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Work Stress and Musculoskeletal Disorders Symptoms: The Effect of Psychosocial and Psychological Risk Factors

직무 스트레스와 근골격계 질환 증상: 심리적, 심리사회적 위험요인의 영향을 중심으로

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Abstract

Work Stress and Musculoskeletal Disorders Symptoms: The Effect of Psychosocial and Psychological Risk Factors

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The use of computer is a common activity for most people regardless of their occupation, gender and age. Mobile computing products such as laptops, computer tablets and smart phones encourage computer usage anytime and anywhere. In a certain way, computer products help people to improve their quality of life. The usage of computers is not always in a good and comfortable condition. Sometimes, computer users need to use their computers in a stressful psychological and psychosocial condition. It is feared that computer usage under this stressful psychological and psychosocial conditions will contribute to musculoskeletal disorder symptoms.

The influence of psychological and psychosocial factors on musculoskeletal disorders has been debated for years. Many researches including cross sectional studies, experimental studies in laboratories or data collection in field areas have been conducted in order to determine the influence of psychological and psychosocial factors on musculoskeletal disorders. Yet, none of the psychological and psychosocial factors has been consistently and significantly associated with this disorder.

Inconsistent roles of psychological and psychosocial factors on musculoskeletal disorders have been found in cross sectional studies among several occupations including dentists and construction workers. Even for experimental studies in a laboratory setting, there were various results obtained. These results indicate the inadequate knowledge regarding this issue.

Psychological and psychosocial factors on musculoskeletal disorders are a broad field. There are many elements that can be included. In previous cross sectional studies, most of the time, the psychological and psychosocial factors investigated were different between each other. Even though there were studies examining the same factor (i.e mental demand), the assessment/questionnaires used were different, which might significantly affect the results. The same mechanism happened in previous experimental studies. Most of the time, the methodology used to induce the psychological and psychosocial stress were different between each other, which consequently might produce different results.

Based on this motivation, the main objective of this dissertation is to find out and determine the relationship and the effect of psychological and psychosocial factors on musculoskeletal disorder symptoms especially during mobile computing product usage. Nevertheless, the role of physical factors on musculoskeletal disorders is well known and has been recognized for decades. Therefore, this dissertation also includes physical factors as part of this study.

There are two phases of study in this dissertation. In the first phase, three cross sectional studies were done between three different occupations. These occupations include dentists, internship doctors and construction workers. These three occupations have different levels of physical demand as well as psychological and psychosocial stress. The main aim of these studies is to find out the relationship between psychological and psychosocial factors and the prevalence of musculoskeletal disorders in the field area.

Six psychological and psychosocial factors have been assessed based on the same criteria (i.e job satisfaction, mental demand) using the same questionnaires which is Job Stress Questionnaire from NIOSH. From these studies, different degree of association between psychological and psychosocial factors and prevalence of musculoskeletal disorders has been found.

In the second phase, three experimental studies were used to determine the effect of psychological and psychosocial factors on three independent variables during mobile computing product usage. These independent variables are muscle activity, visual discomfort and head posture. All these variables are connected to musculoskeletal disorder

symptoms even though the exact mechanism is still unknown and debatable.

Several stressors were used in the first experiment during four computer devices usage. Several hypotheses were developed in order to find out the role of psychological and psychosocial factors on muscle activity during different computer device usage. Inconsistent results regarding the influence of psychological and psychosocial on muscle activity in previous studies were taken into consideration and included into the hypothesis. The role of different device usage on muscle activity was also analyzed.

There are different types of activities that can be elicited using computers such as typing, gaming, programming and many others. Reading is one of the most common activity during computer usage. Therefore, in the second experiment, the roles of psychological and psychosocial factors on visual discomfort as well as other body parts that shows signs of discomfort were analyzed during reading activities using laptops and computer tablets. The results obtained from this experiment were assumed to be related to head posture.

Mobile computing products' mobility allows the user to use them in various ways and places. Thus, in the final experiment, computer position were also included as part of the experiment. The effect of time pressure during laptop and computer tablet usage on different positions were analyzed in terms of visual discomfort and head posture.

Musculoskeletal disorders are multifactorial disorders. Different risk factors may act on the different mechanisms and consequently cause the same symptoms. It is expected that this study would provide

some insight and contribute some knowledge to other researchers regarding the role of psychological and psychosocial factors on musculoskeletal disorders especially during mobile computing product usage.

Keywords: musculoskeletal disorders; physical factors; psychological and psychosocial factors; computer usage; mobile computing products
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CHAPTER 1

INTRODUCTION

1.1 Background and problem statement

Mobile computing products are one of the most rapidly growing products and have become an important part of human life. Unique and distinct advantages compared to traditional desktop computer especially in terms of weight, size and mobility have trigger a technology revolution. Aside from physical factors advantage, mobile computing products especially tablet computers and smartphones can use various applications to improve users' lifestyle and daily works. In addition to the unique characteristic of mobile computing products, easier internet access boosts these products' popularity to a whole new level. However, the popularity of mobile computing products also raises concerns on the users' health especially regarding the musculoskeletal disorders (MSDs).

Field and laboratory researches repeatedly indicated the influence of computer usage on MSDs. Physical factor such as unsuitable monitor position and improper chair height along with sitting for a long duration especially with an unnatural posture has been blamed as a major cause for MSDs prevalence among computer user. Many efforts regarding MSDs problems during computer usage have been carried

out by many ergonomic and health professionals. It includes studies related to computer monitor such as the angle, its height, screen contrast, screen size; related to desk such as its height, with and without hand support; related to chair such as its height, adjustability, its material, size, hand support; related to the computer equipment itself such as mouse design, mouse size, material of the mouse; related to environment such as lighting and noise; and related to the user him/herself such as their height, body size, body measurement, posture, age and gender.

Despite considerable ergonomic improvements and numerous researches on work environment and physical factors, MSDs have continued to be one of the major problems among computer user. It is understandable since MSDs are multifactorial disorders. Different risk factors may act on the different mechanism and consequently cause the same symptom. For example, neck and shoulder pain may be caused by the increment of trapezius muscle activity, awkward posture and mechanical overload. The study on MSDs is not only limited to the physical and environmental factors but other factors such as psychological and psychosocial have been explored by numerous researchers in order to get a better understanding in MSDs problems. The study not only limited to occupation that involve high physical activity but also on occupation with low physical demand but may involve high psychological and psychosocial demand such as office worker and computer user.

Unlike other high-risk occupations such as construction work or nursing in hospital, physical work for computer usage can be

considered as relatively low (Hughes et al., 2007). In spite of this fact, the occurrences of MSDs symptom for this type of occupation (low physical work but psychologically stressful) is high (Blangsted et al., 2004; Jensen, 2003; Jensen et al. 2002) which indicates the role of psychological and psychosocial stress.

The significant effects of psychological and psychosocial stress such as time pressure, low social support, high job demands and high mental workload on MSDs have been reported in various occupational fields such as dentists and offshore oil installation workers (Palliser et al., 2005; Chen et al., 2005). However, at the same time, there are other studies also reported that psychological and psychosocial stress did not have significant effect on the prevalence of MSDs. For example, there were studies found that psychosocial factors influence the prevalence of MSDs among dentist (Palliser et al., 2005, Lindfors et al., 2006) while another study found inconsistency influence of psychosocial factors on MSD complaints and chronicity among dentist (Alexopoulos et al., 2004). The same inconsistency was found in studies regarding the influence of psychological and psychosocial factors on MSDs for construction workers (Engholm and Holmstrom, 2005; Latza et al., 2002; Jensen and Kofoed, 2002; Latza et al., 2000).

Contradiction of psychological and psychosocial factor effect also reported in studies regarding the effect of psychosocial stress on a muscle activity during computer usage. Out of twenty studies regarding the effect of psychosocial stress on trapezius muscle activity during computer usage, half of them found significant relationship while not the other half (Taib et al., 2016). This result indicates that our

knowledge regarding the effect of psychological and psychosocial factors on MSDs is insufficient.

For mobile computing products, the design of the products itself, may also contribute to MSDs. The design of laptop computer is a simple example to picture the situation. Most laptops are designed with screen attached to the keyboard. This design makes it impossible to be adjusted separately in terms of height and distance for both screen and keyboard. Besides, laptops normally have smaller screen size compared to desktop computer. It has been shown that users prefer to move closer to the visual display whenever accessing a smaller visual display unit in order to see the smaller fonts more clearly (Szeto and Lee; 2002; Villanueva et al., 1998). Several studies found that users assumed forward posture when they used laptop compared to desktop computer, which consequently produce greater neck flexion and head tilt angles (Szeto and Lee; 2002; Straker et al., 1997). Forward head posture which consequently produces greater neck flexion and head tilt angles was more frequently assumed by laptop user compared to traditional PC user.

Furthermore, there are many aspects during computer usage that can contribute to visual discomfort including screen glare, bad resolution, high luminance contrast, too small detail and unsuitable screen angle and distance (Hemphala et al., 2014). As shown in previous studies, there are correlation between visual discomfort and neck as well as shoulder pain (Helland et al., 2008; Wiholm et al., 2007; Aaras et al. 2001; Aaras et al., 1998). In addition for certain characteristic of mobile computing products such as smaller screen and

keyboard, psychological and psychosocial stress such as time pressure may increase visual discomfort and consequently contributes to neck and shoulder pain.

Aside from that, many people are not aware that the design of mobile computing product itself not only affect physical body but induced psychological and psychosocial stress condition as well. For instance, small screen might induce visual demand and makes the user experienced visual strain and tiredness (Szeto and Lee, 2002; Straker et al., 1997; Villanueva et al., 1998) and small keypad might needs user' concentration and precision (Szeto and Lee, 2002; Villanueva et al., 1998). Furthermore, smaller screen might produce larger error rates and decrease the satisfaction (Sears et al., 1993). In addition, small screen might limit the information that can be obtained by the user especially on the video or text information (Kim et al., 2011; Lombard et al., 1997). Consequently, it might increase the psychological and psychosocial stress. Yet, in spite of the popularity of mobile computing products, there is no study that has used any mobile computing product in their psychological and psychosocial stress experiment.

Research on the effect of psychological and psychosocial factors on MSDs comprised of various elements such as muscle activity, posture, visual discomfort, and cognitive demand. Still, there are some limitations.

Firstly, there were many surveys done regarding the effect of psychosocial factors on MSDs in different occupations. However, most of the time, the psychological and psychosocial factors investigated by those studies were not the same. For instance, mental demand was

examined in a study by Palliser et al. (2005) but not in another study by Latza et al. (2002). Even though there were studies examining the same factor (i.e job satisfaction), the items used in their questionnaire were different. For instance, Palliser et al. (2005) analyzed job satisfaction based on five items stated in Generic Job Stress Questionnaire which was mostly regarding mental concentration while in Alexapoulos et al. (2004), they examined job satisfaction based on a Job Content Questionnaire which was mostly regarding excessive work, insufficient time and conflicting demands. Meanwhile, in other studies, the psychological and psychosocial factors were examined based on their own version of questionnaires (Samat et al., 2011; Lindfors et al., 2006; Engholm and Holmstrom, 2005). These differences might significantly affect the results (Sobeih et al., 2006).

Secondly, significant relationship between muscle activity, visual discomfort and head posture on MSDs has been found in previous studies. However, only a few studies (if there is any) emphasized on the influence of psychological and psychosocial factors on visual discomfort and head posture. Meanwhile, even though there were many studies tried to determine the effect of psychological and psychosocial factors on muscle activity, the results obtained were inconsistent. These results indicate that our knowledge regarding this issue is insufficient.

Thirdly, as mobile computing products (such as laptop, tablet and smart phone) have gone popular nowadays, there were many ergonomic studies conducted regarding their usage. Yet, only a few studies (if there is any), involved psychological and psychosocial factors. All of these previous studies used desktop computer as their

equipment. The characteristics of mobile computing products itself (i.e smaller screen and smaller keyboard) might contribute to the development of psychological and psychosocial stress. Besides, these characteristics may have some influences on users' muscle activity, posture and visual discomfort which consequently lead to a greater impact on MSDs problems.

In summary, there are several research questions in this study:

1) Is there any relationship between psychological and psychosocial factors with prevalence of MSD symptoms?
2) What is the effect of psychological and psychosocial factors on muscle activity, head posture and visual discomfort?
3) Since mobile computing products have been extremely popular nowadays, will these products' design influence the psychology (accordingly stress) of the participants, and consequently contributes to the MSDs? If yes, in what terms they influence the user: muscle activity, posture, or visual discomfort?

1.2 Purpose of this research

Built upon the background described earlier, the purpose of this research is as follows:

First, this research will provide some insights on the prevalence of MSDs and its relationship with psychological and psychosocial factors in several occupations, which includes the dentist profession, construction workers and internship doctors. As mentioned, previous studies examined different psychological and psychosocial factors and even though there were studies examining the same factor, the questionnaires that they used were different. Therefore, in the cross sectional studies section, the relationship between MSDs prevalence and psychological as well as psychosocial factors will be assessed based on the same criteria (i.e job satisfaction, mental demand, job requirements, work hazards, workload and responsibility) from the same questionnaire (Job Stress Questionnaire from NIOSH). Aside from these psychological and psychosocial factors, other factors that might contribute to the prevalence of MSDs and related to that particular occupation will be assessed too. For example, from the literature review, physical factors and ergonomic factors are very important and might become an important contributor to the development of MSDs in dentist profession. Thus, physical factors such as the frequency where they need to work very fast, very hard, using vibrating tools, and with awkward postures; as well as ergonomic factors such as whether the light is sufficient, whether they took occasional break and whether they use dental mirror for indirect vision

will be assessed as well. This part of the study will allow us to see the association between psychological and psychosocial factors and the prevalence of MSD symptoms in several professions.

Secondly, computers are used by most people across the world regardless of their profession. Thus, a study regarding the effect of psychological and psychosocial factors during the usage of computers is suitable to show the influence of psychological and psychosocial factors on MSDs especially in a laboratory setting. As the role of muscle activity on the development of MSDs has been recognized, many studies attempt to determine the effect of psychological and psychosocial factors on muscle activity especially on trapezius muscle. Yet, the inconsistencies in results show our insufficient knowledge regarding the role of psychological and psychosocial factors. Besides, even though significant relationships between visual discomfort and head posture on MSDs has been found in previous studies, only a few studies (if there are any) has emphasized on the influence of psychological and psychosocial factors on these two variables. Thus, another part of this dissertation will involve experimental studies regarding the effect of psychological and psychosocial factors on muscle activity, visual discomfort and head posture during mobile computing product usage. These experiments may contribute to the growing body of evidence examining the role of psychological and psychosocial factors on MSDs.

Thirdly, even though mobile computing products (i.e laptop, tablet and smart phone) have gone viral for years, a study regarding the effect of its usage under psychological and psychosocial factors is very

difficult to be found (if there are any). The advantages of mobile computing products are based on their size and mobility. These characteristics make them easy to use anytime and anywhere. However, these characteristics may also contribute to the development of MSDs. For example, the size of smart phones allows users to use it in a small and crowded space / area such as in a subway train. In this space, sometimes, it is inconvenient for the user to place the phone higher (because of privacy reasons or having difficulty to use it in that position) which subsequently force users to bend or look down if they want to use the phone). Significant relationship between posture and visual discomfort on MSDs prevalence has been found in some studies (Rithcher et al., 2011; Helland et al., 2008; Hemphala and Eklund, 2012; Wiholm et al., 2007). Therefore, the characteristics of mobile computing products such as having a small screen, small keyboard, inseparable keyboard and screen may contribute to the awkward posture and eye discomfort and may be worse if it is used under psychological and psychosocial stress such as time pressure. Besides, these characteristics themselves may cause psychological stress. For example, a small screen may increase visual demand while small keyboards may need more precision as compared to the use of a desktop computer. Therefore, another experimental part of this study is to determine the effect of psychological and psychosocial factors on muscle activity, head posture and visual discomfort during the usage of mobile computing products under certain particular conditions.

1.3 Organization of the dissertation

Organization of the dissertation and workflow is depicted in Figure 1.1. In chapter I, the background, problem statement and purpose of this study are presented. Chapter II includes the literature review regarding MSDs. The effect of different methods used to induce stress and the characteristics of the participants are also reviewed and discussed in this chapter. In chapter III, the hypothesis, methodologies, results and discussion from three cross-sectional studies were presented. Chapter IV presents the hypotheses, methodologies, results and discussion from three experiments on muscle activity, visual discomfort and head posture. Chapter V provides the review of the findings and the contribution of this study.

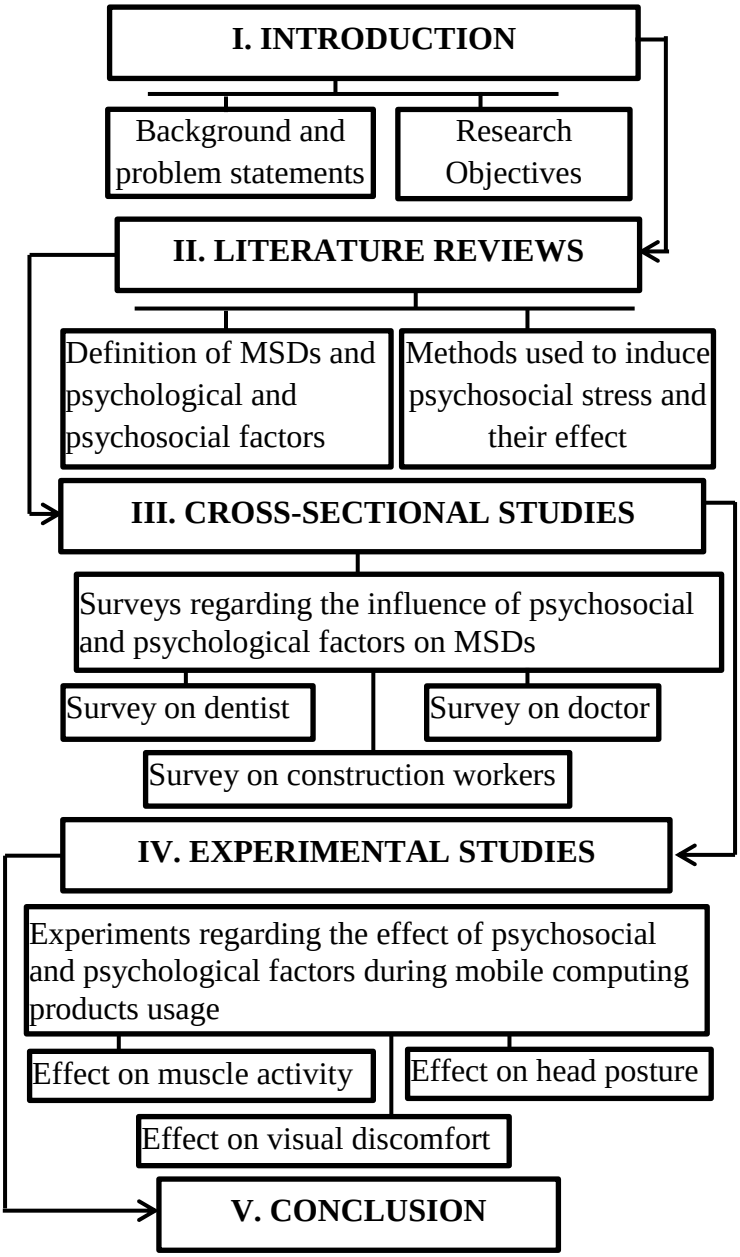


Figure 1.1: Organization of the dissertation and workflow

CHAPTER 2

LITERATURE REVIEWS

2.1 Musculoskeletal disorders (MSDs)

Musculoskeletal disorders (MSDs) are defined as health problems of the musculoskeletal systems such as muscles, tendons, skeleton and ligaments (WHO, 2003). It can be noticed by discomforts, symptoms or pain in musculoskeletal which reflect some conditions such as neck pain, back pain, carpal tunnel syndrome, myofacial dysfunction syndrome and many others (Rambabu and Suneetha, 2014; Fung et al., 2008). The most common early symptoms of MSDs are discomfort, fatigue and pain (Fung et al., 2008). MSD can be ranging from light, mild and infrequent; to severe, irreversible and disabling injury (Rambabu and Suneetha, 2014; WHO, 2003; Fung et al., 2008).

MSDs are a well-known health problem among working population professions around the globe. Not only that, MSDs also contributed to productivity loss and high cost consumption. Aside from worker's compensation, medical care and recovery cost, there are many indirect costs involved including sick leave, retraining costs, work productivity and quality decreased as well as low morale (Fung et al., 2008). It cost billions of dollars annually in some countries like Australia, US and Netherlands (Fung et al., 2008; Blatter et al., 2005; National Research Council and the Institute of Medicine, 2001). It has

been a major concern for many professions such as dentist, construction workers, automotive workers and computer workers. In US alone, more than 70 million physician office visits annually were caused by MSDs (Sobeih et al., 2006). MSDs problem might lead to sick leave, declining in performance or in a worse case forcing them to leave their profession (Kursun et al., 2014; Rambabu and Suneetha, 2014).

MSDs have been characterized as multifactor (Kaminskas and Antanaitis, 2010). Among the factors that have been recognized as contributors to the MSDs symptoms were physical, psychosocial, environmental and individual factors. The most popular factor for MSDs development was caused by physical factors. The problems most likely will happen when the mechanical workload is higher compared to the capacity of load that can be tolerate by musculoskeletal systems. The result of this overload might cause injuries in muscles, tendons and ligaments (e.g: strains and ruptures) and bones (e.g: fractures and degenerative changes) (WHO, 2003). Aside from mechanical overload, there are other physical factors that have been known as a contributor to the MSDs. These factors include repetition frequency, posture and exposure time as well as constant muscle activity for a prolong time.

2.2 The influence of psychological and psychosocial factors on MSDs

There is another theory regarding the cause of MSDs. This theory stated that there is another factor that can contribute on MSDs problems which is psychological and psychosocial factors. Psychological factors

refer to opinions, feelings and other mental characteristics that affect the attitude and actions of the human minds. In more specific, psychological stress happened when a person perceives that the demand from their environment surpass his or her adaptive capacity (Cohen et al., 1995). Psychological factor is internally oriented while psychosocial factor is externally oriented which involve psychological and social aspects. Psychosocial factors could be time pressure, low social support, high job demands, high mental workload, high memory demands, low reward, surveillance of workers and high efforts (Eijckelhof et al, 2013; Bahar et al., 2013; Larsman et al., 2006; Bloemsaat et al., 2005; Blangsted et al., 2004; Arien et al., 2001; Karasek et al., 1998; Siegrist et al., 1997).

Several theories have been suggested regarding the effect of psychosocial factors on MSDs. One of them is called Cinderella hypothesis. This hypothesis suggested that low but constant muscle activity may cause motor units (functional units of the muscle) with low activation threshold to be continuously active (Hagg, 1991). The possible outcome of this constant activation is metabolic disturbances and exhaustion, which consequently may increase pain sensitivity and hinder repairing process of damaged muscle fibres (Lundberg et al., 2002). It is suggested that psychosocial factors might retain low threshold motor units active (Sjogard et al., 2000). Thus, psychosocial factor may need to be considered as an important contributor to MSDs problems because it is normally lasts longer than physical demands which consequently contributed to motor unit overuse.

However, the effect of psychosocial factors on MSDs is still

debatable. For instance, physical work for computer usage can be considered relatively low (Hughes et al., 2007). In spite of this fact, the occurrences of MSDs symptom for this type of occupation (low physical work but psychologically stressful) is high (Blangsted et al., 2004; Jensen, 2003; Jensen et al., 2002). Thus, some researchers argued that this indicates the role of psychosocial stress such as tight deadlines and high mental workloads.

Yet, out of 20 studies regarding the effect of psychological and psychosocial stress on trapezius muscle activity during computer usage, half of them found significant relationship while the other half were not (Taib et al., 2016). This inconsistency result regarding the effect of psychological and psychosocial factors on MSDs have been reported repeatedly in many studies from different kind of profession. For example, there were studies found that psychological and psychosocial factors influence the prevalence of MSDs among dentist (Palliser et al., 2005, Lindfors et al., 2006) while others studies found inconsistency influence of psychological and psychosocial factors on MSD complaints and chronicity among dentist (Alexopoulos et al., 2004). The same result was obtained from construction field. Several studies attempted to determine the effect of psychological and psychosocial factors on MSDs among construction workers. However, the results were also inconsistent (Engholm and Holmstrom, 2005; Latza et al., 2002; Jensen and Kofoed, 2002; Latza et al., 2000).

2.3 The effect of different method used to induce stress and the characteristics of the subjecs: A review from previous studies

As mentioned, MSDs problem among computer user was very high although computer usage does not involve high physical activity. In the meantime, the role of muscle activity on MSDs has been recognized. Therefore, in order to find out the effect of psychological and psychosocial factors on MSDs, many studies tried to determine the influence of psychological and psychosocial factor on muscle activity during computer usage. However, the results obtained by those studies were not consistent.

In order to find the reason behind the inconsistencies of result regarding the effect of psychological and psychosocial factors on muscle activity, the purpose of this section is to review the differences that possibly produce that outcome. It includes the differences in terms of the method used to induce the psychological and psychosocial stress and the characteristic of the subjects such as their age, gender, health and the equipment. The focus of this section is regarding the effect of psychological and psychosocial factors on muscle activity during computer usage.

Relevant articles regarding the effect of psychological and psychosocial stress on muscle activity during computer work have been identified based on searches performed in several databases including PubMed, Scopus, Google Scholar and other databases. Several single keywords and keywords combinations were used to identify the relevant articles. Search term comprising words like psychological,

psychosocial, stress, workplace stressor, cognitive load, computer use, computer work, MSD, muscle activity, typing, computer mouse, keying, keyboard were used. Then, the articles were screened based on the title and relevant abstract. The inclusion criteria include the involvement of psychological / psychosocial stress / workplace stressor and computer usage. Then, the articles inclusion criteria were filtered by choosing the articles that involved muscle activity. Aside from that, related articles were searched using cited references from the main paper as well. Finally, redundant articles were excluded and they were sorted to identify a continuation study from the same author. Some studies have to be excluded because of several reasons; they used tasks that were not related to any computer work (e.g: walking); there was no comparison of muscle activity done before and after the task or between low and high stress conditions; how they induced the stress among subjects was not mentioned. As a result, 25 articles were categorized as final articles and have been included in this section.

Most of the studies present in this section measured muscle activity in trapezius muscle along with other neck-shoulder muscle like sternocleidomastoid, anterior scalene and cervical extensor, forearm muscle such as extensor digitorum and extensor carpi radialis as well as upper arm muscle such as bicep and tricep. Besides that, participants of the study were also different between each case where some study used healthy subject only while some others were not, some involved both gender and there was a study involved elderly subjects.

The articles involved in this review were summarized in the table 2.1. This table also presented some criteria used in their study such as

which muscle they studied, the gender of the subjects, either their subjects symptomatic or asymptomatic and finally their subjects' occupations.

Table 2.1: Summary of muscle studied, gender, health condition and subjects' work

Author	Muscle	No of subjects				Subject's occupation
		Gender		Health		
		Men	Women	Healthy	Symptomatic	
Ekberg et al. (1995)	Left and right upper Trapezius muscles	10	20	30	0	Students
Schleifer et al. (2008)	Left and right upper trapezii muscles	5	18	23	0	-
Wang et al. (2011)	Cervical erector spinae, upper trapezii, extensor carpi radialis and flexor carpi ulnaris	7	7	14	0	-
Bloemsaat et al. (2005)	Trapezius, deltoid, biceps, triceps, flexor digitorum superficialis, extensor digitorum, extensor carpi radialis longus and extensor carpi ulnaris	5	9	14	0	-
Mclean and Urquhart (2002)	Trapezius and levator scapulae muscles	4	6	10	0	-
Chou et al. (2011)	Upper trapezius and cervical erector spinae	7	7	7	7[a]	-
Johnston et al. (2008)	Sternocleidomastoid, anterior scalene, cervical extensor and upper trapezius muscles	-	-	55[b]	52[c]	85 workers and 22 female non-working controls
Blangsted et al. (2004)	Right and left trapezius muscle	0	12	12	0	-

Elke et al. (2001)	Right and left trapezius and cervical erector spinae muscle	-	-	-	-	11 students and 2 administrative assistants
Rietveld et al. (2007)	Extensor digitorum, deltodius and trapezius tranversus	-	-	20	20[d]	Employee of a company
Xiaopeng and Arijit (2011)	Left hand extensor digitorum muscle	-	-	8	0	Graduate students
Hughes et al. (2007)	Left and right extensor carpi ulnaris and flexor carpi ulnaris muscles	9	9	18	0	Typist
Birch et al. (2000)	trapezius, infraspinatus, deltoid, and extensor digitorum muscles (mouse operating side)	0	14	2	12[e]	CAD operators
Visser et al. (2004)	extensor digitorum muscles, flexor digitorum superficiales, trapezius descendens muscles (dominant side)	4	6	10	0	-
Wahlstrom et al. (2002)	first dorsal interosseus, extensor digitorum and right and left trapezius muscles	8	7	15	0	-
Finsen et al. (2001)	right flexor digitorum superficialis muscle, extensor carpi radialis brevis muscle and extensor digitorum communis muscle	0	9	9	0	Students
Sandfeld and Jensen (2005)	extensor carpi radialis, extensor digitorum superficialis, extensor carpi ulnaris, flexor carpi radialis, right and left trapezius and right neck extensor muscle	16[f]	17[g]	33	0	-
Szeto et al. (2005)	bilateral cervical erector spinae, upper trapezii, lower trapezii and anterior deltoids	0	41	20	21[h]	Office workers
Gerard et al. (2002)	finger flexor digitorum superficialis, finger extensor digitorum communis	2	16	18	0	Typist

Shahidi et al. (2013)	Bilateral upper trapezius, cervical extensor, and sternocleidomastoid muscles	22[i]	57[j]	79	0	Office workers
Laursen et al. (2002)	Right extensor carpi radialis, flexorcarpi radialis, extensor digitorum, extensor carpi ulnaris and neck extensor and right and left of upper part of the trapezius muscles	0	12	12	0	-
Szeto and Lin (2011)	Extensor carpi ulnaris, extensor carpi radialis, flexor carpi ulnaris and flexor carpi radialis	0	17	8	9[k]	Office workers
Aasa et al. (2011)	Right extensor carpi radialis trapezius and cervical erector spinae	0	10	10	0	Students
Garza et al. (2013)	Right and left extensor carpi radialis	32	85	117	0	Office workers
Eijckelhof et al. (2013)	Right and left trapezius muscle	32	85	117	0	Office workers

[a] Neck pain subject
[b] 33 Workers and 22 non-working subjects
[c] 38 Mild pain and 14 moderate neck pain subject
[d] Diagnosed with repetitive strain injury (RSI)
[e] Neck or upper extremities symptom
[f] 8 Young people and 8 elderly
[g] 9 Young people and 8 elderly
[h] Discomfort related to computer use
[i] 15 for stress study and 7 for control
[j] 45 for stress study and 12 for control
[k] Pain, aching, burning, numbness or tingling in the right wrist/hand region
- Not mentioned in the study

2.3.1 Method used to induce psychological and psychosocial stress during computer usage

There are many tasks used by previous researchers to induce the psychological and psychosocial stress during computer usage including time pressure, noise, precision and stroop task. This sub-section explained the task used by researchers to induce psychological and psychosocial stress among their subjects. The tasks including:

i) Arithmetic Task

Mental arithmetic task is a task used to increase subjects' mental load by performing a sequence or combination of arithmetic operation mentally. It is a very popular method used by psychosocial researcher to stimulate stress (Karthikeyan et al., 2011; Lundberg, 1994). Besides, it is easy to implement and does not need many tools and equipment (Linden, 1991). Wang et al., (2011) and Schleifer et al., (2008) adopt serial backward successive subtractions in their studies.

ii) Time Pressure and Precision Task

Time pressure is a common stress among computer user and it is likely to be contributors to MSDs (Heiden et al., 2005). Although the work pace is depending on the computer user himself, tight deadline always lead to time pressure (Birch et al., 2000).

Speed task is normally considered as one of the physical stressor, it is however also can be considered as psychological and psychosocial stress at the same time. This is because people always work faster

under time pressure. Meanwhile, speed and precision are regularly needed for computer mouse user in their daily job (Szeto and Lin, 2011).

The normal method to impose time pressure in laboratory during typing process is by asking the participants to type the passage faster or set a shorter time based on their normal typing speed.

iii) Stressful Environment

In a real working world, sometimes people get involved in a job that has a stressful environment, even for those who work in the office. Thus, several researchers use stressful environment conditions to induce the stress.

Many researchers used different kinds of stressful environment conditions to induce the stress including unfriendly attitude (Blangsted et al., 2004; Shahidi et al., 2013), lack of support (Blangsted et al., 2004), supervision by the experimenter attitude (Blangsted et al., 2004; Shahidi et al., 2013), incentives (Mclean and Urquhart, 2002; Shahidi et al., 2013; Garza et al., 2013; Eijckelhof et al., 2013b), verbal provocation (Wahlstrom et al., 2002; Chou et al., 2011; Johnston et al., 2008; Visser e al., 2004), noise (Mclean and Urquhart, 2002), say loudly for any mistake made by the participants (Mclean and Urquhart, 2002; Chou et al., 2011; Johnston et al., 2008), negative performance feedback (Shahidi et al., 2013; Visser et al., 2004) and over-commitment (Garza et al., 2013; Eijckelhof et al., 2013b).

iv) Stroop or Color-Word Task

Another popular method to induce stress during stress test is by using colour-word task or also known as stroop task (Larsman et al., 2009; Johnston et al., 2008; Lundberg et al., 1994). This test which is based on stroop effect theory (Stroop, 1935) where the name of a color is printed in a different color (e.g: 'blue' word is printed in green).

Ekberg et al. (1995) and Johnston et al. (2008) modified this task to induce stress by adding another disturbance which is using a voice to express the name of third color in addition to the normal stroop task.

v) Skill and Intelligence

For some jobs, people need to think and solve problems during computer work. Programmers for example, they need to think the structure of programming language and do the typing process simultaneously. For a job like this, it requires a certain level of skill and intellectual level. Eventually, it will cause stress to the computer user. Xiaopeng and Arijit (2011) use music and IQ test to see the effect of music and mental load induction on left extensor digitorum muscle activity while Rietveld et al. (2007) used a dual intelligence and skill computer task to provoke stress among subjects.

2.3.2 The effect of psychological and psychosocial stressors as well as characteristic of the subjects on trapezius muscle activity

From literature review, there are differences of effect obtained depending on the psychological and psychosocial stressors used to induce the stress and the characteristic of the subjects involved. Thus, this section tried to determine the influence of both categories.

2.3.2.1 The effect of task used to induce the stress

There are many muscles that have been studied in this review section. However, in order to compare the effect of psychosocial stress task on muscle activity, a common muscle studied need to be identified. Most of the study for computer work used trapezius muscle as a muscle of interest. It is expected because most of the complaint from computer users is about neck pain (Johnston et al., 2008). In this review, only several papers did not examined the effect on trapezius muscle including Xiaopeng et al. (2011), Hughes et al. (2007), Finsen et al. (2001), Gerard et al. (2002), Szeto and Lin (2011) and Garza et al. (2013). Even though there are some differences in terms of expression used for EMG value by the researchers, the effect of psychosocial stress on muscle activity still can be seen. As mentioned, there were several tasks used by previous researchers to induce psychological and psychosocial stress including arithmetic task, time pressure and color-word. Table 2.2 summarizes the effect of task used to induce psychological and psychosocial stress on trapezius muscle activity.

Table 2.2: The effect of task used to induce stress on trapezius muscle activity

Type of task	Author	Effect on trapezius muscle activity
Arithmetic Task	Ekberg et al., (1995)	Slightly increased but not significant
	Schleifer et al., (2008)	Significantly increased
	Wang et al., (2011)	No difference
Time Pressure (speed task) and / or Precision task	Wang et al., (2011)	Increased but not significant
	Bloemsaat et al., (2005)	No difference
	Sandfeld and Jensen, (2005)	Decreased when motor demand increased but increased when visual demand increased
	Szeto et al., (2005)	Significantly increased
	Aasa et al., (2011)	No difference
	Birch et al., (2000)	Increased but not significant
	Visser et al., (2004)	No difference
	Mclean and Urquhart, (2002)	Increased but not significant
Skill and Intelligence	Elke et al., (2001)	Significantly increased
	Bloemsaat et al., (2005)	Significantly increased
	Rietveld et al., (2007)	Significantly increased

Stressful Environment	Mclean and Urquhart, (2002)	Significantly increased
	Chou et al., (2011)	Increased but not significant
	Blangsted et al., (2004)	No difference
	Garza et al., (2013)	Reward does not have any significant effect. Over-commitment has a significant effect.
	Wahlstrom et al., (2002)	Significantly increased
	Shahidi et al., (2013)	Significantly increased
	Visser et al., (2004)	Significantly increased
	Johnston et al., (2008)	Increased but not significant
Stroop or color-word task	Johnston et al., (2008)	Lower than normal typing task
	Ekberg et al., (1995)	Slightly increased but not significant Lower compared to arithmetic task
	Laursen et al., (2002)	Significantly increased

Many previous studies recognized the effect of psychological and psychosocial stress on trapezius muscle activity during computer work. Some studies show that it increased trapezius muscle activity. Meanwhile, some other studies reviewed in this section reported that stress has no effect on trapezius muscle activity.

Besides that, the effect on trapezius muscle activity is depending on the type of task used to induce the stress. Different tasks affect the muscle activity differently. In comparison to the other type of task, by using stroop task to induce the stress during computer work has the lowest effect on trapezius muscle activity. In the meantime, stress induced by stress environment condition or skill and intelligence task has a high effect on muscle activity. In these two categories, only Blangsted et al., (2004) did not find this kind of impact, which probably due to a lack of statistical power (Eijckelhof et al., 2013a). Furthermore, there was also no measurement done in the study to ensure the level of subjects' stress caused by the task demands (Schleifer et al., 2008).

2.3.2.2 The effect of characteristic of subjects

i) The effect of gender

Many previous studies described that gender plays a role in MSDs symptom. Women were found to have more complaints of MSDs problem both in general and working population (Hooftman et al., 2013; Jensen et al., 1998). Riedl et al. (2013), however, argued that men experienced higher level of stress in some cases during human

computer of interaction. This review paper however does not find any proof of both cases. Even though there are many studies used male and female in the same study, all of these studies did not show any different effect of stress on women compared to men or vice versa on trapezius muscle activity (Hughes et al., 2007; Visser et al., 2004; Blangsted et al., 2004). Only Johnston et al. (2008) reported that women experienced greater muscle activity but not in trapezius muscle. Another significant difference between genders obtained by Ekberg et al. (1995) but only in the baseline systolic blood pressure and typing speed.

ii) The effect of health

Szeto et al. (2005) found that there are differences between healthy and unhealthy subjects with unhealthy subject have a greater increase during faster condition task especially on the right cervical erector spinae, upper trapezii and lower trapezii muscles. Same results was obtained by Johnston et al. (2008) where they found that there are significant effect between healthy and unhealthy group on sternocleidomastoid, anterior scalene, cervical extensor muscle. However, at the same time, Johnston et al. (2008) and another two studies reviewed in this section which are Rietveld et al. (2007) and Chou et al., (2011) also reported that there is no difference of effect between healthy and unhealthy subjects on trapezius muscle. Unhealthy subjects might have higher baseline for muscle activity but the stress has the same effect for both healthy and unhealthy subjects in trapezius muscle.

iii) The effect of age

As there is only one study in this section involved young and elderly groups, general effect cannot be identified. However, it should be noted that the study shows that elderly generally have a higher muscle activity in all muscle studied (Sandfeld and Jensen, 2005).

iv) The effect of occupation and mobile computing product

The effect of subjects' occupation cannot be identified because almost all of the studies used different types of occupation background. Some studies only used students as subjects, while some others chose typists or office workers. Furthermore, several studies reviewed in this paper did not even mention the subjects' occupation.

The effect of mobile computing products also cannot be recognized because none of the studies in this section used laptop, computer tablet or mobile phone as part of their study.

CHAPTER 3

CROSS-SECTIONAL STUDIES

3.1 Cross-sectional studies

This research is divided into two parts. The first part of this study is cross-sectional studies. The aim of these studies is to see the association between psychological and psychosocial factors and prevalence of MSD symptoms among workers from different occupations. Several occupations have been selected including dentist profession, internship doctors and construction workers. As mentioned, previous studies examined different psychological and psychosocial factors and even though there were studies examining the same factor, the questionnaires that they used were different. Therefore, in the cross sectional section, the relationship between MSDs prevalence and psychosocial factors will be assessed based on the same criteria (i.e job satisfaction, mental demand, job requirements, work hazards, workload and responsibility) from the same questionnaire (Job Stress Questionnaire from NIOSH).

There were several reasons why these occupations were selected. Based on literature review and some interviews conducted with several dentists, medical officers and construction engineers, these occupations met the early requirement needed in this study. At least, on the earlier stage, based on literature review and interview, it seems that these

occupations have a different physical and psychosocial challenge between each other. Therefore, it will allow us to see the influence or the association of psychological and psychosocial factors on the three types of occupation. Based on interviews with two dentists, it seems that dentist profession in Malaysia involves high physical aspect especially in terms of awkward posture but low / moderate in terms of psychological and psychosocial factors (depends on their working place and other factors). In order to examine their patients' mouth, the dentists need to work frequently in awkward posture. Some tooth position required more awkward posture than the others. For instance, based on the interview, upper molar tooth treatment was difficult to be viewed clearly using dental mirror. Thus, sometimes, it required the dentist to bend and directly took a look at the tooth. Their job normally requires the usage of both of their hands to do each procedure including tooth filling, extraction or scaling. For their working condition, normally, each dentist was provided with an assistant to help them to prepare items related to the procedure. In each health clinic, there were several dental clinics. Each dental clinic was normally managed by a dentist and every two dental clinics shared an assistant.

Meanwhile, based on literature review and interview with two medical officers, it seems that internship doctor in Malaysia involve high challenge especially in psychology and social aspects but low / moderate in terms of physical activity. Aside from working in a very hazardous environment, involves other people's life, exposed to legal or illegal consequences, internship doctors also need to work for a very long hours. After working hours, they also need to study in order to

ensure they know all the procedures or information regarding their job for the next day.

In opposite with the dentist and internship doctors, it is known that construction works involve high physical activity. In a construction field, there were many trades involved including bricklayers, concrete workers, electrician and many others. All these trades have their own challenge. Furthermore, based on literature and interviews with two construction engineers, it also involves moderate / high psychological and psychosocial challenge. Each of the construction has their own schedule to maintain. However, most of the time, there were many unexpected things happened during the construction such as unsuitable weather, design changes or inadequate raw material supply. Consequently, construction workers need to work under time pressure in order to finish the construction on time. This condition sometimes reduced job satisfaction and increased workload among construction workers.

Thus, these surveys were conducted to see the influence of psychological and psychosocial factors on MSDs in different professions that have different level of psychological and psychosocial challenges.

Although this study emphasize on mobile computing products usage, none of the surveys was done on occupation that involve full time computer usage such as data entry operator. There are several reasons why the survey was not done on data entry operators. Firstly, the aims of these surveys were to see the relationship between psychological and psychosocial and prevalence of MSDs. Therefore,

occupations with different levels of physical and psychological and psychosocial challenge were chosen. Even though, data entry operators require low physical demand, the environment they are working normally involve low / medium psychological and psychosocial challenge depending on their individual characteristic and working environment (i.e supervisor, working place condition etc.). Even if they are working on high psychological and psychosocial stress, it should not be higher than stress faced by internship doctors. Besides, the occupation as internship doctors involves someone else's life, which cannot be compared with the level of psychological and psychosocial challenges faced by data entry operators.

The limitation of cross-sectional studies has been recognized. For instance, aside from limited capability to withdraw causal and effect relationship, there will be always a possibility for inaccurate recall of information (Woods, 2005). However, in the meantime, cross-sectional studies allow us to have an early picture regarding the relationship between the exposures of these workers on psychological and psychosocial factors and prevalence of MSD symptoms.

The next section provides overview regarding MSDs and physical, psychological and psychosocial challenge on dentist, internship doctors and construction workers occupations.

3.2 Overview regarding MSDs as well as physical, psychological and psychosocial challenge on dentist, internship doctors and construction workers occupations

i) Dentist profession

MSDs have become a major concern for those in the dental profession. A high prevalence of MSDs among dentists has recently been reported, especially disorders affecting the neck, shoulder, back, and wrist (Kursun et al., 2014; Samat et al., 2011; Hayes et al., 2009; Karmen et al., 2011; Melis et al., 2014). MSDs can lead to an inordinate amount of sick leave, a decline in performance, or — in the worst case — the need to abandon the profession (Kursun et al., 2014). Dentists' posture while sitting and working is relatively static and awkward, and their activities require repetitive hand and wrist motions and occasionally excessive force (Khan and Chew, 2013; Kumar et al., 2012; Warren, 2010; Lindfors et al., 2006). Tasks that demand a certain level of precision will sometimes force the dentist to adopt unnatural postures (Akesson et al., 1999). Furthermore, dentists are exposed to high-frequency vibrations from handpieces or scalers, which also contributes to these disorders (Warren, 2010; Cherniack et al., 2006).

Aside from the obvious physical factors, psychosocial factors can be an indirect cause of MSDs for dentist. Some studies have shown that the dental profession itself is challenging, not only physically but also psychosocially (Rolander et al., 2008; Bejerot et al., 1998), which

might contribute to MSDs (Ford and Ozimba, 2014; Lindfors et al., 2006; Ylipaa et al., 2002). Previous studies showed that dentist, whose work is characterized by high levels of psychosocial or psychological stress have been found to be more likely to report or develop pain in their bodies (Lindfors et al., 2006; Palliser et al., 2005; Leclerc et al., 1999). Stress factors include time pressure, a considerable mental workload, and low levels of job control and support from co-workers. Without a proper management system, these same factors might affect the practicing dentist.

MSDs can be ameliorated or prevented by adopting an ergonomic approach when choosing dental equipment, instrument design, and working techniques (Kursun et al., 2014; Khan and Chew, 2013). Previous studies have shown that the prevalence of MSD symptoms was lower among dentists who changed their working techniques and conditions accordingly. Such adaptations may include adjusting the position of the body when accessing different quadrants of the mouth; using additional equipment, such as mirrors, to get a better view when direct access to surfaces is problematic; working with the elbows positioned lower than the shoulders; stretching periodically; and pausing occasionally to relieve muscle strain or tension (Kursun et al., 2014; Khan and Chew, 2013; Melis et al., 2004). Furthermore, ergonomically designed furniture and dental tools might promote good posture and thus reduce the likelihood of MSDs (Kursun et al., 2014). A study by Khan and Chew (2013) involving 575 dental students in Malaysia indicated that the majority (92%) had never attended a

training session or workshop on the application of ergonomics in the practice of dentistry.

The debilitating effects of MSDs might lead the dentist to seek medical treatment, which could include the use of a drug, such as cortisone injection, or an alternative form of treatment, such as chiropractic care, massage therapy, or acupuncture. For psychological stress, relief might be achieved by playing sports, doing yoga, or just taking a rest. If the symptoms persist with no attempt to prevent or remedy them, they are likely to get worse over time or whenever they are triggered. For this reason, it is important to determine whether dentists use any of these approaches or medications to avoid or reduce the effects of MSD symptoms.

ii) Internship doctors

Healthcare personnel especially for those who are working in hospital setting are vulnerable to a wide range of hazards. Aside from working indoors with potential exposure to a variety of diseases and toxic chemical agents, health care personnel especially doctors need to perform their job under very stressful working environment (Ito et al., 2014; Lin et al., 2008; Arnetz, 2001; Mirbod et al., 1995). For instance, their job involves not only other people's life but they are also exposed to legal or illegal consequences such as get sue or get threaten by their patient. Besides that, they are the front line who need to deal with undiagnosed airborne disease, more vulnerable to other blood

transfusion disease (i.e in the case of needle stick injury while handling patients etc) and at risk of unexpected factor (i.e raging patient). Furthermore, young hospital doctors especially those who are on their internship period, work excessively long hours, do not have enough rest as well as sleep and need to work under high pressure caused by not only their patients (and families) but also by their immediate supervisor (medical officer and specialist) (Ito et al., 2014; Spurgeon and Harrington; 1989). Other elements during the period of internship in Malaysia include ward rounds, patient (and families) consultations, exams and report writing.

Doctors (in internship period) in Malaysia are constantly exposed not only to physical factors but also to a great deal of psychological and psychosocial factors. All these factors will increase and might contribute to the occupational fatigue and injuries including MSDs. MSDs are well-known health problems for all profession all over the world including health care worker. It is estimated that nearly one-third of sick leave cases among health care workers are associated with MSDs (Mehrdad et al., 2012).

Internship doctors faced a variety working environment during their internship period. Each of them needs to go through at least six departments (out of seven departments) for two years of their internship period. Each four months, they will move to another department. The departments include Medical, Orthopedic, Pediatric, Anesthesia, Accident and Emergency (A&E), Obstetrics and Gynecology (O&G) and Surgical. Each of this department has their own physical, psychological and psychosocial challenges. For instance, internship

doctors who are working in Medical department need to work under extra pressure caused by a large number of patients. For those who are working in this department, they need to work very fast in order to reduce the patients' waiting time but at the same time need to satisfy the need of the patient and provide correct judgment regarding patients' condition. Meanwhile, for those internship doctors who are working in Orthopedic department, they will face extra physical challenges. In this department, they frequently need to assist their supervisor (medical officer or specialist) to do a big operation. For example, in certain operation, they need to assist by holding the patient's leg in an awkward posture in order to allow their supervisor to do the operation needed. In summary, doctors faced a variety of physical, psychological and psychosocial challenges during their internship period.

iii) Construction workers

Construction industry is one of the most important industries especially for a developing country like Malaysia. This industry has been contributed a lot to the development of economic in Malaysia (Department of Statistics, 2015). However, the construction industry is also associated with occupational risks and hazards and regarded as one of the most hazardous industries especially on MSDs (Boschman et al., 2012; Fung et al., 2008, Ueno et al., 1999).

The cost related to MSDs among construction workers not only involve the hospital fee, but also includes the productivity lost, sick leave, disability pension and many others. For instance, in a study on a

14 474 construction workers in Germany by Arndt et al. (2005), 2247 of them (16%) were granted a disability pension and MSDs were one of the major reason. MSDs with the construction industry were ranking third for sickness absence in Germany (Latza et al., 2000). Similar figures have been reported in Japan where Japanese Ministry of Labor stated that low back pain is the major cause of occupational leave for more than three days and that the construction industry has the second highest rate in terms of the number of patients (Kaminskas and Antanaitis, 2010; Ueno et al., 1999). In Malaysia, diseases of the musculoskeletal system and connective tissue have been reported as one of the ten principal causes of hospitalization in private hospital in year 2013 (MOH, 2014).

There are several factors that might contribute to the prevalence of MSDs symptoms in construction workers. Heavy physical work, especially in different awkward postures is considered as the main contributor for MSDs (Kaminskas and Antanaitis, 2010). Construction workers were normally exposed to vibrations, noise and dust and frequently involved in high physical activity such as lifting and carrying heavy weight (Kaminskas and Antanaitis, 2010; Fung et al., 2008).

Aside from physical factors, individual factors such as age also play a role in the prevalence of MSDs among construction workers. In a study on 85 191 males in the Swedish construction industry, Holmstrom and Engholm (2003) found that MSDs increase with age. Besides that, the prevalence of MSDs in certain body locations was different depended on their trades (Jensen and Kofoed, 2002; Tola et al.,

1988). For example, even though they are working in the same industry, the prevalence of MSDs in neck region was higher among painters compared to bricklayers (Kaminskas and Antanaitis, 2010; Holmstrom and Engholm, 2003). This main reason might be because, unlike bricklayer, painters need to frequently look up which consequently exhausted neck muscle and developed pain in that body region. Meanwhile, bricklayers have the higher prevalence of MSDs in lower back region compared to painters (Kaminskas and Antanaitis, 2010; Holmstrom and Engholm, 2003). This is because most of the time bricklayer did their job in the bent position (Kaminskas and Antanaitis, 2010).

The third factor that might be contributed to the development of MSDs is psychological and psychosocial factors. It has been suggested that the psychosocial factors may cause the motor units (functional units of the muscle) to be active continuously (Hagg, 1991) which possibly will increase pain sensitivity (Lundberg et al., 2002). The effect of psychological and psychosocial factors among construction workers have been reported several times (Sobeih et al., 2006; Engholm and Holmstrom, 2005; Jensen and Kofoed, 2002). Construction workers may exposed on different kind of psychological and psychosocial stressor at one time such as time pressure, low job control and low support from supervisor (Engholm and Holmstrom, 2005; Latza et al., 2002). Several studies attempt to determine the effect of psychological and psychosocial factors on MSDs among construction workers. However, the results have been inconsistent

(Engholm and Holmstrom, 2005; Latza et al., 2002; Jensen and Kofoed, 2002; Latza et al., 2000).

3.3 The purpose of these cross sectional studies

From the overview section, we can see the different physical, psychological and psychosocial challenges faced by dentists, internship doctors and construction workers. Even for those who are working in the same profession, the physical, psychological and psychosocial challenges might be different depending on their department and trades as can be seen in the overview for internship doctors and construction workers. In general, these cross sectional studies aimed to determine the association between physical, psychological and psychosocial factors with the prevalence of MSDs in three different professions in Malaysia.

Very little research has focused on the occupational health of dental personnel in Malaysia (Samat et al., 2011); rarer still are studies examining the association of psychological and psychosocial stress on MSDs among dental personnel, especially dentists. In Malaysia, the focus has been on dental students, mainly their perceived stress while they are in university (Telang et al., 2013; Khan and Chew, 2013; Ahmad et al., 2011). Thus, a part of this study was designed to investigate the association of physical, psychological and psychosocial factors on MSDs among practicing dentists in Malaysia. It is essential to understand both types of factors in managing problems related to

MSDs. Moreover, the ways in which dentists manage their symptoms are also important and might actually contribute to the severity and frequency of the symptoms. Therefore, this study also assessed the mechanisms they used to cope with MSD-related problems.

Meanwhile, there are many studies regarding prevalence of MSDs among healthcare personnel. However, most of the studies only focused on nurse, dentist, surgeons and physical therapists and mainly concentrated on low back pain and the relationship with physical factors (Mehrdad et al., 2012; Szeto et al., 2009; Kant et al., 1992). Only a few of the studies (if any) focused on general doctor especially on the young medical doctors who undergo their internship. Furthermore, a study that involved psychological and psychosocial factor is rarely explored. Therefore, one of the purposes of this study is to provide a general picture of the perceived MSDs problems among internship doctors and their relationship with physical, psychological and psychosocial factors.

In the meantime, even though the effect of physical factors has been recognized, the effect of psychological and psychosocial factors on construction workers still debatable. Furthermore, only a few studies attempt to determine the associations between psychological and psychosocial factors and the prevalence of MSDs among construction workers especially in Malaysia. Therefore, the purpose of this study was to determine the prevalence of MSDs symptoms among construction workers in Malaysia and its association with physical, psychological and psychosocial factors.

3.4 Methods

Each participating dentist, internship doctor and construction worker was provided with a statement outlining the information needed for this research, as well as a 5-page survey and a stamped envelope with a return address on it. The survey was divided into four sections for internship doctors as well as construction workers and five sections for dentist. These sections are: background information, physical factors, psychological and psychosocial factors, musculoskeletal symptoms, and treatment choices and ergonomic conditions. Consent to participate was assumed when a respondent returned the completed anonymous survey. The only criterion to participate in this study was at least 12 months experience working as a dentist, internship doctor or in construction area.

Although there were some differences of the information collected for each profession, basically, the background information collected were regarding their gender, age, height, weight, years of practice, number of patients, and duration of work per week,

For dentist, questions in the physical factors section concerned the dentists' dominant hand, number of patients seen per day, characteristics of their chair, difficulty in reaching their instruments, and questions (on a scale of 5) about how often they needed to work very fast, work very hard, use vibrating tools, and assume awkward postures (CDC, 2014; Samat et al., 2011; Warren, 2010). Meanwhile, for internship doctors, physical factors section concerned their main

working position, did they do stretching exercise during breaks, how often they need to work physically very fast (their working pace), physically very hard (i.e lifting patient, lifting or carry heavy load), use vibrating tools and with awkward postures. For construction workers, questions in the physical factors section concerned the workers' main job (the choices including painters, bricklayers, scaffolder, carpenters, concrete workers, crane operators, electricians, asphalt workers, steel workers and others), and about how often they needed to work very fast, work very hard, use vibrating tools, and assume awkward postures.

Psychological and psychosocial factors were divided into six different areas, as described in the Generic Job Stress Questionnaire developed by the National Institute for Occupational Safety and Health (NIOSH) (CDC, 2014; Palliser et al., 2005). These areas included intragroup conflict (3 items), job requirements (8 items), job satisfaction (4 items), mental demands (5 items), work hazards (4 items), and workload and responsibility (8 items). Intragroup conflict was mostly regarding the relationship between the participants and member of their team. For instance, dentists need to work with an assistant. Therefore, intragroup conflict questions were regarding their relationship and friendliness with their assistant. The score for each category was grouped into three levels; high, medium and low. The questions asked regarding the psychological and psychosocial factors were shown in Appendix 1.

The section on musculoskeletal symptoms was based on the Standardized Nordic Questionnaire (SNQ) (Kuorinka et al., 1987), a

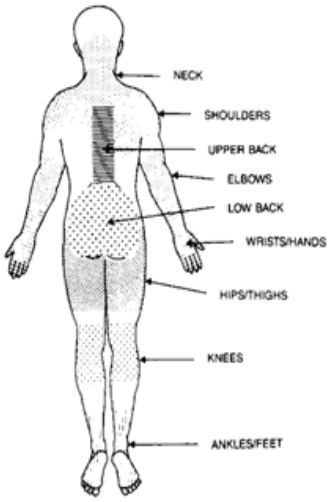
reliable, valid, and popular tool used by researchers and health professionals to collect information from respondents concerning MSDs (Hayes et al., 2013; Kuorinka et al., 1987). Several studies have used the SNQ to identify MSDs among dentists (Hayes et al., 2013; Rolander et al., 2013; Samat et al., 2011). A diagram showing the body as divided into nine regions was used as an aid to the respondents in describing and locating any symptoms they had experienced (e.g., ache, pain, or discomfort) within the preceding 12 months (Figure 3.1).

The fifth section (for dentist) covered treatments used and ergonomic conditions in their workplace and was based on the study conducted by Kursun et al. (2014) involving postgraduate dental students. It included questions about how the dentist dealt with MSD symptoms (e.g., types of treatments sought) and specific ergonomic work conditions (e.g., sufficient light, working posture, stretching exercises, and procedures to accommodate indirect vision).

Statistical analysis was done using the Statistical Package for Social Sciences (SPSS) version 17. Means and standard deviations were calculated for continuous variables, and frequencies and percentages were determined for categorical variables. Differences in MSD prevalence were investigated by means of t-test or analysis of variance (ANOVA) for continuous variables and the chi-square / Fisher's exact test for categorical variables.

How to answer the questionnaire:

You may be in doubt as how to answer, but please do your best anyway. Please answer every question, even if you have never had trouble in any part of your body. The questions are on the next page.



In this picture you can see the approximate position of the parts of the body referred in the questionnaire. Limits are not sharply defined and certain part overlap. You should decide for yourself in which part you have or have had your trouble (if any).

Have you at any time during the **last 12 months** had trouble (ache, pain, discomfort) in:	To be answered **only** by those who have had trouble	
	Have you at any time during the **last 12 months been prevented from doing your normal work** (at home or away from home) because of the trouble	Have you had trouble at any time during the **last 7 days**?
Neck 1 No 2 Yes	1 No 2 Yes	1 No 2 Yes
Shoulders 1 No 2 Yes, in the right shoulder 3 Yes, in the left shoulder 4 Yes, in both shoulders	1 No 2 Yes	1 No 2 Yes
Elbows 1 No 2 Yes, in the right elbow 3 Yes, in the left elbow 4 Yes, in both elbows	1 No 2 Yes	1 No 2 Yes
Wrist/hands 1 No 2 Yes, in the right wrist/hand 3 Yes, in the left wrist/hand 4 Yes, in both wrists/hands	1 No 2 Yes	1 No 2 Yes
Upper back 1 No 2 Yes	1 No 2 Yes	1 No 2 Yes
Low back (small of the back) 1 No 2 Yes	1 No 2 Yes	1 No 2 Yes

Figure 3.1: Example of musculoskeletal symptoms information collected in this study (based on SNQ)

Cross sectional study on dentist and internship doctors are registered with the National Medical Research Registration of Malaysia (NMRR-14-1624-23718 and NMRR-15-1578-27429 respectively) and were declared exempt from an ethics review by the Medical Research Ethics Committee of Malaysia.

3.5 Results

In order to present the results clearly, the results section has been divided into three which are the results for dentist, internship doctors and lastly for construction workers.

3.5.1 Dentists

3.5.1.1 Demographic data

A total of 85 dentists participated in this survey; three of the surveys that were returned were missing more than 5% of the data, and these participants were consequently excluded from the analysis. Demographic data for the 82 participants in terms of means, standard deviations (SD), and percentages are summarized in Table 3.1. Body mass index (BMI), as used in this study, was based on guidelines from the Malaysian Ministry of Health (MOH, 2004). The cutoff point for BMI in Malaysia is lower than that stated by the World Health Organization for several reasons, one of which is that Asian subjects

have a higher percentage of body fat at a similar BMI cutoff point than do Caucasian subjects (MOH, 2004).

Table 3.1: Demographic data of the dentists (n=82)

	Mean	**SD**	**No. of participants**	**%**
Age (year)	30.0	3.9		
Height (cm)	160.2	6.8		
Weight (kg)	64.4	10.4		
No. of years in practice	4.51	3.45		
No. of patients per day	16.6	7.0		
Working time per week (hour)	44.7	5.4		
Age (year):				
<29.9			47	57.3
30.0 to 34.9			26	31.7
>35.0			9	11.0
BMI (kg/m^2)*:				
Normal (18.5–22.9)			22	26.8
Pre-obese (23.0–27.4)			44	53.7
Obese (27.5–34.9)			16	19.5
Gender:				
Male			27	32.9
Female			55	67.1
Marital status:				
Single			37	45.1
Married			45	54.9

*BMI cutoff point for Malaysian based on MOH (2004).

3.5.1.2 Musculoskeletal symptoms

The prevalence of MSD symptoms among these dentists in Malaysia was found to be very high. Figure 3.2 shows the survey results reflecting the prevalence of symptoms over the preceding 12 months in terms of nine body regions. The most prevalent region affected was the shoulder area, followed in descending order by the neck, upper back, lower back, and wrists/hands. None of the participants was totally free of MSD symptoms during the 12-month period. Of 82 participants, only two (2.4%) reported MSD symptoms at a single anatomic site during the last year; the other 80 dentists reported having discomfort or pain in a minimum of two locations (13.4% reported sites, 26.8% reported three, and 28.0% reported four, followed by 14.6%, 11.0%, and 3.7% reporting five, six, and seven locations, respectively).

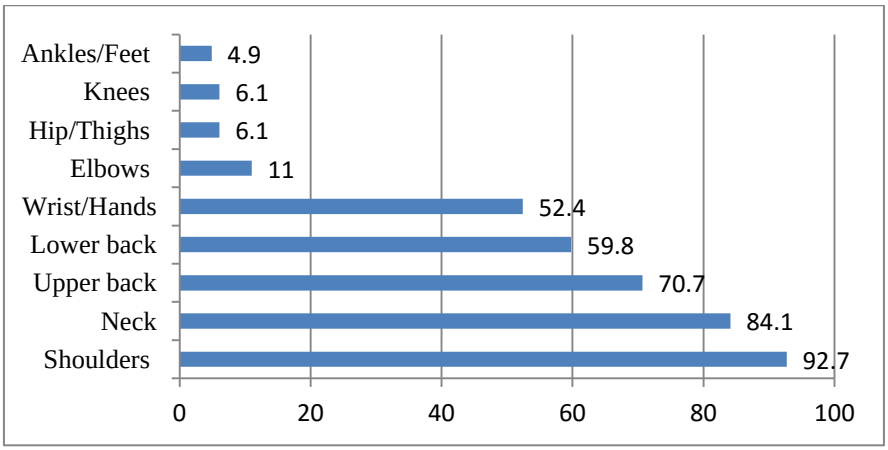


Figure 3.2: Prevalence (%) of MSD symptoms affecting specific body regions over a 12-month period

Figure 3.3 shows the percentage of participants who encountered problems when performing their normal activities at those times when symptoms were present (by body region). The highest percentage involved the shoulders and wrists/hands. In addition, it should be noted that even though most of the participants were right-handed, about 43% of the participants experienced symptoms in both shoulders. A similar result was found in the elbow area, in that two thirds of symptomatic participants had problems in both elbows.

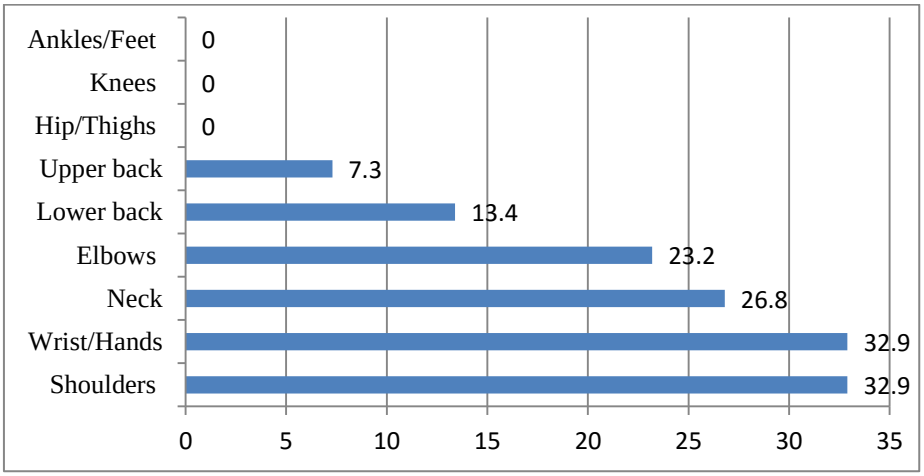


Figure 3.3: Percentage of dentists who had problems performing normal activities when symptoms appeared (by body region)

Meanwhile, based on Chi-square and Fisher exact test analysis, neck and ankles/feet pain has been found to be significantly associated with the frequency the dentist need to work very fast ($p = 0.036$ and $p = 0.028$ respectively) and knees pain has been found to be significantly

associated with the frequency the dentist need to work very hard ($p = 0.004$). Shoulders and ankles/feet pain has been significantly associated with the frequency they work with awkward posture ($p = 0.024$ and $p = 0.033$ respectively). Meanwhile, age has been found to be significantly associated with elbows pain ($p = 0.042$) where older dentist were more likely to experience elbow pain in the past 12 months.

In some cases, there were significant association between physical factors and MSD symptoms that prevented them from performing normal activities have been found. For instance, neck pain has been found to be significantly associated with the frequency they need to work very fast ($p = 0.001$) and with vibrating tool ($p = 0.031$). Meanwhile, elbow and lower back pain has been significantly associated with the frequency they work with awkward posture ($p = 0.013$ and $p = 0.005$ respectively).

A significant relationship was found between prevalence of MSD symptoms in the upper back that prevented them from performing normal activities with certain sociodemographic variables such as age ($p = 0.015$), BMI ($p = 0.047$) and years of practice ($p = 0.017$). Besides that, another significant relationship has been found between neck pain and years of practice ($p = 0.017$).

3.5.1.3 Physical factors

By and large, the equipment and instruments used by these dentists in Malaysia were in good condition. For instance, all had well-designed chairs with back support and adjustability. Most of the participants were right-handed, and about 75% reported that it was easy or very easy to reach their instruments (Table 3.2). Nevertheless, one important aspect of their working environment was of concern. When asked how often they worked very fast, worked very hard, used vibrating equipment, or worked in an awkward position, most of the dentists responded "often" or "very often." As can be seen in Figure 3.4, none of the participants answered "rarely" for any of the conditions posed.

Table 3.2: Physical aspects according to dominant hand, chair characteristics, and degree of difficulty in reaching instruments

Physical aspect	**% (n)**
Dominant hand	Right: 93.9 (77) Left: 6.1 (5)
Chair characteristics:	
Has back support	100 (82)
Has foot rest	76.8 (63)
Adjustable	100 (82)
Access to instruments	Very easy/easy: 75.6 (62)

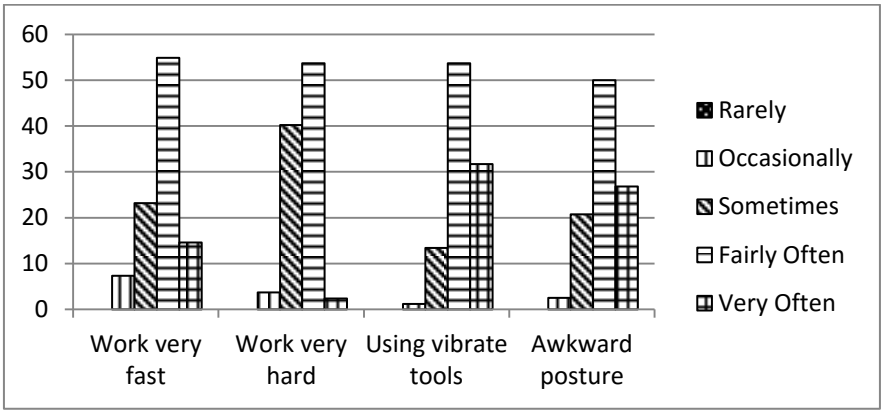


Figure 3.4: Percentage of dentists involved in certain behaviors according to frequency of involvement

3.5.1.4 Psychological and psychosocial factors

Six categories of psychological and psychosocial factors were assessed in this study based on the NIOSH Generic Job Stress Questionnaire. The level of stress imposed on the dentists was evaluated for each category, and the results were separated into low, medium and high.

Almost all the participants were satisfied with their job as a dentist in Malaysia; in fact, 35% reported being "very satisfied." The majority of the participants reported low stress in two categories (job satisfaction and work hazards) and medium stress in the other four categories (intragroup conflict, job requirements, mental demands, and workload and responsibility). As can be seen in Table 3.3, there was a certain degree of relationship regarding the result of psychological and psychosocial factors and MSD symptoms. Prevalence of MSD symptoms in each body part has been significantly associated with

different psychological and psychosocial stressors. Only pain at wrist/hands has been significantly associated with three psychological and psychosocial stressors while the others have been significantly associated with only two or one psychological and psychosocial stressors. None of the stressors has been significantly associated with upper back, lower back and knees pain.

However, if we compare the data with musculoskeletal pain that prevented them from carrying out normal activities, the results will be a bit different. For instance, neck has been found to be significantly associated with job satisfaction instead of mental demand (Table 3.4).

Based on t-test and ANOVA analysis, generally, none of the demographic data such as gender, marital status and BMI were significantly associated with the psychological/psychosocial stress perceived by the dentists. However, there were some exceptions. For instance, there were significant differences of job satisfaction stress between male and female ($t = -2.381$, $p = 0.020$), intragroup conflict between single and married dentist ($t = 3.100$, $p = 0.003$) and different group of age ($F = 6.944$, $p = 0.002$), workload and responsibility stress between different group of age ($F = 4.236$, $p = 0.018$). Post-hoc Benferoni test indicates that older dentist has a higher intragroup conflict stress and workload and responsibility stress compared to the younger dentist. Meanwhile, there was significant difference between number of patient and job requirement stress ($F = 4.652$, $p = 0.005$) in which dentists who have a higher number of patients have a higher level of stress.

Table 3.3: Percentage and number of dentist in the low, medium and high stress groups and their significant association with prevalence of MSD symptoms at specific body parts

Psychological & psychosocial stressor	Low stress, % (n)	Medium stress, % (n)	High stress, % (n)	Chi square / Fisher's exact test (p value and effect size)								
				Neck	Shoulders	Elbows	Wrist/ hands	Upper back	Lower back	Hips/ thighs	Knees	Ankles/ feet
Intragroup conflicts	43.9 (36)	56.1 (46)	0 (0)	-	-	-	0.031 large	-	-	-	-	-
Work hazards	74.4 (61)	23.2 (19)	2.4 (2)	-	<0.000 large	-	-	-	-	-	-	0.017 large
Job satisfaction	80.5 (66)	18.3 (15)	1.2 (1)	-	-	0.016 large	0.008 large	-	-	0.013 large	-	-
Job requirements	3.7 (3)	67.1 (55)	29.3 (24)	-	-	-	-	-	-	-	-	-
Mental demands	2.4 (2)	56.1 (46)	41.5 (34)	0.011 medium	-	-	0.003 medium	-	-	-	-	-
Workload & responsibility	0 (0)	87.8 (72)	12.2 (10)	-	0.025 medium	-	-	-	-	-	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant
Strength of the relationship / Effect size were based on phi (0.1 = small, 0.3 = medium, 0.5 = large) or Cramer's V (df = 2, small = 0.07, medium = 0.21, large = 0.35)

Table 3.4: Significant association between musculoskeletal pain that prevented dentists from carrying out their normal activities and prevalence of MSD symptoms at specific body parts

Psychological and psychosocial stressors	Body regions			
	Neck	Upper back	Lower back	Elbow
Intragroup conflicts	-	0.022 small	-	-
Work hazards	-	-	-	-
Job satisfaction	0.002 large	-	0.001 large	-
Job requirements	-	0.041 medium	-	0.026 medium
Mental demands	-	-	-	-
Workload & responsibility	-	0.002 medium	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant
Strength of the relationship / Effect size were based on phi or Cramer's V value

3.5.1.5 Treatment choices and ergonomic conditions

This study found that 46 of the participants (56.1%) sought treatment for their MSD. Of these, only four participants (8.7%) chose medication and 26 (56.5%) preferred physiotherapy. Nineteen of the dentists (41.3%) relied on exercise to relieve their discomfort or pain. Meanwhile, almost half the participants (45.1%) did not get proper rest or take breaks during working hours. This could be because almost half the dentists (47.6%) considered their workload to be somewhat heavy.

A smaller percentage of the participants (40.2%) did stretching during work breaks. As for posture, about half of them (58.5%) were mainly seated while doing their job, 20.8% mainly stood, and the rest did both. Most of them (78.0%) changed their position frequently during clinical activities, and all used a dental mirror to provide indirect vision. In 34.1% of cases, the dentists reported that they did not have sufficient light at their workplace.

3.5.2 Internship doctors

3.5.2.1 Demographic data

In total, there were 91 internship doctors participated in this study. However, five of the collected surveys did not answer important questions such as questions regarding musculoskeletal symptoms or psychological and psychosocial and consequently excluded from the analysis. Demographic data of the participants in terms of mean, standard deviation (S.D) and percentages were summarizes in Table 3.5.

Table 3.5: Demographic data of the internship doctors (n=86)

	Mean	SD	No. of participants	%
Age (year)	26.0	0.55		
Height (cm)	160.0	7.61		
Weight (kg)	57.2	10.67		
Working time per week (hour)	72.3	10.5		
Current posting:				
Medical			10	11.6
Pediatric			14	16.3
Orthopedic			12	14.0
Surgical			14	16.3
Anestesia			13	15.1
Obstetrics and Gynecology (O&G)			11	12.8
Accident and Emergency (A&E)			12	14.0
BMI (kg/m^2)*:				
Underweight (< 18.5)			8	9.3
Normal (18.5–22.9)			44	51.2
Pre-obese (23.0–27.4)			33	38.4
Obese (27.5–34.9)			1	1.2
Gender:				
Male			40	46.5
Female			46	53.5
Marital status:				
Single			84	97.7
Married			2	2.3

*BMI cutoff point for Malaysian based on MOH (2004).

3.5.2.2 Musculoskeletal symptoms

Among 86 (or 100%) internship doctors participated in this study, 32 (or 37.2%) of them were free from any musculoskeletal symptoms over the preceding 12 months. Meanwhile, 28 (or 32.6%) of them reported that they having musculoskeletal discomfort or pain symptoms at a single body region during the last year, 16.3% reported two regions, 9.3% reported three, followed by 2.3%, 1.2%, and 1.2% reporting four, five and six regions respectively. As shown in figure 3.5, over the preceding 12 months, the most prevalent region affected was the neck area, followed in descending order by the wrist/hands, lower back, upper back, ankles/feet and knees. None of the doctors reported musculoskeletal pain at elbows and hip/thighs.

Meanwhile, of those nine body regions, the highest percentage of participants reported that the symptoms prevented them from performing their normal activities when symptoms were present at neck and wrist/hands (5.8%), followed by upper and lower back (4.7%) and finally ankles/feet (1.2%). None of the participants reported they encountered problems to perform their normal activities at those times when symptoms were present at other body region.

Meanwhile, based on Chi-square and Fisher exact test analysis, none of the physical factor has been associated with musculoskeletal symptom among doctors except one. Lower back pain has been found to be significantly associated with awkward posture ($p = 0.038$).

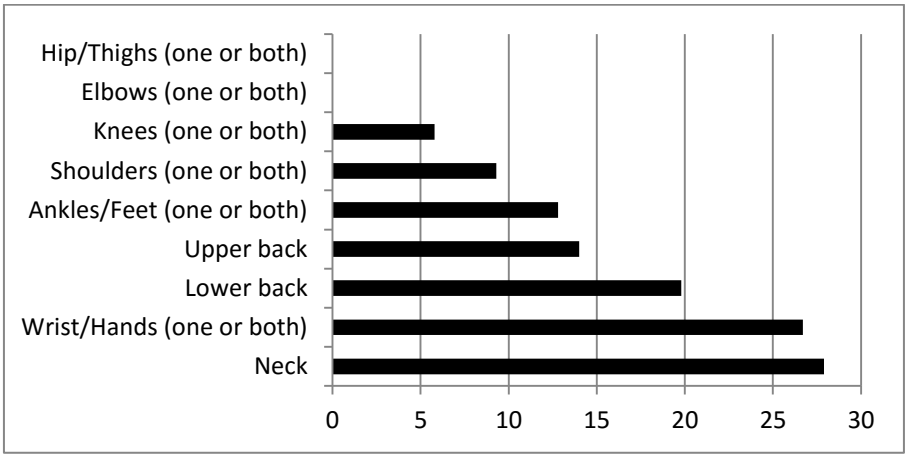


Figure 3.5: Prevalence (%) of MSD symptoms affecting specific body regions among internship doctors over a 12-month period

3.5.2.3 Physical factors

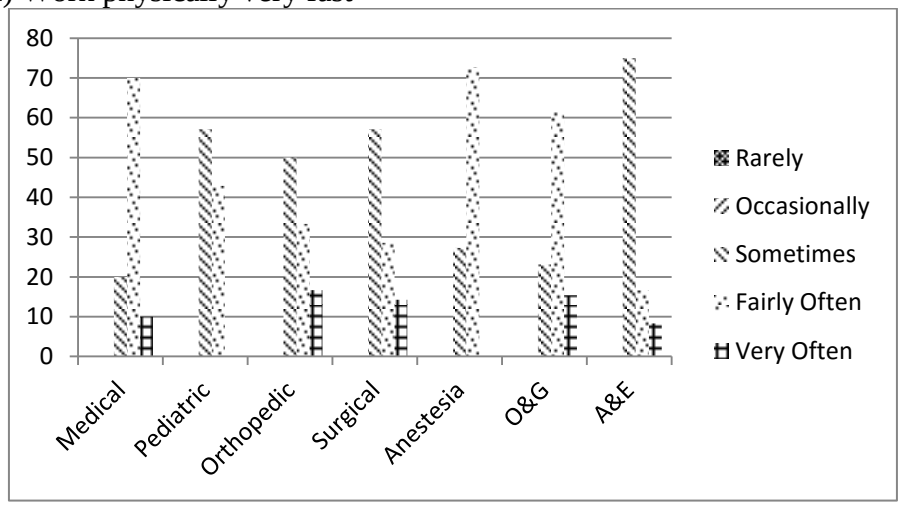
None of the participants answered mainly sitting for their working position. Most of them (58.1%) stated that they were mainly standing during working while 32.6% reported their working position was mainly walking. Although there were only three answer choices which are “mainly sitting”, “mainly standing” and “mainly walking”, some of the participants (9.3%) answered both “mainly standing” and “mainly walking” for their working position.

Besides that, none of the participants get proper rest or take breaks during working hours. It is understandable since most of them (75.6%) reported that they have a lot of work load while the rest reported they have “a great deal” of work load. Meanwhile, only a small percentage of the participants (34.9%) did stretching during work breaks.

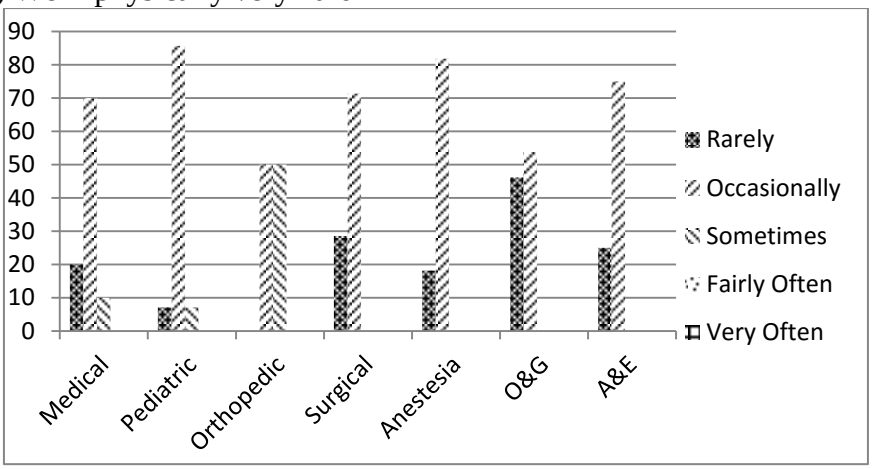
With high work load and a little of time to do their work, more than half (54.7%) of the doctors often need to work physically very fast. Meanwhile, although they work in health line, it seems the doctors did not need to do something that physically very hard such as lifting patient. More than half of the participants reported that they were occasionally or rarely need to work physically very hard. Besides that, unlike dentist, the doctors rarely and occasionally need to work on awkward posture. As mentioned, there were some differences of physical and psychological challenge faced by the internship doctors depended on their department. Therefore, for physical as well as psychological and psychosocial factors results were divided into different departments for the analysis as shown in Figure 3.6.

Meanwhile, based on Chi-square and Fisher exact test analysis, the frequency of the doctors in medical department need to work very fast has been associated with wrist / hands pain ($p = 0.033$).

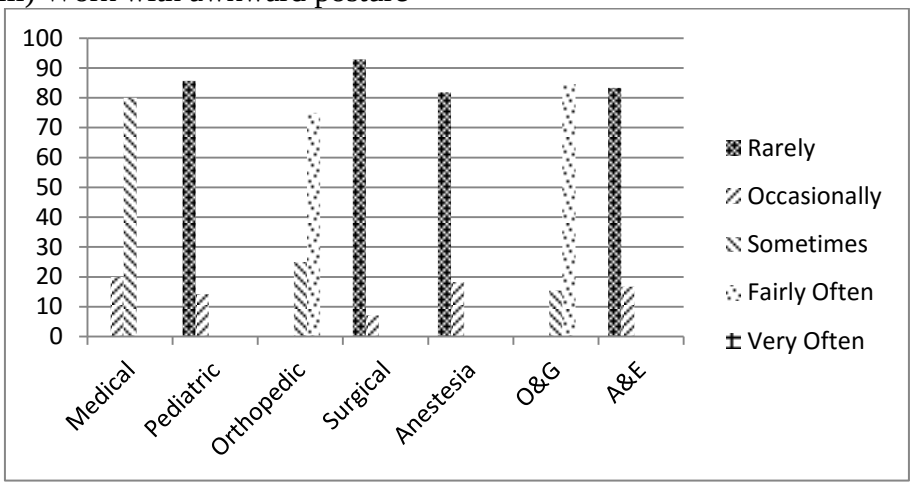
i) Work physically very fast



ii) Work physically very hard



iii) Work with awkward posture



iv) Work with vibrating tools

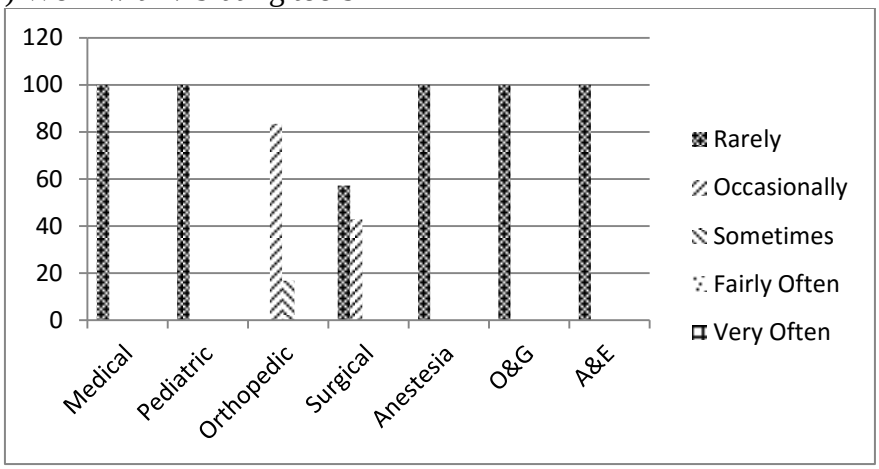


Figure 3.6 (i-iv): Percentage of internship doctors (by departments) involved in certain behaviors according to frequency of involvement

3.5.2.4 Psychological and psychosocial factors

There were six categories of psychological and psychosocial factors assessed in this study. The level of stress imposed on the internship doctors was evaluated for each category, and the results were separated into low, medium and high (Table 3.6). The results were presented based on different departments.

In most cases, there were no significant associations found between psychological and psychosocial factors on the prevalence of MSDs among internship doctors. However, there were some exceptions as shown in Figure 3.6.

Yet, if we compare the data with musculoskeletal pain that prevented them from carrying out normal activities, the results will be a bit different. None of the psychological and psychosocial stressor has been significantly associated with musculoskeletal pain among internship doctors.

Based on t-test and ANOVA analysis, none of the demographic data such as gender, marital status and BMI were significantly associated with psychological and psychosocial stress perceived by the doctors.

3.5 Treatment choices

As expected, all 54 doctors who were not free from MSDs sought treatment for their problems. Although all of them chose medication as

a treatment, some still used other method such as physiotherapy (n = 5) and exercise (n = 7) as part of the treatment.

Table 3.6: Percentage and number of internship doctors (by departments) in the low, medium and high stress groups and their significant association with prevalence of MSD symptoms at specific body parts

i) A&E department

Psychological & psychosocial stressors	Low stress, % (n)	Medium stress, % (n)	High stress, % (n)	Chi square / Fisher's exact test (p value and effect size)								
				Neck	Shoulders	Elbows	Wrist / hands	Upper back	Lower back	Hips / thighs	Knees	Ankles / feet
Intragroup conflicts	100 (12)	0 (0)	0 (0)	-	-	-	-	-	-	-	-	-
Work hazards	66.7 (8)	33.3 (4)	0 (0)	-	-	-	-	-	-	-	-	-
Job satisfaction	58.3 (7)	41.7 (5)	0 (0)	-	-	-	-	-	-	-	-	-
Job requirements	0 (0)	83.3 (10)	16.7 (2)	-	-	-	-	-	-	-	-	-
Mental demands	0 (0)	91.7 (11)	8.3 (1)	-	-	-	-	-	-	-	-	-
Workload & responsibility	0 (0)	100 (12)	0 (0)	-	-	-	-	-	-	-	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant
Effect size were based on phi (0.1 = small, 0.3 = medium, 0.5 = large) or Cramer's V (df = 2, small = 0.07, medium = 0.21, large = 0.35)

ii) Anesthesia department

Psychological & psychosocial stressors	Low stress, % (n)	Medium stress, % (n)	High stress, % (n)	Chi square / Fisher's exact test (p value and effect size)								
				Neck	Shoulders	Elbows	Wrist / hands	Upper back	Lower back	Hips / thighs	Knees	Ankles / feet
Intragroup conflicts	81.8 (9)	18.2 (2)	0 (0)	-	-	-	-	-	-	-	-	-
Work hazards	0 (0)	90.9 (10)	9.1 (1)	-	-	-	-	-	-	-	-	-
Job satisfaction	63.6 (7)	36.4 (4)	0 (0)	-	-	-	-	-	-	-	-	-
Job requirements	0 (0)	90.9 (10)	9.1 (1)	-	-	-	-	-	-	-	-	-
Mental demands	0 (0)	90.9 (10)	9.1 (1)	-	-	-	-	-	-	-	-	-
Workload & responsibility	0 (0)	90.9 (10)	9.1 (1)	-	-	-	-	-	-	-	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant
Effect size were based on phi (0.1 = small, 0.3 = medium, 0.5 = large) or Cramer's V (df = 2, small = 0.07, medium = 0.21, large = 0.35)

iii) Medical department

Psychological & psychosocial stressors	Low stress, % (n)	Medium stress, % (n)	High stress, % (n)	Chi square / Fisher's exact test (p value and effect size)								
				Neck	Shoulders	Elbows	Wrist / hands	Upper back	Lower back	Hips / thighs	Knees	Ankles / feet
Intragroup conflicts	70 (7)	30 (3)	0 (0)	-	-	-	-	-	-	-	-	-
Work hazards	10 (1)	80 (8)	10 (1)	-	-	-	-	-	-	-	-	-
Job satisfaction	10 (1)	70 (7)	20 (2)	-	-	-	-	-	-	-	-	-
Job requirements	0 (0)	10 (1)	90 (9)	-	-	-	-	-	-	-	-	-
Mental demands	0 (0)	20 (2)	80 (8)	0.022 large	-	-	-	-	-	-	-	-
Workload & responsibility	0 (0)	40 (4)	60 (6)	-	-	-	-	-	0.048 large	-	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant
Effect size were based on phi (0.1 = small, 0.3 = medium, 0.5 = large) or Cramer's V (df = 2, small = 0.07, medium = 0.21, large = 0.35)

iv) Orthopedic department

Psychological & psychosocial stressors	Low stress, % (n)	Medium stress, % (n)	High stress, % (n)	Chi square / Fisher's exact test (p value and effect size)								
				Neck	Shoulders	Elbows	Wrist / hands	Upper back	Lower back	Hips / thighs	Knees	Ankles / feet
Intragroup conflicts	91.7 (11)	8.3 (1)	0 (0)	-	-	-	-	-	-	-	-	-
Work hazards	50.0 (6)	50.0 (6)	0 (0)	-	-	-	-	-	-	-	-	-
Job satisfaction	33.3 (4)	66.7 (8)	0 (0)	-	-	-	-	-	-	-	-	-
Job requirements	0 (0)	75.0 (9)	25.0 (3)	-	-	-	-	-	-	-	0.045 large	-
Mental demands	0 (0)	75.0 (9)	25.0 (3)	0.018 large	-	-	0.045 large	-	-	-	0.045 large	-
Workload & responsibility	0 (0)	91.7 (11)	8.3 (1)	-	-	-	-	-	-	-	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant
Effect size were based on phi (0.1 = small, 0.3 = medium, 0.5 = large) or Cramer's V (df = 2, small = 0.07, medium = 0.21, large = 0.35)

v) Pediatric department

Psychological & psychosocial stressors	Low stress, % (n)	Medium stress, % (n)	High stress, % (n)	Chi square / Fisher's exact test (p value and effect size)								
				Neck	Shoulders	Elbows	Wrist / hands	Upper back	Lower back	Hips / thighs	Knees	Ankles / feet
Intragroup conflicts	78.6 (11)	21.4 (3)	0 (0)	0.027 large	-	-	-	-	0.033 large	-	-	-
Work hazards	35.7 (5)	64.3 (9)	0 (0)	-	-	-	-	-	-	-	-	-
Job satisfaction	35.7 (5)	50.0 (7)	14.3 (2)	-	-	-	-	-	-	-	-	-
Job requirements	0 (0)	85.7 (12)	14.3 (2)	-	-	-	-	-	-	-	-	-
Mental demands	0 (0)	85.7 (12)	14.3 (2)	-	-	-	-	-	-	-	-	-
Workload & responsibility	0 (0)	92.9 (13)	7.1 (1)	-	-	-	-	-	-	-	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant
Effect size were based on phi (0.1 = small, 0.3 = medium, 0.5 = large) or Cramer's V (df = 2, small = 0.07, medium = 0.21, large = 0.35)

vi) Surgical department

Psychological & psychosocial stressors	Low stress, % (n)	Medium stress, % (n)	High stress, % (n)	Chi square / Fisher's exact test (p value and effect size)								
				Neck	Shoulders	Elbows	Wrist / hands	Upper back	Lower back	Hips / thighs	Knees	Ankles / feet
Intragroup conflicts	92.9 (13)	7.1 (1)	0 (0)	-	-	-	-	-	-	-	-	-
Work hazards	57.1 (8)	42.9 (6)	0 (0)	-	-	-	-	-	-	-	-	-
Job satisfaction	71.4 (10)	28.6 (4)	0 (0)	-	-	-	-	-	-	-	-	-
Job requirements	0 (0)	92.9 (13)	7.1 (1)	-	-	-	-	-	-	-	-	-
Mental demands	0 (0)	85.7 (12)	14.3 (2)	0.033 large	-	-	-	-	-	-	-	-
Workload & responsibility	0 (0)	85.7 (12)	14.3 (2)	-	-	-	-	-	-	-	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant
Effect size were based on phi (0.1 = small, 0.3 = medium, 0.5 = large) or Cramer's V (df = 2, small = 0.07, medium = 0.21, large = 0.35)

vii) O&G department

Psychological & psychosocial stressors	Low stress, % (n)	Medium stress, % (n)	High stress, % (n)	Chi square / Fisher's exact test (p value and effect size)								
				Neck	Shoulders	Elbows	Wrist / hands	Upper back	Lower back	Hips / thighs	Knees	Ankles / feet
Intragroup conflicts	92.3 (12)	7.7 (1)	0 (0)	-	-	-	-	-	-	-	-	-
Work hazards	76.9 (10)	23.1 (3)	0 (0)	-	-	-	0.038 large	-	-	-	-	-
Job satisfaction	61.5 (8)	30.8 (4)	7.7 (1)	-	-	-	-	-	-	-	-	-
Job requirements	0 (0)	84.6 (11)	15.4 (2)	-	-	-	-	-	-	-	-	-
Mental demands	0 (0)	100.0 (13)	0 (0)	-	-	-	-	-	-	-	-	-
Workload & responsibility	0 (0)	100.0 (13)	0 (0)	-	-	-	-	-	-	-	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant
Effect size were based on phi (0.1 = small, 0.3 = medium, 0.5 = large) or Cramer's V (df = 2, small = 0.07, medium = 0.21, large = 0.35)

3.5.3 Construction workers

3.5.3.1 Demographic data

105 male construction workers from five construction sites participated in this study. However, 11 of the collected surveys did not answer important questions such as questions regarding musculoskeletal symptoms or psychological and psychosocial and consequently excluded from the analysis. As previous surveys, body mass index (BMI) used in this study was based on Ministry of Health (MOH) Malaysia's guidelines (MOH, 2004). Demographic data of the participants in terms of mean, standard deviation (S.D) and percentages were summarizes in Table 3.7.

Table 3.7: Demographic data of the construction workers (n = 94)

	Mean	SD	No. of participants	%
Age (year):	29.15	3.57		
≤ 30			61	64.9
> 30			33	35.1
Height (cm)	168.20	4.45		
Weight (kg)	64.74	5.05		
Employment period (year):	4.12	2.07		
≤ 5			73	77.7
> 5			21	22.3
Main job:				
Bricklayer			32	34.0
Scaffolders			12	12.8
Carpenters			4	4.3
Electricians			3	3.2
Concrete workers			24	25.5
Steel workers			10	10.6
BMI (kg/m^2)*:				
Underweight (< 18.5)			2	2.1
Normal (18.5–22.9)			58	61.7
Pre-obese (23.0–27.4)			33	35.1
Obese (27.5–34.9)			1	1.1
Smoker:				
Yes			86	91.5
No			8	8.5
Marital status:				
Single			20	21.3
Married			74	78.7

*BMI cutoff point for Malaysian based on MOH (2004).

3.5.3.2 Musculoskeletal symptoms

Among 94 (or 100%) construction workers participated in this study, only two (2.1%) of them were free from any musculoskeletal symptoms over the preceding 12 months. Meanwhile, 11 (11.7%) of them reported that they having musculoskeletal discomfort or pain symptoms at a single body region during the last year, 39.4% reported two regions, 20.2% reported three, followed by 19.1%, 4.3%, and 3.2% reporting four, five and six regions respectively. As shown in Figure 3.7, over the preceding 12 months, the most prevalent region affected was the upper back area, followed in descending order by the wrist/hands, shoulders, knees, elbows, lower back, neck, hip/thighs and ankles/feet.

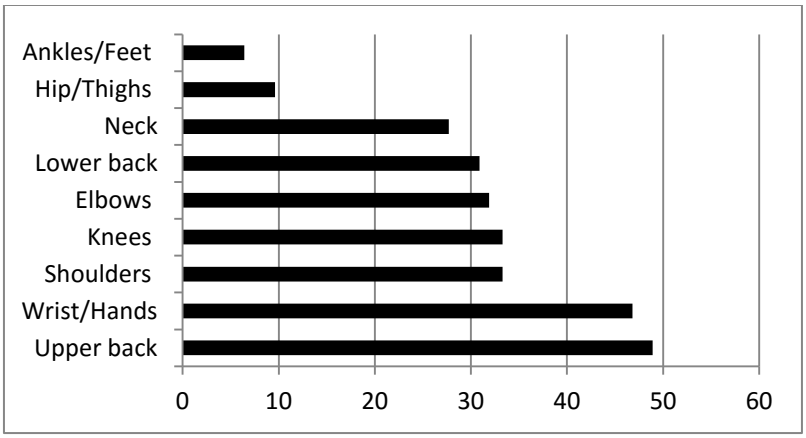


Figure 3.7: Prevalence (%) of MSD symptoms affecting specific body regions among construction workers over a 12-month period

Based on Chi-square and Fisher exact test analysis, generally, none of the demographic data such as age, BMI, marital status and year

of employment has been significantly associated with musculoskeletal symptom among construction workers. There were a few exceptions to this general observation, however. Hip/thighs pain has been found to be significantly associated with BMI (p = 0.010). Neck, upper back and knees pain has been found to be significantly associated with the type of job they mainly did (p = 0.001 and p = 0.013 respectively). Shoulder pain has been significantly associated with different group of age (p = 0.025) and employment (p = 0.009).

Figure 3.8 shows the percentage of participants who encountered problems when performing their normal activities at those times when symptoms were present (by body region). The highest percentage involved the upper back region followed by knees and lower back regions.

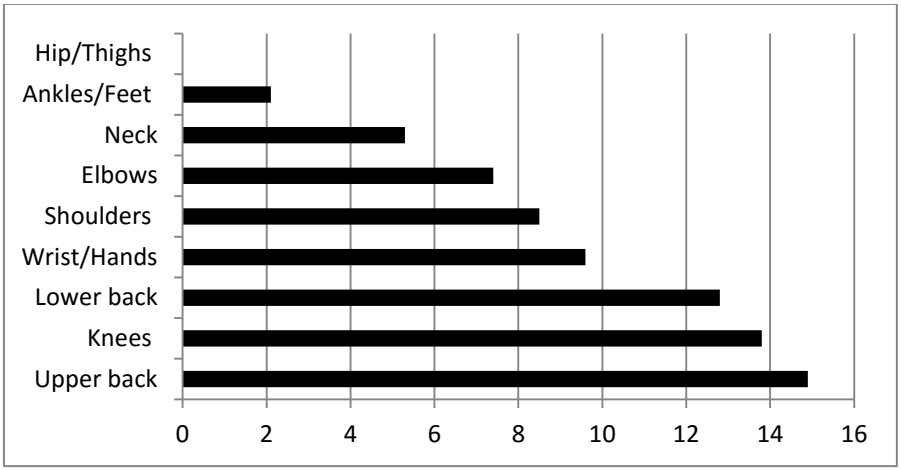


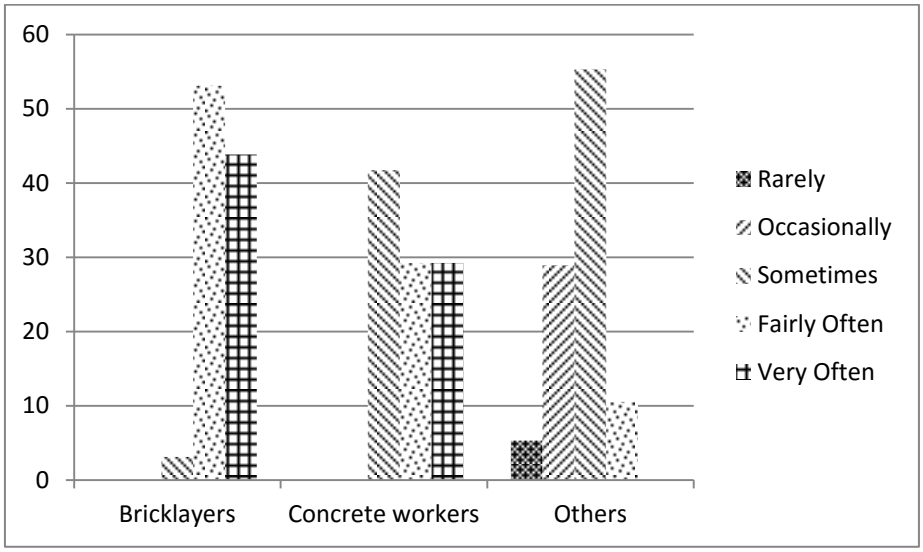
Figure 3.8: Percentage of construction workers who had problems performing normal activities when symptoms appeared (by body region)

3.5.3.3 Physical factors

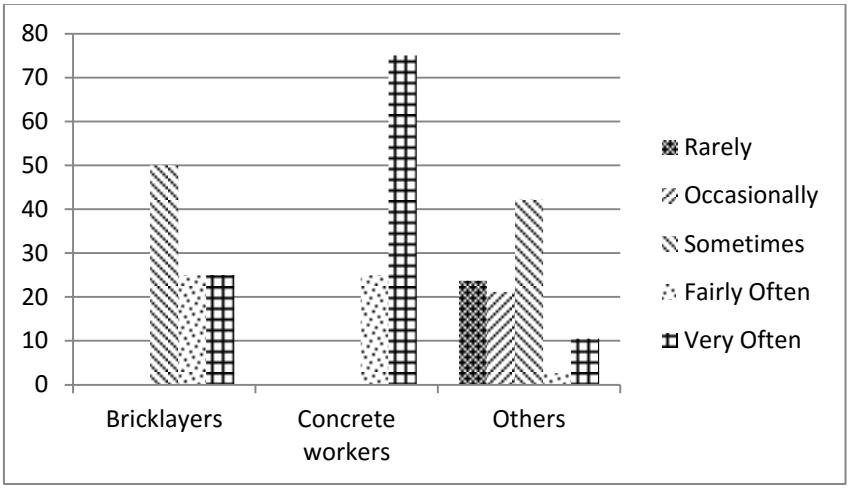
There were variations regarding how often they need to work physically very fast, physically very hard, with vibrating tools and with awkward posture. However, it seems that certain characteristic of the job depends on the main job they did (Figure 3.9 (i-iv)). For instance, all painters stated that they rarely worked with vibrating tools while most bricklayers reported they often work with awkward posture. Therefore, the result of this section has been divided into three main trades which were bricklayers (n = 32), concrete workers (n = 24) and other trades (n = 38).

i) Working physically very fast

ii) Working physically very hard



iii) Working with vibrating tools



iv) Working with awkward posture

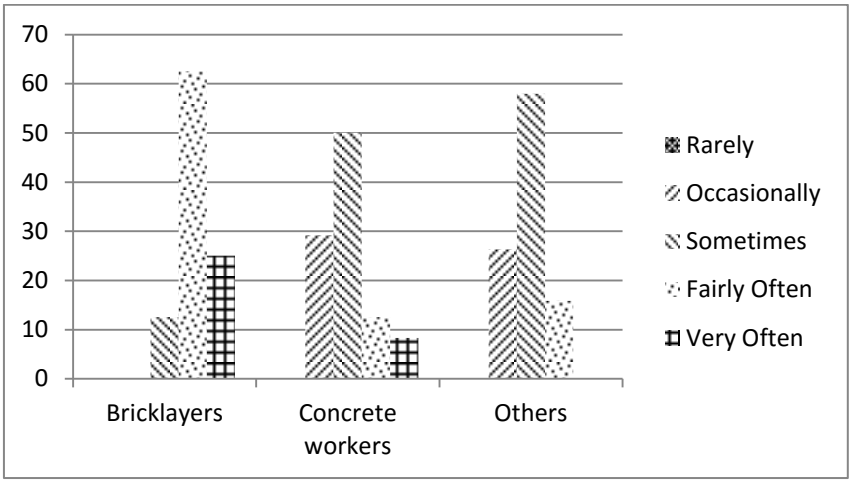


Figure 3.9 (i – iv): Percentage of participants (construction workers) involved in certain behaviors according to frequency of involvement

There were different degree of significant association between frequency of certain behavior (work physically very fast, very hard, with vibrating tools and with awkward posture) and musculoskeletal pain for bricklayers, concrete workers and other trades in construction. For instance, frequency the bricklayers need to work physically very fast has been significantly associated with upper back pain ($p = 0.007$). However, this significant association has not been found in concrete workers or other trades in construction.

For bricklayers, frequency the workers need to work physically very hard has been significantly associated with knees and ankles/feet pain ($p = 0.005$ and $p = 0.028$), and frequency the workers need to work with awkward posture has been significantly associated with knees pain ($p = 0.011$).

For concrete workers, frequency the workers need to work physically very hard and with awkward posture have been significantly associated with neck pain ($p = 0.007$ and $p = 0.017$ respectively).

Meanwhile, for those who experienced pain in any region, in general, there were no significant association between physical factors and MSD symptoms that prevented them from performing normal activities. However, there were some exceptional cases. Frequency they need to work with awkward posture has been associated with knees pain ($p = 0.018$) for bricklayers and with upper back pain ($p = 0.034$) for other trades.

3.5.3.4 Psychological and psychosocial factors

As previous surveys, this study also assessed six categories of psychosocial factors which based on the NIOSH Generic Job Stress Questionnaire. The level of psychological and psychosocial stress imposed on the construction workers was evaluated for each category, and the results were separated into low, medium and high has been analyzed.

As can be seen in Table 3.8, none of the psychological and psychosocial level of stress has been significantly associated with MSDs symptoms in any body part region for all three trades (bricklayers, concrete workers and others) in this study. The same results were obtained where there was no significant association between psychological and psychosocial level of stress and MSD symptoms that prevented them from performing normal activities.

Table 3.8 (i – iii): Percentage and number of construction workers (by trades) in the low, medium and high stress groups and their association with prevalence of MSD symptoms at specific body parts

i) Bricklayers

Psychological & psychosocial stressors	Low stress, % (n)	Medium stress, % (n)	High stress, % (n)	Chi square / Fisher's exact test (p value and effect size)								
				Neck	Shoulders	Elbows	Wrist / hands	Upper back	Lower back	Hips / thighs	Knees	Ankles / feet
Intragroup conflicts	43.8 (14)	50.0 (16)	6.3 (2)	-	-	-	-	-	-	-	-	-
Work hazards	93.8 (30)	6.3 (2)	0 (0)	-	-	-	-	-	-	-	-	-
Job satisfaction	90.6 (29)	9.4 (3)	0 (0)	-	-	-	-	-	-	-	-	-
Job requirements	87.5 (28)	12.5 (4)	0 (0)	-	-	-	-	-	-	-	-	-
Mental demands	34.4 (11)	65.6 (21)	0 (0)	-	-	-	-	-	-	-	-	-
Workload & responsibility	0 (0)	78.1 (25)	21.9 (7)	-	-	-	-	-	-	-	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant

Effect size were based on phi or Cramer's V

ii) Concrete workers

Psychological & psychosocial stressors	Low stress, % (n)	Medium stress, % (n)	High stress, % (n)	Chi square / Fisher's exact test (p value and effect size)								
				Neck	Shoulders	Elbows	Wrist / hands	Upper back	Lower back	Hips / thighs	Knees	Ankles / feet
Intragroup conflicts	45.8 (11)	50.0 (12)	4.2 (1)	-	-	-	-	-	-	-	-	-
Work hazards	100 (24)	0 (0)	0 (0)	-	-	-	-	-	-	-	-	-
Job satisfaction	83.3 (20)	12.5 (3)	4.2 (1)	-	-	-	-	-	-	-	-	-
Job requirements	100 (24)	0 (0)	0 (0)	-	-	-	-	-	-	-	-	-
Mental demands	29.2 (7)	62.5 (15)	8.3 (2)	-	-	-	-	-	-	-	-	-
Workload & responsibility	0 (0)	66.7 (16)	33.3 (8)	-	-	-	-	-	-	-	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant

Effect size were based on phi or Cramer's V

iii) Other trades

Psychological & psychosocial stressors	Low stress, % (n)	Medium stress, % (n)	High stress, % (n)	Chi square / Fisher's exact test (p value and effect size)								
				Neck	Shoulders	Elbows	Wrist / hands	Upper back	Lower back	Hips / thighs	Knees	Ankles / feet
Intragroup conflicts	34.2 (13)	52.6 (20)	13.2 (5)	-	-	-	-	-	-	-	-	-
Work hazards	100 (38)	0 (0)	0 (0)	-	-	-	-	-	-	-	-	-
Job satisfaction	92.1 (35)	7.9 (3)	0 (0)	-	-	-	-	-	-	-	-	-
Job requirements	86.8 (33)	10.5 (4)	2.6 (1)	-	-	-	-	-	-	-	-	-
Mental demands	28.9 (11)	65.8 (25)	5.3 (2)	-	-	-	-	-	-	-	-	-
Workload & responsibility	0 (0)	81.6 (31)	18.4 (7)	-	-	-	-	-	-	-	-	-

(-) means no statistic are computed because the data belong to only one group (constant) or it is computed but the result is not significant

Effect size were based on phi or Cramer's V

3.6 Discussion

3.6.1 Prevalence of MSDs

The prevalence of MSD symptoms among dentists in Malaysia was found to be very high, especially in the upper-body region, with 84.1% of problems affecting the neck and 92.7% affecting the shoulders. These values are higher than those reported in studies conducted in countries such as Poland, Australia, Sweden, the United States, and New Zealand, where the prevalence of MSDs of the neck reportedly ranges from 20% to 72% (Patel et al., 2012; Hayes et al., 2009; Alexopoulos et al., 2004; Palliser et al., 2005; Melis et al., 2004) and MSDs of the shoulder range from 21% to 81% (Patel et al., 2012; Hayes et al., 2009; Palliser et al., 2005). The typical position of working with the head bent forward and rotated, with the upper arm abducted, imposes a greater load on the dentist's neck and shoulder muscles (Patel et al., 2012; Polat et al., 2007; Gijbels et al., 2006; Leggat and Smith, 2006), thus explaining the predominance of symptoms in these regions.

High prevalence of MSD symptoms were found in the upper back (71%), lower back (60%), and wrists/hands (52%). These results are consistent with those in previous studies in which 54% to 67% of dentists had MSD symptoms in the back (upper and lower) (Leggat and Smith, 2006; Anton et al., 2003; Finsen et al., 1998) and 34% to 54%

had symptoms in the wrist/hand area (Leggat et al., 2007; Szymanska, 2002; Akesson et al., 2000). MSDs of the hip/thigh, knees, and ankles were relatively uncommon, with only 5 to 6% of all participants reporting these complaints. It is important to note that none of the participants in this study were free of MSD symptoms during the 12 months prior to the survey. Although the prevalence of MSD symptoms reported here seems to be surprisingly high, it is still consistent with other studies reporting that only a small percentage of participants are free of any MSD symptoms (Puriene et al., 2008; Polat et al., 2007; Leggat and Smith, 2006; Marshall et al., 1997).

Compared to dentist, the prevalence of MSD symptoms among internship doctors was lower, with almost 63% doctors reported to have a problem on certain body regions during the 12 months prior to this survey. It is difficult to directly compare the result with other studies since there were only a few studies focusing MSDs on general medical doctors especially on internship doctors. However, if it is compared physicians, the results obtained from this study are consistent with previous studies where 20% to 68% of the physicians in India, China and Iran reported that they had MSD symptoms (Rambabu and Suneetha, 2014; Lahoti et al., 2014; Mehrdad et al., 2012; Smith et al., 2006).

Meanwhile, as expected, prevalence of MSD symptoms among construction workers were very high with 97.9% of the workers reported that they experienced some pain and discomfort in at least one body regions during the 12 months prior to this survey. This value is

higher compared to the previous cross sectional based studies regarding prevalence of MSD complaints among construction workers (Alghadir and Anwer, 2015).

3.6.2 The association between sociodemographic variables and prevalence of MSDs

In general, no relationship between MSD-related complaints and sociodemographic variables such as age, gender, BMI, years in practice, or number of patients seen per day has been found for all three professions examined in this study. However, there were a few exceptions to this general observation especially for dentist.

Some studies have argued that age might be of some significance with respect to the incidence of MSD among dentists. For example, younger, less experienced dentists may position themselves improperly during dental procedures and thus incur higher rates of MSD symptoms (Samat et al., 2011; Harutunian et al., 2011; Leggat and Smith, 2006). Leggat et al. (2007) found that the incidence of neck pain was higher among younger dentists, while Harutunian et al. (2011) reported that back pain was more frequent among young dentists. In this study, there was no significant relationship between age and MSD-related complaints, consistent with the results of many other studies (Samat et al., 2011; Polat et al., 2007; Newell and Kumar, 2004). However, it should be noted that a significant relationship was found between age and prevalence of MSD symptoms in the lower back that prevented

some older dentists from engaging in their normal activities. The fact that most of the participants in this study were young dentists (25 to 35 years of age) may have affected our results.

Similarly, no significant relationship was found between years in practice and MSD symptoms, which is in keeping with the findings in other studies (Kerosuo et al., 2000; Lalumandier et al., 2001). Yet, again, there was an exception to this general conclusion. Dentists who had been in practice shorter were significantly more likely to have symptoms affecting the upper back and neck that prevented them from engaging in normal activities; however, as was the case with the age variable, the explanation might be that most of our participants were younger dentists.

BMI was another variable that was significantly related specifically to upper back symptoms but not with other symptoms. Dentists with a higher BMI were more likely to have symptoms affecting the upper back that prevented them from carrying out normal activities while construction workers with a higher BMI were more likely to have symptoms affecting the upper back hip/thighs region. One reason for this might be that excess weight imposes a higher load on the muscles, causing earlier fatigue (Polat et al., 2007). Thus, overweight workers might incur higher loads than a worker with normal weight.

With regard to treatment measures, almost half the participants did not seek treatment of any kind despite their MSD symptoms. This failure to seek relief might have contributed to high prevalence of MSD

symptoms seen in this study. If symptoms persist without medical treatment or preventive measures, they might be getting worse (Harshid et al., 2012). Unlike dentists, all of the symptomatic doctors used medication as part of the treatment. This might prevent the symptoms from worsen. Besides, with their knowledge, they should at least know their symptoms better than common people and how the symptoms should be treated.

Other contributing factors may include the fact that some participants failed to take frequent breaks or to do stretching exercises during their breaks, which constitute measures for reducing and preventing MSD symptoms (Harutunian et al., 2011). However, Marshall et al. (1997) reported that dentists who took frequent work breaks did not experience fewer MSD symptoms than did those who rarely took breaks.

A third of the dentists in this study reported that they did not have sufficient light at their workplace, which might have forced them to work with an awkward posture. Consequently, their pains would have become worse and would not be considered gone even if they changed their working position frequently.

Less than half the dentists surveyed engaged in exercise as a treatment or preventive measure to reduce their MSD symptoms. This finding is similar to that of a study in New Zealand in which fewer than half the dentists considered physical fitness a priority (Ayers et al., 2009). This factor may also have contributed to the high prevalence of MSD symptoms in our study, because regular exercise has been found

to be effective in preventing and reducing dental work–related pain (Harshid et al., 2012; Ayers et al., 2009; Lalumandier et al., 2001).

3.6.3 The association between physical, psychological as well as psychosocial factors and prevalence of MSDs

The high prevalence of MSD symptoms among dentists is related to the fact that these professionals must maintain prolonged and unnatural postures to allow a good view of the narrow work region of the patient's mouth and must also perform procedures that require repetitive movements and the exertion of force (Polat et al., 2007; Gijbels et al., 2006; Thornton et al., 2004; Marshall et al., 1997). Furthermore, most of them experienced discomfort or pain in more than two anatomic sites. This fact reveals a worrisome health problem among dentists in Malaysia.

Another important finding was that about 40% of the participants had symptoms that affected both shoulders even though the majority of them were right-handed. One possible explanation for this result is the type of procedures they do more often. For example, dentists who always perform tooth extractions will be more likely to develop MSD symptoms affecting their dominant shoulder, because the workload during this procedure is focused on the dominant hand. Dentists who perform many dental filling procedures will be more likely to develop MSD symptoms that affect both shoulders, because both arms are unsupported and are needed to hold the dental mirror in one hand and

another dental instrument in the other hand for an extended time.

In dentist profesion, many studies have reported that awkward postures, vibration, and repetitive forces are risk factors for MSD symptoms (Wunderlich et al., 2010; Thornton et al., 2004; Alexopoulos et al., 2004; Melis et al., 2004; Finsen et al., 1998). For example, dental work that requires a prolonged awkward position might overstress muscles and joints, causing neck, shoulder, and back pain (Melis et al., 2004). In our study, we asked dentists how often their job required them to work very fast, very hard, with a vibrating tool, and with awkward posture. More than half answered that they "often" needed to work very fast and very hard, and about 80% said they "often/very often" needed to work with a vibrating tool and with awkward posture. Further statistical analysis showed some of the MSD symptoms were significantly associated to these factors.

Meanwhile, it would be difficult to conclude that being a dentist in Malaysia can be considered psychosocially stressful. It is found that almost all the participants were satisfied with their jobs (in fact, 35% reported being "very satisfied"), in keeping with the results of a study by Samat et al. (2011) in which 93.4% of dental personnel in Malaysia reported being satisfied with their profession. Nevertheless, statistical analysis showed that there were significant relationship between some of the psychological and psychosocial stressors and prevalence of MSD symptoms among these dentists.

From the result, we can see the influence of both physical and psychological and psychosocial factors on MSD symptoms among

dentist in Malaysia. Upper and lower back pain, for example, has been significantly found to be related to awkward posture while wrist/hands pain was significantly associated with three psychological and psychosocial stressor. Meanwhile, neck pain has been significantly associated with both physical and psychological and psychosocial factors.

Meanwhile, the highest prevalence among the doctors in this study was on neck region. Unlike dentist, in this study, except for those who are currently working in Orthopedic and O&G departments, doctors have been reported that only rarely working in awkward posture. Thus, generally, awkward posture should not be a cause for high prevalence of MSD at the neck region among the internship doctors. Further analysis by statistical method showed the influence of psychological and psychosocial stress. In four departments, musculoskeletal pain and discomfort at neck region seems to be significantly associated with mental demand and intragroup conflict stressors. Typically, the influence of psychological and psychosocial factors on MSDs was low and disregard compared to the physical activity. However, psychological and psychosocial stress may play a role on muscle activity as proposed in Cinderella Hypothesis (Hagg, 1991).

The same mechanism could be happened on wrist / hands, lower back and knees symptoms among internship doctors. Both of these regions also have been found to be significantly associated with some of the psychological and psychosocial stressors. However, it should be noted that the significant association is not consistently obtained for all

departments. For instance, neck pain has not been significantly associated with any psychological and psychosocial factors for Anestesia and A&E departments.

Besides psychological and psychosocial stressors, physical factor may also play a role in prevalence of MSDs symptom at all these body regions. Although it is not included in the survey, it is known that internship doctors need to use their hand frequently in their work. For example, aside from writing report, they need to help the surgeons while doing operation by holding the instrument or patients' body part. They also need to withdraw patients' blood, insert IV line and suturing. With more than half of them reported that they are often need to work physically very fast, it will not be strange for them to accidentally injure their hand. Furthermore, their working hours per week are very long. With the average of 72.5 working hours per week, it is almost double compared to the normal working hours for office workers. Longer working hours may increase the probabilities for them to injure their hand. Yet, it should be noted that this is just an assumption based on doctors' working nature and long working hours.

Out of these seven departments, doctors who are working in Orthopedic and O&G departments reported that they often work in awkward posture. This working condition (working in awkward posture) will affect the doctors especially on upper and lower back. All these doctors will go through six out of seven departments (they can choose either to go through Anesthesia or A&E department while the other five are compulsory) throughout their internship period. It is expected that all these doctors will somehow get affected by working in awkward

posture condition whenever they go through Orthopedic and O&G departments.

Aside from upper body, it seems internship doctors also faced some problems on lower body parts such as ankle and knees. Aside from certain significant association between psychological and psychosocial stressor with knees pain, physical factor might also play a certain role for pain in this body region. It could be understood if we measure the work position and working hours. All of the participants stated that they were mainly stood, mainly walked or did both for their work position. With almost 73 working hours per week and mainly stood or walked as the work posture, the prevalence of MSDs symptoms at ankles and knees should be expected.

The influence of physical factors on MSDs has been recognized especially for occupation that involved high physical activity such as construction workers. However, the influence of psychological and psychosocial factors has been debatable. There were studies attempted to determine the effect of psychological and psychosocial factors on MSDs among construction workers. However, the results have been inconsistent (Engholm and Holmstrom, 2005; Latza et al., 2002; Jensen and Kofoed, 2002; Latza et al., 2000). Thus, aside from physical factor, this study tried to determine the relationship between psychological and psychosocial stressors on MSD symptoms among construction workers.

Unexpectedly, in this study, even though the prevalence of MSD symptoms among construction workers in Malaysia is very high, none of the psychological and psychosocial stressors in this study has been significantly associated with MSD symptoms in any of the nine body

regions among all trades in construction workers. This result is consistent with several previous studies (Sobeih, 2006; Engholm and Holmstrom, 2005; Latza et al., 2000; Holmstrom et al., 1992). In a study on 85 191 male construction workers, Engholm and Holmstrom (2005) found that low job satisfaction is not significantly associated with MSDs at any body location. In another study on 571 male construction workers, Latza et al., (2000) found that none of the psychological and psychosocial factors in their study including monotonous work, time pressure, low job control, poor social support and job satisfaction has been significantly associated with low back pain.

There might be several reasons on why this result was obtained. Firstly, the percentage of construction workers who were in high level of psychological and psychosocial stress was low. Although construction workers are working in high hazardous environment, in terms of psychological and psychosocial, the level of stress caused by hazardous environment is not high. This result is consistent with other studies (Sobeih, 2006; Ringen et al., 1995). Secondly, physical activity in construction workers is much higher. The role of physical demand on MSD has been recognized. Carry and lifting heavy load such as brick, woods and steels has been a routine for construction workers. Therefore, it is assumed that the MSD symptoms experienced by the construction workers are heavily influenced by physical demand. Consequently, the role of psychological and psychosocial factors on MSD symptoms among construction workers has been covered by a bigger influence which is physical demand.

Upper back has become the most frequently reported region to have a problem by the construction workers, consistent with another study (Boschman et al., 2012) and followed by wrist / hand region. In addition, this study also found that the highest percentage of participants who had problems performing normal activities when the symptoms appeared is also upper back region. Aside from upper back and wrist / hand regions, shoulder and knees are one of the most common region for the construction workers to feel the pain and uncomfortable. This result is also consistent with another study in the USA (Cook et al., 2003)

The results obtained might be due to the big number of participants involved in this study who mainly works as bricklayers. This study showed that bricklayers often work in awkward posture condition and physically very hard condition such as lifting and carrying heavy load. This is understandable since the nature of their work require them to carry and lifting bricks, frequently bending, twisting and assume awkward posture. These situation normally involved wrist / hand and back regions which consequently produced the obtained results. The same reason can be apply for knees pain. This study also found that knees pain has been significantly associated with the job that they mainly did and the frequency they need to work in awkward posture. It is understandable as the kneeling posture is one of the awkward posture that commonly assumed by bricklayers for prolonged time. Consequently, it causes knees pain especially among bricklayers.

This study was undertaken to determine the relationship between

physical, psychological and psychosocial factors on the problem of MSDs among dentists, internship doctors and construction workers in Malaysia. The results do reflect at a certain degrees to which both these types of factors contribute to MSDs.

In most MSD symptoms, there were physical factor significantly associated to it which indicated the influence of physical factor. However, most of the physical factor examined in this study is not significantly associated with prevalence of MSDs among internship doctors. There were a few reasons on why this result was obtained. First of all, it should be noted that even though the terms "physical factors was not significantly associated" was used, it does not means that the physical factor is not related to the prevalence of MSDs among internship doctors. In these cross sectional studies, most of the physical factors questions asked were regarding the frequency they work in a certain conditions (such as work very hard, very fast, with awkward posture and with vibrating tools). Insignificant result does not means that these conditions does not related to the prevalence of MSDs, but the frequency of these doctors working under these conditions is not significant. Secondly, as mentioned, there were limitations of cross sectional study including inaccurate recall of information. Besides, the frequency (rarely, occasionally, etc) is subjective and the actual number might be a bit different between each doctor which consequently might affect the result. Thirdly, most of the doctors are working almost in the same physical condition where none of them answered "mainly sitting" for their working position and most of them rarely working using

vibrating tools. Except for those from Orthopedic department, most of the doctors are occasionally working physically very hard (such as lifting patient or hold heavy object). Meanwhile, except for those from Orthopedic, Medical and O&G departments, most of the doctors are rarely working with awkward posture. As a result, it is difficult to find out the association between physical factors and prevalence of MSDs among internship doctors as most of them are working in the same physical condition.

There were different degrees of association between psychological and psychosocial factors with prevalence of MSDs in three main occupations investigated in this study. In some cases among dentist and internship doctors, there were significant association found between psychological and psychosocial stressors with prevalence of MSDs. However, none of the stressors has been significantly associated with prevalence of MSDs among construction workers. As mentioned, there might be several reasons on why this result was obtained. In the early stage of this study, it is found that most studies investigated different psychological and psychosocial factors and used different set of questionnaire. It has been hypothesized that this is one of the reason on why psychological and psychosocial factors were inconsistently found to be significantly associated with prevalence of MSDs in the previous studies. Therefore, this study used the same questionnaire with the same psychological and psychosocial factors for all three cross sectional studies. Yet, out of six stressors, only mental demand stressor is a little bit consistent to be found significantly associated with

prevalence of MSDs among dentist and internship doctors especially on neck area. None of other five stressors has been found to have the same consistency. In addition, if we look at all three main occupations investigated in this study, none of the stressors was consistent to be found significantly associated with MSDs. From this result, it can be concluded that these factors are significant but only in a certain condition and environments.

Because these were a cross-sectional study, a direct relationship between causes and effects could not be drawn. Nevertheless, based on these results, several conclusions can be made. Firstly, psychological and psychosocial factors are significant contributor to the MSDs problems. However, if an occupation involve high physical activity such as construction workers, physical factors will play more significant role on MSDs problems. Yet, the role of psychological and psychosocial should not be neglected. It has been demonstrated that the same muscle motor units activated by physical demand can also be triggered by mental stress (Lundberg et al., 2002). This means that those muscles will be activated continuously either during breaks at work or even after they finish their work and back to home which consequently cause metabolic disturbances and exhaustion as well as hinder repairing process of damaged muscle fibres (Lundberg et al., 2002). Secondly, the outcomes of psychological and psychosocial stress have been linked to poor mental health including sleeping problems, anxiety and depression (Engholm and Holmstrom, 2005). These mental health problems are not only affect the workers' health

but also their performance. Besides, it might lead to another problem such as self-injury and bring harms to others. For instance, sleeping problems and depression might cause a person to lose their focus during work. For internship doctors, lose some focus may lead to misdiagnosed. Meanwhile, for high risk occupation such as construction workers, lose some focus may cause self-injury such as falling from high place or hit their own hand during hammering process. Besides, working in non-optimal condition may also lead to MSDs. Thirdly, the psychological and psychosocial factors itself may have some effect on physical factors. For example, under time pressure, the workers need to work very fast. This additional pace caused by time pressure may lead the workers to compromise their working posture and consequently lead to MSDs problems. Dentist, for instance, sometimes need to compromise the optimal working posture in order to do their job quickly. Meanwhile, bricklayers need to frequently twisting and bending their body. Under time pressure, the way they twist or bend their body may not be properly done and cause MSD problems.

In this study, even though it is not consistent, psychological and psychosocial stressors have been repeatedly associated with prevalence of MSDs among dentists and internship doctors. Both of these occupations required high mental demands in order to do their job properly and their job especially internship doctors directly affect other persons' life. Based on the interview with two medical officers, it has been discovered that for the doctors, their thinking process for work is not only limited during working time. Sometimes, they still thinking

either every decision they made during working time were right or not, or is there any way they could provide a better diagnosis or treatment for their patient. Moreover, they were required to work on-call once or twice per week. Besides, during internship period, even without enough rest, they always need to study to ensure they know how to do a certain procedure every time the orders given by their superior. All these contributed to psychological and psychosocial stress. As mentioned, this stress might lead to continuously muscle activation, poor mental health and also has effect on physical factors. Consequently, MSD problems became worse with these psychological and psychosocial stressors existence.

From this study, we can see the influence of psychological and psychosocial factors on the prevalence of MSDs. Therefore, it is essential for the administration and management level to ensure the working conditions for their workers are comfortable or at least can help them minimize the psychological and psychosocial stress. For instance, several years ago, internship doctors in Malaysia need to work from 8 a.m today until 5 p.m on the next day during on-call period. However, today, they only need to work from 8 a.m today until 12 p.m on the next day during on-call period. At least, some improvement has been made on their working hours. This improvement will not only reduce their fatigue, but also their stress.

3.7 Summary

This study attempted to determine the association between physical, psychological and psychosocial factors on the prevalence of MSD symptoms among three different occupations which are dentist, internship doctor and construction worker. It is found that the prevalence of MSD symptoms especially among dentists and construction workers in Malaysia were quite high, even if compared to other studies regarding prevalence of MSDs on dentists and construction workers in other countries. Besides physical factors, it is also found that psychological and psychosocial factors also have a significant relationship with MSD symptoms.

CHAPTER 4

EXPERIMENTAL STUDIES

4.1 Introduction of the chapter

In the previous chapter, several cross-sectional studies have been done in order to determine the association between physical, psychological and psychosocial factors with the prevalence of MSD symptoms. As in the previous studies, this study also found some inconsistency where in some conditions, psychological and psychosocial stressors have been significantly associated with the prevalence of MSDs, while in some other conditions were not. As mentioned, there might be several reasons on why this result was obtained. However, the previous chapter was cross-sectional studies; therefore, a direct relationship between causes and effects could not be drawn.

In order to gets a better view regarding the influence of psychological and psychosocial factors on MSDs, several experiments have been conducted. This chapter will discuss about these experiments. The experiment will be focusing on computer usage (desktop computer and mobile computing products) because of several reasons. Firstly, computer products were used by most people over the world regardless their working profession, age, education level and gender etc. It can be considered as a common activity among most people. MSDs symptom among computer user is a worrying issue and something that should not

be taken lightly by all computer user. Therefore, these experiments can contribute a little of knowledge on MSD symptoms among computer user. Secondly, there were many previous studies regarding psychological and psychosocial stress involving computer usage. Thus, a deeper understanding regarding this issue will be presented in this study. Thirdly, even though there were many studies regarding psychological and psychosocial stress involving computer usage, none of them use mobile computing products such as laptop, tablet computer and mobile phone. Therefore, this study can contribute significantly from this aspect. Last but not least, computer usage does not involved high physical activity. Thus, it is easier to see the effect of psychological and psychosocial factors on MSDs during experiments.

There were three experiments done in this study in order to determine the effect of physical, psychological and psychosocial factors on MSDs. Based on literature, MSD symptoms are significantly related to muscle activity, posture and visual discomfort. Thus, these three experiments were designed to determine the effect of psychosocial factors on muscle activity, head posture and visual discomfort during desktop computer and mobile computing product usage.

Next section will discuss the detail regarding the hypothesis, methodology, result, discussion and conclusion of the experiments.

4.2 The effect of psychological and psychosocial stress on muscle activity

4.2.1 Introduction and hypothesis

In the modern world, the use of computers and the internet are common. More and more people feel the need to access them anytime and anywhere. The needs and use of this kind of technology ubiquitously brought an explosion in the popularity of mobile computing products. The popularity of mobile computing products raises several concerns including well-known health problems such as musculoskeletal disorders (MSDs). MSDs not only affect workers' health conditions but also reduce performance and involve a very high cost (Mclean and Urquhart, 2002; Brisson et al., 1999). MSDs were responsible for 34% of all workplace injuries and illnesses in the year 2012 and reportedly cost between $45 to $54 billion to U.S economy (BoLS, 2012; NRC, 2001). Upper body pains such as neck and shoulder pains are the most typical issues among MSD patients as a result of static posture, working technique and constant static muscle activity (Mclean and Urquhart, 2002; Korpinen et al., 2013; Korpinen et al., 2013; Ewa et al., 2011; Gerr et al., 2006; Szeto et al., 2005; Blangsted et al., 2004). These problems might be worse for mobile computing product such as tablet and smart phone users because of the inseparable screen and keyboard. This condition is worse for the laptop users because it cannot be adjusted freely like general display terminals except for the angle (Moffet et al., 2002). Even though tablets can be used in various

positions, a previous study shows that head and neck flexion angles for several typical positions during tablet usage are far from recommended neutral angles for visual display unit (Young et al., 2012). Consequently, there might be more concern for development of neck and shoulder discomfort.

The same thing might happen with smart phone usage because, like tablets, smart phones also have the capability and flexibility to be used in various positions. Although flexibility provides a huge benefit, it may also cause problems to users. For example, the size of smart phone allows users to use it in a small and crowded space / area such as in a subway train. In this space, sometimes, it is inconvenient for the user to place the phone higher (because of a privacy reason or have difficulty to use it in that position) which subsequently force users to bend or look down if they want to use the phone.

Many previous studies show that there is another factor that might play a role to the MSD symptom which is called psychological and psychosocial stress (Shahidi et al., 2013, Eijckelhof et al., 2013a; Wang et al., 2011; Lundberg et al., 2002). It includes time pressure, low social support, high job demands, high mental workload, high memory demands, low reward, surveillance of workers, and high efforts (Blangsted et al., 2004; Shahidi et al., 2013; Eijckelhof et al., 2013b; Larsman et al., 2006; Bloemsaat et al., 2005). In order to study the effect of psychological and psychosocial stress in a laboratory setting during computer usage, previous studies use different kinds of methods to induce stress including arithmetic tasks, time pressure and

color-word tasks. The methods used by previous studies are summarized in Table 4.1.

The effect of psychological and psychosocial stress on muscle activity might depend on the type of task used to induce the stress. Different tasks may produce different levels of stress, hence lead to different effects on the muscle activity. Based on literature review, it seems that stress induced by a stressful environment (including noise, verbal provocation, calling out any mistakes and evaluation by a supervisor) has the largest effect on trapezius muscle activity (but not on other muscle activity) followed by skill and intelligence tasks, time pressure tasks, arithmetic task and color-word tasks (Mclean and Urquhart, 2002; Szeto et al., 2005; Shahidi et al., 2013; Wang et al., 2011; Bloemsaat et al., 2005; Ekberg et al., 1995; Johnston et al., 2008; Wahlstrom et al., 2002). Therefore, it is believed that psychological and psychosocial stress will show an increment trend on trapezius muscle activity (First Hypothesis).

The difference from results obtained by previous researchers is because of different levels of stress produced by each category which consequently have a different level of effect on trapezius muscle activity (Second Hypothesis). It is believed that stressful environment has the largest effect followed by time pressure and color-word task.

Table 4.1: Summary of method used by previous studies to induce psychological and psychosocial stress

Methods	Authors
Arithmetic task	Wang et al., 2011; Ekberg et al., 1995; Hughes et al., 2007; Schleifer et al., 2008
Time pressure / speed task and precision task	Mclean and Urquhart, 2002; Szeto et al., 2005; Wang et al., 2011; Bloemsaat et al., 2005; Hughes et al., 2007; Szeto et al., 2011; Aasa et al., 2011; Birch et al., 2000; Sandfeld and Jensen, 2005
Stressful environment	Mclean and Urquhart, 2002; Blangsted et al., 2004; Shahidi et al., 2013; Garza et al., 2013; Chou et al., 2011; Johnston et al., 2008; Visser et al., 2004; Wahlstrom et al., 2002
Color-word Task	Ekberg et al., 1995; Johnston et al., 2008; Laursen et al., 2002
Skill and intelligence task	Finsen et al., 2001; Xiaopeng et al., 2011; Elke et al., 2001; Rietveld et al., 2007

Previous studies regarding mobile computing products show that they might cause worse MSDs problems on the user compared to desktop computer usage because of their physical factors. For example, detachable screens make the neck angles and head tilt of mobile

computing product users become larger compared to desktop computer user (Young et al., 2012; Szeto and Lee, 2002; Straker et al., 1997). A recent study by Kim et al. (2013) between four virtual keyboards showed that muscle activity on the shoulder muscle was slightly higher for smaller virtual keyboards compared to other keyboards which might be caused by the visual demand. Meanwhile, a study by Villanueva et al. (1998) on the effect of desktop and four portable computer usages showed that muscle activity in the neck extensor muscles for portable computers were significantly higher than desktop computers. The discomfort survey also showed that subjects have most musculoskeletal complaints and eye discomfort when they use the smallest portable computer. In addition, posture is also affected. Thus, it is expected that muscle activity during mobile computing product usage is higher compared to desktop computer usage on the same task (Third Hypothesis).

Aside from that, many people are not aware that these physical factors not only affect the physical body but induce psychological and psychosocial stress conditions as well. For instance, a small screen might induce visual demand that makes the user experience visual strain and tiredness (Szeto and Lee, 2002; Straker et al., 1997; Villanueva et al., 1998) and a small keypad might require user' concentration and precision (Szeto and Lee, 2002; Villanueva et al., 1998). Furthermore, a smaller screen might produce larger error rates and decrease satisfaction (Sears et al., 1993). In addition, a small screen might limit the information that can be obtained by the user, especially via -video or text (Kim et al., 2011; Lombard et al., 1997).

Consequently, it might increase psychosocial stress. Yet, in spite of the popularity of mobile computing products, to my knowledge, there is no study that has used any mobile computing product in their psychosocial stress experiment. It is expected that the increment of muscle activity during a mobile computing product's usage under psychosocial stress conditions is larger compared to personal computer usage under the same conditions (Fourth Hypothesis).

Therefore, based on first and second hypotheses, the objective of this study is to see the effect of different tasks (color-word, time pressure and stressful environment) used to induce the psychosocial stress on muscle activity. Meanwhile, based on the third hypothesis, another objective of this study is to see if there is any difference in effect for the usage of different computer products (desktop computer, laptop, tablet and smart phone) while working on the same task. Finally, based on the fourth hypothesis, the last objective of this study is to determine whether psychosocial stress conditions will have a different effect on muscle activity increment with different products.

4.2.2 Methods

4.2.2.1 Subjects

Fourteen healthy male students without musculoskeletal symptoms in the neck, shoulder and arm region were recruited from a university campus. Participants were experienced computer users. They also used at least one of these four devices at least for 4 hours per day and have

experience in using other devices. Each participant provided informed consent before taking part in the experiment. Most of the participants have their own laptop and smart phone. Demographic data of the participants and their computer use profile were summarized in Table 4.2.

Table 4.2

Demographic data of the participants and their computer use profile

	Mean	**SD**
Age (years)	20.25	0.96
Weight (kg)	63	19.32
Height (m)	1.66	0.05
Body Mass Index (BMI)	22.99	7.01
Desktop computer usage (hours / week)	6.25	13.97
Laptop usage (hours / week)	25.58	14.58
Tablet usage (hours / week)	1.75	1.76
Smart phone usage (hours / week)	49	27.19

4.2.2.2 Workstation

Subjects sat at the same workstation (fixed table height) for all device usage. They can adjust their position and chair height to the most comfortable position before they start the experiment for each device and psychosocial stress task. There is no arm-rest provided. For the desktop computer, they can adjust the height of the monitor and for

other devices; they can adjust the screen angle. The monitor used for desktop is Samsung CX1765 (445 x 340 mm), Lenovo Z480 (355.6 x 230 mm) for laptop, iPad Mini (200 x 134.7 mm) for tablet and Galaxy Note 2 (151.1 x 80.5 mm) for smart phone.

4.2.2.3 Procedure

In this experiment, if the participants are required to perform all conditions using all devices, even without any replication, they need to perform at least 16 trials. It will take a lot of time to do the experiment. Besides, the participants need to rest for the same amount of time in order to minimize the effect of fatigue. Thus, a large amount of trials and time needed for each participant to perform all conditions for all devices. In order to reduce the influences of other factors such as fatigue, or stress caused by a long experiment, the participants were instructed to perform the four conditions by using only two devices. In order to avoid any bias, the devices that they used were chosen randomly. However, in order to allow the participants to experience all the conditions used to induce stress, each of the participants used one of these combinations: desktop and tablet, laptop and tablet, desktop and smart phone, or laptop and smart phone. Besides that, each participant was needed to do two extra tasks using a third device. Subjects were allowed to rest for five minutes after each task. As the hypothesis of this study is that a stressful environment has the largest effect on muscle activity followed by color-word, time pressure and lastly plain copying; the experiment started with plain copying and ended with

stressful environment in order to avoid any lasting effect from the last session.

Plain copying

Plain copying was chosen as a reference because it can be done using these entire products and there is no need for the subjects to use any extra equipment such as a mouse or stylus. Many previous studies used plain copying as a baseline for muscle activity (Mclean and Urquhart, 2002; Hughes et al., 2007; Johnston et al., 2008). The participants need to copy some text at their own comfortable pace and condition. They were instructed to make a correction if they see any error as they hit the key, but not to try to find the error by reading through all their works (Mclean and Urquhart, 2002).

Color-Word Task

In this task, the name of a color was presented in another color on a power point slide with black background on a tablet screen while the researcher pronounced the name of the third color using voice (Ekberg et al., 1995; Johnston et al., 2008). The words appear in a random position. Subjects were needed to type in which color the words were written on using four short keys: “D” = red, “F” = green, J = “blue”, “K” = yellow. Different sets of color-word tasks were used for each different device. They were reminded not to miss any words and they were told that if they make more than 10 mistakes, 10% out of their monetary compensation would be deducted.

Time pressure

This task is based on Hughes et al. (2007) study. In this task, participants were asked to type at 20% faster than their comfortable pace. In order to help the participants to work in suitable pace, the new typing speeds were calculated and the target end word for each 1 minute interval were underlined. Subjects were told the time for every 1 minute interval to help them identify their performance during the task. Participants were advised that the main objective was to achieve the target, even if it meant committing more typing errors. It was not only that, the participants were also reminded if they could not achieve the target after five minutes, 10% of their compensation would be deducted.

Stressful environment

This task is the same as time pressure task. Aside from working under supervision, participants were not allowed to do any correction and every time subjects made a mistake, the experimenter said it out loud. In addition, participants were encouraged to work faster every 30 seconds. Furthermore, an alarm clock with sound was placed in the same room (Mclean and Urquhart, 2002). The participants were told if they could not achieve the target after 5 minutes or made more than 10 mistakes, another 10% of their compensation would be deducted, respectively.

4.2.2.4 Questionnaire

Participants needed to fill out another questionnaire after they had finished the experiment. There were three parts of this questionnaire, namely:

1) Part 1 - Perceived Task Stress

   They need to compare the perceived stress between three tasks (color-word, time pressure and stressful environment) with the plain-copying task. The scale are from “much more relax”, “quite relax”, “slightly relax”, “no different”, “slightly stressful”, “quite stressful” and “much more stressful”.

   All other tasks (color-word, time pressure and stressful environment) were compared to the plain-copying task in order to see the effect of different task on perceived stress clearly by letting the plain-copying task to act as a reference point. This is because plain-copying task was done under stress-free condition while all other tasks were done under some stressors which allow the comparison of perceived stress between stress and no stress tasks. Since all other tasks were anchored on one reference point, which is plain-copying task, this can increase the internal consistency (44).

2) Part 2 - Perceived Device Stress

   They need to compare the perceived stress between at least two devices for the same task. The same scales as in part 1 were used.

3) Part 3 - Perceived Condition Stress

   Some tasks have three or more stressors imposed on the participants simultaneously. For instance, the stressful environment

task contains noise, time pressure, monetary reduction, verbal provocation and negative feedback. Thus, this part was used to find the effect of every stressor towards the participants. The participants were asked to rate from “0” for not stressful at all up to “5” for very stressful.

4.2.2.5 Electromyography (EMG) and Maximum Voluntary Contractions (MVC)

Muscle activity was recorded from the dominant upper trapezius, deltoid, extensor digitorum and extensor carpi ulnaris muscles using bipolar Ag-Cl surface electrodes. The distance used between recording areas was 20 millimeters (Laursen et al., 2002; Finsen et al., 2001). The skin was prepared by cleaning the located area. The EMG signals were sampled at 1024Hz. The precise locations of EMG were based and adopted from previous studies (Szeto et al., 2005; Perotto et al., 2011). The EMG signals were measured using an EMG LAXTHA device and the signals were analyzed using TeleScan software version 3.09 (LAXTHA Inc., Korea). Isometric maximum voluntary contractions were performed for each muscle. At least three MVC were made for each muscle, and each MVC lasted at least three seconds.

4.2.2.6 Data Analysis

The data were band filtered using 5 Hz and 500 Hz and then root mean square was calculated for three 5 s epochs at 60s, 180s and 300s after the task was started. The value was then normalized with maximum EMG obtained from MVC. The average value was calculated from these three epochs.

As the number of subjects was quite small, the result was analyzed by descriptive statistic and the trend only.

4.2.3 Results

Perceived task stress

The difference of mean stress between plain-copying (0.000) and color-word (0.1667) was very low and not significant. Thus, color-word can be considered as a “no stress” task. The time pressure task (mean = 1.4167) is considered as in the middle of “slightly stressful” and “quite stressful” compared to the plain-copying task while the stressful environment task (mean = 2.1667) is considered as slightly more than “quite stressful” compared to plain-copying task and time pressure.

Perceived device stress

Unexpectedly, there were no differences in stress between devices for any task.

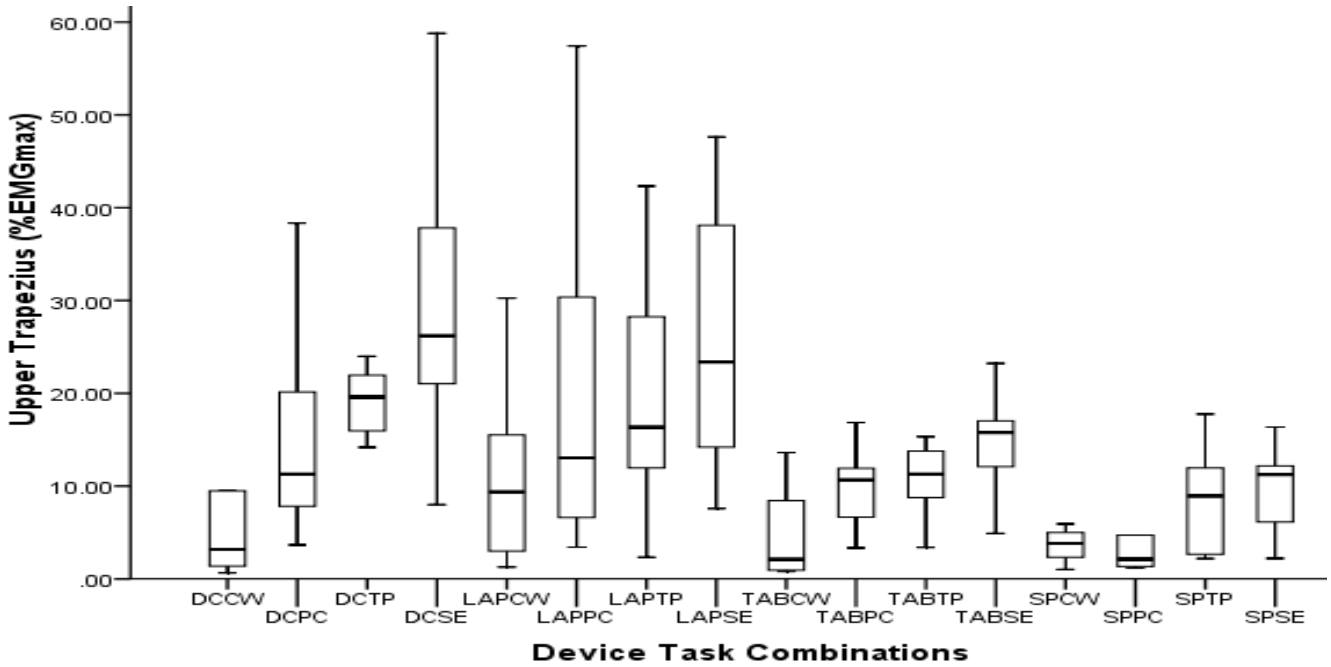
Perceived stress for each of the stressor

In this section, the highest stress was induced by "the needs to change the screen between alphabets and symbols", followed by noise and typing accuracy. Other significant stressors were time pressure, verbal provocation, negative feedback, and small keypad. There are other stressors that can be considered as insignificant to the participants which are different color-word for both on screen and using voice, random positioning of appearance during color-word task, supervision by the researcher, small screen and compensation (monetary) reduction.

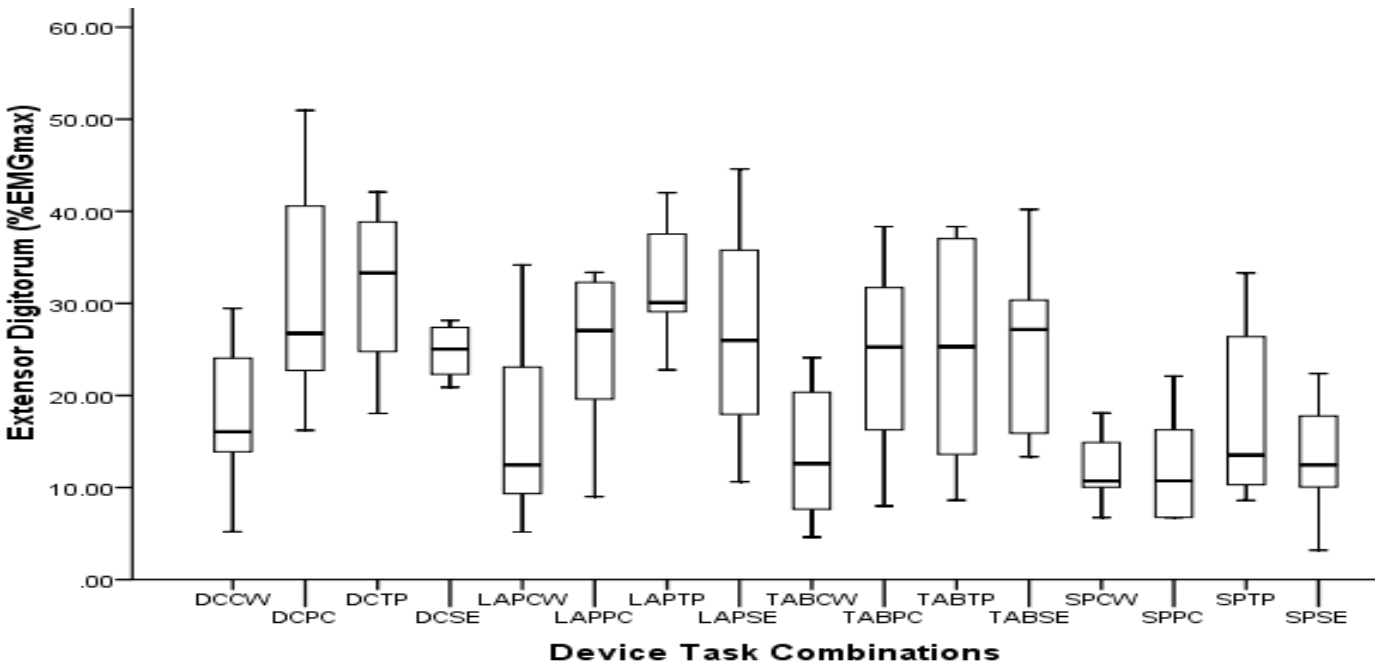
Muscle Activity

EMG values for each muscle were analyzed into two categories which are by the effect of different tasks and by the effect of different devices. Figure 4.1 (i – iv) shows a box and whisker plot with medians and 25-75 percentiles of electromyography activity (%EMGmax) for the upper trapezius, extensor digitorum, extensor carpi ulnaris and anterior deltoid respectively. There are 16 combinations of devices and tasks. The first two or three alphabets were devices (DC = desktop computer, LAP = laptop, TAB = tablet and SP = smart phone) and the last two alphabets were tasks (CW = color word, PC = plain copying, TP = time pressure and SE = stressful environment). For instance, DCCW means that a color-word task was done using desktop computer. Some data need to be excluded because of certain technical errors. Thus, on average, there were eight participants for each combination of device and task.

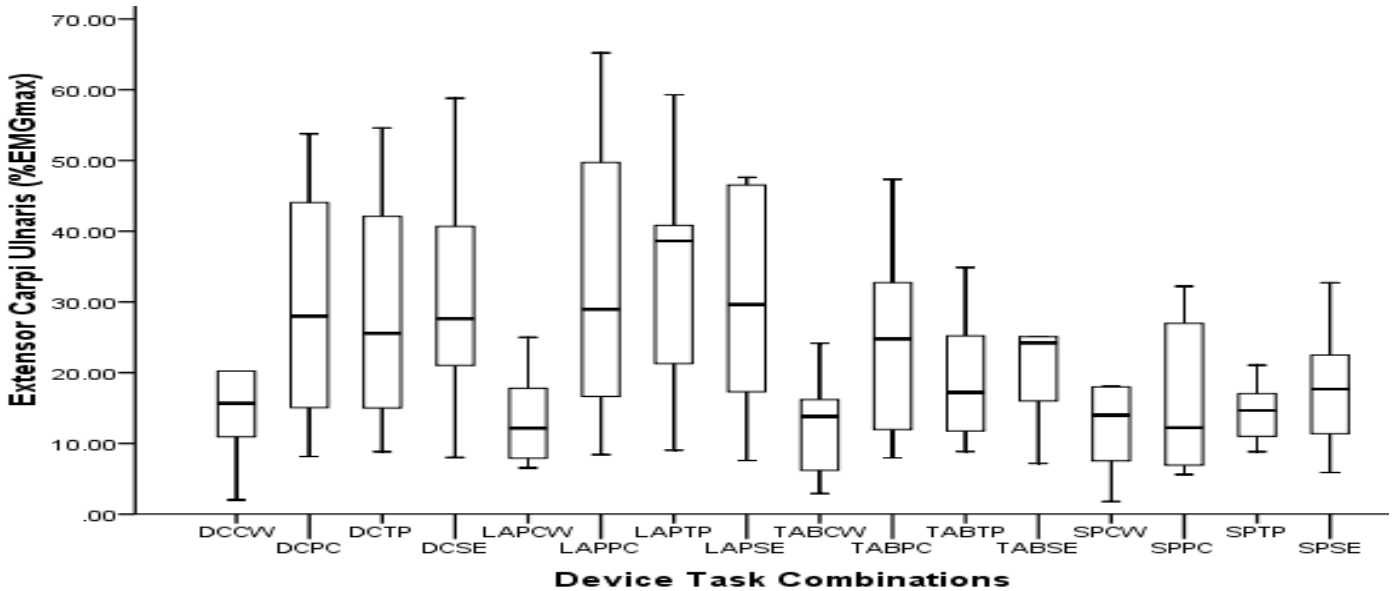
i)


Upper Trapezius (%EMGmax)
60.00
50.00
40.00
30.00
20.00
10.00
.00
DCCW
DCPC
DCTP
DCSE
LAPCW
LAPPC
LAPTP
LAPSE
TABCW
TABPC
TABTP
TABSE
SPCW
SPPC
SPTP
SPSE
Device Task Combinations

ii)


Extensor Digitorum (%EMGmax)
60.00
50.00
40.00
30.00
20.00
10.00
.00
DCCW
DCPC
DCTP
DCSE
LAPCW
LAPPC
LAPTP
LAPSE
TABCW
TABPC
TABTP
TABSE
SPCW
SPPC
SPTP
SPSE
Device Task Combinations

iii)


Extensor Carpi Ulnaris (%EMGmax)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
.00
DCCW
DCPC
DCTP
DCSE
LAPCW
LAPPC
LAPTP
LAPSE
TABCW
TABPC
TABTP
TABSE
SPCW
SPPC
SPTP
SPSE
Device Task Combinations

iv)

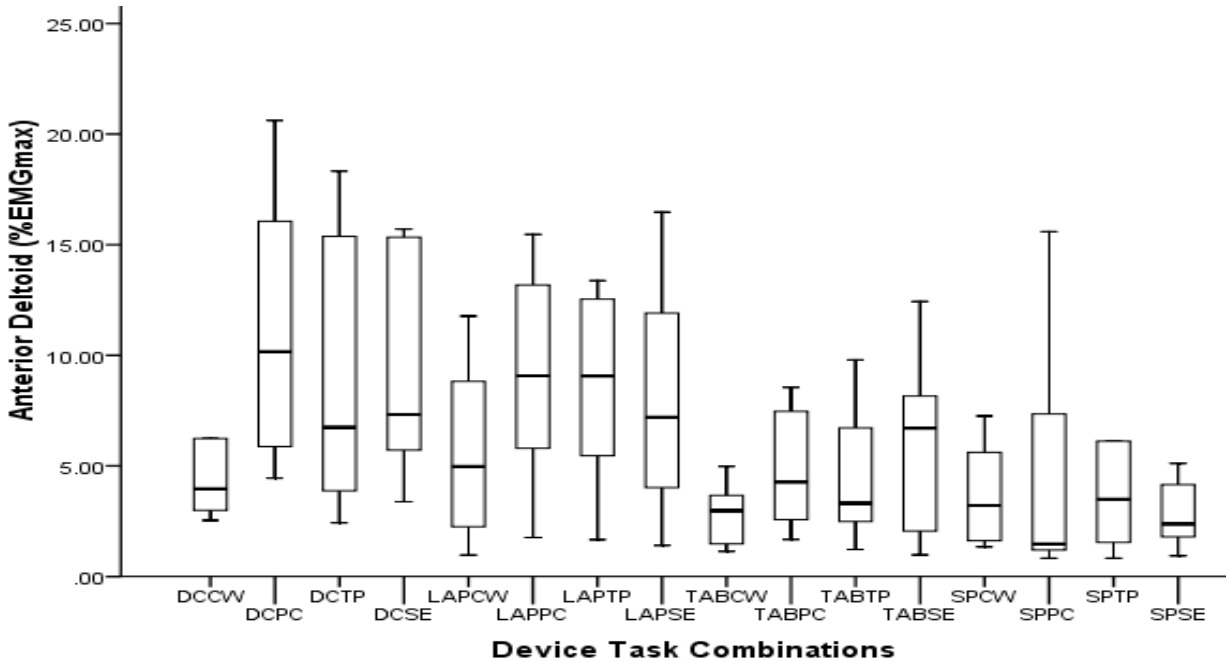


Figure 4.1 (i - iv): Box and whisker plot with medians and 25-75 percentiles of electromyography activity (%EMG$_{max}$) under 16 combinations of devices and tasks for i) upper trapezius, ii) extensor digitorum, iii) extensor carpi ulnaris and iv) anterior deltoid.

There is a clear effect of the level of stress on the upper trapezius muscle activity. Generally, there was a clear trend where trapezius muscle activity increased during time pressure task compared to plain-copying or color-word tasks and had a greater increment when they did stressful environment task as can be seen in Figure 4.1. Aside from the trapezius muscle, other muscles also show some increment. However, there is no clear relationship of the increment pattern.

At the same time, the comparison between a desktop computer and tablet / smart phone or between laptop and tablet / smart phone showed a decrement trend (Figure 4.1). Muscle activity during the usage of a tablet and smart phone for all muscles and tasks is much lower compared to the muscle activity during the usage of a desktop computer and laptop.

Performances

The performance of participants was different depending on the task and the devices. The fastest typing speed was during the stressful environment task. Generally, the result shows that there are increments of typing speed from the plain-copying task to the time pressure and stressful environment tasks. However, there is not much difference of typing speed between different devices for the same task which means most of the participants can type on smart phones or tablets as fast they type on desktops or laptops. Nevertheless, it should be noted that this might be true only for slow typists. Meanwhile, numbers of errors increased significantly for each task and the same thing happened for all devices. The lowest number of errors was obtained during the usage

of a smart phone. The mean of typing speed in terms of words per minute (WPM) and number of error were summarized in Table 4.3.

Table 4.3:
Mean of the participants' performance in terms of WPM and number of error

Device	Words per minute (WPM)			Number of error		
	Plain copying	Time pressure	Stressful environment	Plain copying	Time pressure	Stressful environment
Desktop	24.1	27.4	30.9	0.6	12	16.6
Laptop	26.1	30.7	31.6	0.6	8.3	13.3
Tablet	21.1	25.3	26.6	0.4	8.3	9.9
Phone	20.9	24.7	27.5	0.4	7.3	9.6

Net values for performance were calculated to see the actual performance by the participants. Interestingly, the highest performance was obtained during the plain copying task using a desktop. In addition, the net performances of the participants were better during comfortable conditions compared to during stressful conditions. Besides that, during the time pressure and stressful environment tasks, the best performance was obtained during the usage of a laptop.

4.2.4 Discussion

Previous studies showed a different result in regards to the effect of psychological and psychosocial stress on muscle activity. Even for the most common muscle studied which is the trapezius muscle, the effect of stress on muscle activity can be divided into two main groups. One

group found that when a certain psychological and psychosocial stress exists, the trapezius muscle will become affected and the muscle activity will be increased significantly (Bloemsaat et al., 2005; Szeto et al., 2005; Shahidi et al., 2013; Schleifer et al., 2008; Visser et al., 2004; Wahlstrom et al., 2002; Laursen et al., 2002; Rietveld et al., 2007). On the other hand, another group of researchers found that the existence of a certain psychological and psychosocial stress did not have any significant effect on trapezius muscle activity (Blangsted et al., 2004; Wang et al., 2011; Ekberg et al., 1995; Aasa et al., 2011; Birch et al., 2000; Chou et al., 2011; Johnston et al., 2008). Meanwhile, there are several studies that can be categorized in a third group where this group obtained a combination of the two aforementioned results (Mclean and Urquhart, 2002; Sandfeld and Jensen, 2005; Garza et al., 2013; Visser et al., 2004).

It is predicted that there is a relationship between the task used to induce the stress and the effect on trapezius muscle activity. It is believed that this relationship is the main reason that leads to the result obtained by these previous researchers. This is because each of the tasks used to induce stress produces a different level of stress and consequently has a different effect on muscle activity.

There is a wide range of stressors used in this study since normally, in the real work environment, multiple stressors or factors are present simultaneously. The effect of each one of them might be small but the combination of them might create a big effect. Previous researchers who obtained a significant activity increment in trapezius muscle activity used different kinds of stressors. In order to

differentiate the effect of each stressor, part 3 of the questionnaire was used so that participants could rate the effect of each stressor separately. As a result, there were seven stressors that can be considered as significant in inducing the stress in this study.

This result was supported by part 1 of the questionnaire that shows the color-word task was considered as a 'no stress' task. This is because four insignificant stressors were used in color-word task. At the same time, time pressure task was in the position between 'slightly' and 'quite stressful' tasks. This is expected as the time pressure task contained several stressors that can cause significant stress to the participants. Finally, the stressful environment task was considered 'quite stressful' because not only did it have the same stressor as the time pressure task, but also some additional stressors that can cause significant stress.

As we were interested in finding the relation of muscle activity to the level of stress, the core part of this study is to prove that there is a different level of perceived stress between each of the tasks. Then, the result was validated by an EMG result in order to determine the effect of psychosocial stress on muscle activity, especially on the trapezius muscle.

The effect of different task used to induce psychosocial stress on muscle activity

The results obtained from the EMG measurements have proven the first and second hypotheses. The first hypothesis is accepted as true because the result showed a clear increment trend of trapezius muscle activity

for the time pressure and stressful environment tasks compared to the plain-copying or color-word tasks.

Meanwhile, the second hypothesis stated that the increment is dependent on the level of stress. The higher the level of stress is, the higher the increment of trapezius muscle activity. This hypothesis stated that the plain-copying task has the lowest effect on trapezius muscle activity while the stressful environment has the highest effect. It was expected that the highest trapezius muscle activity in this study would result from the stressful environment task, followed by the time pressure task, and finally the color-word task. The result obtained has proven this hypothesis. The EMG result was matched with part 1 of the questionnaire's result. This is because in most conditions, there was an increment of trapezius muscle activity between the plain-copying or color-word task with the stressful environment task even though there was no significant increment between the plain-copying or color-word task with time pressure task. In addition, in the event there is a increment, the increment in trapezius muscle activity for the first comparisons is higher than the latter. Besides that, the different increment of trapezius muscle activity can be seen clearly where the lowest activity was obtained during the plain copying task and the highest was obtained during the stressful environment task for all devices.

This result is concurrent with previous research regarding the effect of psychosocial stress on trapezius muscle activity. These researches also showed that there were no significant differences for trapezius muscle activity during the color-word task (Ekberg et al.,

1995; Visser et al., 2004), greater effect during time pressure task (Szeto et al., 2005; Wang et al., 2011) and the highest effect happened during the stressful environment task (Mclean and Urquhart, 2002; Shahidi et al., 2013; Wahlstrom et al., 2002). Aside from the trapezius muscle, other muscles did not show this kind of relationship.

The effect of different devices used under psychosocial stress on muscle activity

In third hypothesis, it is believed that mobile computing products can produce psychosocial stress because of its characteristics. However, this hypothesis cannot be accepted as true. This is because in comparison to the desktop computer, only a laptop showed a greater trapezius muscle activity. However, the differences are very small. The results show that muscle activity during the usage of tablet and smart phone is lower than during the usage of desktop computers and laptops. There is a contradiction between this study and Kim et al. (2013) which showed that muscle activity in the shoulder muscle was slightly higher for a smaller virtual keyboard. However, this inconsistency might happen because of the differences in study design and equipment. Thus, direct comparison might not be meaningful.

There are several reasons why this result was obtained. First, in many conditions, laptops and desktops are quite similar. The main difference is that laptops do not have a detachable monitor which makes the angle of viewing quite limited compared to desktops. Thus, the result obtained was as expected. However, it is not significant enough. Secondly, most of the participants were not people who could

do the typing process without needing to take a look at the keyboard. Thus, when they do the copying on a desktop computer or laptop, their heads move from monitor to keyboard and to monitor again in the process. This movement is minimized during the usage of tablets and smart phones, and consequently might lower their muscle activity. Meanwhile, lower activation in other muscles can be explained by the difference of keyboard size and touch screen capability. Since the keyboard / keypad size is very small for tablets and smart phones, the participants do not move or use their muscles as much as when they use desktop computers and laptops. In addition, the force they need to press a touch screen button is lower than the actual keyboard. Finally, in a study to determine the effect of precision demand and mental pressure on the load of the upper extremity, the authors found that unlike mental pressure, the precision had a small effect on trapezius muscle activity (Visser et al., 2004). However, they also argued that in a case where the performance is essential, precision might has a hidden effect. This is because precision plays an important role in performance during computer work, and consequently on mental pressure. This relationship is also found in another study (Szeto et al., 2011). Thus, based on this argument, we also want to argue that since the participants can do the typing task with less number of errors during the usage of tablet and smart phone, this might be another reason why trapezius muscle activity is less compared during the usage of a laptop or desktop computer. The fourth hypothesis cannot be taken as true as the third one has been rejected. Furthermore, there is no fixed patent of muscle activity increment found in any muscles for any devices.

Performance

The best performance was obtained during the usage of desktop computer and plain copying task. This is interesting because the best result was obtained during the comfortable condition without any stress. Even though the participant can increase their typing speed, the stress made them make more mistakes. This result indicates that the best environment for the workers is the comfortable environment. Besides that, during the time pressure and stressful environment tasks, the best performance was obtained during the usage of laptop. This result might indicate that under stressful conditions, the best performance can be obtained using the device that they are most comfortable or has most experienced to.

Stressors

There are many stressors used in this study to induce psychosocial stress. Even though this study cannot clearly differentiate the effect of each stressor, the result from questionnaire (part 3) found that there were six stressors which considered as not stressful enough to increase the trapezius muscle activity. This result is matched with some previous studies which used some of these stressors and no significant differences in trapezius muscle activity were found. For instance, the effect of different color-word either on screen or using voice (Ekberg et al., 1995; Johnston et al., 2008), supervision by the experimenter (Blangsted et al., 2004) and adding to or deducting the compensation (Garza et al., 2013). However, the comparison between this study and the previous ones for significant stressors are difficult to be made as

these previous studies also combine more than one stressor in their experiments (Mclean and Urquhart, 2002; Shahidi et al., 2013; Wahlstrom et al., 2002).

Limitations

There are several limitations in this study. First of all, there is no female participant involved. Many previous studies described that gender plays a big role in MSDs symptoms. However, none of the previous studies regarding the effect of psychosocial stress on trapezius muscle activity reported any difference in effect between men and women (Schleifer et al., 2008; Johnston et al., 2008; Visser et al., 2004). Thus, it is believed that it will not affect the result of this study that much. Another limitation is the limited choice of posture and small number of participants. As the design of the experiment for this particular study is quite big, only one posture was used for each device and task even though the range of posture is so wide, especially for mobile computing products. Different posture might have a different effect on muscle activity especially because this study involved four different kinds of devices. There could be another limitation caused by the questionnaire design. As the perceived task stress for a particular task was compared to another task, there might be some biases. Participants may generate the plain-copying task as an anchor (no stress), and then the perceived stress could be increased as they know the other tasks were done under some stressors (Epley and Gilovich, 2001). Also, the order of task could have an impact on the perceived stress of tasks. For example, participants can remember better the

difficulties and stresses of the more stressful ones than the less stressful ones as they conducted experiment in the order of perceived stress level. Consequently, the perceived stress for the last task (stressful environment) might be overestimated. The same thing might happen on perceived device stress. Finally, the participants in this study are young adults. Thus, the result might not be applicable to older adults.

4.2.5 Summary

This present study has examined the effect of psychological and psychosocial stress on muscle activity using different devices including desktop computers, laptops, tablets and smart phones. Combinations of several stressors were used for each task done in this study. The results from the questionnaire showed a clear distinction of stress perceived by the participants for each task. Based on the different of results found in previous studies regarding the effect of psychological and psychosocial stress on trapezius muscle activity (significantly increased, no significant effect or mixed result), it is believe that it is caused by different level of stress. The result from this present study shows a clear indication that trapezius muscle activity will increase with the existing of psychosocial stress. Not only that, the increment of the activity was influenced by the level of stress used. The trend showed that the higher the level of stress is, the higher the increment of trapezius muscle activity. This result might indicate that the effect of psychological and psychosocial stress is worse on neck compared to other muscle. Meanwhile, it is found that the usage of tablets and smart phones are

better than desktops and laptops in terms of muscle activity. Besides that, even though desktop computer is the best device to use during comfortable environment, it does not appear so in stressful environment. However, these results may only be applicable for slow typists and for particular postures. Psychosocial stress is common in a working world. Some precautions should be taken if the job involves a great level of stress. It will help the company in reducing the MSDs problem in the future.

4.3 The effect of time pressure on head posture, visual and body discomfort

4.3.1 Introduction

Computers play a very important role in our daily life. It has been widely used since almost two decades ago. Consequently, it leads to a concern to many people that it might cause a problem to the user especially in relation to the musculoskeletal disorder. Yet, over the last decade, the needs to use it everywhere at any time have been increased. Since that, the popularity of mobile computing product such as laptop computer has been increased dramatically. For instance, in 2008, the number of laptop is increasing in Australia to 63% of all household (The Nielson Company, 2009). In addition, Chang et al. (2008) reported that more than 80% college student used laptop computer as their personal computer. Today, the popularity of mobile computing product is spreading to tablet computer. On the earlier stage of its introduction, tablet computers were used as an alternative to smartphones and laptops in order to improve the user experience for certain tasks especially for browsing the web, playing games and to send email (Trudeau et al., 2013). However, because of its mobility and capability, the tablets become really popular. Nevertheless, even after gained this kind of popularity, there is no international or national guidelines provided for mobile computing products.

The clear advantage of mobile computing products compared to desktop computer is the mobility, light weight and space saving.

However, it does not means that the usage of mobile computing product will be better for the user's musculoskeletal health compared to when they used desktop computer. The reason lies in the fact that most laptops are designed with screen attached to the keyboard. Meanwhile, tablets integrate the display and the keyboard functionality via a touch screen. The design of these both products makes it impossible to be adjusted separately in terms of screen height and distance, and keyboard height and distance. Several studies found that the user assumed forward posture when they used laptop compared to desktop computer which consequently produce a greater neck and head tilt angles (Szeto and Lee; 2002; Villanueva et al., 1998; Straker et al., 1997). As tablet computer was normally designed with a single screen that contains keyboard and other interfaces, as well as a smaller size than laptop computer, it is expected that on the same height, these physical constraints would require tablet computer user to compromise their typing posture by increasing their head posture compared to laptop computer user and consequently increase the neck and upper back discomfort (Hypothesis 1).

There is another factor that might be related to MSDs symptoms which is the visual discomfort. Even though there were relatively few studies conducted concerning this issue, some studies found correlation between visual discomfort and neck as well as shoulder pain (Helland et al., 2008, Wiholm et al., 2007; Aaras et al. 2001; Aaras et al., 1998). There are a number of theories regarding the relationship between these two matters. Ritcher et al. (2011) showed that they might be physiologically related (i.e ciliary muscle contraction related to

trapezius muscle activity increment). Aside from that, gaze stabilization process also may play a role between visual discomfort and MSDs symptoms on neck and shoulder. For instance, if the head turns to the left, the eyes will react by moving to the left in order to keep the gaze stable at the targeted object (Zetterbeg et al., 2013; Wiholm et al., 2007). The process to stabilize gaze and optimally fixate at the target object might increase the mechanical load on the neck and subsequently affect that area. Other theory includes the change of body posture caused by eye fatigue (Rithcher and Forsman, 2011) or non-optimal correction in spectacles (Hemphala et al., 2014) and consequently became a risk factor to MSDs. Even though the actual mechanism regarding the influence of visual discomfort on neck / shoulder pain is still unknown, previous studies showed that people with visual discomfort were more likely to have upper body symptoms (Helland et al., 2008; Hemphala and Eklund, 2012; Wiholm et al., 2007).

In the beginning of computerization of office work era, symptoms from the eyes called “computer vision syndrome” have been reported all over the world (Toomingas et al., 2014). The symptoms include impaired visual performance, headache, tiredness, irritation, red and sore eyes, dry or watery eyes, and blurred or double vision (Toomingas et al., 2014; Woods, 2005). There are many aspects during computer usage that can contribute to visual discomfort including screen glare, bad resolution, high luminance contrast, too small details and unsuitable screen angle and distance (Hemphala et al., 2014). Computer can be used in various ways and some of the most common are to read

documents and typing activity. Today, with the popularity and the capability of mobile computing products, the user can read the document not only in desktop and laptop computer, but also in other mobile computing products such as tablet computer and smart phone. There are less viewing distance between eye and screen for tablet computer and smart phone compared to desktop / laptop computer, which as a result might increase the demand on visual system (Zetterberg et al., 2013). Previous study by Kim et al. (2013) between four virtual keyboards showed that muscle activity on the shoulder muscle was slightly higher for smaller virtual keyboards compared to other keyboards which might be caused by the visual demand. Besides, a study by Villanueva et al. (1998) on the effect of desktop and four portable computer usages showed that subjects have most musculoskeletal complaints and eye discomfort when they use the smallest portable computer. Furthermore, it has been reported that the user prefer to move closer to the visual display whenever accessing smaller visual display unit in order to see the smaller fonts more clearly (Szeto and Lee; 2002; Villanueva et al., 1998). Therefore, it is believed that not only eye discomfort but also neck as well as upper back discomfort will increase during tablet computer usage compared to laptop usage (Hypothesis 2).

Physical factor is not the only factor that might contribute to MSDs. Previous studies show that psychological and psychosocial factors also can contribute to MSDs. Johnston et al. (2007) found that psychosocial factors may increase the risk for neck pain even without the involvement of physical factors. In a real working world,

psychological and psychosocial stress is a common thing; for instance, time pressure. Time pressure was defined as the stress on the worker when they were asked to work at a faster pace in order to meet deadline while maintaining the high standard performance (Szeto et al., 2005). Time pressure was found repeatedly as one of the psychological and psychosocial factors that significantly increased neck muscle activity and neck symptoms (Taib et al., 2014; Johnston et al., 2007; Huang et al., 2003; Szeto et al., 2005). However, only a few studies tried to determine the effect of psychological and psychosocial factors on posture during computer usage. Shahidi et al., (2013) found that mental concentration significantly increase forward head posture but did not increase with the introduction of psychosocial stress. However, time pressure may increase the subject focus and consequently increase the possibility of "static posture". Thus, it is expected that, during typing activity, the neck angle will not increase significantly under time pressure but will still increase neck discomfort (Hypothesis 3).

Meanwhile, the effect of computer usage (such as reading some document) on visual discomfort might become worse with the existence of time pressure. This situation (reading document under a time constraint) is not something unfamiliar. For instance, university student may read 'pdf' file on their computer before taking an exam on the next day. They may require reading the file very quickly in order to finish certain syllabus under a particular time. Higher muscle contraction may be necessitated in order to stabilize the gaze under a time pressure. Thus, it is expected that the visual and upper body discomfort is higher

during computer usage under a time pressure condition compared to a normal and relax condition (Hypothesis 4).

Aside from visual and body discomfort, time pressure condition may also affect users' performance or in this case their reading comprehension, typing speed and number of error. There were many studies regarding the effect of time pressure on reading comprehension. However, contradict results have been reported. Some studies found that time pressure increased the reading comprehension (Chang, 2010; Walczyk et al., 1999) while some others did not found any significant relationship (Meyer et al., 1999; Lesaux et al., 2006). One of the ideas concerning reading comprehension increment is based on short term memory theory. Short term memory storage has a limited capacity and its content diminishes quickly. Thus, if a reader reads too slowly, he or she will forget what they have read and the outcome is a poor comprehension (Chang 2010). However, it is also suggested that if the reader spent more time to read and process the reading material, it will be committed to the long term memory (Meyer et al., 1999) which caused no significant differences between time and untimed condition. Since they have their own advantage and disadvantage, it is believed that there is no differences of reading comprehension under relax or time pressure condition (Hypothesis 5). However, bigger screen size for laptop may provide some advantages for the user to view the content clearly and to read faster compared to the tablet computer. Thus, it is expected that reading comprehension during laptop usage is better compared to tablet computer usage (Hypothesis 6).

Meanwhile, in terms of typing speed, previous studies found the speed is decreased when the user used smaller visual display unit (Taib et al., 2016; Szeto and Lee; 2002; Villanueva et al., 1998). One of the reasons is the keyboard's smaller size makes it is difficult to position the hand and required high degree of finger dexterity and concentration to type properly (Szeto and Lee; 2002). In the meantime, under time pressure, there were differences of result. Mclean and Urquhart (2002) found the performance during time pressure is increased, while it is remained constant in another study by Gerard et al. (2002). Previous experiment compared the performance of the user under normal and time pressure condition using different mobile computing products and it is found that the performance was decreased when the user used laptop under time pressure compared to normal condition but remained constant when they used tablet computer. Therefore, the same result is expected in this study (Hypothesis 7)

The environments of using mobile computing products are not the same as desktop computer. For instance, unlike desktop computer, the user can use laptop or tablet on their lap. The usage of laptop or tablet on the lap might reduce the posture variability since the user needs to stabilize it with their arms and legs (Asundi et al., 2010). This restriction may encourage "static posture" which has been associated with MSDs development. Besides that, lower computer screen height will not only makes it difficult for the user to read the text on the screen clearly but might also increase neck angle. It is expected that the discomfort will be higher compared to when they use the device on desk (Hypothesis 8).

Therefore, the purpose of this study is to determine the influence of time pressure on the visual and upper body discomfort as well as on reading comprehension and typing performance during laptop and tablet computer usage on different computer positions.

4.3.2 Methods

This study was divided into two different experiments. First experiment was emphasizing on reading activity and reading comprehension while second experiment was focusing on typing activity and head posture.

4.3.2.1 Subjects

In the first experiment, 32 healthy university students (25 males and 7 females), who are free from any previous eyes and upper body injury for the past 12 months were participated in this study. These subjects have the experience in using both laptop and tablet and own either one or both of them. Before the experiment, brief information regarding the experiment was provided to each participant before they signed the informed consent. Demographic data of the subjects for the first experiment including age, gender and Body Mass Index (BMI) and their computer profile usage were summarized in Table 4.4.

Table 4.4: Demographic data and computer profile usage for the first experiment

	Mean	S.D	n	%
Age (years)	23.0	2.1		
BMI (kg/m^2)	25.9	4.5		
Laptop usage (hours / week)	26.3	8.8		
Tablet usage (hours / week)	2.7	6.4		
Patients per day	16.6	7.0		
BMI(kg/m^2):				
Normal (18.5 – 22.9)			9	28.1
Pre-obese (23.0 – 27.4)			14	43.8
Obese 1 (27.5 – 34.9)			9	28.1
Gender:				
Male			25	78.1
Female			7	21.9
Wearing spectacles:				
Yes			12	37.5
No			20	62.5

Meanwhile, in the second experiment, 30 male students were recruited to participate in this study. All participants were an experienced computer user, owned and had experienced working with either laptop or tablet computer. Each subject was free from any MSDs symptoms on the neck, shoulder and arm region for the past 12 months and provided informed consent before taking part in the experiment. Demographic data of the subjects for the second experiment were summarized in the Table 4.5.

Table 4.5: Demographic data and computer profile usage for the second experiment

	Mean (SD)
Age (years)	22.77 (1.59)
Height (cm)	165.13 (8.18)
Weight (kg)	70.00 (11.84)
BMI (kg / m^2)	25.63 (3.81)
Laptop usage (hours / week)	25.97 (8.95)
Tablet usage (hours / week)	2.72 (6.58)
	n (%)
Wearing spectacles: Yes No	 5 (16.7) 25 (83.3)

4.3.2.2 Workstation, devices and computer positions

In both experiments, a fixed table was used as a workstation. The subjects may adjust the screen angle and the distance between their position and computer screen before they began the experiments for each condition. The laptop and tablet computer used in this study was Lenovo Z480 (355.6 x 230 mm with resolution 1366 x 768 pixels) and iPad Mini (200 x 134.7 mm with resolution 1024 x 768 pixels) respectively; and the psychological and psychosocial factors involved was time pressure plus reward. Screen brightness level for both laptop and tablet was set at the brightest to induce visual discomfort (uniform brightness for the whole experiment). The average distance between chair and the devices was about 60cm.

There was another variable in the second experiment which was the computer positions. There were two positions used in this study; the laptop or tablet was used either on the desk or on the lap while sitting on the chair. The sequence of the usage of devices and computer positions used were randomized.

4.3.2.3 Procedures

In the first experiment, each subject was required to go through four reading and answer sessions:

1) under normal and comfortable condition using laptop,
2) under normal and comfortable condition using tablet,
3) under time pressure condition using laptop,
4) under time pressure condition using tablet.

In each session, the subjects were asked to read, understand and memorize roughly six short stories and answer five multiple-choice questions at the end of each story. The questions were provided on the next page after each story. Once they finished reading and memorizing the first story, they moved to the 5-questions page and answered the questions. They were not allowed to go back to the first story page. After that, they moved to the second story and repeated the procedure until all the questions have been answered. This study was done individually in a quiet room.

Before they start the experiment, they were asked to do the trial for a minute to ensure that they were satisfied with all conditions (i.e chair height and position, screen angle for laptop and tablet) at the

beginning and getting familiar with the experiment's procedure. Laptop and tablet were used only to read the document. The subjects were required to write down their answers on a sheet of paper. For the normal and comfortable condition, subjects can have as much time as they need to read and memorize the stories and then answer all the questions while for the time pressure condition, the subjects were required to read, memorize and answer all the questions in ten minutes time. In order to reduce any bias, the subjects were randomly assigned to four different set of stories and questions.

During the time pressure session, aside from limited time, they were told that if their performance were the best among others, the amount of their compensation will be doubled. At the same time, they were also told that they must finish answering all questions in 10 minutes (regardless their performance in terms of correct answer). If not, their compensation will be reduced 10%. These methods were used in order to encourage them to read and answer as fast as possible. Besides, subjects were also being informed on the time left every two minutes in order to give them some time frame to improve their performance.

Meanwhile, in the second experiment, there were three independent variables which were computer devices, psychological and psychosocial factors as well as computer positions. For each independent variable, there were two levels as stated below:

1) Computer devices: laptop and tablet computer
2) Psychological and psychosocial factors: under normal and under time pressure condition
3) Computer positions: on desk and on lap

The subjects were instructed to do a typical word processing task. Each subject is needed to go through the combination of these three independent variables (there were eight combinations in total). In order to avoid any bias, aside from psychological and psychosocial factors, the sequence of two other variables done was randomly chosen. For psychological and psychosocial factors, the subjects were required to do the task at relax and comfortable pace under normal condition and at 20% faster under time pressure condition. In order to help the subjects to work in appropriate pace under time pressure condition, the finish target after five minutes task were underlined. Besides, in order to improve their performance, the subjects were told that the time for every one minute interval. They were also reminded that the main objective was to finish the task, even if it means committing more errors. In order to encourage the subject to type faster without compromising their performance, the subjects were told that if they cannot achieve the target after five minutes, 10% of their compensation will be deducted but it will be doubled if their pace increment and performance was the best among all other subjects.

Before they started typing, they were asked to do the trial for a minute to ensure that they were satisfied with all conditions (i.e chair height and position, screen angle for laptop and tablet) at the beginning.

Lateral photographs were taken for every two minute interval of each typing task. This study assessed the head and neck angles through photographic analysis of visual markers placed on body landmarks (right outer canthus, right tragus, and C7). In this study, head angle was defined as the angle between vertical line and the vector pointing from OC1 to Cyclops while neck angle was defined as the angle between vertical line and the vector pointing from C7 to OC1 as shown in Figure 4.2 (Young et al., 2012; Chiou et al., 2012). At the beginning and the end of each typing task, the subjects were asked to rate their discomfort in eye, neck, upper back and lower back, using a 10 cm visual analogue.

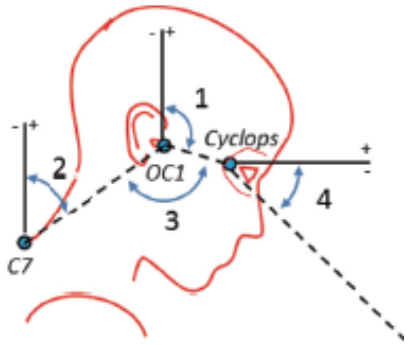


Figure 4.2: Angles definitions (Young et al., 2012): 1) Head angle and 2) Neck angle

4.3.2.4 Questionnaire

The questionnaire was divided into several parts which are the background; health history; five pages of combination of Standardised Nordic Questionnaire (SNQ) and Visual Analogue Scale (VAS) combination; and finally perceived task, device and condition stress. Meanwhile, as previous studies showed the influence of stress on MSDs, the questionnaire was also used to examine perceived task, device and condition stress caused by the experiment.

At the beginning of the experiment, the subjects were required to fill in the background and health history part. The background information includes their age, gender, dominant hand, BMI, whether they are wearing a spectacles and the total time spent using laptop and tablet computer per day and per week. Meanwhile, health history part was based on SNQ where the questions were regarding ache, pain and discomfort they felt for the last 12 months.

Before and after each session, subjects were allowed to relax their body or rest for 10 minutes and in the meantime they were asked to fill in a questionnaire regarding visual and upper body discomfort. Combination of SNQ and 10 cm VAS were used for visual and upper body discomfort. A body diagram as shown in SNQ (Kuorinka et al., 1987) was used as an aid to the subjects in locating any discomfort they had experienced while 10 cm VAS was used as measurement for the discomfort. For VAS, one end-point was labeled as “No discomfort” while “Extreme discomfort” was labeled at another end-point. Both SNQ and VAS are reliable and popular instruments used by health

professionals and researchers to measure pain and discomfort experienced by the subjects (Helland et al., 2008; Aaras et al., 1998; Ekberg et al., 1995). The subjects were considered to have visual discomfort if they have any of these symptoms: impaired visual performance, headache, feeling tired, red, dry or watery eyes, irritated and sore eyes, blurred or double vision (Toomingas et al., 2014; Woods, 2005; Lie and Watten, 1994).

Finally, after all the experiments were finished, the subjects were asked to answer the last part of the questionnaire which were perceived task stress, perceived device stress and perceived condition stress. This part was based on the previous experiment.

i. Perceived task stress - They were required to compare the stress between undergone the experiment under a time pressure or under a normal and comfortable condition. The scales were "much more relax", "quite relax", "slightly relax", "no different", "slightly stressful", "quite stressful" and "much more stressful".
ii. Perceived device stress - They were required to compare the stress between undergone the experiment using laptop or tablet computer under both normal and time pressure conditions. The same scales as perceived task stress were used.
iii. Perceived condition stress – Aside from time pressure, they were asked to rate the stress they felt from other variables including supervision by the experimenter, screen size, compensation reduction / double reward, and fixation on screen.

The subjects were asked to rate from “0” for not stressful at all up to “5” for very stressful.

4.3.2.5 Data analysis

In both experiments, significant differences between tasks (normal and time pressure), devices (laptop and tablet) and computer positions (on desk and on lap) on visual and upper body discomfort were evaluated using paired sample t-test if the assumption for normality (by using Shapiro-Wilk test), homogeneity of variances (by using Levene’s test) and no outlier were met. If not, non-parametric Wilcoxon test was used for statistical analysis. Same analysis was used for perceived task stress. Even though non-parametric Wilcoxon test provides a lower statistical power compared to the t-test, it is more robust if the assumption for t-test was not met (Kitchen, 2009). One sample of t-test was used for perceived device stress analysis while ANOVA with Bonferroni as Post Hoc test was used for perceived condition stress.

For reading comprehension, the performance of subjects was compared according to 10-minutes average. For example, if Subject 1 used 13 minutes to answer all questions during the normal session, the average number of correct answer for 10 minutes was calculated. Then, it was compared with the number of correct answer that he/she successfully obtained during the time pressure session (which also took 10 minutes). The differences between task and devices were also analyzed by using paired sample t-test or Wilcoxon test. Statistical Package for the Social Sciences (SPSS) version 17.0 was used for data

analysis with significance level set at $p < 0.05$ with 95% confidence interval.

4.3.3 Results

Head Posture

In the second experiment, the changes of head posture in terms of head and neck angles were measured. Head and neck angles were analyzed into three categories which were based on different tasks (under normal or time pressure condition), different devices (using laptop or tablet computer) and different computer positions (on desk or on lap). Figure 4.3 and Figure 4.4 shows the box and whisker plot with medians and 25-75 percentiles of head and neck angles value under eight combinations of devices tasks and computer positions for each body part. The first alphabet was referred as tasks (N = Normal, T = Time Pressure), second alphabet as devices (L = laptop, T = tablet) while the last alphabet was computer positions (D = desk, L = lap). For example, TLL means that a time pressure task was done using laptop computer on lap.

As can be seen in Figure 4.3 and Table 4.6, there were no significant differences of head posture (in terms of head angle) between different tasks (between normal and time pressure). However, opposite results were obtained for differences between devices and computer positions where significant differences were found between different devices (laptop and tablet) and different computer positions (on desk and on lap) where head angle during tablet usage were significantly

higher compared to laptop usage and head angle during laptop or tablet usage on lap were significantly higher compared to laptop or tablet usage on desk.

Meanwhile, significant differences for neck angle were only found between different devices where neck angle during tablet usage were significantly higher compared to during laptop usage (as can be seen in Figure 4.4 and Table 4.7).

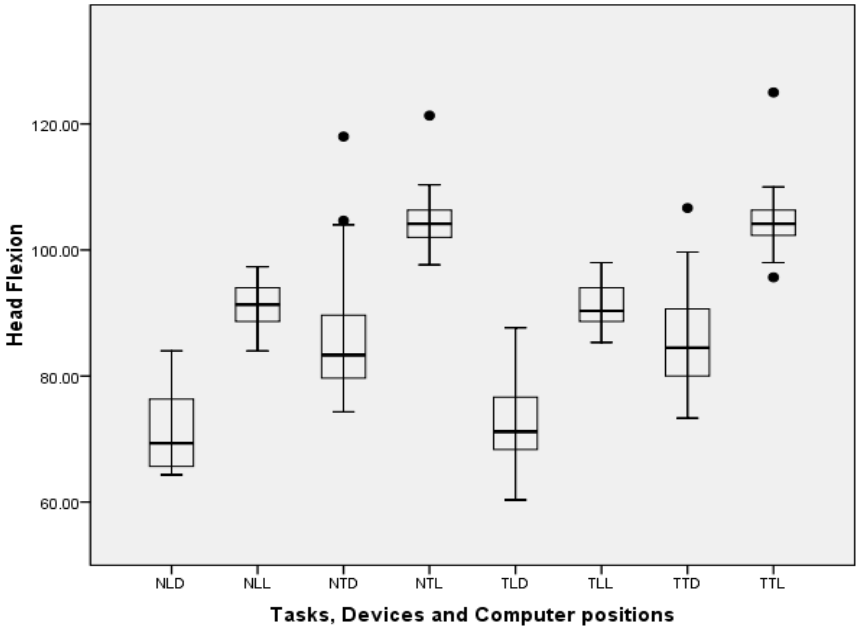


Figure 4.3: Head angle under eight combinations of tasks, devices and computer positions

Table 4.6: Significant differences between tasks, devices and computer positions on head angle

Differences between tasks	p value:
NLD and TLD	0.058
NLL and TLL	0.633
NTD and TTD	0.542
NTL and TTL	0.800
Differences between devices	
NLD and NTD	**< 0.000**
TLD and TTD	**< 0.000**
NLL and NTL	**< 0.000**
TLL and TTL	**< 0.000**
Differences between computer positions	
NLD and NLL	**< 0.000**
NTD and NTL	**< 0.000**
TLD and TLL	**< 0.000**
TTD and TLL	**< 0.000**

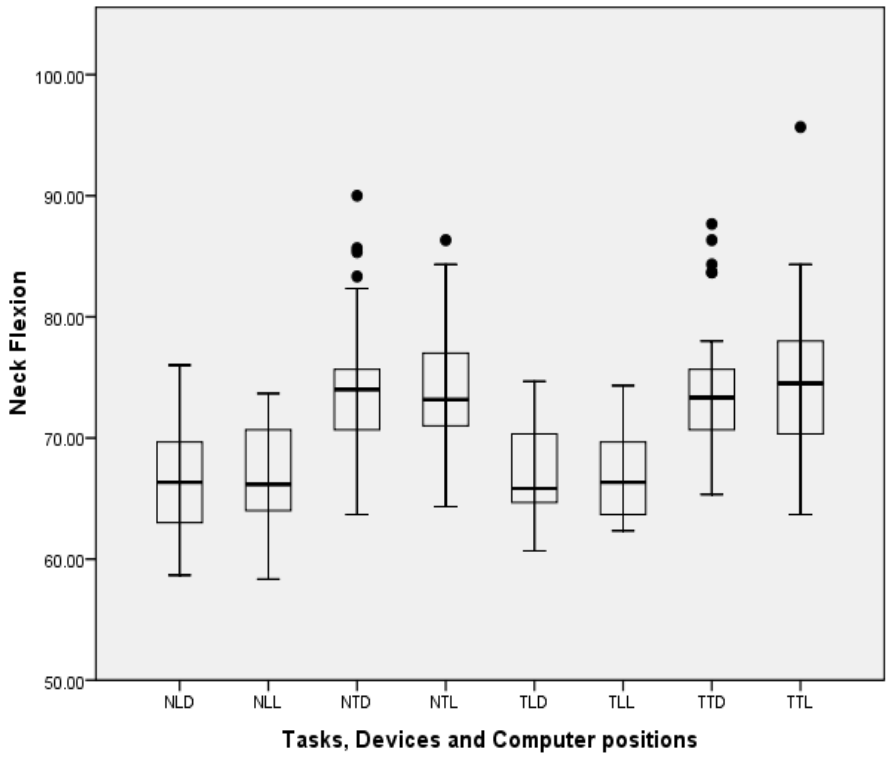


Figure 4.4: Neck angle under eight combinations of tasks, devices and computer positions

Table 4.7: Significant differences between tasks, devices and computer positions on neck angle

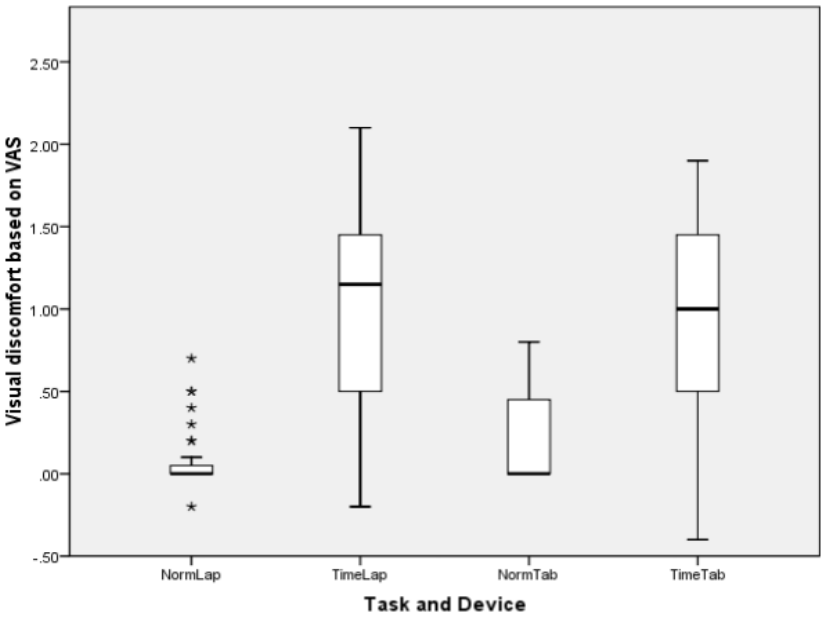
Differences between tasks	p value:
NLD and TLD	0.522
NLL and TLL	0.223
NTD and TTD	0.239
NTL and TTL	0.187
Differences between devices	
NLD and NTD	**< 0.000**
TLD and TTD	**< 0.000**
NLL and NTL	**< 0.000**
TLL and TTL	**< 0.000**
Differences between computer positions	
NLD and NLL	0.940
NTD and NTL	0.714
TLD and TLL	0.836
TTD and TLL	0.448

The effect of different tasks, devices and computer positions on visual and upper body discomfort

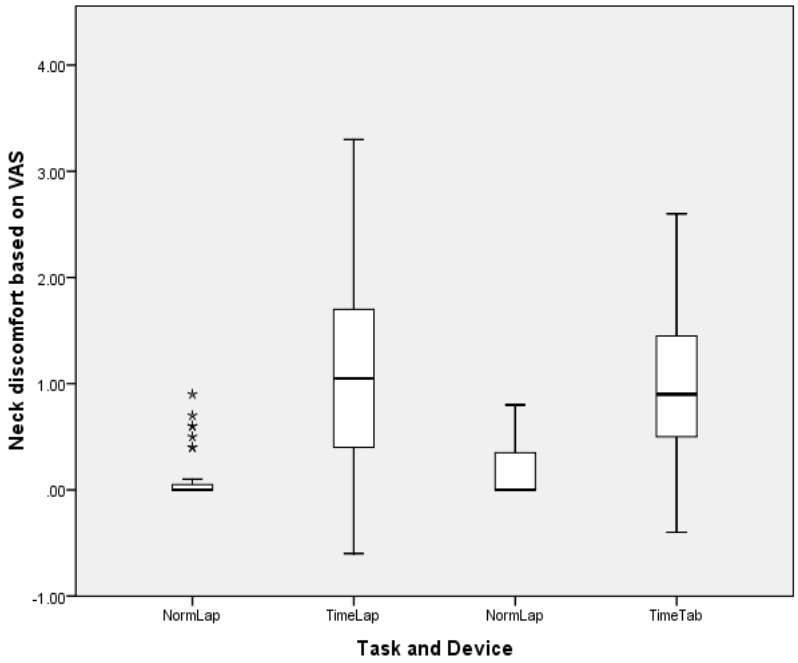
Visual and body discomfort for each body part were analyzed based on two categories (tasks and devices) for the first experiment and three categories (tasks, devices and computer positions) for the second experiment

Figure 4.5 (i - iv) shows the box and whisker plot with medians and 25-75 percentiles of discomfort value under four combinations of devices and tasks in each body part for the first experiment. The first four alphabets were referred as tasks (Norm = Normal, Time = Time Pressure) while the last three alphabets were devices (Lap = laptop, Tab = tablet). For example, TimeLap means that a time pressure task was done using laptop computer. Discomfort value presented here was the difference of discomfort before and after the experiment of each session. Negative value indicates that the subject felt a worse discomfort before the session compared to after the session.

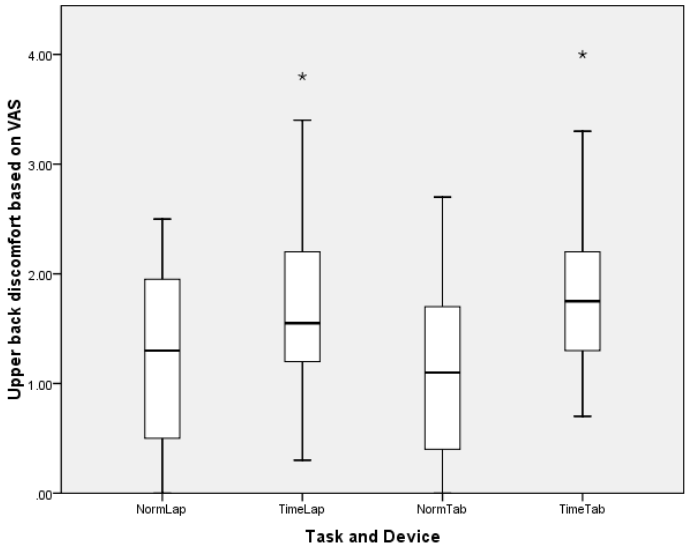
i)


Visual discomfort based on VAS
2.50
2.00
1.50
1.00
.50
.00
-.50
NormLap
TimeLap
NormTab
TimeTab
Task and Device

ii)


Neck discomfort based on VAS
4.00
3.00
2.00
1.00
.00
-1.00
NormLap
TimeLap
NormLap
TimeTab
Task and Device

iii)



iv)

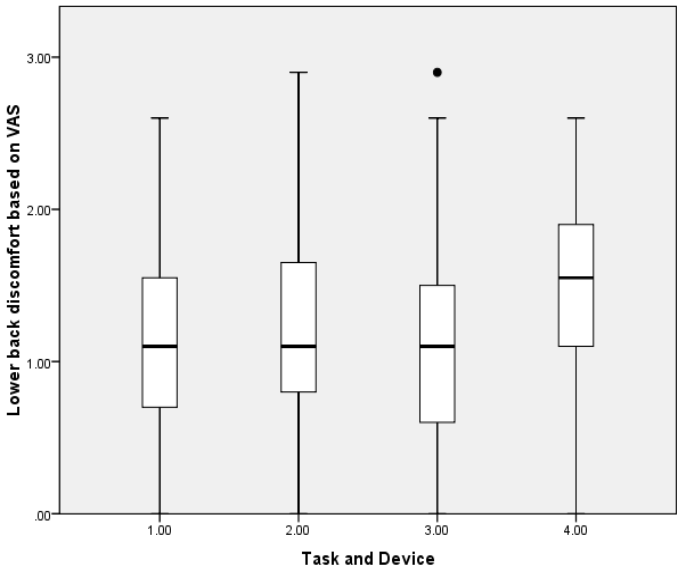
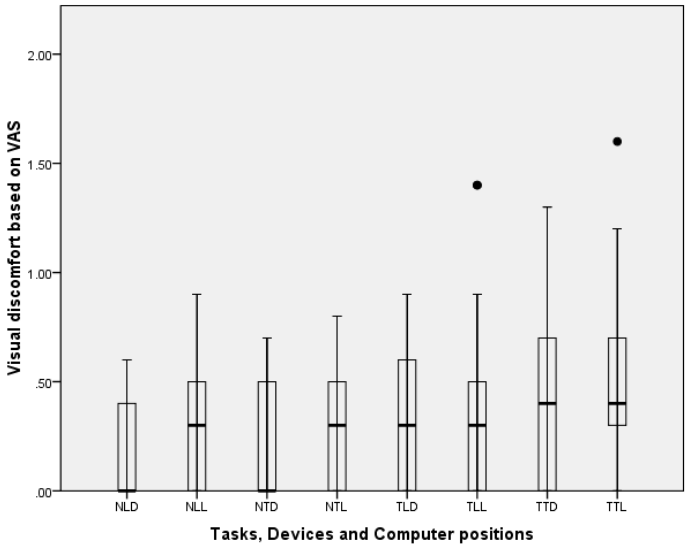


Figure 4.5 (i - iv): The box and whisker plot with medians and 25-75 percentiles of discomfort value (differences between before and after the experiment) under four combinations of devices and tasks for each body parts

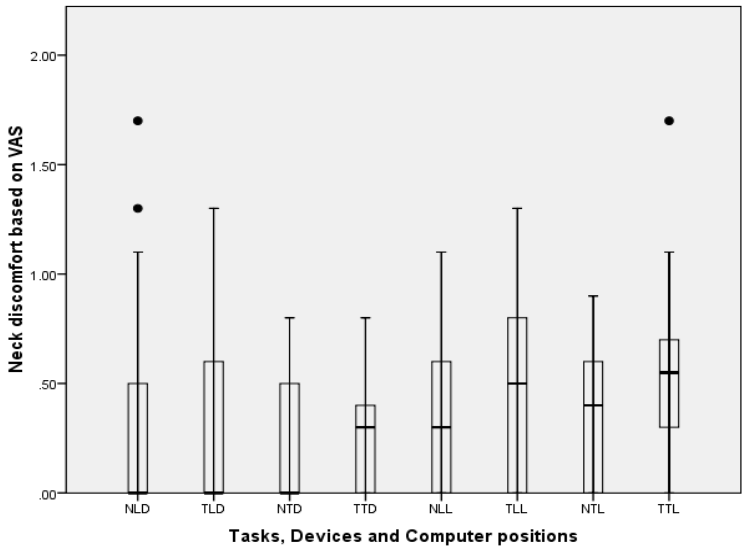
Generally, there is an increment of discomfort felt by the subjects in time pressure session compared to the normal session. However, there is an exception where most of the subjects not even felt any discomfort on shoulder area in all conditions.

Meanwhile, Figure 4.6 (i - iii) shows the box and whisker plot with medians and 25-75 percentiles of discomfort value under eight combinations of tasks, devices and computer positions in each body part for the second experiment. The first alphabet was referred as tasks (N = Normal, T = Time Pressure), second alphabet was devices (L = laptop, T = tablet) while the last alphabet was computer positions (D = desk, L = lap). For example, TLL means that a time pressure task was done using laptop computer on lap. Discomfort value presented here was the difference of discomfort before and after the experiment of each session. Zero value means there is no differences of discomfort felt by the subject before and after the session.

i)



ii)



iii)

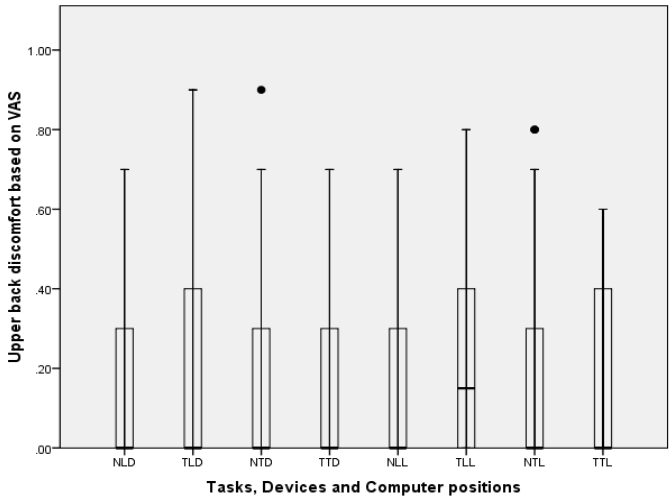


Figure 4.6 (i - iii): The box and whisker plot with medians and 25-75 percentiles of discomfort value (differences between before and after the experiment) under eight combinations of tasks, devices and computer positions for visual, neck and upper back.

Task differences

The statistical analysis of task differences shows only the discomfort value for lower back during laptop computer usage met all the normality, homogeneity of variances assumptions and no outliers for paired sample t-test. Besides this one, all other data were analyzed by using Wilcoxon test. The statistically significant results for visual and body discomfort were obtained from the comparisons of the normal and time pressure conditions both for laptop and tablet computer usage. Table 4.8 shows the discomfort differences between two tasks for the first experiment.

Table 4.8: The statistical analysis results for visual and body discomfort between normal and time pressure condition (for the first experiment)

Body Parts	Devices	Task (Mean discomfort)		Mean (j) – Mean (i) (Discomfort scale)	p value
		Normal (i)	Time pressure (j)		
Visual	Laptop	0.08	0.96	0.88	**< 0.000**
	Tablet	0.20	0.94	0.74	**< 0.000**
Neck	Laptop	0.13	1.15	1.02	**< 0.000**
	Tablet	0.15	1.05	0.90	**< 0.000**
Shoulder	Laptop	0.08	0.08	0.00	0.786
	Tablet	0.03	0.08	0.05	0.285
Upper back	Laptop	1.17	1.69	0.52	**0.007**
	Tablet	1.06	1.86	0.80	**0.001**
Lower back	Laptop	1.11	1.23	0.12	0.339
	Tablet	1.09	1.51	0.42	**0.030**

As can be seen in table 4.8, aside from shoulder, only lower back discomfort during laptop usage did not change significantly under time pressure. Most subjects felt some discomforts in certain body parts after the experiment for each session (normal or time pressure) compared to before the experiments were done or after they took a rest. However, the discomfort feeling was greater when they undergone the experiment under the time pressure session.

Meanwhile, Table 4.9 shows the discomfort differences between two tasks for the second experiment (typing activity).

Table 4.9: The statistical analysis results for visual and body discomfort between normal and time pressure condition (for the second experiment)

Body Parts	Computer positions	Devices	Tasks (Mean discomfort)		Mean (l) – Mean (k) (Discomfort scale)	p value
			Normal (k)	Time pressure (l)		
Visual	Desk	Laptop	0.16	0.34	0.18	**0.004**
		Tablet	0.23	0.42	0.19	**0.023**
	Lap	Laptop	0.27	0.35	0.08	0.419
		Tablet	0.30	0.50	0.20	**0.009**
Neck	Desk	Laptop	0.28	0.28	0.00	0.359
		Tablet	0.21	0.24	0.03	0.662
	Lap	Laptop	0.35	0.48	0.13	**0.038**
		Tablet	0.37	0.54	0.17	**0.014**
Upper back	Desk	Laptop	0.12	0.19	0.07	0.344
		Tablet	0.19	0.16	-0.03	0.753
	Lap	Laptop	0.17	0.23	0.07	0.112
		Tablet	0.17	0.16	-0.01	0.753

Device differences

Meanwhile, for device differences, aside from upper back discomfort during the normal session, paired sample t-test were also done on visual, neck and lower back discomfort under the time pressure. Table 4.10 shows the statistical differences results for visual and body discomfort during laptop and tablet computer usage (for the first experiment).

Table 4.10: The statistical analysis results for visual and body discomfort during laptop and tablet computer usage (for the first experiment)

Body Parts	Task	Devices (Mean discomfort)		Mean (k) – Mean (l) (Discomfort scale)	p value
		Laptop (k)	Tablet (l)		
Visual	Normal	0.08	0.20	-0.12	0.078
	Time pressure	0.96	0.94	0.02	0.787
Neck	Normal	0.13	0.16	-0.03	0.736
	Time pressure	1.15	1.05	0.10	0.255
Shoulder	Normal	0.08	0.03	0.05	0.357
	Time pressure	0.08	0.08	0.00	1.000
Upper back	Normal	1.17	1.05	0.12	0.556
	Time pressure	1.69	1.86	-0.17	**0.011**
Lower back	Normal	1.11	1.09	0.02	0.978
	Time pressure	1.23	1.51	-0.28	**< 0.000**

Unlike the comparison between tasks, there was no significant change in terms of discomfort among subjects during laptop and tablet computer usage except for upper and lower back areas. Even for those areas, significant differences were obtained only for the time pressure

session. Besides that, there was only a small difference of discomfort value for most of the body part during tablet usage compared to laptop.

For the second experiment, significant differences between two devices found was only on visual discomfort during the usage of device on lap (Table 4.11). Generally, there were no significant differences between laptop or tablet usage.

Table 4.11: The statistical analysis results for visual and body discomfort during laptop and tablet computer usage (for the second experiment)

Body Parts	Computer positions	Tasks	Devices (Mean discomfort)		Mean (l) – Mean (k) (Discomfort scale)	p value
			Laptop (k)	Tablet (l)		
Visual	Desk	Normal	0.16	0.23	0.07	0.241
		Time Pressure	0.34	0.42	0.08	0.129
	Lap	Normal	0.27	0.30	0.03	0.460
		Time Pressure	0.35	0.50	0.15	**0.010**
Neck	Desk	Normal	0.28	0.21	-0.07	0.736
		Time Pressure	0.28	0.24	-0.04	0.667
	Lap	Normal	0.35	0.37	0.02	0.516
		Time Pressure	0.48	0.54	0.06	0.105
Upper back	Desk	Normal	0.12	0.19	0.07	0.439
		Time Pressure	0.19	0.16	-0.03	0.623
	Lap	Normal	0.17	0.17	0.00	0.864
		Time Pressure	0.23	0.16	-0.07	0.112

Computer position differences

In the second experiment, there was another variable which was computer positions. Table 4.12 shows the statistical analysis for discomfort differences between two computer positions.

Table 4.12: The statistical analysis results for visual and body discomfort between two computer positions (for the second experiment)

Body Parts	Device	Tasks	Computer positions (Mean discomfort)		Mean (n) – Mean (m) (Discomfort scale)	p value
			Desk (m)	lap (n)		
Visual	Desk	Normal	0.16	0.27	0.11	0.063
		Time Pressure	0.23	0.30	0.07	0.382
	Lap	Normal	0.34	0.35	0.01	0.986
		Time Pressure	0.42	0.50	0.08	0.339
Neck	Desk	Normal	0.28	0.35	0.07	0.204
		Time Pressure	0.21	0.37	0.16	**0.042**
	Lap	Normal	0.28	0.48	0.20	**0.009**
		Time Pressure	0.24	0.54	0.30	**0.001**
Upper back	Desk	Normal	0.12	0.17	0.05	0.081
		Time Pressure	0.19	0.17	-0.02	0.876
	Lap	Normal	0.19	0.23	0.04	0.307
		Time Pressure	0.16	0.16	0.00	0.795

Performances

For the first experiment, the average number of correct answer for both tasks and devices in 10 minutes were compared. There was no significant difference in any comparison neither by tasks nor devices. Besides, during laptop (tablet) usage under normal session, the average number of correct answer was 26.6 (26.2 for tablet) and the average time taken for the subjects to finish answering all the questions was 13.6 minutes (13.2 minutes for tablet).

In the meantime, for the second experiment, the average numbers of correct words typed by the subjects were compared. Generally, there were no significant differences of performance found between laptop/tablet usage on desk and on lap. However, there were significant differences found between different tasks and different devices. The results obtained shows that in average, the subject can typed faster during time pressure compared to normal condition and during laptop usage compared to tablet usage (Table 4.13).

Table 4.13: Average (SD) number of correct words typed by subject in all conditions

Tasks	Devices				p value			
	Laptop		Tablet					
	Desk[c]	Lap[d]	Desk[e]	Lap[f]	c * d	e * f	c * e	d * f
Normal[a]	153.7 (16.5)	150.0 (23.4)	137.6 (25.0)	132.8 (18.5)	p = 0.107	p = 0.170	**p < 0.000**	**p < 0.000**
Time Pressure[b]	171.7 (35.9)	162.4 (30.6)	153.7 (20.8)	149.3 (22.9)	**p = 0.002**	p = 0.190	**p = 0.005**	**p < 0.000**
a * b	**p < 0.000**	**p < 0.000**	**p = 0.005**	**p < 0.000**				

Perceived task, device and condition stress

The difference of perceived stress between undergone the experiment in a normal and comfortable condition (mean = 0.000) and in a time pressure condition (mean = 0.906 for the first experiment and mean = 0.9333 for the second experiment) were significant ($p < 0.000$). Therefore, it can be interpreted that undergone the experiment under time pressure can be considered as slightly stressful for both experiments.

There were differences in the result of the perceived stress between laptop and tablet usage under normal and time pressure condition for first and second experiment. In the first experiment, during normal condition, most of the subjects do not feel any difference of stress between laptop and tablet usage. However, under time pressure, there were significant differences ($p = 0.032$) between tablet (mean = 0.000) and laptop (mean = -0.906). This indicates that most of the subjects felt slightly relax to undergo the experiment using laptop when they were under a time pressure.

Meanwhile, in the second experiment, the subjects felt slightly relax to undergo the experiment using laptop compared to tablet computer in both normal and time pressure conditions.

Using "no stress" (mean = 0.000) as a reference point, in the first experiment, "supervision by the experimenter" (mean = 1.188, $p < 0.000$) seem to be the largest stressors, followed by "small screen" (mean = 1.156, $p < 0.000$), "time pressure" (mean = 0.906, $p < 0.000$) and "compensation reduction / double reward" (mean = 0.594, $p = 0.007$). In the meantime, for the second experiment, "use device on lap"

seem to be the largest stressors (mean = 2.077, $p < 0.000$), followed by "small screen" (mean = 1.333, $p < 0.000$), "time pressure" (mean = 1.200, $p < 0.000$), "compensation reduction / double reward" (mean = 1.133, $p < 0.000$), and "supervision by the experimenter" (mean = 1.067, $p = 0.001$). It can be concluded that all psychological and psychosocial stressors seem to be significant to the subjects in both experiments even though there is only a slight increment.

4.3.4 Discussion

In the previous studies, either based on survey or based on field study showed that there were significant correlation between neck and head angles as well as visual discomfort on neck pain and discomfort (Szeto et al., 2005; Helland et al., 2008, Wiholm et al., 2007; Aaras et al. 2001; Aaras et al., 1998). There were other studies showed that the use of laptop or tablet computer either on desk or lap may increase neck angle, head angle and eyes discomfort compared to desktop computer (Young et al., 2012; Szeto and Lee; 2002; Villanueva et al., 1998).

As time pressure normally encourage the computer user to focus on computer screen for a prolonged time, it is assumed that time pressure will increase eyes discomfort. In the meantime, the mobility and size of laptop and tablet provide advantage for these products to be used everywhere and without desk (i.e on lap) if needed. However, it may increase head and neck angles as well as eyes discomfort.

Thus, this study was designed in order to determine the effect of time pressure on head posture (head and neck angles) and eyes as well

as upper body discomfort during laptop and tablet usage under different computer positions (on desk and on lap). This study was divided into two experiments which were based on reading activity for the first experiment and based on typing activity on the second experiment.

The effect of time pressure on visual and body discomfort

In the first experiment, subjects have reported that their visual discomfort as well as upper body discomfort such as neck, upper and lower back becomes slightly worse when they did the experiments under time pressure condition (the fourth hypothesis is accepted as true). In the normal session, if the subjects started to feel any discomfort, they will keep out their view from the computer screen in order to reduce or avoid the visual discomfort. Therefore, in the normal session, there is not much changes in both visual and body discomfort during the usage of laptop or tablet.

In contrary, during time pressure session, most of the subjects tried to read and memorised the stories as fast as possible which led them to concentrate on the screen for a longer time. Consequently, they experienced worse visual discomfort compared to when they undergone the same task under the normal and relax condition.

The same discomfort increment could not be obtained for shoulder during time pressure session compared to normal session. This is a contradiction compared to the previous studies where these studies reported that people with visual discomfort were more likely to have discomfort on shoulder (Wiholm et al., 2007; Aaras et al., 1998). This

inconsistency might be caused by the difference in experimental design. Therefore, direct comparison might not be suitable.

In the second experiment, there were no significant differences of head and neck angle found between typing under normal or time pressure condition (the third hypothesis has been accepted as true). Yet, this result has been expected. This result is in line with Shahidi et al. (2013) where the authors found that psychosocial stress did not increase forward head posture.

However, the subjects have reported that their visual discomfort become slightly worse when they did the experiments under time pressure condition. The same result has been obtained for neck discomfort in certain condition. It seems that the subjects felt worse neck discomfort when they did the experiment on lap. Since there were no significant changes in head posture, the increment of neck discomfort might be due on another mechanism such as the increment of muscle activity.

It should be noted that even though visual discomfort and certain body parts discomfort seems to be worse in the presence of time pressure, the definite reason behind it cannot be concluded. Although there were correlation and different theories regarding the increment of visual discomfort and upper body discomfort as mentioned in the introduction section, none of the theories' variables such as ciliary muscle contraction, trapezius muscle activity or changes of body posture were measured in this experiment. Moreover, psychosocial and psychological stressor like time pressure does not only develop visual discomfort but other factors as well. For instance, time pressure was

found repeatedly as one of the psychosocial factors that significantly increased neck muscle activity and neck symptoms (Taib et al., 2016; Johnston et al., 2007; Huang et al., 2003; Szeto et al., 2005). In the last part of the questionnaire namely perceived task and condition stress, there were several other stressors aside from time pressure including small screen, supervision, using laptop/tablet on lap and reward significantly contributed to the increment of stress. Even though the effect of each stressor is relatively small, the simultaneous effect might be more significant to them. As shown in previous study, all these factors may increase the subjects' stress as well as muscle activity and become a risk to MSDs.

The effect of different devices use

Small screen and keyboard are one of the computer characteristics that might cause visual and body discomfort. Differences in size, especially for tablet computer might contribute to a greater visual and upper body discomfort. Besides, as the design of tablet computer were different compared to laptop especially in terms of size and screen (with touch keyboard), it is expected that the subjects' head posture will increase and experience a greater visual and upper body discomfort during tablet computer usage compared to laptop.

In perceived condition stress section, small screen has been identified as one of the significant factor in developing stress among the subjects. In a study that investigated the changes in posture during tablet usage in different configurations (with or without an accessory stand and/or a table or desk) and tasks (typing, colouring or watching a

movie), Young et al. (2012) reported that, in general, head angle obtained during tablet usage in their study were greater than notebook usage in previous studies (Asundi et al., 2010; Sommerich et al., 2002). These increments reflect the increment of upper and lower cervical spine segment which play a major role in neck pain especially for prolong duration usage (Chiou et al., 2012).

In the second experiment where the head posture was measured, it is found that the head and neck angles were significantly increased during tablet computer usage compared to laptop usage. Yet, generally, in both experiments, there were no significant differences for visual and body discomfort during laptop and tablet computer usage (second hypothesis cannot be accepted as true).

This result is inconsistent in comparison with previous study where Villanueva et al. (1998) reported that smaller screen size increase musculoskeletal complaints. This obtained result might be due to several aspects. Firstly, even though the head and neck angles were significantly larger as can be seen in the second experiment, the different of the posture may not big enough to cause a difference in body discomfort. On average, mean of head angle increased 6% to 8% while neck angle increased 13% to 15% during tablet computer usage compared to laptop usage. Secondly, short period time for this experiment might be another reason. Mobile computing products such as laptop and tablet computer were commonly used for a longer period of time and sometimes for hours straight. In contrast, this study only provides five minutes for each session. As a result, it may not be enough to make the user feel the pain as if they use the laptop (or tablet)

in that angle for a longer time. Perhaps, for a prolong duration, even if the increment of head and neck angles is not big, it will become a big difference in MSDs development especially on neck area. Therefore, in this study, first hypothesis can only be accepted as partially true. Even though head posture is significantly increased during tablet computer usage compared to laptop usage, the same patterns were not obtained for neck and upper back discomfort. Yet, as mentioned, this result might be different if each session were done for a longer duration.

Besides that, this study does not involve computer usage extensively. The laptop and tablet were only used as a screen to display the short stories and as an interface for the user to read the stories in the first experiment and the subject needs to do some typing activity in the second experiment. In a real life, typically, laptop and tablet are used for various things such as gaming, drawing, programming and many others. Therefore, it is expected that different results will be obtained if the laptop and tablet were used differently and extensively.

The effect of different computer positions

As expected, the use of laptop and tablet computer on lap increased head posture. However, the significant result was obtained only for head angle but not neck angle. In comparison with the laptop (or tablet computer) usage on the desk, the use of laptop on the lap reduced posture variability (Asundi et al., 2010). Besides, in order to stabilize the laptop, the user did not have much space on the lap as their option. In contrast, the use of laptop on desk gave them more space to choose either to place the laptop far or near; or more right, more left or in the

middle. On lap, a short distance between laptop (or tablet computer) with body, and far distance between eyes and screen force the user to bend and consequently increased neck angle. Besides, laptop or tablet computer usages on lap restricted the users' body movement and encouraged static posture which has been associated with MSDs development.

Meanwhile, neck discomfort has been significantly increased during laptop (or tablet computer) usage on lap compared to on desk. Moreover, mean discomfort for laptop (or tablet computer) usage on lap during normal and comfortable condition was higher compared to the mean discomfort for laptop (or tablet computer) on desk for both normal and time pressure conditions. From this result, we can see the influence of computer position on neck discomfort. Therefore, at least for neck discomfort, the eighth hypothesis could be accepted as true.

Reading comprehension and typing performance

Subjects' reading comprehension were analysed based on the number of correct answer in a particular time period. Even though this method is unnecessarily accurate, it still gives us a rough estimation on how well the subjects could read, understand and memorise the stories.

Based on short term and long term memory theories, there were some advantages and disadvantages regarding reading comprehension in the normal and time pressure condition (Chang, 2010; Meyer et al., 1999). Thus, it is believed that there is no significant difference between reading under normal and time pressure condition on reading comprehension (fifth hypothesis). The result obtained showed that this

hypothesis could be accepted as true. This result is in line with some previous studies (Meyer et al., 1999; Lesaux et al., 2006). In the normal session, they were able to provide correct answers for most of the question, but a longer time was needed. For the same amount of time (10 minutes), even though the subjects were required to read, understand and memorise the stories quickly, their performance under time pressure condition was comparable to their performance during normal condition. Previous studies have pointed out that there was a limitation of our working memory. Reading comprehension will be compromised if the reader read slower or faster than certain reading rates (Meyer et al., 1999). At the same time, time pressure may improve reading comprehension by stimulating their effort and motivation (Walczyk et al., 1999). This study may encourage a proper amount of reading rates for the subjects to read without compromising their reading comprehension which consequently produced the obtained results.

In the earlier stage of this study, we hypothesized that the differences in screen size between laptop and tablet computer will make a difference in terms of reading comprehension to the subjects. However, the sixth hypothesis cannot be taken as true as there was no significant difference of performance found. Even though a bigger screen size may provide a bigger font and clearer view compared to a tablet, it does not lead to any significant differences to the subjects. Although smaller screen size for tablet can develop stress on the user, it may also provide some advantages. Smaller screen size allows the user to read and at the same time easily gaze on the other passage of the

story. As a result, they can view the whole picture of the story easier and memorise it better.

This study found that neck discomfort was increased when the subjects used laptop or tablet on lap. Besides, the users' postures were more restricted during laptop or tablet usage on lap. Thus, it is expected that the performance (in terms of typing speed) will be significantly lower during laptop or tablet usage on lap. However, unexpectedly, there were no significant differences of typing speed between laptop or tablet usage on lap and on desk. Unlike previous experiment, this present experiment found that the subjects' typing speeds were better during time pressure condition compared to normal condition (the seventh hypothesis could be accepted as partially true). It might be due to the stress perceived by the subjects. On average, stress perceived by the subjects on this study was lower compared to the previous experiment. Lower perceived stress might help them to do the typing activity faster without making many mistakes.

Limitation

Previous studies reported that there were many variables related to visual and body discomfort such as trapezius muscle activity increment, greater neck angle, forward body posture, and ciliary muscle contraction. However, all these variables were not measured in the first experiment and only head posture was measured in the second experiment. It is important to measure all these variables (i.e muscle activity, posture) to justify the exact reason behind the body discomfort changes.

Besides that, there is no “formal” examination made on the eye normality and on the visual and body discomfort. All these variables were based on self-measured and clarification. However, as mentioned in the methodology section, VAS method used to measure visual and body discomfort is a valid and popular tools that has been used by various researchers and medical professionals to measure pain and discomfort.

The number of female subjects was quite small compared to male. Previous studies showed that female were more likely to experience dry eye than male (Blehm et al., 2005) which might lead to greater visual discomfort and consequently greater body discomfort.

4.3.5 Summary

In this study, the influence of tasks (normal or time pressure), devices (laptop or tablet) and computer positions (on desk and on lap) on visual and body discomfort during reading and typing activity have been examined. Although the actual mechanism is still unknown, the results from VAS showed that time pressure produced a significant influence on visual discomfort. Generally, this study did not find significant effect of laptop and tablet usage on visual and body discomfort. Meanwhile, laptop or tablet computer usage on lap has a significant effect on neck discomfort and head angle. Time pressure is common especially in the working environment. Work schedule and time management, if properly managed may help to reduce the discomfort caused by time pressure.

CHAPTER 5

CONCLUSION

5.1 Review of findings

In this study, three cross sectional surveys were done in order to determine the association between physical, psychological and psychosocial factors with the prevalence of MSD symptoms among three occupation workers. At the early stage, these occupations were chosen because they met certain requirements of this study. Based on literature review and interviews, three occupations with different physical demand as well as psychological and psychosocial challenge were chosen which were dentists, internship doctors and construction workers.

This study found that, in terms of physical factors, construction workers were mainly involve in high physical activity (such as lifting and carry heavy load) and awkward posture, dentist usually used vibrating tools and working in awkward posture during while treating patient and internship doctors usually working in standing or walking position. Meanwhile, in terms of psychological and psychosocial factor, level of stress among construction workers was the lowest compared to dentists and internship doctors.

The association between psychological and psychosocial factor and prevalence of MSD symptoms found in this study were quite

different depending on the occupation. For instance, there were significant association found between psychological and psychosocial factors with prevalence of MSD symptoms. However, none of the stressor has been associated with any of the symptoms appeared in any body region among construction workers.

There might be several reasons on why this result was obtained. Firstly, in comparison with dentist and internship doctors, the percentage of construction workers who were in high level of psychological and psychosocial stress was lower. Although construction workers are working in high hazardous environment, in terms psychological and psychosocial factors, the level of stress caused by hazardous environment was not high. Secondly, compared to dentist and internship doctors, physical demand in construction workers was much higher. The role of physical demand on MSDs has been recognized. Carrying and lifting heavy load such as brick, woods and steels has been a routine job for construction workers. Therefore, it is assumed that the MSD symptoms experienced by the construction workers were heavily influenced by physical demand. Consequently, the role of psychological and psychosocial factors on MSD symptoms among construction workers has been covered by a bigger influence which was physical demand. It is assumed that the influence of psychological and psychosocial factors will be more stand out if the physical demand for those certain occupations is lower. As summary, the association between physical, psychological and psychosocial factors with prevalence of MSD symptoms can be seen even though the significant associations for each occupation were at different level.

Cross-sectional studies have a certain limitation where a direct relationship between causes and effects could not be drawn. Therefore, in order to get a better view regarding the influence of psychological and psychosocial factors on MSDs, several experiments have been carried out.

In chapter 4, three separate experiments have been conducted. The aim of these experiments was to determine the effect of physical, psychological and psychosocial factors on three different dependent variables which were muscle activity, visual discomfort and head posture. From the literature review, these three variables were related to MSD symptoms especially on neck pain. Computer usage has been chosen as part of the experiment based on several reasons such as low physical activity and closely related to most people. Meanwhile, mobile computing products such as laptop and tablet computer have been popular for years, however, a study regarding the effect of psychological and psychosocial factors on MSDs during mobile computing product usage is really difficult to find (if there is any). Thus, it is unknown either mobile computing products usage under psychological and psychosocial stressors will have a bigger influence on muscle activity, visual discomfort and head posture. Therefore, for the first experiment, this study used four devices including desktop computer, laptop, tablet computer and smart phone as part of the experiment.

In the first experiment, four tasks (color word, plain copying, time pressure and stressful environment) have been done using four devices (desktop computer, laptop, tablet computer and smart phone) in

order to determine the influence of this factor on four muscle activity. As a result, it is found that psychological and psychosocial factors have some influence on muscle activity. Activities in several muscles have been increased with the appearance of perceived psychological and psychosocial stress. However, the pattern of muscle activity increased when the level of perceived stress increased was only obtained on trapezius muscle activity. Besides that, there were no significant differences of muscle activity between desktop computer and laptop as well as between tablet computer and smart phone. It might be due to the almost similar size and characteristic by those devices between each other. Therefore, in the second experiment, the computer products used were only laptop and tablet computer.

In the second experiment, concentration was given on visual discomfort. Even though the exact mechanism is debatable, many studies found the relationship between visual discomfort and neck as well as shoulder pain. Therefore, this study tried to determine the changes of visual discomfort as well as other body areas discomfort while reading and comprehending some text under time pressure. Although this experiment did not involve any typing activity, this experiment still found the effect of time pressure on visual discomfort as well as neck and upper back discomfort. However, the exact reason why the neck and upper back discomfort increased when visual discomfort increased is unknown. Based on observation, it is assumed that the changes on neck and upper back discomfort were caused by changes in posture where eyes fatigue may encourage the body to bend forward to see the screen more clearly which consequently increase

neck and upper back discomfort. Meanwhile, there was no significant change in terms of discomfort among subjects during laptop and tablet computer usage except for upper and lower back areas. Even for those areas, significant differences were obtained only for the time pressure session. Besides that, there was only a small difference of discomfort value for most of the body part during tablet usage compared to laptop. Although this study did not find significant changes of discomfort between laptop and tablet computer, it does not means it would not have any effect. Analysis from perceived stress showed that the subjects' perceived stress increased when they use smaller product such as tablet computer compared to laptop.

Literature review showed that the increment of head posture (in terms of head and neck angles) might contribute to neck pain. Aside from that, in the second experiment, it is assumed that there were changes in head posture in order to compensate the eyes fatigue, which consequently increased neck and upper back discomfort. Therefore, in the third experiment, aside from visual, neck and upper back discomfort, head posture (in terms of head and neck angles) were also measured. Besides that, this time, the subjects were asked to do some typing activity in normal and time pressure condition, using laptop and tablet computer both on desk and on lap. However, under time pressure condition, even though visual and neck discomfort significantly increased compared to normal condition, the head posture did not significantly change which indicated that there might be another reason for the discomfort increment such as the increment in muscle activity. Besides that, even though there was no significant differences of

discomfort found between laptop and tablet computer usage, the opposite result were obtained for head posture. Both head and neck angles were significantly increased during tablet computer usage compared to laptop usage. Meanwhile, neck discomfort has been significantly increased during laptop (or tablet computer) usage on lap compared to on desk which indicates the influence of computer position on neck discomfort.

In conclusion, this study found the association and role of psychological and psychosocial factors on MSDs development particularly in terms of muscle activity and visual as well as upper body discomfort especially on the neck region.

5.2 Contributions

This research was able to make some contributions in several aspects.

Firstly, this research provides some understanding regarding the prevalence of MSDs in several occupations. Besides that, the occupations selected for this study which was dentists, internship doctors and construction workers involved different physical, psychological and psychosocial challenges. Therefore, this research also contributes in terms of providing some insights regarding the association of psychological and psychosocial factors in the incidence of MSDs in several occupations with different challenges.

Secondly, there were many previous studies regarding psychological and psychosocial stress concerning computer usage especially that involve trapezius muscle activity. This research contributes by given a perspective from a different angle especially regarding the inconsistencies results obtained by those previous studies. Besides, even though significant relationships between visual discomfort and head posture on MSDs has been found in previous studies, only a few studies (if there are any) has emphasized on the influence of psychological and psychosocial factors on these two variables. This research provides understanding up to a certain degree on how psychological and psychosocial factors affect visual discomfort and head posture.

Thirdly, even though there were many studies regarding psychological and psychosocial stress involving computer usage, none of them use mobile computing products such as laptop, tablet computer and mobile phone. Examining the impact of mobile devices as it is impacted by psychological and psychosocial factors allow this research to build on the growing body of evidence in examining the impact of mobile devices.

5.3 Limitation and future work

In this dissertation, the dependent variables such as muscle activity, head posture and visual discomfort were measured separately in different experiment. In some cases, it seems that the dependent variables might be related with each other. For instance, in second experiment, it is assumed that visual discomfort caused the subjects to change their posture. However, in the second experiment, head posture was not measured. Thus, in the third experiment, aside from visual and body discomfort, the head posture was also measured. Yet, there was no significant relationship found between visual or upper body discomforts with head posture. Therefore, it is hypothesized that the changes of upper body discomfort were caused by the increment of muscle activity. Nevertheless, in the third experiment, none of the muscle activity was measured.

In order to find out the exact mechanism on how visual discomfort related to upper body discomfort, all variables such as visual discomfort, body posture and muscle should be measured simultaneously.

It should be noted that all participants and subjects in this dissertation were Malaysian. Besides, aside from dentists, internship doctors and construction workers, most of them were students. Therefore, it is difficult to generalize the results to general populations. However, the results of this study can be generalized to other people who are working in the same environment or conditions as in this study especially for computer users who are working under time pressure.

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Appendix

(Example of Psychological and Psychosocial Factors Questions)

Conflict at work

Please answer the following questions about your work situation. Please use the scale below:

1 Strongly Disagree 2 Moderately Disagree 3 Neither Agree nor Disagree 4 Moderately Agree 5 Strongly Agree

1. There is harmony within my group.	1	2	3	4	5
2. There is difference of opinion among the members of my group.	1	2	3	4	5
3. There is friendliness among the members of my group.	1	2	3	4	5

Job requirements

Now we would like you to indicate how often certain things happen at your job. Please use the scale below:

1 Rarely 2 Occasionally 3 Sometimes 4 Fairly Often 5 Very Often

1. How often does your job leave you with *little* time to get things done?	1	2	3	4	5
2. How often is there a marked increase in the work load?	1	2	3	4	5
3. How often is there a marked increase in the amount of concentration required on your job?	1	2	3	4	5
4. How often is there a marked increase in *how fast* you have to think?	1	2	3	4	5
5. How often does your job let you use the skills and knowledge you learned in school?	1	2	3	4	5
6. How often are you given a chance to do the things you do the best?	1	2	3	4	5
7. How often can you use the skills from your previous experience and training?	1	2	3	4	5

Job satisfaction

We would like you to think about the *type of work you do in your job*.

1. Knowing what you know now, if you had to decide all over again whether to take the type of job you now have,

   what would you decide?

   1 I would decide without hesitation to take the same job.

   2 I would have some second thoughts.

   3 I would decide definitely NOT to take this type of job.

2. If you were free right now to go into any type of job you wanted, what would your choice be?

   1 I would take the same job.

   2 I would take a different job.

   3 I would not want to work.

3. If a friend of yours told you he/she was interested in working in a job like yours, what would you tell him/her?

   1 I would strongly recommend it.

   2 I would have doubts about recommending it.

   3 I would advise against it.

4. All in all, how satisfied would you say you are with your job?

   1 I am very satisfied.

   2 I am somewhat satisfied.

   3 I am not too satisfied.

   4 I am not at all satisfied.

Mental demand

Please indicate the degree to which you agree or disagree with the following statements about your job. Please use the scale below:

1 Strongly Agree	2 Slightly Agree	3 Slightly Disagree	4 Strongly Disagree

1.	My job requires a great deal of concentration.	1	2	3	4
2.	My job requires me to remember many different things.	1	2	3	4
3.	I must keep my mind on my work at all times.	1	2	3	4
4.	I can take it easy and still get my work done.	1	2	3	4
5.	I can let my mind wander and still do the work	1	2	3	4

Work hazards

Please use the scale below:

1 Never	2 Occasionally	3 Sometimes	4 Fairly Often	5 Very Often

1. How often does your job expose you to verbal abuse and/or confrontations with your supervisor, clients or the general public? 1 2 3 4 5

2. How often does your job expose you to the threat of physical harm or injury? 1 2 3 4 5

3. How often have you been physically assaulted within the past 12 months while performing your job? 1 2 3 4 5

4. How often does your job personally subject you to potential legal liability? 1 2 3 4 5

Workload and responsibility

The next few items are concerned with various aspects of your work activities. Please indicate how much of each aspect you have on your job. Please use the scale below:

1 Hardly Any	2 A Little	3 Some	4 A Lot	5 A Great Deal

1. How much time do you have to think and contemplate?

   1 2 3 4 5

2. How much work load do you have?

   1 2 3 4 5

3. What quantity of work do others expect you to do?

   1 2 3 4 5

4. How much time do you have to do all your work?

   1 2 3 4 5

5. How many projects, assignments, or tasks do you have?

   1 2 3 4 5

Abstract (in Korean)

컴퓨터 활용은 직업, 성별, 나이를 막론하고 현대인의 일상적 활동이 되었고, 노트북, 태블릿 PC, 스마트폰 등의 모바일 컴퓨팅 제품들은 컴퓨터 사용의 시간적 공간적 제약을 해소하였다. 이러한 컴퓨팅 제품이 때로는 인간의 삶의 질을 향상시켜주는 역할을 하지만 컴퓨터 활용이 항상 편안하고 좋은 환경에서만 이루어지는 것은 아니다. 사용자들은 때때로 심리적, 심리사회적으로 스트레스가 많은 환경에서 작업을 수행해야 한다. 그러한 심리적, 심리사회적으로 스트레스가 많은 환경에서의 컴퓨터 활용은 근골격계 질환을 초래할 염려가 있다.

수년간 근골격계 질환에 대한 심리적, 심리사회적 요인의 영향을 두고 많은 논쟁이 있어왔다. 근골격계 질환에 대한 심리적, 심리사회적 요인의 영향을 밝혀내기 위해 횡단적 연구, 실험실 환경에서의 실험 연구, 현장 데이터 수집 등 다양한 연구가 이루어져왔다. 하지만, 아직 어떠한 심리적, 심리사회적 요인들도 일관되고 유의미하게 근골격계 질환과 관련 있다고 밝혀진바는 없는 실정이다.

치과의사, 건설 환경 작업자와 같은 몇몇 직업 군을 대상으로 한 횡단적 연구에서는 근골격계 질환과 관련된 심리적, 심리사회적 요인들의 영향력이 비일관적으로 나타났다. 실험실 환경에서의 실험 연구에서도 다양한 결과들이 도출되었다. 이는 해당 주제에 대한 연구가 아직까지 불충분하기 때문인 것으로 생각된다.

근골격계 질환 관련 심리적, 심리사회적 요인은 광범위한 분야이므로 다양한 요소들이 고려되어야 한다. 기존의 횡단적 연구에서 파악된 심리적, 심리사회적 요인은 대부분 연구 별로 다른 결과를 나타내었다. 동일한 요인을 (예: 정신적 요구) 대상으로 한 연구에서도 사용된 평가 및 설문지가 상이했으며 이에 따른 연구결과에 대한 영향을 배제할 수 없다. 기존의 실험 연구에서도 마찬가지의 양상을 보였다. 전반적으로 심리적, 사회심리적 스트레스를 유발하기 위해 실험에 사용된 방법론이 연구 별로 상이함에 따라 연구결과 또한 상이하게 나타난 것이라 생각된다.

이러한 연유로, 본 학위 논문은 모바일 컴퓨팅 기기 사용을 중심으로 심리적, 심리사회적 요소와 근골격계 질환의 관계를 파악하는 것을 주 연구 목적으로 한다. 그러한 반면, 근골격계 질환을 유발하는 물리적 요인은 수 십 년 간의 연구를 통해 잘 알려져 있다. 그러므로 본 학위논문은 물리적 요인 또한 한 부분으로써 다루어보고자 한다.

본 학위 논문은 크게 두 단계로 구분할 수 있는데, 첫 단계는 세 개의 다른 직업 군을 대상으로 한 세 개의 횡단면적 연구를 포함하고 있다. 대상 직업 군은 치과의사, 인턴의, 건설 환경 작업자이다. 해당 직업 군 별로 신체적 요구 수준과 심리적, 심리사회적 스트레스는 각기 다른 수준을 띄고 있다. 본 연구의 주된 목적은 심리적, 심리사회적 요인과 근골격계 질환과의 관계를 각 직업 군별로 알아보고자 함이다.

NIOSH 의 직무 스트레스 관련 설문지와 동일한 기준을(예: 직무 만족도, 정신적 요구) 바탕으로 총 여섯 가지의 심리적, 심리사회적 요인이 평가되었다. 본 연구에서는 심리적,

심리사회적 요인 별로 근골격계 질환과의 관계 수준이 다르게 도출되었다.

두 번째 단계에서는 모바일 컴퓨팅 기기의 사용과 관련된 세 개의 독립 변수에 대한 심리적, 사회심리적 요소들의 영향을 알아보고자 세 개의 실험 연구가 이루어 졌다.

해당 독립 변수는 근육 사용량, 시각적 불편도, 두부 자세이다. 정확한 작용 기제는 아직 불분명하지만, 해당 변수들은 모두 근골격계 질환과 관련되어 있다.

네 가지의 컴퓨터 기기를 사용 하는 첫 번째 실험에서는 몇 가지의 스트레스 유발 인자가 사용되었다. 다른 컴퓨팅 기기를 사용 할 때의 근육 사용량에 대한 심리적, 심리사회적 요인의 역할을 파악하기 위해 몇 가지의 가설을 상정하였다. 기존 연구들의 심리적, 심리사회적 요인들이 근육 사용량에 미치는 영향에 대한 비일관된 결과들을 참고하여 본 연구의 가설에 반영하였다. 또한 다른 기기 사용이 근육 사용량에 미치는 영향을 분석하였다.

타이핑, 게임, 프로그래밍 등 컴퓨터를 사용함에 따라 다른 종류의 활동이 도출될 수 있지만, 읽기는 컴퓨터 사용 중 가장 보편적인 활동 중 하나이다. 그러므로 두 번째 실험에서는 노트북과 태블릿을 사용하여 읽기 작업을 수행 할 때의 시각적 불편도 및 여타 신체 부위의 불편도에 대한 심리적, 심리사회적 요인들의 영향을 알아보고자 하였다. 해당 실험 결과가 두부 자세와 관련이 있을 것이라 예상 하였다.

모바일 컴퓨팅 기기의 이동성은 사용자로 하여금 장소와 방법에 구애 받지 않고 기기를 사용할 수 있도록 해준다. 따라서 마지막 실험에서는 컴퓨터의 위치가 실험의 한 부분으로써 포함되었다. 노트북 및 태블릿을 각기 다른 위치에서 사용할 때 시간적 압박이 미치는 영향을 시각적 불편도와 두부 자세의 측면에서 분석하였다.

근골격계 질환은 다인성 질환으로 다양한 위험 요소가 다양한 방식으로 동일 증상을 유발한다. 본 연구가 다른 연구자들에게 심리적, 심리사회적 요소가, 특히 모바일 컴퓨팅

기기 사용시, 근골격계 질환에 미치는 영향에 대해 약간의 견문과 지식을 제공할 수 있기를 기대한다.