30-500 is appropriate for most studies (Roscoe, 1975). In the second phase of the study, 16 females were volunteered to participate in the experiment. Previously, the same sample size also have been used by Szeto et al., (2002) in studying neck-shoulder postures in office workers. All participants were free from serious muscle illness and have not undergone any muscle strength training involving upper extremities in previous 12 months. These selection criteria are important to obtain a good agreement of validity of the research findings. All respondents have signed the written consent form before the data collection.

3.4 Experimental Procedure

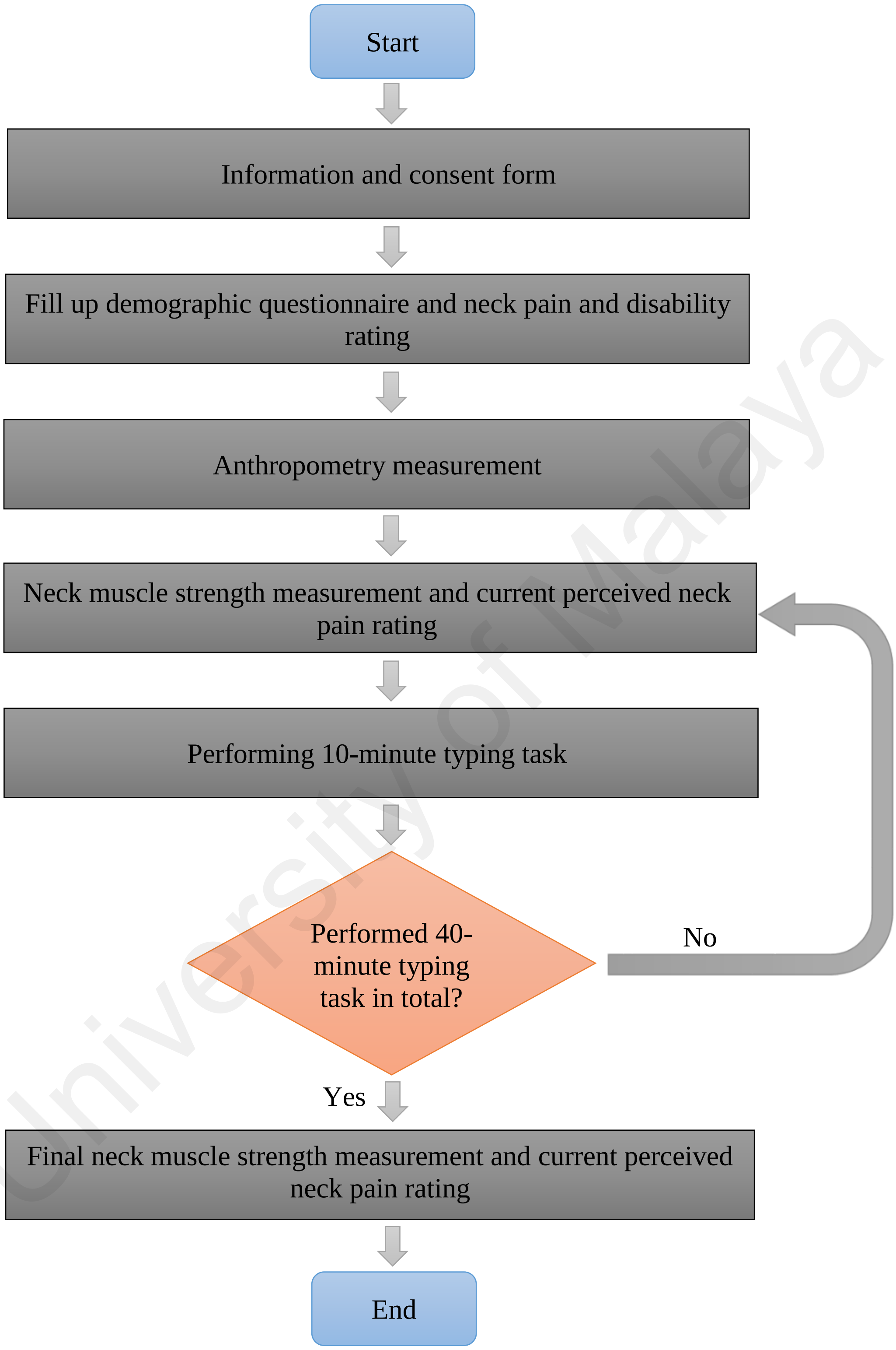

Figure 3.1: Flow chart of experimental procedure

An experiment was performed to assess the effect of duration of computer usage on neck muscle strength and perceived neck pain rating. This procedure was as shown in Figure 3.1. Before the experiment begun, all participants were given a set of questionnaire in order to obtain their demographic information. An anthropometric measurement also was taken from each participant.

Preceding the experiment, the subjects were asked to adjust each of the workstation components so that it complied with the ergonomic workstation setup, as shown in Figure 3.2. The workstation setting remained unchanged throughout the experiment.

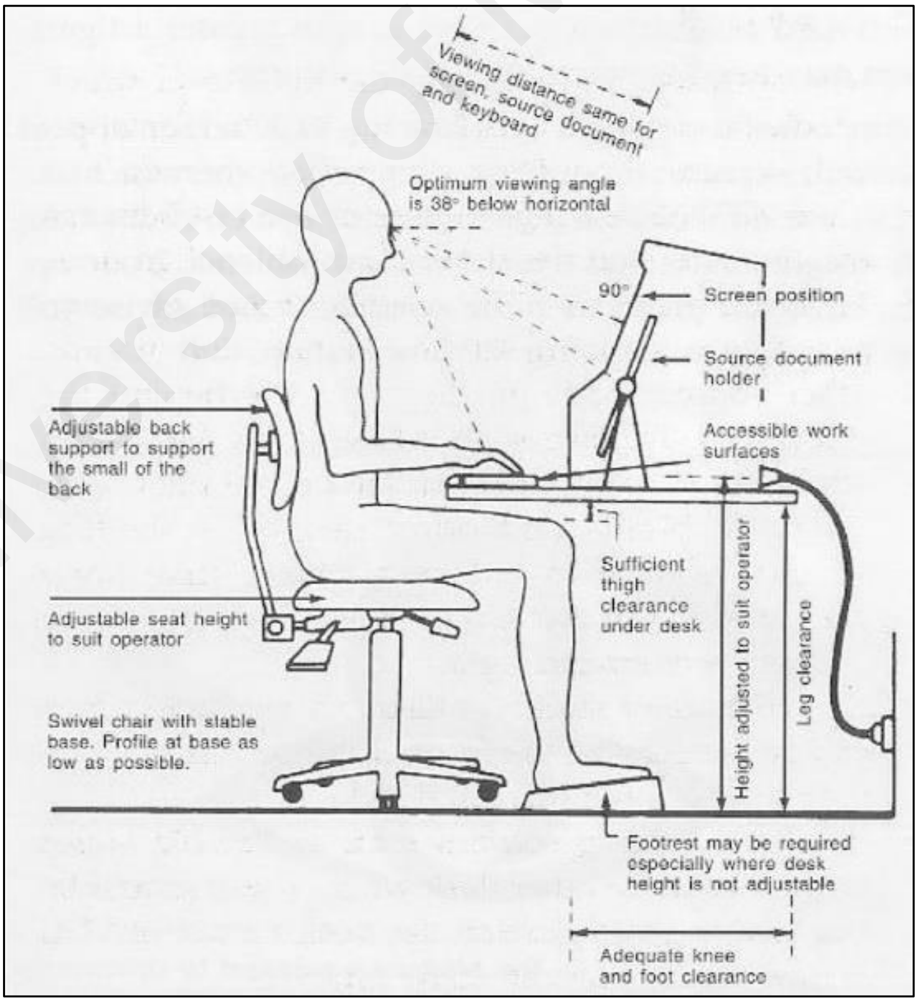

Figure 3.2: Ergonomic workstation setup (Source: Health Wallpaper, 2014)

Five neck muscle strength measurements and perceived neck pain rating were collected during the experiment. Maximum isometric neck strength was measured in two directions, which were extension and flexion. The subjects were asked to engage in a typing task which only involved keyboard as the input device. The subjects performed the typing task for 10 minutes before data was collected. It was shown in previous research that 10 minutes of computer task was sufficient to change the cervical muscle control pattern (Szeto et al., 2009). The participants were instructed to perform 40-minutes typing task in order to obtain the trend of any changes in both measurements.

3.5 Questionnaires

A set of questionnaires was prepared to acquire information from the subjects on demographic characteristics, workstation and job demand background, neck pain symptoms and the consequent disability.

3.5.1 Demographic Background

There were 11 questions prepared for obtaining demographic characteristic, including age, gender, marital status, and employment status. The information on the history of neck pain also was acquired from the participants. This set of questionnaire was used by Johnston et al. (2008) previously. These details were required in analyzing the individual factors contributing to the neck pain occurred. The questionnaire was as shown in Appendix A.

3.5.2 Workstation Set Up and Job Demand

There were 18 questions regarding the design of the workstation and the job demand of the test subjects. The questions concerning the workstation set up are such as the position of monitor and the characteristics of the chair. The questions related to job demand are such as the hours of working, duration of working with computer and duration of working before taking a break. The aim of this questionnaire is to identify the physical and the psychosocial factors in the development of the neck pain. The questionnaire was as shown in Appendix A.

3.5.3 Perceived Neck Pain and Disability

The Northwick Park Neck Pain Questionnaire (see Appendix B), which consists of 9 questions, was established to measure neck pain and the resulting disability of the patient. It was developed at Northwick Park Hospital in Middlesex England (Leak et al., 1994). It provides an objective measure for observing symptoms over a period of time. The survey includes the question about the neck pain intensity, the effect on sleeping and duration of symptoms. The subjects were to rate the closest severity and disability perceived, based on the description for each rating score.

3.6 Perceived Neck Pain during Experiment

The objective of this rating (see Appendix C) was to carry out comparison of intensity of neck pain perceived by the respondents throughout the computer task. This scale was based on 10-point Borg scale (0: No pain at all; 10: Extremely strong pain). Borg scale was reported to have higher sensitivity for assessing muscle fatigue (Grant et al., 1999). This questionnaire was to be given to the respondents at prior, every 10 minutes and after the computer task.

3.7 Anthropometry Measurement

One of the important keys of workstation design is the dimensional aspect that should match with the individual's anthropometry. Failure to satisfy this condition would result to reduction of work productivity, or worse, unnecessary injury to the employees (Das & Sengupta, 1996). Therefore, a collection of anthropometry data is required for designing or adjusting the workstation that is comfortable and conducive.

In this study, nine significant anthropometric measurements were taken, adopted from Vasavada et al.'s (2008) study. The list of measurements is as stated:

- Neck Circumference
- Head Circumference
- Head Depth
- Head Width
- Head Height
- Neck Length (C1-C7)
- Sternum-Tragus Length
- Neck Depth
- Neck Width

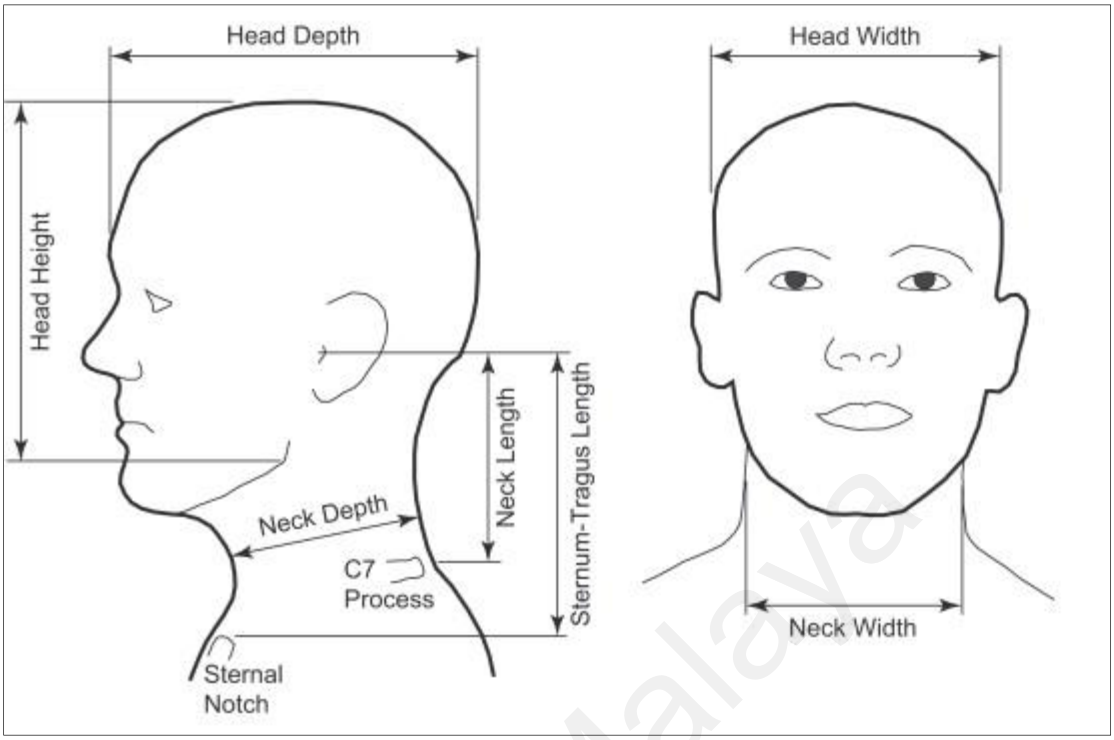

Figure 3.3: Lateral and frontal external head and neck anthropometric dimensions (Source: Vasavada et al., 2008)

The neck anthropometric dimensions were as shown in Figure 3.3. The length, depth and width of the head and neck were measured by using anthropometric instruments while the circumference of the head and neck were measured by using medical measuring tape. The instruments used were as shown in Figure 3.4. All measurements were taken three times. The averages of the measurements were used for analysis.

Figure 3.4: Martin anthropometer measuring set (Source: Mentone Educational Centre)

3.8 Neck Muscle Strength Measurement

Neck muscle strength measurements are useful in the quantification of musculoskeletal injuries (Cagnie et al., 2007). In this study, neck muscle strength was measured in flexion and extension by using HHD (Microfet2, Hoggan Health, West Jordan, UT).

To measure the neck muscle strength, the subjects were instructed to sit upright on a chair, with hands rested on their lap. Neck flexion strength was measured by applying horizontal force on the glabella through the dynamometer, and the subject was instructed to resist the force while maintaining the head and neck in a neutral posture. Extension strength was measured in similar manner, with the force applied to the opisthocranion. The location of glabella and opisthocranion are as shown in Figure 3.5. Each measurement continued for approximately 6 seconds, or until the subject could no longer resist. The subjects rested at least 30 seconds between trials, and the highest value of three strength measurements was considered to be the subject's maximum strength. This method was adopted from previous research (Kumar et al., 2001; Vasavada et al., 2008), with slight modification as suggested by a local physiotherapist. This technique was as shown in Figure 3.6.

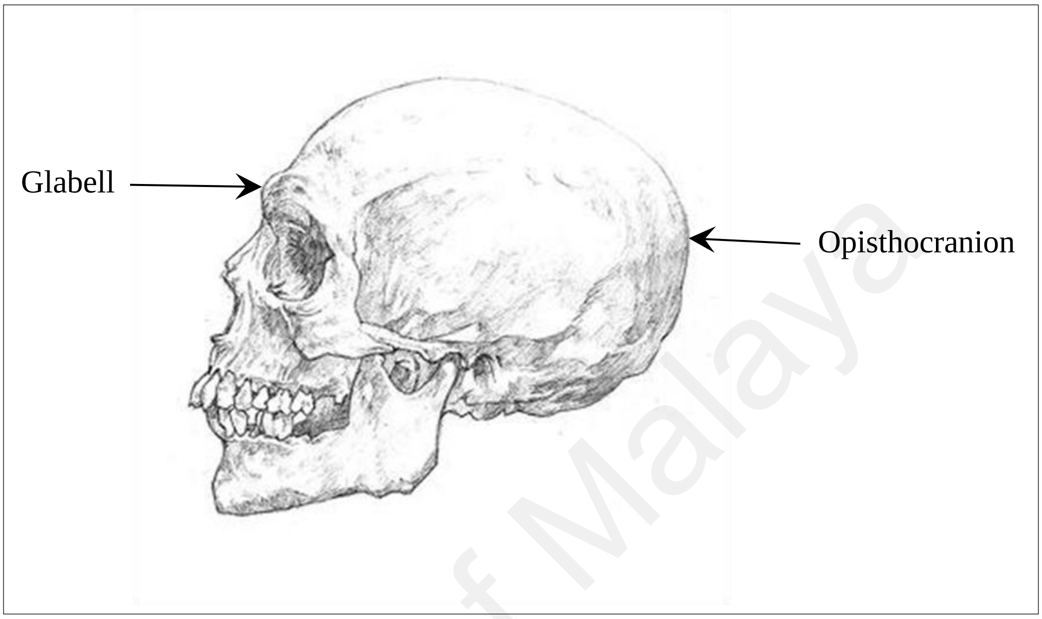

Figure 3.5: The location of glabella and opisthocranion on the human skull

Figure 3.6: The technique of neck muscle strength measurements. (a) Extension. (b) Flexion

3.9 Data Analysis

The data collected from the office workers was analyzed using the Statistical Package for Social Sciences (SPSS) version 20. Before performing any analysis, the normality test was done in order to determine whether the data was normally distributed and to assign appropriate analyses to test the hypotheses.

The relationship between risk factors (individual, workstation and task demand) and the neck symptoms and neck pain and disability was investigated using non-parametric analysis, which were Mann Whitney U Test and Kruskal-Wallis test, depends on the number of categories in the variables to be investigated. Comparison between risk factors in relation to neck muscle strength before the experiment was done by parametric test, which were t-test and ANOVA analysis.

Repeated Measures ANOVA has been performed to provide an analysis of variance of neck muscle strength and perceived neck pain at different time points during experiment. The relation between anthropometric and neck muscle strength data was investigated by calculating Pearson Product Moment Coefficient (r) for normally distributed data and Spearman’s Rho for non-normal distributed data. These analyses were performed to test the hypotheses that the size of head and neck will influence the difference in strength. Pearson Product Moment Coefficient (r) also was calculated to determine the correlation between duration of typing task, neck muscle strength and perceived neck pain in the participants of the experiment. All analyses were performed with significant level was defined at $p<0.1$ and $p<0.05$.

The extrapolation analysis was provided to answer the main question of this study which is to predict the onset of neck pain based on models of three predictors (neck extensor muscle strength, neck flexor muscle strength and duration of computer usage). This analysis was performed to generate the pattern of reduction/increment in muscle strength and perceived neck pain throughout the experiment. It also gives an overview of possible ability to produce a model for prediction and prevention of work-related neck pain. This analysis was performed using Microsoft Excel 2013.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents an analysis and discussion on the data collected from survey and measurements. The survey was obtained from returned questionnaire distributed to office workers. From the survey, this chapter shows the distribution of demographic data, workstation set-up and job task demand among the respondents. The relationship between individual, physical and psychological factors with the neck pain and disability score is also stated and elaborated in this chapter. The relationship was analyzed using two statistical methods which were Mann Whitney U Test and Kruskal-Wallis test.

The anthropometry data was composed by measuring the test subjects' body dimensions. The neck muscle strength data was collected by exerting force in flexion and extension directions towards their glabella and opisthocranion, respectively.

The process of analyzing the measurement data was divided into three parts. First, the data was analyzed by using descriptive analysis to understand the background of the research population. Secondly, the data were analyzed to find the associations between input and output parameters. In this section, the association between demographic data, the neck muscle strength measurement, the perceived neck pain and the duration of computer work were studied and discussed. The relation between anthropometry and muscle strength measurements also is presented in this section. Lastly, the data was used to predict the neck muscle strength and the level of perceived neck pain with the duration of computer usage for employees.

4.2 Survey Data

This section presents background information on 51 female respondents. There were 9 demographic characteristic factors examined in this study such as age, marital status, frequency of physical activity and duration of employment. The results are tabulated in Table 4.1.

Table 4.1: The individual factors for 51 female workers

Individual Factors	**n**	**Valid Percent**
Age		
20-29	22	43.1
30-39	18	35.3
40-49	9	17.6
>50	2	3.9
Marital Status		
Single	24	47.1
Married	27	52.9
Physical Activity		
Rarely	22	43.1
At least Once a week	29	56.9
Vision Correction		
None	20	40.0
Yes	30	60.0
Working Period		
Less than 7 years	23	45.1
7 years or more	28	54.9
Job Type		
Managerial	11	44.0
Clerical	14	56.0
Occupational Status		
Permanent	34	68.0
Contract	16	32.0
Typing style		
Touch style	11	22.0
Touch type with extra force	4	8.0
A few finger at a time	35	70.0
History of neck pain		
Yes	31	60.8
No	20	39.2

The women computer workers participated in this study were aged between 23 and 56 years old (mean=33.3; SD=8.46). Table 4.1 shows that almost half (43.1%) of the respondents were at the age range of 20-29 years old and only 3.9% of the respondents were at the age range of 50-59 years old. Majority of the respondents have been married (52.9%), performed physical activities at least once a week (56.9%) and using vision correction (60.0%). Most respondents had more than 7 years of work experience (54.9%) and using a few fingers at a time when typing (70.0%). The result also shows that 60.8% of respondents claimed to have history of neck pain, while the remaining 39.2% of them stated otherwise.

There were eleven workstation factors studied in this research such as the height of monitor screen and the monitor position. The results are reported in Table 4.2.

Table 4.2: The workstation design factors for 51 female workers

Workstation Characteristic Factors	n	Valid Percent
Height of monitor screen		
Eye level	38	74.5
Below eye level	11	21.6
Above eye level	2	3.9
Distance of monitor		
At arm length away	36	70.6
More or less than arm length	15	29.4
Position of monitor		
In front	44	86.3
To the side	7	13.7
Resting arm on desk while keying		
Yes	41	80.4
No	10	19.6
Arm parallel to floor while keying		
Yes	29	58.0
No	21	42.0
Adjustable back rest on chair		
Yes	24	47.1
No	27	52.9
Arm rest on chair		
Yes	34	66.7
No	17	33.3
Chair support thigh		
Yes	30	60.0
No	20	40.0
Neck support on chair		
Yes	13	25.5
No	38	74.5
Chair have castor base		
Yes	47	92.2
No	4	7.8
Ability of chair to swivel		
Yes	46	90.2
No	5	9.8

From Table 4.2, it shows that most of the respondents (74.5%) had their monitor screen at their eye level. 70.6% of respondents reported their monitor screen to be at arm-length distance. 86.3% of respondents claimed that they worked with the monitor screen to be in front of them. The result also shows that 80.4% of respondents were able to rest their arms on their desk while keying on the keyboard. Most respondents (58.0%) were able to set their arm parallel to the floor while performing keying task.

In terms of chair features, Table 4.2 highlighted that most chairs at the workstation used by the respondents have no adjustable back rest (52.9%) and neck support (74.5%). However, most of chairs have arm rest (66.7%), thigh support (60.0%), castor base (92.2%) and ability to swivel (90.2%).

There were seven job demand factors investigated in this study. The results are illustrated in Table 4.3.

Table 4.3: The job demand factors for 51 female workers

Job Demand Factors	n	Valid Percent
Working hours per day		
8 hours or less	34	68.0
More than 8 hours	16	32.0
Overtime hour per week		
Less than 8 hours	28	57.1
At least 8 hours	21	42.9
Computer used per day		
Less than 6 hours	21	41.2
At least 6 hours	30	58.8
Time spent sitting before taking a break		
Less than 2 hours	31	60.8
At least 2 hours	20	39.2
Time spent on computer before changing to non-computer task		
Less than 2 hours	35	70.0
At least 2 hours	15	30.0
Sharing workstation		
Yes	5	9.8
No	46	90.2
Using telephone while keying		
Less than 8 times/day	38	74.5
At least 8 times/day	13	25.5
Perception towards Workstation Comfort		
Very Comfortable	3	5.9
Comfortable	42	82.4
Uncomfortable	6	11.8

Table 4.3 shows that 68.0% of the participants were working for 8 hours per day or less and most of them used computer for at least 6 hours per day (58.8%). Most of these employees took less than 2 hours sat at the workstation before taking a break (60.8%) and changed to a non-computer task (70.0%). 90.2% of respondents did not share workstation with other colleagues. 74.5% of them used telephone while performing keying task less than 8 times per day. Majority of respondents (82.4%) reported their workstation as comfortable.

4.3 Measurements Data

4.3.1. Anthropometric Measurements

Table 4.4 shows the results of the anthropometric data of 16 subjects who participated in the experiment. The means of height, body mass and body mass index of the sample are 156.32 ± 5.17 cm, 57.25 ± 10.87 kg and 23.51 ± 4.90, respectively. The neck length (C1-C7)/neck circumference and neck width/neck depth ratios are 0.31 ± 0.09 and 0.99 ± 0.07, respectively. The subjects were in fixed position while the measurements were taken.

Table 4.4: The mean and standard deviation of anthropometric dimensions of subjects.

Measurement	Mean	SD (mm)
Weight	57.25	10.87
Height	156.32	5.17
BMI	23.51	4.90
Neck Circumference	30.65	2.10
Head Circumference	54.38	1.92
Head Depth	17.64	0.74
Head Width	14.09	0.96
Head Height	20.43	1.21
Neck Length (C1-C7)	9.50	2.51
Neck Depth	8.60	0.62
Sternum-Tragus Length	17.04	1.88
Neck Width	8.47	0.60
Neck Length (C1-C7) / Neck Circumference	0.31	0.09
Neck Width / Neck Depth	0.99	0.07
Neck Circumference / Head Circumference	0.56	0.03

4.3.1 Neck Muscle Strength Measurements and Perceived Neck Pain Score

Table 4.5 and 4.6 provide the mean muscle strength measurements and perceived neck pain score by the subjects at each time point of the experiment, respectively.

Table 4.5: Muscle strength measurements at different time point of experiment

Time Spent on Computer	Extension (N)			Flexion (N)		
	Mean	SD	% Reduction	Mean	SD	% Reduction
Before	61.9	19.88		54.3	21.21	
10 mins	57.6	16.74	6.95	53.8	20.31	0.94
20 mins	54.3	15.79	5.71	49.7	18.27	7.63
30 mins	51.5	14.51	5.18	47.9	18.84	3.59
40 mins	51.1	18.34	0.66	48.2	19.59	-0.64

Table 4.6: Perceived neck pain score at different time point of experiment

Time Spent on Computer	Rating of perceived neck pain		
	Mean	**SD**	**% Increment**
Before	1.0	1.187	
10 mins	1.1	0.968	9.51
20 mins	1.6	1.233	40.36
30 mins	2.1	1.538	30.31
40 mins	2.4	1.758	15.65

Generally, Table 4.5 shows that neck muscle strength decreased for both extension (17.3%) and flexion (11.2%) after 40 minutes of typing. In contrast, Table 4.6 shows that the rating of perceived neck pain increased twofold (220 percent) after 40 minutes of typing. Flexion/extension strength ratios for each time point were similar (below 1.00).

4.4 Different Associations Between Variables

4.4.1 Relationship between Neck Pain and Disability with Risk Factors

The significant difference between each group of individual factors and the neck pain and disability score were investigated. Non-parametric analysis were used since the data has no normalized distribution. Mann Whitney U Test was used for the analysis except for age and typing style groups which used Kruskal-Wallis test. The results are presented in Table 4.7.

Table 4.7: Differences between individual factors and neck pain and disability score.

Individual Factors	p-value (two-tailed)
Age	0.813
Marital Status	0.636
Physical Activity	0.620
Vision Correction	0.641
Working Period	0.947
Job Type	0.007**
Occupational Status	0.620
Typing style	0.925
History of neck pain	0.003**

**Significant at the 0.05 level

From the analysis for individual factors (Table 4.7), two items were found to have significant different level of responses between respondents. On job type, the respondents who were in clerical job have significantly higher neck pain and disability score than those in managerial job with U = 27.5, p = 0.007 (two-tailed). The mean neck pain and disability score among employees in clerical group was 24.1, higher than ones from managerial group which was 10.7. This is thought to be due to the static posture and load of work that the workers from clerical group are obliged to perform during the working hours. On the other hand, the workers from managerial work are obliged to move around and spend most of the time changing the position and activities. Hence, they suffered less neck pain and disability than those from clerical group.

The respondents with history of neck pain have given significantly higher neck pain and disability score than those with no history of neck pain with U = 157, p = .003 (two-tailed). This result was supported by previous findings (Johnston et al., 2008; Leaver et al., 2013). Nolet et al. (2011) stated that an individual with previous history of neck pain was more likely to report neck pain in future. Nevertheless, this study has lack of knowledge of the characteristics of previous neck pain such as the cause, the duration and the time of occurrence. This information might be useful to predict the severity of current neck pain symptom. For example, Smedley et al. (2003) have acknowledged that the highest risk of recurrent neck pain may occur when previous musculoskeletal symptoms have been prolonged and present in the past one year.

The Mann-Whitney U and Kruskal Wallis tests were used to test for significant differences between the workstation characteristic factors and the neck pain and disability score. The results are reported in Table 4.8.

Table 4.8: Differences between workstation characteristic factors and neck pain and disability score.

Workstation Characteristic Factors	**p-value (two-tailed)**
Height of monitor screen	0.274
Distance of monitor	0.555
Position of monitor	0.005**
Resting arm on desk while keying	0.686
Arm parallel to floor while keying	0.629
Adjustable back rest on chair	0.643
Arm rest on chair	0.346
Chair support thigh	0.532
Neck support on chair	0.820
Chair has castor base	0.419
Ability of chair to swivel	0.162

**Significant at the 0.05 level

Concerning workstation design factors, the position of monitor screen at the respondents' side was the only significant risk factor to higher neck pain and disability. It was known that placing the monitor to the side of the user's body may cause neck and shoulder pain due to twisting and awkward posture. Looking off to one side for prolonged period of time may cause fatigue and shortening of cervical muscles which may lead to an increase in neck pain (Hoobchaak, 2013). The higher neck pain and disability score associated with positioning of monitor to the side of the user, was consistent with the results published study (Szeto & Sham, 2008). Other characteristics showed a non-significant relationship towards having a neck pain and disability.

There were seven job demand factors investigated in this study. A test for significant differences was conducted using the non-parametric Mann-Whitney U and Kruskal Wallis tests. Only one variable ("Overtime hour per week") was treated with parametric t-test since the data was normally distributed. The results are illustrated in Table 4.9.

Table 4.9: Differences between job demand factors and neck pain and disability score.

Job Demand Factors	**p-value (two-tailed)**
Working hours per day	0.091*
Overtime hour per week	0.683
Computer used per day	0.969
Time spent sitting before taking a break	0.139
Time spent on computer before changing to non-computer task	0.199
Sharing workstation	0.657
Using telephone while keying	0.034**
Perception towards Workstation Comfort	0.987

*Significant at the 0.10 level
**Significant at the 0.05 level

Table 4.9 illustrated that there is significant association between neck pain and disability score and working hours per day ($p < 0.1$). This finding may be resulted from the higher workload of employees who worked for longer working hours. Consequently, it will cause tiredness, fatigue and job stress (Park et al., 2001). Elevated mental stress may produce higher risk of getting neck pain due to increase in activation of neck muscles (Nimbarte et al., 2012).

The findings also showed significant relationship between frequency of simultaneous usage of telephone and keyboard and neck pain and disability score ($p < 0.05$). The use of telephone while working may cause the worker to adopt awkward postures. For example, a worker is required to tilt the head in order to hold the receiver in between shoulder and head. This posture may put stress on the neck region and consequently may result in neck pain (Patel, 2013). Significant relationship has been found between the time spent on the telephone and self-reported neck symptoms previously (Bernard et al., 1994). Meanwhile, Johnston et al. (2008) has found no association between these two parameters. However, this latter finding did not emphasize on duration of the telephone use during computer work, which could be the cause of different result from Bernard et al. (1994).

No relation was found between any other job demand factors and neck pain and disability score.

4.4.2 Neck Muscle Strength, Perceived Neck Pain and Duration of Computer Task

In the repeated measures ANOVA analysis, the results showed that the mean neck muscle strengths in both direction and the score of self-rated neck pain had significant difference between time points ($p < 0.05$). On the other hand, the mean flexion/extension neck strength ratio was not significantly different between the time points. The results of the post-hoc analysis are summarized in Table 4.10.

Table 4.10: The pairwise comparison between each time point with the starting point of the experiment for neck muscle strengths and perceived neck pain

Variables	Time point (min)	Mean Difference	p	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
Extensor Muscle Strength	10	3.676	0.782	-4.075	11.427
	20	6.964	0.074	-.439	14.366
	30	9.776	0.077	-.687	20.239
	40	10.114	0.009**	2.078	18.149
Flexor Muscle Strength	10	.513	1.000	-4.512	5.537
	20	4.613	0.464	-2.829	12.054
	30	6.394	0.327	-2.856	15.644
	40	6.088	0.049**	.016	12.159
Perceived neck pain	10	-.099	0.970	-.400	.201
	20	-.561	0.001**	-.890	-.232
	30	-1.048	0.000**	-1.650	-.446
	40	-1.313	0.008**	-2.337	-.290

**Significant with significance level of $p<0.05$

As shown, extensor muscle strength elicited a slight reduction from prior to typing task to 10 minutes, 20 minutes and 30 minutes of typing; this is not statistically significant ($p \geq 0.05$). However, the extensor muscle strength reduced after 40 minutes of typing, a significant difference when compared to prior of typing task ($p < 0.05$). Hence, we conclude that 40 minutes of typing is the least duration that could elicit a statistically significant reduction in extensor muscle strength.

Similar finding was also shown for neck flexor muscle strength, which caused a non-significant reduction ($p \geq 0.05$) from the beginning of the experiment to 10 minutes, 20 minutes and 30 minutes of typing. Nevertheless, the neck flexor muscle strength decreased after 40 minutes of typing; this was significantly different than prior of typing task ($p < 0.05$). Therefore, it is concluded that 40 minutes of typing–not before–may lead to a significant reduction in neck flexor muscle strength.

The results from Table 4.10 also indicated that perceived neck pain has a small increment from prior to 10 minutes of typing, which was not statistically significant ($p \geq 0.05$). Unlike the measurements of neck muscle strength, the self-rated neck pain increased significantly after 20 minutes of typing ($p < 0.05$) and increases further following continuous typing. Conclusively, a typing task may cause a significant increment in neck pain rating after 20 minutes of typing.

These findings were supported by previous research which has shown that people who work with computer for a longer time tend to sport an awkward posture by lowering the cervical flexion (FHP) or by increasing the cervical extension, in order to look at monitor screen (Szeto et al., 2002). Yang and Cho (2012) have observed a gradual increase of head flexion angle at the end of a 8-minute typing task, which they assumed to be caused by increased neck muscles tension and weakness. These findings show that the duration of computer usage can be a factor to cause muscle weakness and consequently, neck pain.

Sedentary and light job such as working with computer has been stated to be at risk of WRMD in many previous studies (Foye et al., 2002; Korhan, 2012; Wahlström, 2005). Other light job that has been shown to be at risk of WRMD was light manual assembly (Nur et al., 2014; Zadry et al., 2009). As shown in previous research (Zadry et al., 2009), the workers in light manual assembly have been observed to have tendency to fatigue in muscles at neck-shoulder region with time of working. In other study, fatigue development was found over time of working in across the muscle of the workers who worked in a repetitive low-intensity task (Bosch et al.). Associating this finding with the results of the present study, it was assumed that the workers may encounter muscle fatigue and eventually MSD if they continue to work for more than 40 minutes as the muscle has shown a significant decrease in strength.

Although the neck muscle strength decreased significantly with the time spent on computer work, the neck flexion/extension strength ratio was equivalent throughout the experiment. This shows that the duration of computer work seems to have comparable effects on neck flexion strength and extension muscle strength. The neck extensor muscles play an important role to support the head in an upright position against gravity forces. This explains the great difference in muscle strength between the posterior and anterior muscles (Häkkinen et al., 2004). Häkkinen et al. (2005) stated that the difference in muscle strength was approximately 50% between the posterior and anterior neck muscles.

Neck pain is typically linked to extensive computer users (Ming et al., 2004). Ye et al. (2007) have found a strong association between neck disorders with the workers who worked with visual display terminal for more than 5 hours per day. This corroborates with the finding from this present study that workers perceived higher rating of neck pain when they have to type for a longer duration. This may be due to the subjects' rigid posture for a prolonged period that may increase the likelihood of musculoskeletal injury (Bhattacharya & McGlothlin, 2012). Other possible reason is the increase of head flexion while typing. In studying the kinematic patterns of symptomatic and asymptomatic subjects during prolonged computer task, Szeto et al. (2005) found that both groups had head flexion throughout the one-hour typing. FHP may cause work-related neck and upper limb disorders and hence, increase use of the computer will likely cause such occurrence (Szeto et al., 2002).

Muscular weakness has been stated as the cause of neck pain among office workers (Ylinen et al., 2004). This conclusion supports the discovery in this present study that neck muscle strength decreases significantly over time spent on computer, while the result for perceived neck pain by the workers was increased with time spent on computer work. These findings also confirmed that cervical flexor strength has significant but weak negative association with neck disability in healthy and myogenous temporomandibular disorders patients, as found by Armijo-Olivo et al. (2010). Static loading on the neck region caused by posture maintenance will result in discomfort and fatigue due to declined blood flow to the tensed muscles, which can lead to injury in time (Employee Work-Life Support Services"Ergonomics Best Practices,"). Sustained, long-term abnormal physiological loads imposed by poor posture decrease neck muscle strength that would eventually cause neck pain (Karthikeyan et al., 2013). However, in this present study, no clear association between neck muscle strength and the occurrence of neck pain was discovered. A further investigation on the relationship between neck muscle strength and the level of perceived neck pain could garner a better understanding of the muscles' role in this type of injury.

4.4.3 Neck Muscle Strength and Anthropometric Data

Anthropometric measurement is one of important aspect in assessment of muscle strengths (Sadeghi et al., 2012). Investigation in linking the head anthropometry measurements with the difference in neck muscle strength is relatively new. Hence, specific research exploring this association is currently very limited. Furthermore, very few information exists in the scientific literature as to what head anthropometry factors contribute to increase in neck muscle strength. Therefore, the findings in this thesis aim to explore the relationship between both parameters.

The results of Pearson’s Correlation show a positively correlated relationship between extensor neck muscle strength and head depth as well as head height. This relationship is statistically significant with $r(16) = 0.578$, $p < 0.05$ and $r(16) = 0.558$, $p < 0.05$, respectively. This relationship explains that when the depth and height of the head was greater, the extensor muscle strength of the respondents was greater as well.

Based on these results, it can be assumed that there is a relationship between head measurements and neck extensor muscle strength in biomechanical aspects. This finding in this present study was similar with previous research which reported moderate correlation between head depth and semispinalis cervicis muscle, which is one of neck extensor muscles (Zainon, 2009). However, the researcher also found a moderate correlation between this muscle and neck length, which contradicted with the finding of the present study. The difference of this finding may be due to different subjects' position when muscle strength measurements were taken. The ambiguity of the findings in this study indicates the requirement of further research in this specific issue.

This analysis also affirmed no statistically significant correlation between any of anthropometric data and neck flexor muscle strength ($p > 0.05$). The results of analysis are shown in Table 4.11.

Table 4.11: Pearson's Correlation between neck muscle strength and anthropometric data (*n*=16)

Muscle Strength	Weight	Height	BMI	Neck Circumference	Head Circumference	Head Depth	Head Height
Extension	0.316	0.414	0.179	0.307	0.404	0.578**	0.558**
Flexion	-0.002	0.280	-0.086	0.101	0.324	0.484	0.359

Table 4.11, continued

Muscle Strength	Head Width	Neck Length (C1-C7)	Sternum-Tragus Length	Neck Width	Neck Slender	Neck Shape	Neck/Head Circumference
Extension	0.402	0.089	-0.077	0.244	0.040	-0.372	0.134
Flexion	0.252	0.166	-0.016	0.232	0.144	-0.052	-0.119

**Significant at the 0.05 leveL

4.5 Prediction of Perceived Neck Pain by Extrapolation

In this study, an extrapolation analysis was used in analyzing the data generally to estimate the neck muscle strength and perceived neck pain after a period of time of computer usage. An exponential extrapolation analysis was used as it showed the best-fit characteristic to the data points ($r^2 \rightarrow 1$). Although extrapolation analyses tends to have greater uncertainty, it is still able to present a forecasted pattern of the neck muscle strength and level of perceived neck pain. Figures 4.1-4.3 illustrate the results of the extrapolation analysis showing the forecasted perceived neck pain after 1-hour computer work.

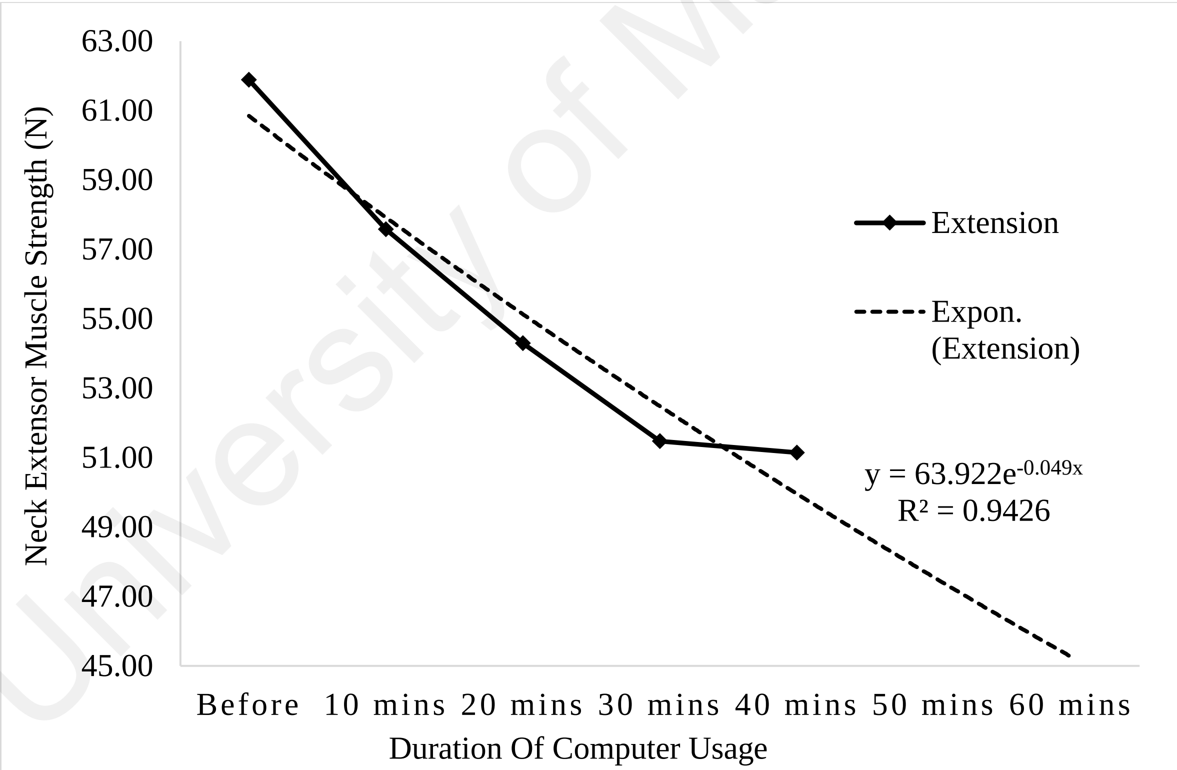

Figure 4.1: The change in neck extensor muscle strength with duration of computer usage.

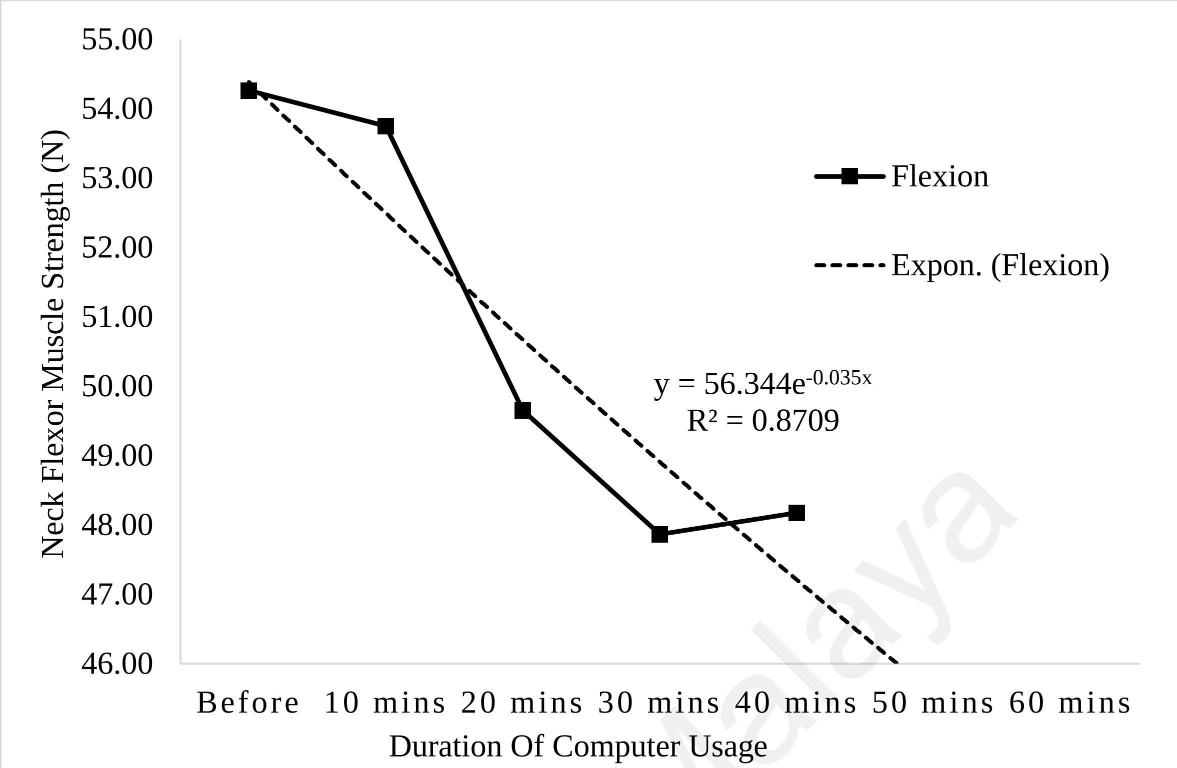

Figure 4.2: The change in neck flexor muscle strength with duration of computer usage.

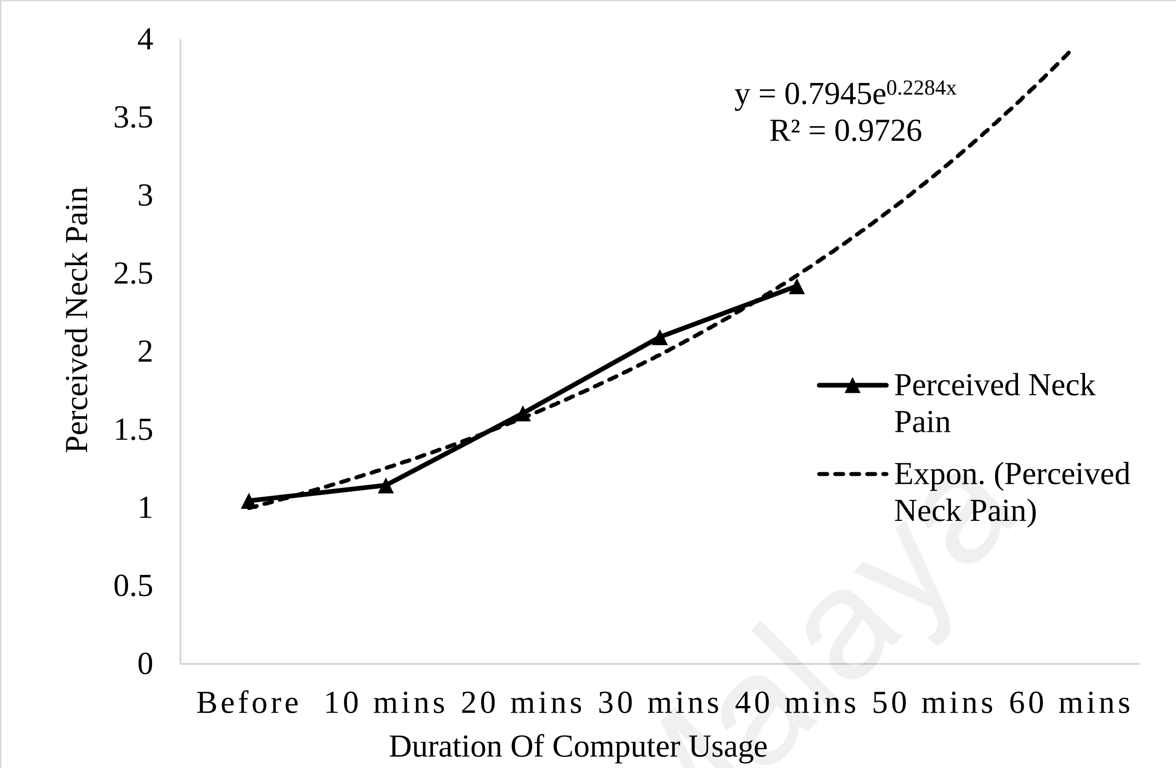

Figure 4.3: The change in perceived neck pain with duration of computer usage.

From Figure 4.1 and Figure 4.2, the reduction of neck muscle strength in both direction investigated was well described by an exponential decay with the increase time of computer usage. This finding is in a good agreement with many previous researches in describing muscle force and fatigue (Geronilla, 2008; Ma et al., 2009; Power et al., 2014; Xia & Law, 2008).

In contrary, the perceived neck pain was shown to increase continuously and exponentially with duration of computer work (Figure 4.3). Figure 4.3 also shows the increase in growth rate of perceived neck pain experienced by the workers as they continue to use computer for longer time.

These findings also have given an insight on the relationship between the neck muscle strength measurements and the perceived neck pain by the subjects. The results have shown that as the neck muscle strength decreases, the perceived neck pain will increase. In a prospective cohort study, Wahlstrom et al. (2004) reported association between perceived muscular tension and an incidence of neck pain. Öztürk and Esin (2011), in a study of female sewing machine operators, showed a high prevalence rate of musculoskeletal pain or discomfort in the neck region (50.5%) and also found 65% of the women had experienced MSD over the last 6 months. From these previous studies, it shows that increasing neck pain perceived by the workers is very much concerned as it may lead to other musculoskeletal symptoms.

According to previous findings, there was more than 20 percent decrease in neck muscle strength in both direction (Häkkinen et al., 2005; Häkkinen et al., 2004; Ylinen et al., 2004). Assuming the workers were healthy before starting the experiment, using the present extrapolation mathematical model, they were predicted to have 20 percent decrease in neck muscle strength after approximately 50 minute and 70 minute of computer work for extension and flexion, respectively. Based on this prediction, the score of perceived neck pain rating would be 2.49 (between "light pain" and "moderate pain") at 50-minute of computer work. To prevent severe discomfort and injury, the workers are encouraged to take short break after 30 minutes of computer work as recommended by The Environmental Health & Environmental Health & Safety of Stanford University.

In a prospective cohort study, Wahlstrom et al. (2004) reported association between perceived muscular tension and an incidence of neck pain. Öztürk and Esin (2011), in a study of female sewing machine operators, showed a high prevalence rate of musculoskeletal pain or discomfort in the neck region (50.5%) and also found 65% of the women had experienced MSD over the last 6 months. From these previous studies, it shows that increasing neck pain perceived by the workers is very much concerned as it may lead to other musculoskeletal symptoms.

Due to limitations, these extrapolation models only forecasted a short time frame which would have higher probability of success. In future study, it is suggested to prolong the experiment with more data points in order to obtain a longer range of pattern changes in both neck muscle strength and perceived neck pain.

Nevertheless, the outcome of this research is very useful to improve the working conditions for better safety and health. The findings of this study can be utilized as a guideline to put a cut-off point between the computer task and the rest break. It is suggested for an organization to put a restriction on the time spent on a computer by the employees to avoid unwanted injuries, as well as increase work productivity.

4.6 Summary

The results of the analyses have been presented and discussed in this chapter.

The risk factors evaluated showed the job type, history of neck pain, position of monitor, working hours per day and using telephone and keyboard simultaneously have statistical significance with the score of neck pain and disability. The history of neck pain and working hours per day were significantly different in neck extensor muscle strength; while only the job type was the only risk factor with significant difference in neck flexor muscle strength. Both neck extensor and flexor muscle strengths were significantly reduced after 40-minute computer work. On the other hand, the workers' perceived neck pain increased significantly only after 20-minute computer work. There were significant correlation between neck extensor muscle strength and two anthropometric data: head depth and head height. Extrapolation analyses stated the neck extensor and flexor muscle strengths will decrease exponentially with the time spent on computer. Oppositely, the perceived neck pain will increase continuously with time of computer task.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

In this final chapter, a brief summary of the study is presented. Details of the major finding in the study are provided, and some recommendations are proposed.

6.2 Conclusions

The aim of the present study was to determine the risk factors and relationship between neck muscle strength with the duration of computer work in contributing to neck pain among women employees at University of Malaya, Malaysia. In order to achieve this aim, the possible risk factors of neck pain symptoms were identified and an experiment was conducted to measure neck muscle strength at several time points of computer work.

A statistical analysis has been performed in order to find the contributing risk factors to neck pain among women office employees. The analysis suggested that the neck pain symptoms were significantly associated with history of neck pain, the position of monitor, the time spent at workstation before taking a break and the usage of telephone while keying. On the other hand, the neck pain and disability score was found to be significantly associated with job type, history of neck pain, the position of monitor, the working hours and the usage of telephone while keying.

The relationship between the neck muscle strength, perceived neck pain and the time spent on computer works also has been determined. The findings affirmed that neck muscle strength in extension and flexion was reduced significantly after 40 minutes of typing. The perceived neck pain's score was increasing with the time spent on computer work and became significant after 20 minutes of typing. The perceived neck pain score was significantly correlated with the duration of computer work as well as neck extensor and flexor muscle strengths, showing that the occurrence of neck injuries was closely related with the changes in neck muscle strength and the time spent on computer work.

The pattern of changes of neck muscle strength and perceived neck pain also was obtained by using an extrapolation method. Based on the extrapolation models, it can be assumed that the neck muscle strengths in extension and flexion were decreased exponentially with the increase of working hours with computer. On the other hand, the perceived neck pain was predicted to increase continuously and exponentially with duration of computer work.

These findings may inform employers about the importance of proper job scheduling in order to prevent any injuries. Since this study emphasized on significant contribution of longer duration at computer to the weaker neck muscle strength and higher perceived neck pain, employers can encourage the workers to take regular short rest break and to alternate with a non-computer work task. Implementation of better ergonomic environment may help the human force to work more effectively, efficiently and productively on their jobs, and eventually creates a successful organization.

6.3 Future Work Recommendations

Based on the findings of this study, the following suggestions are suggested:

1. Further research is required involving higher number of samples, and including both genders.
2. In future studies, a more detailed analysis should be performed to generate a statistical model to predict the duration of computer work for causing neck pain.
3. The objectives of this study can be explored further with different computer task, such as the use of mouse.
4. In order to garner better understanding on the occurrence of neck pain, more information such as duration, cause and time of the incidence should be obtained.
5. In order to support the finding from the present study, more parameters can be measured such as muscle activity, heart rate and posture.
6. The survey can be improved by obtaining the information on environmental factors at the workstation such as the level of noise and the temperature at the workstation.
7. Different technique of muscle strength measurements can be employed to test the reliability of the technique from the present study.

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List of Publications and Papers Presented

ISI JOURNAL

1. Siti Rusyida Rohim, Siti Zawiah Md Dawal. The Effects of Duration of Computer Work on Neck Muscle Strength and Perceived Neck Pain Among Women Workers. Submitted to International Journal of Occupational Safety and Ergonomics.

CONFERENCE

1. Siti Rusyida Rohim, Siti Zawiah Md Dawal. The Perceived Neck Pain Among Women Administrative Staff with Prolonged Computer Usage. Paper presented at 2nd Regional Conference on Campus Sustainability.

Appendix A

Demographic Questionnaire

PERSONAL BACKGROUND
LATAR BELAKANG PERIBADI

1. Name: ____
   Nama

2. Age : ______________________ years
   Umur *tahun*

3. Gender
   Jantina
   - ☐ Male *Lelaki*
   - ☐ Female *Perempuan*

4. Marital status
   Status perkahwinan
   - ☐ Single *Bujang*
   - ☐ Married *Berkahwin*

5. Frequency of physical activity enough to perspire
   Kekerapan melakukan aktiviti fizikal yang cukup untuk berpeluh
   - ☐ Never *Tidak pernah*
   - ☐ Rarely *Jarang-jarang*
   - ☐ Once per week *Sekali seminggu*
   - ☐ Everyday *Setiap hari*

6. Use of vision correction
   Penggunaan alat pembetulan penglihatan
   - ☐ None *Tiada*
   - ☐ Glasses *Cermin mata*
   - ☐ Contact lenses *Kanta lekap*

7. Smoking habits
Tabiat merokok

- [ ] Never smoked *Tidak pernah merokok*
- [ ] Past smoker *Pernah merokok*
- [ ] Current smoker *Merokok*

8. How long have you worked with the organization? ____________________ years
Berapa lamakah anda bekerja di organisasi ini *tahun*

9. Job type
Jenis pekerjaan

- [ ] Managerial *Pengurusan*
- [ ] Clerical *Pengkeranian*
- [ ] Others *Lain-lain*

10. Occupational status
Status pekerjaan

- [ ] Permanent *Tetap*
- [ ] Temporary *Sementara*
- [ ] Contract *Kontrak*

11. Type style
Gaya menaip

- [ ] Touch type *Jenis sentuhan*
- [ ] Touch type with extra force *Jenis sentuhan dengan kekuatan tambahan*
- [ ] A few fingers at a time *Beberapa jari dalam masa yang sama*

12. Do you have any history of neck pain?
Adakah anda mempunyai pengalaman sakit leher?

- [ ] Yes *Ya*
- [ ] No *Tidak*

TASK DEMANDS AND WORKSTATION SET-UP
KEPERLUAN TUGAS DAN STRUKTUR STESYEN KERJA

1. How many hours do you work per day?
   Berapa jamkah anda bekerja sehari?
   - ☐ Less than 8 hours / *Kurang daripada 8 jam*
   - ☐ 8 hours / *8 jam*
   - ☐ More than 8 hours / *Lebih daripada 8 jam*

2. What is your average duration of overtime per month?
   Berapakah tempoh purata anda bekerja lebih masa dalam sebulan?
   - ☐ Less than 8 hours / *Kurang daripada 8 jam*
   - ☐ 8 hours / *8 jam*
   - ☐ More than 8 hours / *Lebih daripada 8 jam*

3. What is the average duration of your computer usage per day?
   Berapakah tempoh purata penggunaan komputer anda dalam sehari?
   - ☐ 0-2 hours / *0-2 jam*
   - ☐ 2-4 hours / *2-4 jam*
   - ☐ 4-6 hours / *4-6 jam*
   - ☐ 6-8 hours / *6-8 jam*
   - ☐ More than 8 hours / *Lebih dari 8 jam*

4. What is the average duration of computer keyboard usage per day?
   Berapakah tempoh purata penggunaan papan kekunci komputer dalam sehari?
   - ☐ 0-2 hours / *0-2 jam*
   - ☐ 2-4 hours / *2-4 jam*
   - ☐ 4-6 hours / *4-6 jam*
   - ☐ 6-8 hours / *6-8 jam*
   - ☐ More than 8 hours / *Lebih dari 8 jam*

5. What is the average duration of computer mouse usage per day?
Berapakah tempoh purata penggunaan tetikus komputer anda dalam sehari?

- ☐ 0-2 hours *0-2 jam*
- ☐ 2-4 hours *2-4 jam*
- ☐ 4-6 hours *4-6 jam*
- ☐ 6-8 hours *6-8 jam*
- ☐ More than 8 hours *Lebih dari 8 jam*

6. How long do you sit at your workstation before taking a break?
Berapa lamakah anda duduk di stesyen kerja anda sebelum mengambil rehat seketika?

- ☐ Less than 30 min/hour *Kurang dari 30 min/jam*
- ☐ 30 min/hour *30 min/jam*
- ☐ 1-2 hours *1-2 jam*
- ☐ 2-3 hours 2-3 jam
- ☐ More than 3 hours *Lebih dari 3 jam*

7. How long do you spend your time at your computer before changing to a non-computer task?
Berapa lamakah anda menggunakan komputer anda sebelum bertukar ke tugasan tanpa menggunakan komputer?

- ☐ Less than 30 min/hour *Kurang dari 30 min/jam*
- ☐ 30 min/hour *30 min/jam*
- ☐ 1-2 hours *1-2 jam*
- ☐ 2-3 hours 2-3 jam
- ☐ More than 3 hours *Lebih dari 3 jam*

8. Do you share the workstation?
Adakah anda berkongsi stesyen kerja?

- ☐ Yes *Ya*
- ☐ No *Tidak*

9. How many times do you use the telephone and the computer keyboard at the same time?
Berapa kalikah anda menggunakan telefon dan papan kekunci komputer pada masa yang sama?

- ☐ Less than 8 times/day *Kurang dari 8 kali/sehari*
- ☐ More than 8 times/day *Lebih dari 8 kali/sehari*

10. How do you feel about your workstation?
Apakah perasaan anda terhadap stesyen kerja anda?

- ☐ Very comfortable *Sangat selesa*
- ☐ Comfortable *Selesa*
- ☐ Uncomfortable *Tidak selesa*
- ☐ Very uncomfortable *Sangat tidak selesa*

11. The height of the top of your monitor screen is positioned at
Ketinggian bahagian atas paparam monitor anda adalah

- ☐ Eye level *Aras mata*
- ☐ Below eye level *Di bawah aras mata*
- ☐ Above eye level *Di atas aras mata*

12. What is the distance of your monitor from you?
Berapakah jarak monitor anda dari diri anda?

- ☐ At arm length away *Sejarak panjang lengan*
- ☐ Less than arm length away *Jarak kurang daripada panjang lengan*
- ☐ More than arm length away *Jarak lebih daripada panjang lengan*

13. Where is the position of your monitor?
Di manakah kedudukan monitor anda?

- ☐ In front *Di hadapan*
- ☐ To the side *Di sisi*

14. Are you able to rest your forearms on desk top when keying?
Adakah anda boleh merehatkan bahagian bawah lengan anda di atas meja ketika menaip?

- ☐ Yes *Ya*
- ☐ No *Tidak*

15. Is the position of your forearms parallel to the floor while working?
Adakah kedudukan bahagian bawah lengan anda selari dengan lantai ketika bekerja?

- ☐ Yes *Ya*
- ☐ No *Tidak*

16. Does your chair have:
Adakah kerusi anda mempunyai:

a) An adjustable back rest?
Tempat rehat belakang boleh laras?

☐ Yes *Ya* ☐ No *Tidak*

b) Arm rest?
Tempat rehat lengan?

☐ Yes *Ya* ☐ No *Tidak*

c) Thigh support?
Sokongan peha

☐ Yes *Ya* ☐ No *Tidak*

d) Neck support?
Sokongan leher?

☐ Yes *Ya* ☐ No *Tidak*

e) A castor base?
Tapak beroda?

☐ Yes *Ya* ☐ No *Tidak*

f) Swivel chair?
Kerusi pusing?

☐ Yes *Ya* ☐ No *Tidak*

Appendix B

Neck Pain and Disability Questionnaire

Instructions:

The questionnaire has been designed to give us information as to how your NECK PAIN has affected your ability to manage in everyday life. Please answer every question and mark in each section ONLY THE ONE BOX which applies to you. We realize you may consider that two of the statements in any one section relates to you but PLEASE JUST MARK THE BOX WHICH MOST CLOSELY DESCRIBES YOUR PROBLEM.

Parameter	**Status**	**Points**
Neck pain intensity	I have no pain at the moment	0
	The pain is mild at the moment	1
	The pain is moderate at the moment	2
	The pain is severe at the moment	3
	The pain is the worst imaginable at the moment	4
Neck pain and sleeping	My sleep is never disturbed by pain	0
	My sleep occasionally disturbed by pain	1
	My sleep regularly disturbed by pain	2
	Because of paun I have less than 5 hour sleep in total	3
	Becaise of pain I have less than 2 hour sleep in total	4
Pins and needles or numbness in the arms at night	I have no pins and needles or numbness at night	0
	I have occasional pins and needles or numbness at night	1
	My sleep is regularly disturbed by pins and needles or numbness	2
	Because of pins and needles or numbness I have less than 2 hour sleep in total	3
	Because of pins and needles or numbness I have less than 2 hour sleep in total.	4

Duration of symptoms	My neck and arms feel normal all day	0

	I have symptoms in my neck or arms on waking which last less than 1 hour	1
	Symptoms are present on and off for a total period of 1-4 hours	2
	Symptoms are present on and off for a total of more than 4 hours	3
	Symptoms are present continuously all day	4
Carrying	I can carry heavy objects without extra pain	0
	I can carry heavy objects but they give me extra pain	1
	Pain prevents me from carrying heavy objects but I can manage medium weight objects	2
	I can only lift light weight objects	3
	I cannot lift anything at all	4
Reading and watching TV	A can do this as long as I wish with no problems	0
	I can do this as long as I wish if I'm in a suitable position	1
	I can do this as long as I wish but it causes extra pain	2
	Pain causes me to stop doing this sooner than I would like	3
	Pain prevents me from doing this at all	4
Working/housework	I can do my usual work without extra pain	0
	I can do my usual work but it gives me extra pain	1
	Pain prevents me from doing my usual work for more than half of the usual time	2
	Pain prevents me from doing my usual work for more than a quarter of the usual time	3
	Pain prevents me from working at all	4
Social activities	My social life is normal and causes me no extra pain	0
	My social life is normal but increases the degree of pain	1
	Pain has restricted my social life but I am still able to go out	2
	Pain has restricted my social life to the home	3
	I have no social life because of pain	4
Driving	I can drive whenever necessary without discomfort	0
	I can drive whenever necessary but with discomfort	1
	Neck pain or stiffness limits my driving occasionally	2

	Neck pain or stiffness limits my driving frequently	3
	I cannot drive at all due to neck symptoms	4

- The question on driving is omitted if the patient did not drive a car when in good health.

Neck pain score = SUM(points for the first 9 questions)

If the all 9 questions are answered then

NPQ percentage = (neck pain score) / 36 * 100%

If only the first 8 questions are answered then

NPQ percentage = (neck pain score) / 32 * 100%

Interpretatation:

• minimum score: 0

• maximum score: 36 if all 9 questions answered 32 if only the first 8

• The percentages range from 0 to 100%.

• The higher the percentage the greater the disability.

Performance:

• The questionnaire has good short term repeatability and internal consistency.

References:

Leak AM Cooper J et al. The Northwick Park Neck Pain Questionnaire devised to measure neck pain and disability. Br J Rheumatol. 1994; 33: 469-474.

Appendix C

Perceived Neck Pain Rating

Name: ____

Date: ______________

SELF-RATING SCALE OF NECK PAIN AFTER BEFORE COMPUTER TASK

For each question, circle ONE number on the scale that describes how you feel:

1. How do you rate your neck pain?

Rating	Description
10	Extremely strong (Maximal)
9	
8	
7	Very strong pain
6	
5	Strong pain
4	
3	Moderate pain
2.5	
2	Light pain
1.5	
1	Very little pain
0.7	
0.5	Just noticeable pain
0.3	
0	No pain at all

2. Your neck pain intensity at the moment

Rating	Description
10	The pain is worst imaginable (Maximal)
9	
8	
7	The pain is very severe
6	
5	The pain is fairly severe
4	
3	The pain is moderate
2.5	
2	
1.5	
1	The pain is very mild
0.7	
0.5	
0.3	
0	I have no pain

3. Please rate the severity of current neck discomfort

Rating	Description
10	Extremely strong (Maximal)
9	
8	
7	Very strong discomfort
6	
5	Strong discomfort
4	
3	Moderate discomfort
2.5	
2	Light discomfort
1.5	
1	Very little discomfort
0.7	
0.5	Just noticeable discomfort
0.3	
0	No discomfort at all

Name: ____

Date: _____________

SELF-RATING SCALE OF NECK PAIN AFTER 10-MIN COMPUTER TASK

For each question, circle ONE number on the scale that describes how you feel:

1. How do you rate your neck pain?

Rating	Description
10	Extremely strong (Maximal)
9	
8	
7	Very strong pain
6	
5	Strong pain
4	
3	Moderate pain
2.5	
2	Light pain
1.5	
1	Very little pain
0.7	
0.5	Just noticeable pain
0.3	
0	No pain at all

2. Your neck pain intensity at the moment

Rating	Description
10	The pain is worst imaginable (Maximal)
9	
8	
7	The pain is very severe
6	
5	The pain is fairly severe
4	
3	The pain is moderate
2.5	
2	
1.5	
1	The pain is very mild
0.7	
0.5	
0.3	
0	I have no pain

3. Please rate the severity of current neck discomfort

Rating	Description
10	Extremely strong (Maximal)
9	
8	
7	Very strong discomfort
6	
5	Strong discomfort
4	
3	Moderate discomfort
2.5	
2	Light discomfort
1.5	
1	Very little discomfort
0.7	
0.5	Just noticeable discomfort
0.3	
0	No discomfort at all

Name: ____

Date: ______________

SELF-RATING SCALE OF NECK PAIN AFTER 20-MIN COMPUTER TASK

For each question, circle ONE number on the scale that describes how you feel:

1. How do you rate your neck pain?

Rating	Description
10	Extremely strong (Maximal)
9	
8	
7	Very strong pain
6	
5	Strong pain
4	
3	Moderate pain
2.5	
2	Light pain
1.5	
1	Very little pain
0.7	
0.5	Just noticeable pain
0.3	
0	No pain at all

2. Your neck pain intensity at the moment

Rating	Description
10	The pain is worst imaginable (Maximal)
9	
8	
7	The pain is very severe
6	
5	The pain is fairly severe
4	
3	The pain is moderate
2.5	
2	
1.5	
1	The pain is very mild
0.7	
0.5	
0.3	
0	I have no pain

3. Please rate the severity of current neck discomfort

Rating	Description
10	Extremely strong (Maximal)
9	
8	
7	Very strong discomfort
6	
5	Strong discomfort
4	
3	Moderate discomfort
2.5	
2	Light discomfort
1.5	
1	Very little discomfort
0.7	
0.5	Just noticeable discomfort
0.3	
0	No discomfort at all

Name: ____

Date: _____________

SELF-RATING SCALE OF NECK PAIN AFTER 30-MIN COMPUTER TASK

For each question, circle ONE number on the scale that describes how you feel:

1. How do you rate your neck pain?

Rating	Description
10	Extremely strong (Maximal)
9	
8	
7	Very strong pain
6	
5	Strong pain
4	
3	Moderate pain
2.5	
2	Light pain
1.5	
1	Very little pain
0.7	
0.5	Just noticeable pain
0.3	
0	No pain at all

2. Your neck pain intensity at the moment

Rating	Description
10	The pain is worst imaginable (Maximal)
9	
8	
7	The pain is very severe
6	
5	The pain is fairly severe
4	
3	The pain is moderate
2.5	
2	
1.5	
1	The pain is very mild
0.7	
0.5	
0.3	
0	I have no pain

3. Please rate the severity of current neck discomfort

Rating	Description
10	Extremely strong (Maximal)
9	
8	
7	Very strong discomfort
6	
5	Strong discomfort
4	
3	Moderate discomfort
2.5	
2	Light discomfort
1.5	
1	Very little discomfort
0.7	
0.5	Just noticeable discomfort
0.3	
0	No discomfort at all

Name: ____

Date: _____________

SELF-RATING SCALE OF NECK PAIN AFTER 40-MIN COMPUTER TASK

For each question, circle ONE number on the scale that describes how you feel:

1. How do you rate your neck pain?

Rating	Description
10	Extremely strong (Maximal)
9	
8	
7	Very strong pain
6	
5	Strong pain
4	
3	Moderate pain
2.5	
2	Light pain
1.5	
1	Very little pain
0.7	
0.5	Just noticeable pain
0.3	
0	No pain at all

2. Your neck pain intensity at the moment

Rating	Description
10	The pain is worst imaginable (Maximal)
9	
8	
7	The pain is very severe
6	
5	The pain is fairly severe
4	
3	The pain is moderate
2.5	
2	
1.5	
1	The pain is very mild
0.7	
0.5	
0.3	
0	I have no pain

3. Please rate the severity of current neck discomfort

Rating	Description
10	Extremely strong (Maximal)
9	
8	
7	Very strong discomfort
6	
5	Strong discomfort
4	
3	Moderate discomfort
2.5	
2	Light discomfort
1.5	
1	Very little discomfort
0.7	
0.5	Just noticeable discomfort
0.3	
0	No discomfort at all

Appendix D

Research Ethics

Consent Form

BORANG MAKLUMAT DAN KEIZINAN PESERTA
PATIENT INFORMATION AND CONSENT FORM
(PROJEK PENYELIDIKAN)
(RESEARCH PROJECT)

Tajuk Kajian: **THE NECK PAIN EXPERIENCED AMONG PROLONGED COMPUTER USERS AND THE RELATIONSHIP WITH THE NECK MUSCLE STRENGTH**

Nama Penyelidik: ***SITI RUSYIDA BINTI ROHIM***

Mengapa kajian ini dijalankan? – Kami ingin mengenal pasti faktor-faktor yang menyumbang kepada kesakitan leher di kalangan pengguna-pengguna komputer di Malaysia, serta menghasilkan satu kaedah bagi mengukur dan meramalkan kesakitan leher di kalangan pengguna-pengguna komputer.

Apakah aktiviti yang terlibat ? - Penyelidikan ini melibatkan kaji selidik keadaan ketika bekerja dan menggunakan komputer; pengambilan bacaan anthropometry dan kekuatan otot leher dengan menggunakan dinamometer digital serta tugasan menaip.

Berapa lamakah kajian ini akan di jalankan? – maksimum 2 jam

Sebagai peserta bagi kajian ini, saya faham bahawa:

1. Penyertaan saya sukarela dan saya boleh berhenti untuk menyertai kajian ini pada bila-bila masa, tanpa denda.
2. Saya menyedari tentang penyertaan saya ini.
3. Tiada risiko-risiko yang terlibat dalam penyertaan kajian ini.
4. Semua soalan-soalan saya tentang kajian telah dijawab dengan memuaskan.
5. Saya telah menerima wang saguhati bagi penyertaan saya ini sebanyak RM ________

Saya telah membaca dan memahami perkara atas, dan memberi persetujuan untuk menyertai:

Nama Peserta: ____

Tandatangan Peserta:___________________________________ Tarikh:__________

Saya telah menjelaskan perkara atas dan menjawab semua soalan ditanya oleh peserta:

Tandatangan Penyelidik : _______________________________ Tarikh:__________

Appendix E

Data from Anthropometry Measurement

Table E.1: Anthropometry measurements of each participants

Subject	Weight	Height	BMI	Neck Circ.	Head Circ.	Head Depth	Head Width	Head Height	C1-C7	Neck Depth	Sternum -Tragus	Neck Width	Neck Slender	Neck Shape	Neck C / Head C
1	46.00	153.00	196.50	278.50	529.00	171.00	149.50	203.50	88.50	80.00	157.00	75.50	0.32	0.94	0.53
2	48.00	152.25	207.00	289.50	526.50	172.00	125.00	194.00	130.00	75.50	186.00	78.50	0.45	1.04	0.55
3	57.00	162.20	217.00	311.50	561.50	188.00	151.00	223.50	112.00	94.00	163.50	91.00	0.36	0.97	0.55
4	51.00	156.90	207.20	316.00	564.50	179.50	136.50	209.00	89.00	81.00	156.50	97.00	0.28	1.20	0.56
5	74.00	152.00	320.30	342.00	558.50	184.50	151.00	215.50	80.00	94.00	150.00	90.50	0.23	0.96	0.61
6	70.00	152.50	301.00	307.50	554.00	185.00	136.00	203.00	88.00	89.00	162.00	81.50	0.29	0.92	0.56
7	60.00	155.05	249.50	327.50	550.00	182.00	139.50	221.50	67.50	92.00	142.00	92.00	0.21	1.00	0.60
8	56.00	151.15	245.10	305.00	562.50	182.00	161.00	201.00	99.00	91.00	194.00	83.00	0.32	0.91	0.54
9	59.00	170.15	203.80	301.50	532.50	174.00	136.50	203.00	160.00	92.00	215.00	83.00	0.53	0.90	0.57
10	79.00	152.25	340.80	350.00	566.00	176.00	145.00	226.50	55.00	93.00	152.00	85.50	0.16	0.92	0.62
11	45.00	156.65	183.40	274.50	521.50	171.50	129.00	199.50	89.00	78.00	167.50	75.50	0.32	0.97	0.53
12	46.00	151.45	200.50	292.50	499.50	158.00	130.50	184.50	86.00	82.50	175.00	86.00	0.29	1.04	0.59
13	55.00	161.80	210.10	286.00	544.00	179.00	150.50	189.50	119.00	83.00	188.00	80.00	0.42	0.96	0.53
14	50.00	156.35	204.50	303.00	532.00	171.00	140.50	202.50	83.00	85.00	176.00	84.00	0.27	0.99	0.57
15	49.00	157.35	197.90	301.50	538.00	172.50	137.50	199.50	92.00	80.00	164.00	83.00	0.31	1.04	0.56
16	71.00	160.10	277.00	317.00	561.00	176.00	136.00	193.50	82.00	86.00	178.00	88.50	0.26	1.03	0.57
Mean	57.25	156.32	235.10	306.47	543.81	176.38	140.94	204.34	95.00	86.00	170.41	84.66	0.31	0.99	0.56
SD	10.87	5.17	49.00	20.97	19.18	7.37	9.64	12.12	25.14	6.20	18.82	6.02	0.09	0.07	0.03

Appendix F

Data of Neck Muscle Strength Measurement

Table F.1: Neck extensor muscle strength measurements of each participants

Name	Before	10 min	20 min	30 min	40 min
1	49.40	36.50	39.10	35.10	28.00
2	37.80	64.50	49.80	55.10	48.50
3	80.10	71.60	69.40	60.10	69.80
4	54.30	49.80	50.70	48.50	42.70
5	60.90	53.40	49.80	36.00	39.10
6	56.90	47.60	37.40	36.00	32.90
7	103.60	102.80	96.10	92.50	98.30
8	64.50	57.40	56.50	56.50	63.60
9	81.40	73.00	59.60	54.30	64.10
10	71.62	64.10	61.80	51.20	52.90
11	60.90	57.40	60.90	57.40	49.80
12	36.00	41.40	38.30	46.70	34.70
13	85.20	70.70	70.30	65.80	70.30
14	45.40	43.10	44.00	41.80	42.70
15	45.80	44.90	51.60	50.70	48.00
16	46.30	43.10	33.40	36.00	32.90
Average	61.88	57.58	54.29	51.48	51.14
SD	19.88	16.74	15.79	14.51	18.34

Table F.2: Neck flexor muscle strength measurements of each participants

Name	Before	10 min	20 min	30 min	40 min
1	26.20	28.90	24.50	16.90	16.90
2	58.30	42.30	36.00	35.60	37.80
3	97.00	97.90	87.20	93.40	85.40
4	48.50	48.00	42.70	45.80	44.50
5	35.60	37.40	34.30	32.90	36.00
6	36.00	30.70	28.50	26.20	30.20
7	92.10	88.50	75.20	64.90	78.30
8	69.80	71.20	64.90	56.90	56.50
9	49.80	56.50	55.60	50.70	56.90
10	55.60	56.90	60.50	51.20	52.90
11	57.80	63.20	60.90	59.20	58.70
12	35.60	34.30	43.10	43.10	35.60
13	77.80	71.60	64.50	67.20	75.20
14	28.50	38.70	36.00	47.60	29.80
15	56.50	50.30	51.60	49.40	47.60
16	43.10	43.60	28.90	24.90	28.50
Average	54.26	53.75	49.65	47.87	48.18
SD	21.21	20.31	18.27	18.84	19.59

Appendix G

Data of Perceived Neck Pain

Table G.1: Perceived neck pain rating of each participants

Name	Before	10 min	20 min	30 min	40 min
1	0.00	0.00	0.10	0.30	0.43
2	0.00	0.50	1.00	1.00	1.50
3	0.00	0.34	1.00	1.83	2.67
4	2.30	2.00	3.00	4.30	5.70
5	0.50	0.50	0.70	2.00	2.00
6	0.00	0.73	0.90	1.50	2.00
7	3.77	3.00	4.33	6.33	7.00
8	0.67	1.17	1.67	2.17	3.00
9	1.67	1.33	3.00	3.00	2.00
10	1.57	1.83	2.00	1.83	2.50
11	1.83	2.00	2.50	2.50	3.00
12	0.17	0.17	0.67	1.00	1.67
13	0.67	1.00	1.00	1.50	1.33
14	0.00	0.17	0.10	0.50	0.70
15	3.00	3.00	3.00	3.00	1.50
16	0.57	0.57	0.73	0.73	0.73
Average	1.05	1.14	1.61	2.09	2.36
SD	1.19	0.97	1.23	1.54	1.75