UNIVERSITI PUTRA MALAYSIA

EFFECT OF ANTI-FATIGUE MAT ON FEET AND BODY MUSCLE DISCOMFORT DUE TO PROLONGED WORK IN UPRIGHT POSITION AMONG STUDENTS

ZUTIQA AQMAR BINTI YAZULI

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ABSTRACT

EFFECT OF ANTI-FATIGUE MAT ON FEET AND BODY MUSCLE DISCOMFORT DUE TO PROLONGED WORK IN UPRIGHT POSITION AMONG STUDENTS

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Introduction: Prolonged standing is one of the risk factors are related to musculoskeletal disorder (MSD) that can lead to the occupational injuries in the workplace. A variety of occupational in manufacturing and service professions are commonly required to spend the majority of the workday in an upright position. The anti-fatigue mat is one of the interventions that can reduce the possibility of workers to get musculoskeletal disorder, especially at the lower limb. **Objective:** The main objective of this study is to determine the effect of the anti-fatigue mat on body comfort due to prolonged standing among students. **Methodology:** The totals of participants were 100 students of Faculty of Medicine and Health Sciences, University of Putra Malaysia; male, the age range is 19-25 years old, no musculoskeletal disorder complaint and physical condition is good. Participants (control group) stood for 2 hours in a controlled room without the anti-fatigue mat while the experimental group stood with the anti-fatigue mat and at the same time sort the mixed items. The respondents were evaluated their discomfort level using Borg's scales questionnaire for every 15 minutes. **Result:** The discomfort rating in experimental group always lower level than control group in all body parts. There was no 'break point' of discomfort rating ≥ 5 between control and experimental group. By using Independent T-test, the result shown there was a statistically significant different between body muscle discomfort (knees) and Borg Scale rating in both groups for every minute. There were strong positive correlations between the feet discomfort and the knees and calves discomfort during standing on the anti-fatigue mat. **Conclusion:** The intervention (anti-fatigue mat) is engineering improvement that may give the effectiveness and relaxation for prolonged standing workers.

Keywords: Prolonged standing, Anti-fatigue mat, Discomfort, Borg's scale

ABSTRAK

KESAN TIKAR ANTI-KELETIHAN KEPADA KETIDAKSELESAAN OTOT KAKI DAN BADAN AKIBAT KERJA BERPANJANGAN DALAM POSISI TEGAK KALANGAN PELAJAR

ZUTIQA AQMAR BINTI YAZULI

Pengenalan: Berdiri yang berpanjangan adalah salah satu faktor risiko yang berkaitan dengan masalah muskuloskeletal (MSD) yang boleh membawa kepada kecederaan pekerja di tempat kerja. Pelbagai pekerjaan dalam sektor pembuatan dan perkhidmatan profesion biasanya menghabiskan sebahagian besar hari kerja dalam kedudukan tegak. Tikar Anti-keletihan adalah salah satu intervensi yang boleh digunakan untuk mengurangkan risiko pekerja daripada mendapat gangguan otot, terutamanya anggota badan yang lebih rendah. **Objektif:** Objektif utama kajian ini adalah untuk mengetahui kesan tikar anti-keletihan dalam memberi keselesaan pada badan ketika kedudukan berdiri yang berpanjangan dalam kalangan pelajar. **Metodologi:** 100 orang pelajar Fakulti Perubatan dan Sains Kesihatan, Universiti Putra Malaysia telah diambil dalam kajian ini; lelaki, lingkungan umur berusia 19-25 tahun, tidak ada gangguan aduan otot dan keadaan fizikal yang baik. Responden (kumpulan kawalan) perlu berdiri selama 2 jam di dalam bilik dikawal tanpa menggunakan tikar anti-keletihan manakala kumpulan eksperimen berdiri dengan menggunakan tikar anti-keletihan dan pada masa yang sama mereka perlu mengasingkan barang-barang yang bercampur. Responden telah menilai tahap ketidakselesaan mereka dengan menggunakan borang soal selidik Borg untuk setiap 15 minit. **Keputusan:** Kedudukan tahap ketidakselesaan bagi kumpulan eksperimen sentiasa pada tahap yang lebih rendah daripada kumpulan kawalan di semua bahagian badan. Semua anggota badan tidak melebihi 'titik rehat' penarafan ketidakselesaan ≥ 5 untuk kumpulan kawalan dan eksperimen. Keputusan menunjukkan signifikan apabila menggunakan tikar anti-keletihan pada otot badan (lutut) dengan menilai menggunakan borang soal selidik Borg' pada setiap minit. Terdapat hubungan positif yang kuat antara ketidakselesaan kaki dan ketidakselesaan lutut dan betis semasa berdiri di atas tikar anti-keletihan. **Kesimpulan:** Intervensi (tikar anti-keletihan) adalah peningkatan teknik yang mungkin memberi kesan dan memberi keselesaan kepada pekerja semasa berdiri yang berpanjangan.

Kata kunci: Berdiri yang berpanjangan, tikar anti-keletihan, Ketidakselesaan otot, skala anti-keletihan Borg

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LIST OF ABBREVIATIONS

%	Percentage
BMI	Body Mass Index
CCOHS	Canadian Centre for Occupational Health and Safety
DOSH	Department of Occupational Safety and Health
ESD	Electro-Static Dissipative
IOSH	Institute of Occupational Safety and Health
LBP	Low Back Pain
MSD	Musculoskeletal Disorder
NFSI	National Floor Safety Institute
NIOSH	National Institute of Occupational Safety and Health
SOCSO	Social Security Organization's
SPSS	Statistical Package Service and Solution
WRMSD	Work-related Musculoskeletal Disorder

CHAPTER 1

1NTRODUCTION

1.0 INTRODUCTION

The musculoskeletal disorder cases related to work in Malaysia increasing year by year and the total compensation for ergonomic cases was found higher than other occupational disease cases. According to the Social Security Organization's (SOCSO) (2013) statistics, there were 694 ergonomics related cases out of 2630 cases of occupational diseases, which mean for every four cases reported to SOCSO; one was related to musculoskeletal disorders quoted by the chairman of National Institute of Occupational Safety and Health (NIOSH) in 2013. Musculoskeletal disorders development has always been related to prolonged static standing among employees in industrial. A variety of occupation in manufacturing and service professions are commonly required to spend the majority of the workday in static and upright position such as cashiers, food services, hair cares, operators and assembly work (King, 2002) .(Zander, King and Ezenwa, 2004).

Prolonged standing is one of the risk factors related to the occupational injuries in the workplace. A study by Tomei et al. (1999) stated that workers who spending over 50% of their working hours by standing and performing jobs processes during a full work shift in an upright position without sitting except break time included in prolonged standing worker. The workers need to perform their processes jobs in standing position throughout working hours because of it more suitable and practicable for handling, pushing, and pulling the heavy goods, equipment, materials and products which are requiring large space and frequent movements (Halim, Omar, Saman and Othman, 2012).

Prolonged standing causes discomfort and muscles fatigue, the workers faced that in the workplace by the end of the workday especially in the lower extremities (Halim et al., 2012). There are many effects of prolonged standing workers such as reduce productivity and quality and increased the accident rate, medical cost and absenteeism. The awareness on occupational health and safety should be provided to the employees because they have a very high probability of an accident at the workplace, especially in industrial sectors. By recruitment and training new workers, the employer needs to spend a large amount of money on that (Halim et al., 2012). There are many scientific methods been used as the intervention to reduce the musculoskeletal disorder cases due to prolonged standing among workers which are anti-fatigue mats and shoe insoles. The conditions of floor play an important role in reducing the fatigue and pain suffered by the employees which are the softer surface of floor give more comfortable than the hard surface (King, 2002).

1.1 Problem Statement

Based on statistics of work-related musculoskeletal disorder (1995-2012) from the Department of Occupational Safety and Health (DOSH), the total numbers of cases in musculoskeletal disorders were increased throughout years. The number of cases increased sharply almost 18 times from 2006 with 14 cases to 268 cases in 2011, it only takes five years. In 2012, the cases of musculoskeletal diseases reported increased almost double compared to the previous year. The government should begin to take these issues in serious matter on how to reduce the numbers of cases. There are many preventive measures can be implemented in industry especially at an engineering control part to reduce the possibility of workers to get musculoskeletal disorder.

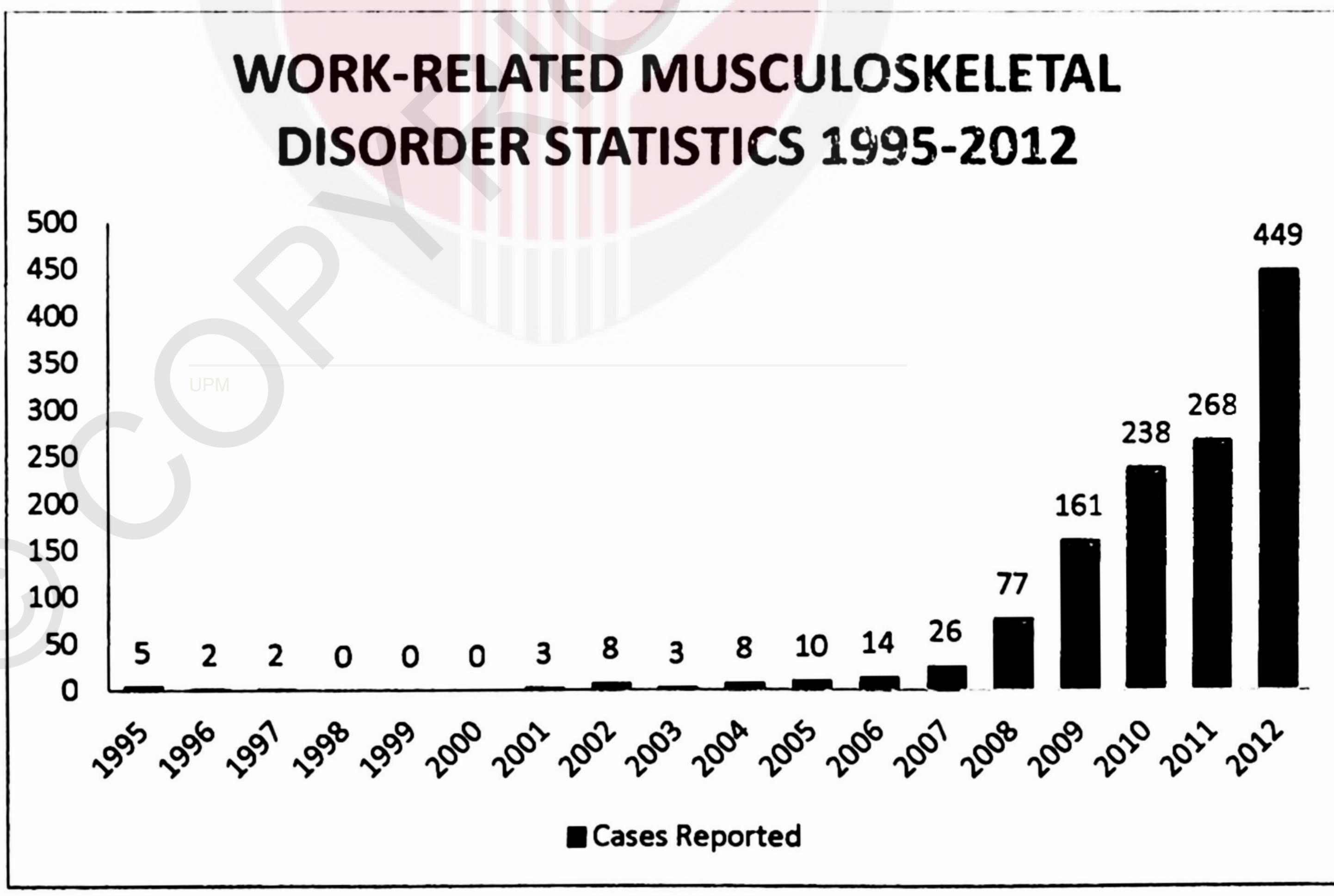


Figure 1.1: Work-related musculoskeletal disorder statistics in 1995 until 2012 (DOSH, 2012)

Social Security Organization's (SOCSO) (2013) stated that the cost for MSDs treatment and compensation for ergonomics-related cases was quite higher than other occupational diseases and that impact the financial. The total amount of compensation increased from 2009 in RM1.04 million to RM1.94 million in 2014 by year. The cost of permanent disability compensation for musculoskeletal disorder cases was RM 25,313/per case, compared to others cases which the average cost at RM 22,841 that based on the Centre of Excellence for Ergonomics study.

There are many occupations required workers to stand in a long time with the minimal movement that may cause problems. The correct posture during standing is very importance for the workers to know during performing their jobs, especially who work in housekeeping, manufacturing, military, and industrial working (Ntousis et al., 2012). The effect of leg muscle fatigue is always been associated with prolonged work in standing position. The leg muscle fatigue can even cause occupational injuries in long-term effect due to improper design in footwear and workstation combined with inadequate rest time (Halim et al., 2012).

A study by King (2002) stated that by altering the floor condition where the workers stand can reduce the discomfort, fatigue and pain muscle during prolonged work. Some of the previous studies also stated that there is no significant difference found between the flooring conditions and lower leg volume in 8 hours (Zander et al., 2004). A study by Lin et al. (2012) also stated that the result still unclear about the significant different between the type of floors and work-related discomfort. A previous study stated that the mat can reduce little fatigue in leg muscles which were gastrocnemius and tibialis anterior muscle during prolonged standing but it was not significant (Kim, Buttle and Marras, 1994).

The primary aim of this study is to examine the effectiveness of the anti-fatigue mat in reducing the discomfort rating on the respondents during prolong standing. Can this anti-fatigue mat support reduce discomfort level? The improvement from the previous need to be done to make the result stronger which are the characteristics of the shoes that the respondents used need to be standardized. So, in this study we used adjustable table that followed the Guideline Standing at Work by Department of Occupational Safety and Health in Malaysia and the standard shoes (sport shoes) for all respondents in order to fill the gap from the previous study that not controls on this variable. The participants have been tested with various experiment conditions while barefoot and wear shoes that cause the result not significant (Lin et al., 2012). The characteristics of participants should be the greater balance of height, weight, and age range, so it can improve the significant differences magnitude (Zander et al., 2004).

1.2 Study Justification

The result of investigations from previous studies gave conflicting information to the occupational industry. This investigation is to determine the effectiveness of anti-fatigue mats compared to the concrete floor in reducing the level of discomfort among respondents. The anti-fatigue mats can reduce the possibility of workers to get musculoskeletal disorder, especially at the lower limb. During standing in a long standing can cause most discomfort in knees, lower legs, ankles and especially feet (Chester et al., 2002). The discomfort or fatigue in muscle leg tends to reduce the productivity and concentration of workers during performing their jobs.

Anti-fatigue mat is used in this study in order to indicate the level of the data distribution of discomfort rating (Borg`s scale) in each respondent. Therefore, this study will be able to provide evidence to reduce the level of discomfort, leg muscle fatigue and increase performances with the intervention of anti-fatigue mat during prolong standing. The result from this investigation can help the employer from occupational industry to protect their workers from getting the musculoskeletal disorder. Other than that, the productivity of the workers can be increased and the absenteeism problem can be solved among the workers. This study can provide an alternative way and effective to the work-related with prolonged standing.

1.3 Objective

General Objective:

To determine the effect of anti-fatigue mat on body comfort due to prolonged standing among students.

Specific Objective:

1. To determine data distribution of discomfort rating (Borg's Scale) between experimental and control groups for every body part.
2. To determine the discomfort 'break point' (Borg's Scale) between control and experimental groups for every body part.
3. To compare the differences of discomfort rating (Borg's Scale) between control and experimental groups.
4. To measure the association between feet and body parts discomfort in experimental and control groups.

1.4 Hypotheses

1. There is positive effects on feet comfort from the usage of the anti-fatigue mat in experimental group compare to control group for every body part.
2. There are significant reductions of discomfort rating among experimental group compare to control group for every body part.

3. There are significant association between the feet and body part discomfort in experimental and control groups.

1.5 Conceptual Framework

There are many risk factors that can be related with MSD which are bending, twisting, heavy lifting, overload work, repetitive or static motion, not suitable workplace design, working in long times without adequate rest time, working environment, and psychosocial factors (IOSH, 2016) and they are classified as occupational factors. Prolonged standing is one of the risk factors that can cause musculoskeletal disorder (MSD). There are many health problems can be related to prolonged standing which is lower extremity swelling, low back pain (LBP), lower extremity discomfort and fatigue and whole body fatigue (Chester, Rys and Konz, 2000). A study by Halim et al. (2012) point out that the discomfort and muscle fatigue especially in the lower extremities of employees caused by prolonged standing in the workplace. Almost 553 000 workers at Great Britain suffered from musculoskeletal disorders in 2014-2015 and 97 000 of them related to lower limb problems (IOSH, 2016).

Many intervention programs have been conducted based on evidence from the previous study to reduce the risk of workers from getting musculoskeletal disorder during performing work. Department of Occupational and Safety health has mentioned that there are some interventions that can be used for prolonged standing workers in Guideline of Standing at Work (DOSH, 2002). Some study reported that the anti-fatigue mats and shoe insoles gave positive impact to the respondents during standing in a long time (Gregory and Callaghan, 2007). Another study also supports that anti-fatigue mats can give more comfort to the workers by reducing the muscle fatigue from standing (Zander et al., 2004) if compared to the normal floor (hard surface). Figure 1.2 showed that the conceptual framework of the different floor conditions can cause leg muscle fatigue among students.

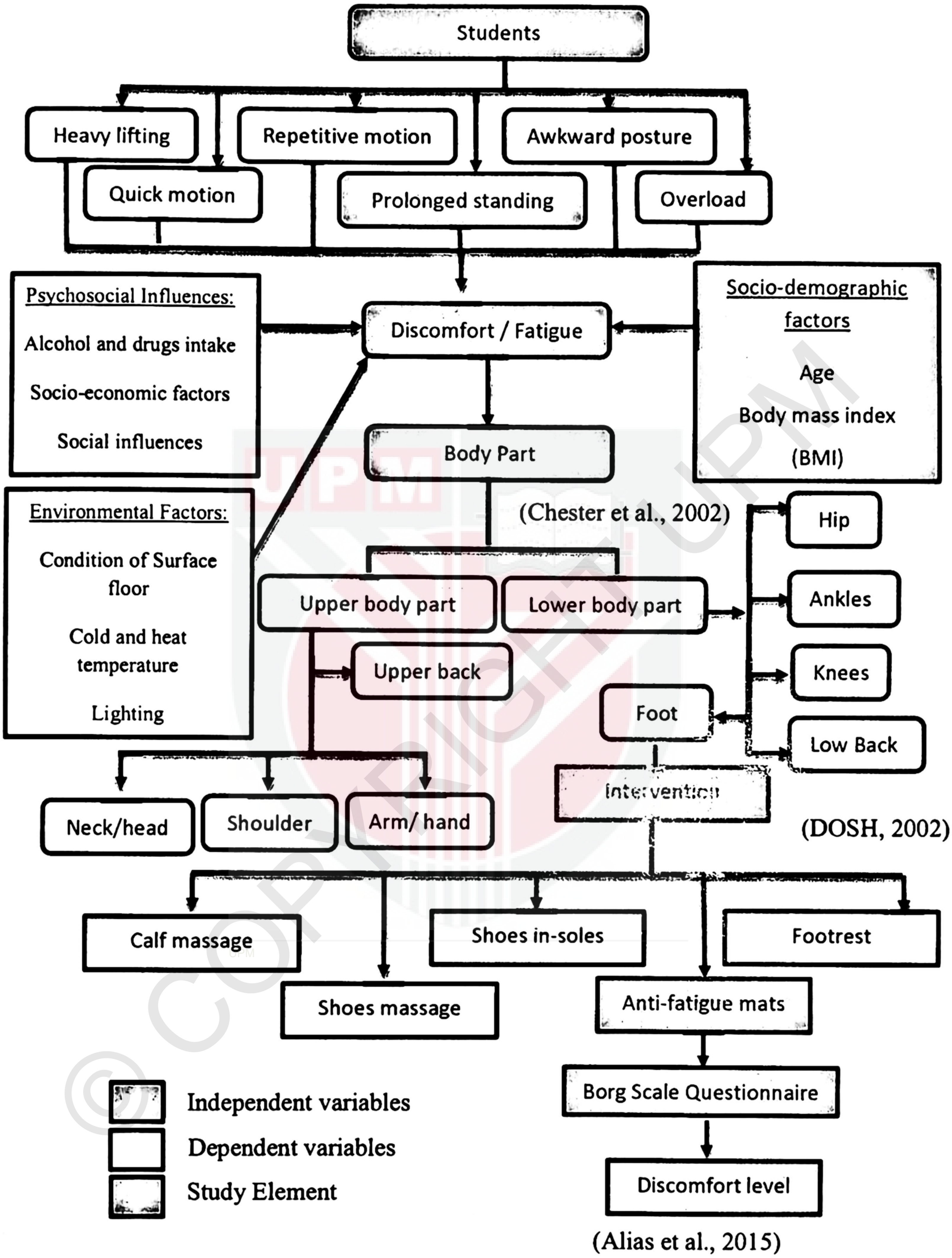


Figure 1.2: Conceptual framework of musculoskeletal fatigue different floor condition

CHAPTER 2

LITERATURE REVIEW

2.0 Literature Review

2.1 Musculoskeletal Disorder (MSD)

A common health problem happens in the occupational field is the musculoskeletal disorder (MSD) (Guo, Chang, Yeh, Chen and Guo, 2004). The common health problems that cause disability in the world are musculoskeletal disorders (MSDs) (Karimi et al., 2016). The musculoskeletal disorder is the condition when the muscle stress because of exposed with static and repetitive motions in a long period of time can cause damage to ligaments, tendons and joints (Sholihah et al., 2015). The common symptoms of the musculoskeletal disorder are the weakness, pain, numbness, skin color changes, tingling, swelling, redness, stiffness and muscle tightness.

There are many risk factors that can be related with MSD which are bending, twisting, heavy lifting, overload work, repetitive or static motion, not suitable workplace design, working in long times without adequate rest time, working environment, and psychosocial factors (IOSH, 2016). Some upper body area may affect due to MSD such as upper back, wrists, hands, neck, shoulders and elbows. The lower part of the body will affect when worker used the leg most of the times such as low back, feet, hips, ankles and legs (Canadian Centre for Occupational Health and Safety, 2016).

From the previous study, the most body parts that frequently affected workers were lower back and waist, followed by shoulder, neck, hand and wrist respectively (Guo et at., 2004). The MSDs issues should be solved to ensure the people are physical can continue their longer life of working without the burden of any type of diseases especially MSDs (Oakman, Rothmore and Tappin, 2016). Workers can perform their job well with high productivity and concentration and prevent the accident from happening in the workplace. Health professional sectors also involved in this problem as stated in a study by Anderson & Oakman (2016), the health professionals also faced work-related musculoskeletal disorder (WRMSD) during performing their jobs especially the workers who have less experience and being exposed a lot of repetitive tasks and manual job such as transferring and lifting the patients at hospital.

2.2 Ergonomic

Ergonomic is a safe, healthy and convenient workplace that fit the workers and their jobs (Andayasari and Anorital, 2009). According to Occupational Safety and Health Administration, ergonomics means the relationship between the physical aspects of the environment (e.g. workplace design) and human factors (e.g. body posture of workers) that do not cause the disturbance. The main aim is to create the ergonomic workplace that suits with the abilities and limitation of the worker including the worker's body size and other factors. A study showed that the number of musculoskeletal disorders among carpet weavers increasing due to work posture and poor ergonomics and working in long static position (Karimi et al., 2016).

The ergonomic intervention should be done to ensure workers not exposed to ergonomic risk in the long period of time that can lead to discomfort, fatigue muscle and stress physically and emotionally that can cause to musculoskeletal disorder (MSD). The ergonomics education needed to increase the musculoskeletal wellbeing awareness among students in Hong Kong due to use of electronic devices and habitual postural that can lead to musculoskeletal disorder issues (Woo, White & Lai, 2016). "Ergonomic risk" is a new term that been used to identify the possible risk of factors in work process that may lead to the development of work-related musculoskeletal disorder (Veselinovic et al., 2016).

2.3 Prolonged Standing

Working in standing position is common in the occupational industry. Some occupation required the workers to stand for a long period of time to perform their jobs because they need to handle heavy products and equipment, reach goods and materials and pull and push excessive loads (Omar, 2012). By performing those works in sitting position, it may make their job become more difficult in term of limitation of body movement. The occupations that usually involved in prolonged standing are assembly-line, sales promoter, machine operators, and others (Canadian Center of Occupational Health and Safety, 2016). The statistics were shown that half of United Kingdom (UK) labors which more than 11 million workers facing health risks is caused by prolonged standing (Hazard, 2005).

The work task can be classified as prolonged work in the upright position is when the workers need to spend more than 50% of total working hours to complete the work task in standing position without living the work area (Halim et al., 2012). Awkward standing position can increase developing the back pain (Kaka et. al. 2016) and lower limb during working. A study by Sartika and Dawal (2010) stated that after 90 minutes of prolonged standing, the muscle fatigue occurs in lower back and leg, soleus (after 5 minutes), Thoracic erector spine (TES) (after 35 minutes) and Lumbar erector spine (LES) (after 30 minutes). A study by Gregory & Callaghan (2008) stated that the development of muscle discomfort caused by first 15 minutes of standing in awkward bending and twisting posture.

2.4 Discomfort

Discomfort, injury and pain occur when the physical tasks required high physical energy that exceeds human body capability (Korhan, 2012). The previous study has been concluded that discomfort has significantly different with prolonged standing especially in the lower extremities of individual (Halim et al., 2012). Muscle stress and mental discomfort in lower extremities caused by prolonged standing at workstations and without sufficient rest and improper footwear (Omar, 2016). Discomfort happen when there is limited blood circulation at lower legs area and static muscle fatigue. Lower leg swellings happen when the blood pooling occurs due to reducing of blood circulation in that area. If the workers perform prolonged standing work without any preventive measure, the workers experience discomfort in lower limb muscles (thighs and legs), lower back and feet (Halim & Omar, 2011). Many countries have been a serious economic and social concern about discomfort especially in the lower back, leg and feet area (Zander et al., 2004).

Another study showed that there are significant differences between muscle discomforts and time which mean the discomfort level increased over the time for the whole body. The level of discomfort change was started from first 30 minutes and after 90 minutes of standing. The mean of statistics was shown that 126% for lower back, 152% for general fatigue, 217% for the hips, 126% for the lower leg, 169% for upper back, 127% for the ankle and 137% for the foot (Sartika & Dawal, 2010). A study has shown that the 50% of healthy respondent experienced low back discomfort after prolonged standing in 2 hours (Gregory & Callaghan, 2008). A study by Chester et al., (2002) showed that the feet experienced most discomfort in standing posture after 90 min, followed by sitting and sit/standing posture. When workers stood in a long time, they have high tendency to lean their body backward to reduce the pain and muscle discomfort during working (Sartika & Dawal, 2010).

2.5 Fatigue

The previous study has been concluded that body fatigue has significantly different with prolonged standing especially in the lower extremities of individual (Halim et al., 2012). When there is limited blood circulation happen especially at the lower legs area and static muscle fatigue, it called fatigue. The reduction of blood circulation at the area may cause blood pooling usually called as lower leg swelling (Zander et al., 2004). The previous study also stated that there are significant differences between the effect of fatigue and the long-term sickness absence. The fatigue also can cause disease if the workplace improvements are not been taken seriously by the employer (Janssen et al., 2016).

2.6 Health Problem

Working in a standing position at a long time without sufficiency rest can lead to many health problems such as swelling of the leg, general muscular fatigue, low back pain, and other health problem (CCOHS, 2016). A study by Sholihah et al., (2016) stated the people who keep standing in the wrong posture for quite a long time can cause musculoskeletal disorder because of the muscle tend to work in the static position, which will lead to increase the tension of muscle and decrease the elasticity of tissue. The static contraction in leg and back also can occur because of prolonged standing (Halim et al., 2012).

The body muscle cannot work only in a static position at a long time. The other problems that will be faced by people who spend most of the times working in the upright position are poor circulation, foot problems, swelling of feet and legs, joint problems, chronic venous insufficiency, high stroke risk, carotid atherosclerosis and circulatory problem (Halim & Omar, 2011). There are also other health problems that related to the prolonged standing which is low back pain, stiffness in shoulder and neck, arthritis in hips and knees and high blood pressure (Johnson, 2016).

A study by Wong, David & Callaghan (2008) proved that 65% of asymptomatic respondents experienced the low back pain caused by prolonged standing in their study. Another study by Lafond et al. (2009) supported that there is the association between the prolonged standing and symptoms of low back pain in industrial population. The loss in the workers' productivity and workday mainly caused by back pain problem as a major work-related musculoskeletal disorder (WRMSD) (Aziz et al., 2015). But not only low back pain may affect due to prolonged standing, Chester, Rys & Konz (2002) had stated in their study that the sit/standing cause discomfort in the hips, upper back, and upper legs, while prolonged standing cause discomfort in lower body, especially in the feet area.

2.7 Intervention

The necessary intervention should be implementing in order to reduce the hazard and risk exposure of the workers that may associate with occupational injuries especially musculoskeletal disorder (Oakman et al., 2016) due to prolonged standing. Since the major risk factors of musculoskeletal disorder have been identified which are prolonged and repetitive task, the employer should introduce the regular short break to reduce the possibility of getting musculoskeletal disorder. Moreover, by shortening the period of exposure to the hazard can reduce the muscle fatigue occurrence and lead to increase the productivity, reduce MSD treatment cost and loss man hour among workers (Aziz et al., 2015). Ergonomic intervention has seen as a solution to musculoskeletal disorder by fitting the work environment to the worker.

There are many methods have been studied before in ergonomic intervention to lessen the discomfort and pain especially in lower limb parts which were the use of anti-fatigue mats, shoe insoles (King, 2002), unstable shoes (Sousa et al.,2016), sloped surface (Wong & Callaghan, 2010) and footrest. A study by King (2002) stated that there was a significant difference between discomfort level and the conditions of the floor when standing on the softer surface gave more comfortable and can reduce fatigue compared standing on the hard surface. The mats and insoles found by respondents more comfortable during prolonged standing (Gregory & Callaghan, 2008).

A study by Sousa et al. (2016) stated that while wearing the unstable shoe in upright position has potential to increase the performance and effectiveness of worker's system of postural control compared to barefoot. A study by Wong & Callaghan (2010) stated that the sloped surface had significantly reduced the low back pain during prolonged standing work. But the previous study has little evidence on the effectiveness of the intervention methods on reducing the discomfort and fatigue of leg muscle. Many studies have been done to proof that the anti-fatigue mat can contribute in reducing the muscle discomfort especially in feet area.

2.8 Anti-fatigue mats

Many occupational industrial used anti-fatigue mats as one of the intervention methods to reduce the musculoskeletal disorder problem. From the previous study claimed that fatigue can be reduced when to implement anti-fatigue mats in the workplace for prolonged standing workers (Zander et al., 2004). Another study also supports that pressure in workers feet during standing in a long time can be reduced by implementing the engineering control in standing surface of the workplace which is anti-fatigue mats (Halim et al., 2012). The previous study also stated that a floor mat gives more comfortable and less fatigue in lower limb especially leg during standing compared standing on a hard surface (Cham & Redfern, 2001). Moreover, the participants were agreed that standing on mats can give more comfortable during standing for a long period of time (Gregory & Callaghan, 2007). The floor conditions and time of standing have significantly influenced the level of discomfort of participants in field and laboratory settings. The most uncomfortable were when the participants were needed to stand in a long time on the hard surface while barefoot; it more comfortable when standing on mats while wearing sports shoes but the scientific evidence remains unclear (Lin, Chen and Cho, 2012).

Table 2.1: Summary of Literature Review of Anti-Fatigue Mat

Researcher (S)	Title	Method	Result
Zander et al., 2004	Influence of flooring condition on lower leg volume following prolonged standing	The effect of different flooring condition on standing fatigue: • Wood block floor • Anti-fatigue mat • Wearing shoe insoles	Several flooring conditions did not result in statistically significant changes in lower leg volume between pre-shift and post-shift.
King, 2002	A comparison of the effect of floor mats and shoe in-soles on standing fatigue	There are many types of standing condition been used in this study: • On hard floor • On hard floor mat • Wearing shoe in-soles • Wearing shoes in soles while standing on a floor mat	There was correlation between height, age and job tenure. Standing on mat, in-soles and combined conditions were more comfortable than standing on hard floor.
Kim et al., 1994	The effect of mats on back and leg fatigue	Five respondent were asked to stand on a concrete surface and two difference thickness of mats for prolonged time: • Concrete surface • Thin mats • Thick mats	The thin mats reduce more fatigue compared to thick mats.
Lin et al., 2012	Influence of shoe/floor condition on lower leg circumference and subjective discomfort during prolonged standing	In this study, there was conducted experimental and observational study filed experiment & laboratory experiment) Experiment 1: Ten subjects needed to perform computer task under two floors and shoe condition during 4 hours standing in laboratory. Experiment 2:	As the result, the standing time and floor type significantly affected the leg discomfort and circumferential shank measurement in both experiment conditions. The shoe condition significantly affected subjective

		Fourteen subjects needed to stand on different floor condition in a real work condition in 4 hours.	rating for leg discomfort.
Halim et al., 2012	Assessment of muscle fatigue associated with prolonged standing in workplace	Twenty respondents involved in this study for measuring the psychological fatigue during 5 hours standing through: • Questionnaire • sEMG measurement	Based on questionnaire, all respondents experienced psychological fatigue due to prolonged standing.
Hansen et al., 1997	Significance of mat and shoe softness during prolonged work in upright position: based on measurement of low back muscle EMG, foot volume changes, discomfort and ground force reactions	Eight female respondents performed simulated standing and standing/walking for 2 hours in laboratory using four conditions: • soft shoes • clogs • soft mat • concrete	By using soft shoes during standing/walking reduce formation of the foot edema and heel impact rather than using clogs. Based on EMG-sign, paravertebral muscle fatigue is larger during standing compared to standing/walking task.
Cook et al., 1992	The effect of surgical floor mats in prolonged standing: an EMG study of the lumbar paraspinal and anterior tibialis muscles	Six males subjects were asked to stand on specially designed surgical floor mat for 2 hours and the other day, needed to stand on linoleum-covered concrete surface also in 2 hours long.	There was no difference in EMG activity obtained from anterior tibialis muscles and paraspinal muscle of low back during standing on surgical mat and linoleum-covered concrete.

CHAPTER 3

METHODOLOGY

3.0 METHODOLOGY

3.0.1 Study design

This study was conducted using the true experimental study. The objective has evaluated the effectiveness of anti-fatigue mats on leg and body discomfort among prolonged standing respondents. Participants were divided into two groups:

a) Experimental group

b) Control group

3.0.2 Study location

This study was conducted in the multi-purpose laboratory 1, Faculty Medicine and Occupational Health Sciences, University of Putra Malaysia (UPM).

3.0.3 Study population

The study population was conducted among the students of Faculty of Medicine and Health Sciences, University of Putra Malaysia.

3.0.4 Sampling

a) Sampling framework

The sampling frame was obtained from the Student Affairs Division and Dean's Office at Faculty of Medicine and Health Sciences, UPM.

b) Sampling unit

The students that had been selected for this study based on inclusion and exclusion criteria:

i. Inclusion Criteria:

1. The gender of the respondents should be male.
2. The age of respondents between 19-25 years old.
3. The Normal Body Mass Index (BMI) of 18.5-24.9

ii. Exclusive Criteria:

1. The respondents have physical injury especially at lower limbs in the past one year.
2. Respondents have the immediate complaint of musculoskeletal disorders at the head, shoulder, neck, upper back, hands, arms, low back, thighs, buttocks, calf, knees, ankles or feet.

3. Respondents who have cardiovascular disease because they already had the problem in blood circulation.
4. The respondents who do not have adequate rest because it can cause greater discomfort level due to the recovery time were not enough.

3.0.5 Sample size

According to Hansen, Winkel & Jorgensen (1997), the prevalence of prolonged standing in 2 hours can cause discomfort in feet. Group comparison (2 groups) sample calculation is used:

Formula:

$$n = \frac{\{z_{1-\frac{\alpha}{2}}\sqrt{2P(1-P)} + Z_{1-\beta}\sqrt{P_1(1-P_1) + P_2(1-P_2)}\}^2}{(P_1 - P_2)^2}$$

Where,

P $= (P_1 + P_2)/2 = 0.195$

P_1 = estimated proportion (larger) = 0.31

P_2 = estimated proportion (smaller) = 0.08

Z1-α = Standard error associated with confidential interval

(Here we decide to choose 95% confidential interval= 1.96)

$Z_{1-\beta}$ = Standard error associated with power

(Here we decide to choose 80% of power = 0.842)

Calculation:

$$n = \frac{\{1.96\sqrt{2(0.195)(0.805)}+0.842\sqrt{(0.31)(0.69)+(0.08)(0.92)}\}^2}{0.0529}$$

$$= \frac{(1.10+0.45)^2}{0.0529}$$

$= 45$

n = 45

So, the sample will be 45 subjects in each group.

(Lameslow, Klar & Lawanga, 1990)

Therefore, a total of 90 students were selected in this study.

3.0.6 Sampling method

A total of 100 male students from faculty were recruited into this study. The respondents were all in good physical condition and with no history of musculoskeletal disorders disease at the time of the experiment process. For three days prior to the data collection process, the respondents were asked to avoid any heavy exercise. The purposive sampling was conducted to recruit the respondents that meet the inclusion and exclusion criteria.

3.1 Instrumentation and data collection techniques

3.1.1 Study variables

An anti-fatigue mat was used in this study. The independent variables were students standing with and without the anti-fatigue mat and the dependent variable was the student's discomfort in leg and body muscle. The other variables were controlled during this study such as Body Mass Index (BMI), sleep hours and age. The anti-fatigue mat criteria followed the suggested criteria mentioned by National Floor Safety Institute (NFSI). Electro-Static Dissipative (ESD) anti-fatigue mat was used as floor mat condition for experimental group. Manufactured by GSE Online Sdn. Bhd., this anti-fatigue mat made of Nitrile Butadiene rubber which is resistant to oil, acid and alkaline and the thickness is 15 mm. The length of the anti-fatigue mat is 5 feet and the width 3 feet.

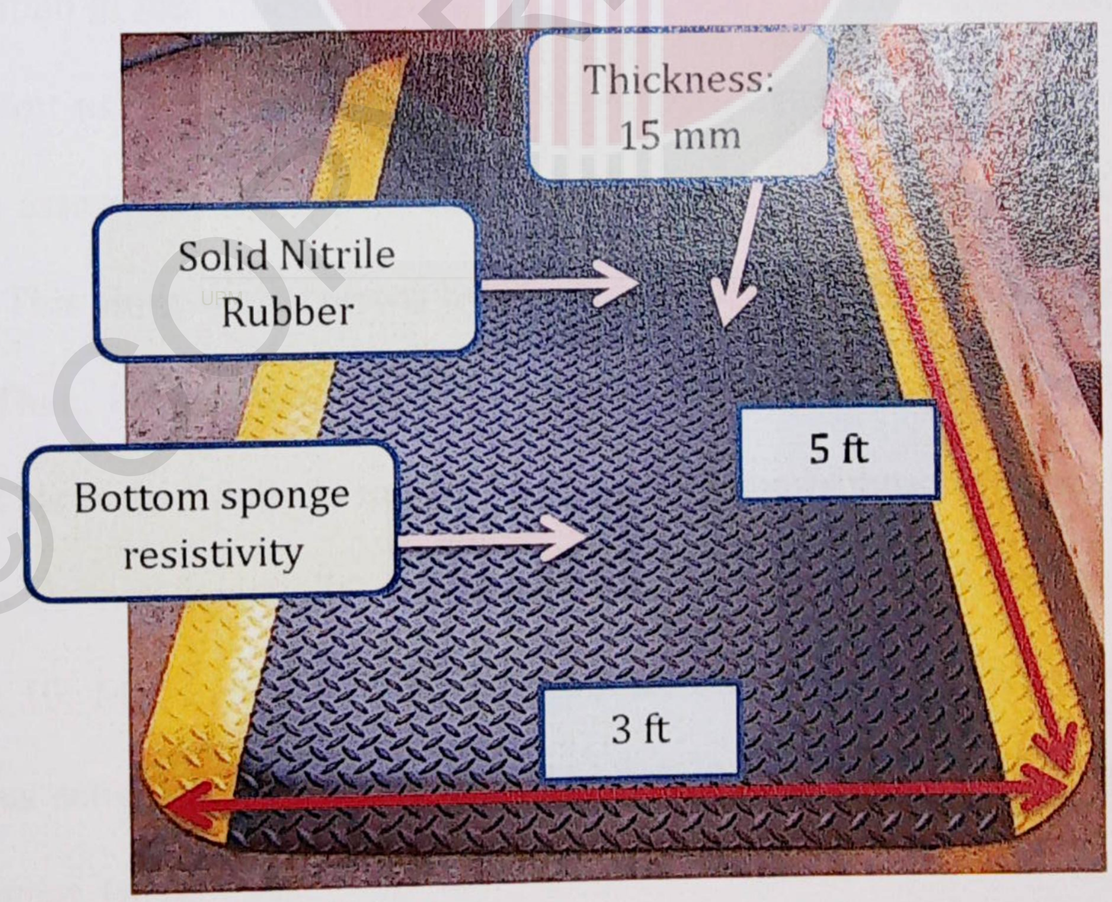


Figure 3.1: Anti-Fatigue Mat

3.1.2 Questionnaire

i) Pre-survey questionnaire

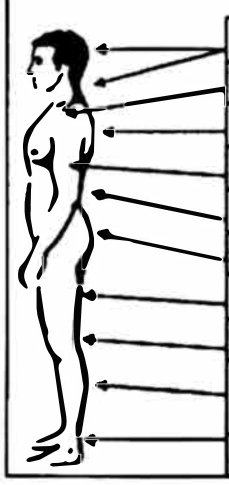
All respondents had answered a pre-survey questionnaire before they decided to voluntarily participate in the study that consists age, heavy activity, sport activity, sleep hours, body mass index and health information. Finally, the procedure was explained and the informed consent letter was distributed (Karmegam et al., 2012). The respondents can withdraw from the study at any time if feeling discomfort during the study.

ii) Questionnaire (Borg Scale Measurement)

There were two parts in the questionnaire. The first part was used to get the personal information of the students participating in the study. In the second part, a body chart of discomfort using the Borg's scale (with numbers supported by written expression) was used to assess the degree of subjective discomfort on the body part (Karmegam et al., 2012). This Borg scale created by Dr. Gunnar Borg in 1982 rated exertion on a 6-20 scale. Then, it been constructed a category (C) ratio (R) scale, it called Borg CR-10 scale. This scale usually been used in clinical diagnosis musculoskeletal pain. The scale starts with "nothing at all," which rates a 0, and ends with "extremely strong," which rates a 10. Moderate activities register 3 to 4 on the Borg scale ("moderate") while vigorous activities usually rate a 5 or higher ("strong" to "very strong") which is the break point. (scale > 5)

Nothing at all		Extremely weak		Very weak		Weak		Moderate		Strong		Very strong		Extremely strong	
0	0.3	0.5	0.7	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10

Figure 3.2: The Borg CR-10 Scale (Borg, 1982)



	Nothing at all		Extremely weak		Very weak		Weak		Moderate		Strong		Very strong		Extremely strong	
	0	0.3	0.5	0.7	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10
Neck or head																
Shoulder																
Upper back																
Arms & hands																
Low back																
Buttocks																
Thigh																
Knees																
Calf (les below knee)																
Ankle & feet																

Figure 3.3: The body chart discomfort using Borg CR-10 scale (Karmegam et. al, 2011)

3.1.3 Workstation setting

Participants (control group) were stood for 2 hours in two different sessions (without anti-fatigue mat only) and participants (experimental group) were stood for 2 hours in two different sessions (with the anti-fatigue mat) in a quiet room in multi-purpose laboratory 1 with air conditioning at 26 ^{0}C and adequate lighting. Other than that, the participants were provided with the standard shoes during the data collection. Each session lasts for 2 hours. Meanwhile, the respondents have sorted the mixed items and separated them in specific boxes on the table based on the color of the items (Sartika & Dawal, 2010). An adjustable table that followed the suggested criteria mentions by DOSH (2002) in their Guidelines on Occupational Safety and Health for Standing at Work was used during the data collection.

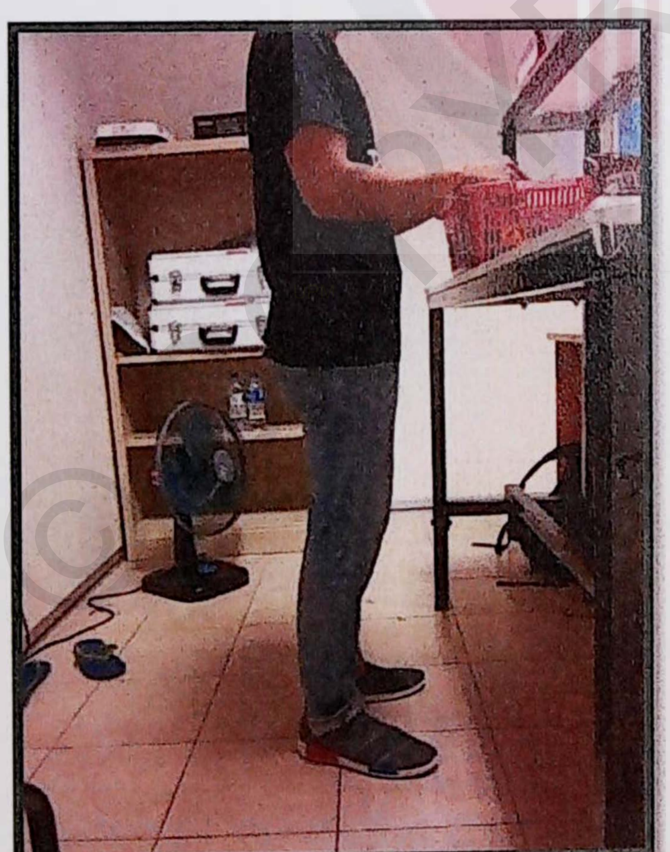


Figure 3.4: The respondent without intervention

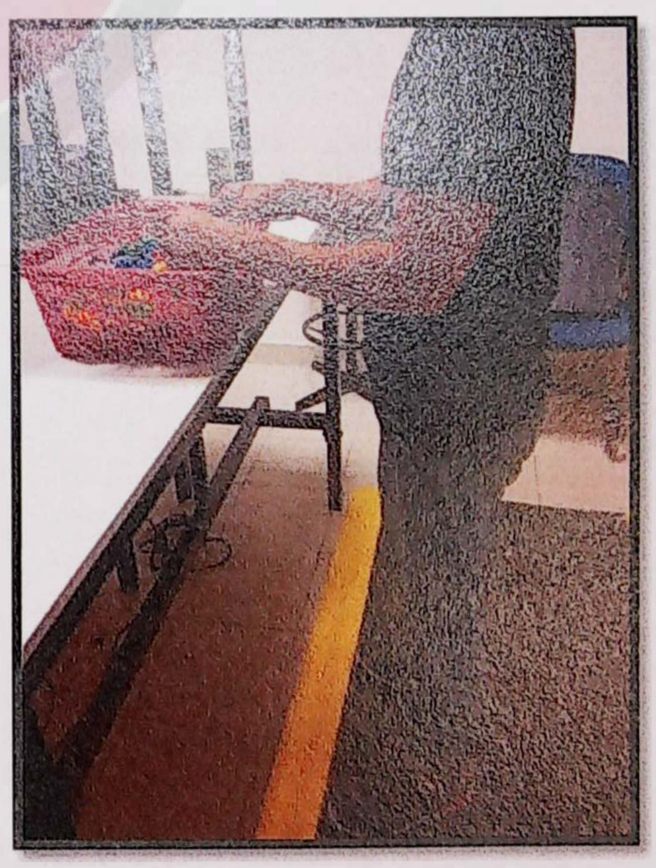


Figure 3.5: The respondent with intervention

Figure 3.6: The standard shoes wear by the respondents

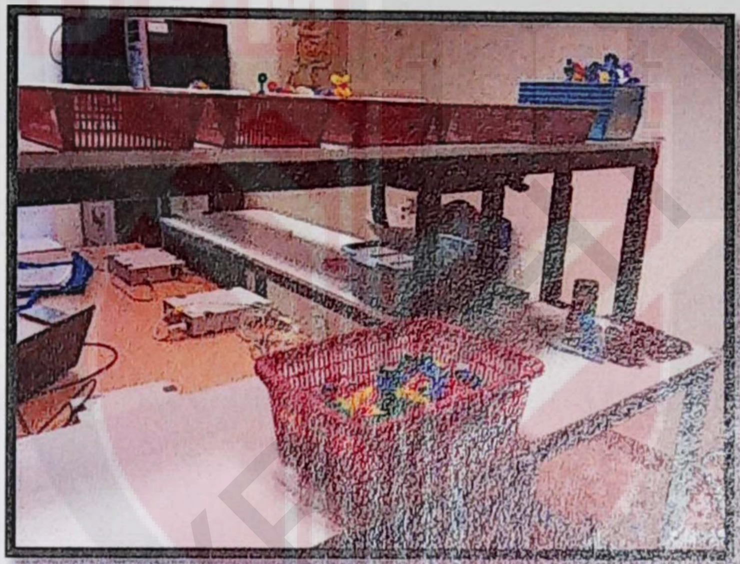


Figure 3.7: The adjustable table that been used

Figure 3.8: The mixed objects that respondents sorted (based on colour) in 2 hours

3.1.4 Measuring Tape and Weighing Scale

The respondents undergo a physical examination to identify their height and weight to ensure that the respondents fulfill the criteria of the study. Measuring tape has been used to measure the height while weighing scale used to measure the body weight of participants. This is important to determine the body mass index (BMI) of respondents. The measuring tape that been used is SECA Bodymeter and the weighing scale that been used is TANITA Digital Weighing Scale.

3.2 Data Collection Procedure

After getting the students' name of list from Student Affairs Division and Dean's Office at Faculty of Medicine and Health Sciences, UPM, collection of data began with the answering of pre-survey questionnaire and consent form to voluntary participated in the study. The respondents had to undergo physical examination (measure height and weight) to fulfill the study criteria. Then, the procedure of the experiment has been explained to the respondents briefly. The respondents were stood on the static posture in a controlled room in the laboratory for two hours and while sorting the mixed objects. The respondents were evaluated their discomfort level using Borg's scales questionnaire for every 15 minutes. For control group, the respondent stood without the anti-fatigue mat while the experimental group stood with the anti-fatigue mat.

3.3 Validity and Reliability

3.3.1 Pre-test

The 10% of the sample population has been calculated to recruit the respondents that not included in this study but also meet the inclusion and exclusion criteria to ensure the validity and reliability of this study.

3.3.2 Standard Operating Procedure

Standard Operating Procedure conducted including every instrument which is Weighing Scale and Measuring Tape.

3.4 Data analysis

The collected data was analyzed by using the univariate and bivariate analysis. All the variables are analyzed using the statistical computer software (Statistical Package Service and Solution Version 22 – SPSS 22).

Table 3.1: Data Analysis

Hypothesis / Specific Objective	Parametric Test
To determine data distribution of discomfort rating (Borg's Scale) between experimental and control groups for every body part.	Descriptive Analysis
To determine the discomfort 'break point' (Borg's Scale) between control and experimental groups for every body	Descriptive Analysis

part.	
To compare the differences of discomfort rating (Borg's Scale) between control and experimental groups.	Independent T-Test
To measure the association between leg and body parts muscle discomfort in experimental and control groups	Pearson correlation

3.5 Ethical Consideration

The approval of the study gained from the Ethic Committee, Universiti Putra Malaysia with the JKEUPM reference number FPSK(EXP16-OSH)U040. Furthermore, the participants need to sign the participation consent form before the questionnaire distributed. The consent form included this information:

- The respondent is willing to participate in the study.
- The nature and purpose of the study explained to the respondents.
- The likely involvement, in terms of time of the respondent.
- The respondents have opportunity to question the researcher.

CHAPTER 4

RESULT

4.0 Result

4.1 Study Background

This study was conducted at Faculty of Medicine and Health Sciences, UPM. Total respondents that participated in the study were 100 male students of University Putra Malaysia, including 50 respondents for control group and 50 respondents for experimental group. The range of age was between 18 to 25 years old. The study subject were included the Body Mass Index with normal range which 18.5 to 24.9.

4.2 Socio-demographic Information of Respondents

The detail background information of the respondents shows in Table 4.1. It was identified the most of the respondents have enough sleep with average sleep for seven hours per day (6.78±1.083) as inadequate sleep is one of the biological factors of muscle discomfort. They physically active when involved in sport (1.3±0.46) and 70% of the respondents not involved with heavy activities (1.7±0.46) as heavy activity one of the factors can contribute to the musculoskeletal disorder.

Table 4.1: Socio-demographic of students who involved in the study (N: 100)

Variables	**Mean ± SD**	
	Control Group	**Experimental Group**
Age	22.40 (1.979)	21.80 (1.616)
Body Mass Index	22.57 (1.73)	21.87 (1.98)
Sleep Hours	6.80 (1.18)	6.90 (0.707)
	Frequency (%)	
Heavy Activity		
Yes	15 (30)	15 (30)
No	35 (70)	35 (70)
Sport		
Yes	35 (70)	35 (70)
No	15 (30)	15 (30)
Health problem		
Yes	5 (10%)	0 (0)
No	45 (90)	50(100)

4.3 Comparison of Borg Scale of Discomfort Rating

4.3.1 Comparison of Borg Scale of Discomfort Rating between Control and Experimental Group for Head.

From the graph of Borg Scale of Discomfort Rating between control and experimental group in this study shows that there was no 'break point' of discomfort ≥5. The line graph in Figure 4.1 shows that the upward trend of head discomfort rating during 120 minutes testing period. The line graphs compare the level of Borg's scale discomfort rating in two groups (control group and experimental group). However, discomfort rating in experimental group always lower level than control group except at minutes 15. Overall, from the graphs, it was clear that the highest peak of discomfort rating at the end of session in control group was over 0.93 on the 10 points scale while 0.36 out of 10 points for experimental groups.

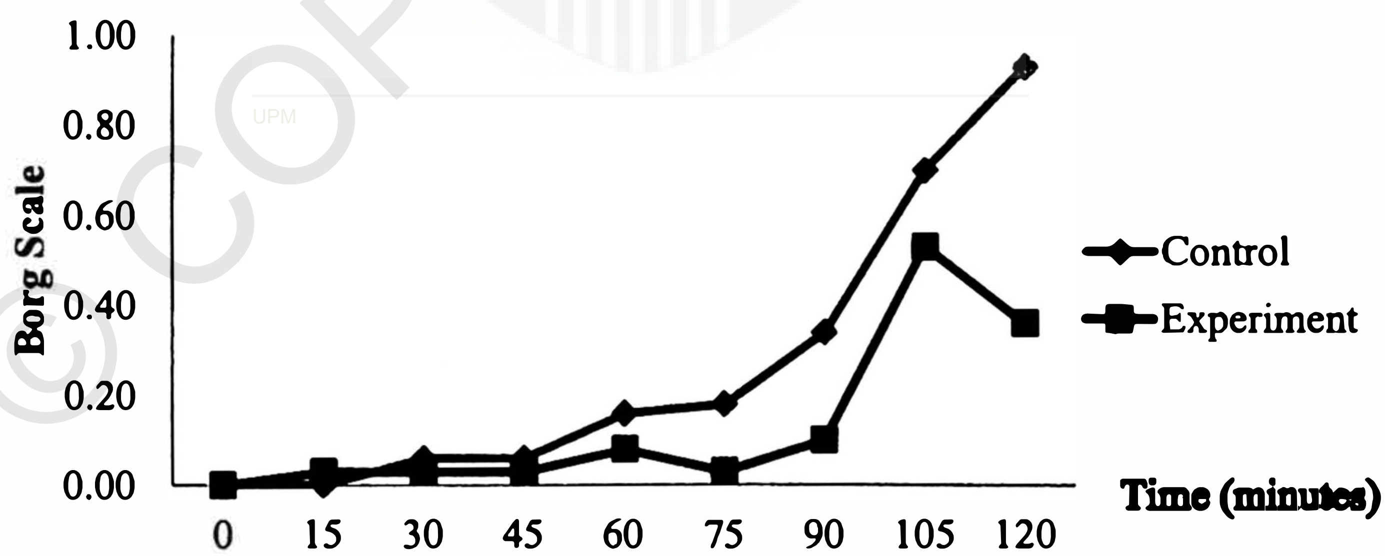


Figure 4.1: Graph of Borg Scale of Discomfort Rating between the control and experimental group for head

From Table 4.2, the data shows that the comfort level has increased when the respondents used anti-fatigue mat (experimental group) compared without anti-fatigue mat (control group). By using independent t-test this study has shows that there was a significant ($p<0.05$) difference of head discomfort between control and experimental group only at minutes 15, 60, 75, 90 and 120.

Table 4.2: Independent T-test of head discomfort between control and experimental group

Time	Mean (SD)		Mean Difference (95% CI)	t-value (df)	p-value
	Control	Experiment			
15	0 (0)	0.03 (0.0909)	-0.03 (-0.0558,-0.0042)	-2.333 (49)	0.024*
30	0.06 (0.1212)	0.03 (0.0909)	0.03 (-0.0126,0.0726)	1.400 (90.875)	0.165
45	0.06 (0.1212)	0.03 (0.0909)	0.03 (-0.0126,0.0726)	1.400 (90.875)	0.165
60	0.16 (0.2080)	0.08 (0.1678)	0.08 (0.0050,0.1550)	2.117 (93.807)	0.037*
75	0.18 (0.2295)	0.03 (0.0909)	0.15 (0.0803,0.2197)	4.297 (64.014)	0.000*
90	0.34 (0.4314)	0.10 (0.2213)	0.24 (0.1033,0.3767)	3.500 (73.119)	0.001*
105	0.70 (1.1632)	0.53 (1.0242)	0.17 (-0.2650,0.6050)	0.776 (98)	0.440
120	0.93 (1.3561)	0.36 (0.8969)	0.57 (0.1128,1.0272)	2.479 (84.986)	0.015*

* Significant difference p-value <0.05

4.3.2 Comparison of Borg Scale of Discomfort Rating between Control and Experimental Group for Shoulder.

From the graph of Borg Scale of Discomfort Rating between control and experimental group in this study shows that there was no 'break point' of discomfort ≥5. The line graph in Figure 4.2 shows that the upward trend of shoulder discomfort rating during 120 minutes testing period. The line graphs compare the level of Borg's scale discomfort rating in two groups (control group and experimental group). However, discomfort rating in experimental group always lower level than control group except at minutes 15. There was a big decrease of shoulder discomfort level between control and experimental group. Overall, from the graphs, it was clear that the highest peak of discomfort rating at the end of session in control group was over 1.39 on the 10 points scale while 0.28 out of 10 points for experimental groups.

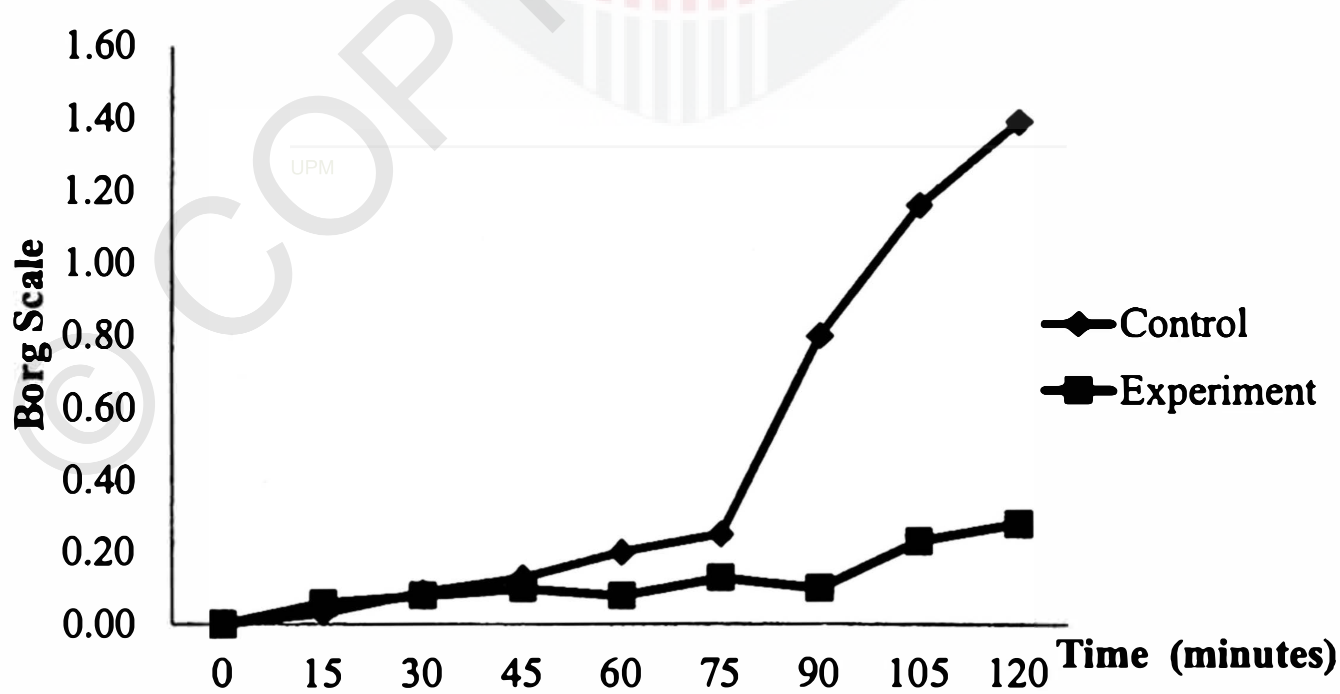


Figure 4.2: Graph of Borg Scale of Discomfort Rating between the control and experimental group for shoulder

From Table 4.3, the data shows that the comfort level has increased when the respondents used anti-fatigue mat (experimental group) compared without anti-fatigue mat (control group). By using independent t-test this study shows that there was a significant ($p<0.05$) difference of shoulder discomfort between control and experimental group only at minutes 60, 75, 90, 105 and 120.

Table 4.3: Independent T-test of shoulder discomfort between control and experimental group

Time	Mean (SD)		Mean Difference (95% CI)	t-value (df)	p-value
	Control	Experiment			
15	0.03 (0.0909)	0.60 (0.1212)	-0.03 (-0.0726,0.0126)	-1.400 (90.875)	0.165
30	0.09 (0.1398)	0.08 (0.1678)	0.01 (-0.0511,0.0711)	0.325 (98)	0.746
45	0.13 (0.2261)	0.10 (0.2213)	0.03 (-0.0588,0.1188)	0.670 (98)	0.504
60	0.20 (0.2634)	0.08 (0.1678)	0.12 (0.0321,0.2079)	2.717 (83.151)	0.008*
75	0.25 (0.2682)	0.13 (0.3066)	0.12 (0.0057,0.2343)	2.083 (98)	0.040*
90	0.80 (1.2446)	0.10 (0.2213)	0.70 (0.3413,01.0587)	3.916 (52.096)	< 0.001*
105	1.16 (1.5559)	0.23 (0.6028)	0.93 (0.4585,1.4015)	3.941 (63.386)	< 0.001*
120	1.39 (1.7481)	0.28 (0.7530)	1.11 (0.5726,1.6474)	4.124 (66.576)	< 0.001*

* Significant difference p-value <0.05

4.3.3 Comparison of Borg Scale of Discomfort Rating between Control and Experimental Group for Upper Back.

From the graph of Borg Scale of Discomfort Rating between control and experimental group in this study shows that there was no 'break point' of discomfort ≥5. The line graph in Figure 4.3 shows that the upward trend of upper back discomfort rating during 120 minutes testing period. The line graphs compare the level of Borg's scale discomfort rating in two groups (control group and experimental group). However, discomfort rating in experimental group always lower level than control group except at minutes 15. Overall, from the graphs, it was clear that the highest peak of discomfort rating at the end of session in control group was over 1.51 on the 10 point s scale while 0.89 out of 10 points for experimental groups.

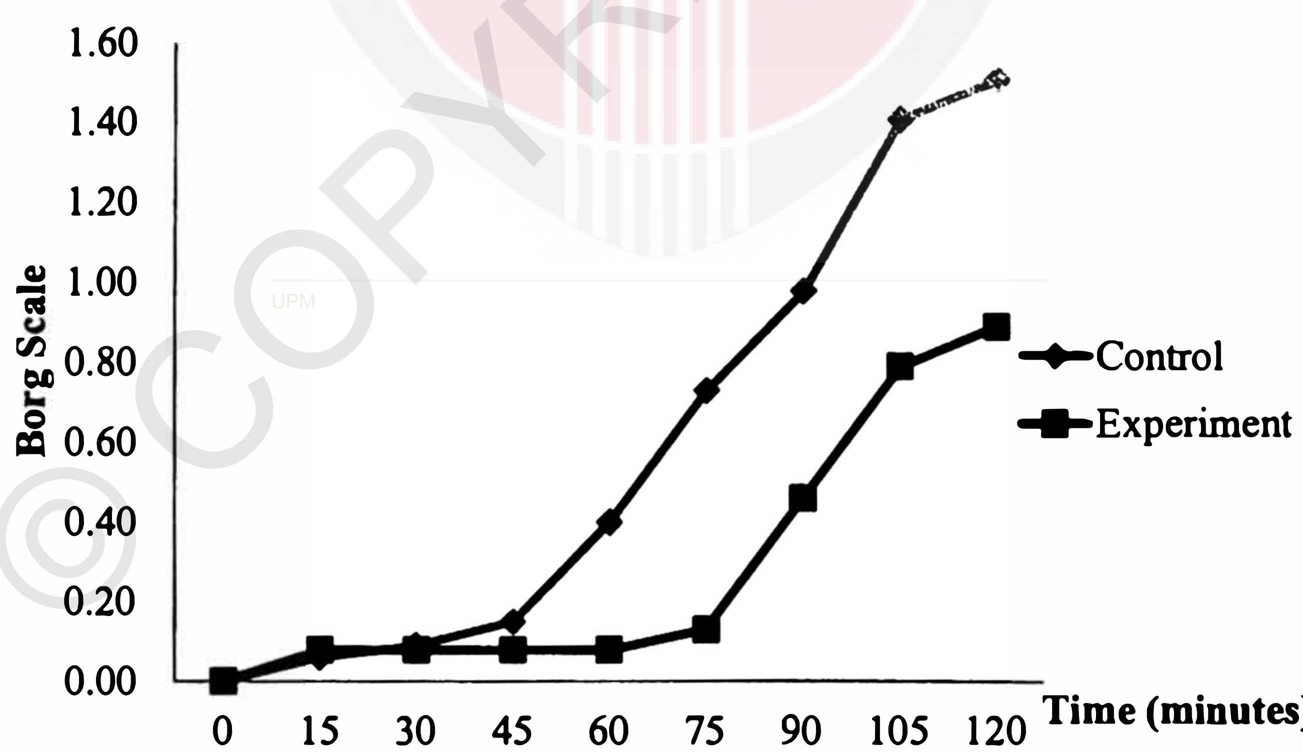


Figure 4.3: Graph of Borg Scale of Discomfort Rating between the control and experimental group for upper back

From Table 4.4, the data shows that the comfort level has increased when the respondents used anti-fatigue mat (experimental group) compared without anti-fatigue mat (control group). By using independent t-test this study shows that there was a significant ($p<0.05$) difference of upper back discomfort between control and experimental group only at minutes 60 and 75.

Table 4.4: Independent T-test of upper back discomfort between control and experimental group

Time	Mean (SD)		Mean Difference (95% CI)	t-value (df)	p-value
	Control	Experiment			
15	0.06 (0.1212)	0.08 (0.1678)	-0.02 (-0.0781,0.0381)	-0.683 (98)	0.496
30	0.09 (0.1389)	0.08 (0.1678)	0.01 (-0.0511,0.0711)	0.325 (98)	0.746
45	0.15 (0.2485)	0.08 (0.1678)	0.07 (-0.0143,0.1543)	1.651 (86.006)	0.102
60	0.40 (0.7478)	0.08 (0.1678)	0.32 (0.1027,0.5373)	2.952 (53.923)	0.005*
75	0.73 (1.4583)	0.13 (0.3066)	0.60 (0.1774,1.0226)	2.847 (53.322)	0.006*
90	0.98 (1.4748)	0.46 (1.1980)	0.52 (-0.0132,1.0532)	1.935 (98)	0.056
105	1.41 (1.7942)	0.79 (2.0954)	0.62 (-0.1542,1.3942)	1.589 (98)	0.115
120	1.51 (1.9067)	0.89 (2.3979)	0.62 (-0.2398,1.4798)	1.431 (98)	0.156

* Significant difference p-value <0.05

4.3.4 Comparison of Borg Scale of Discomfort Rating between Control and Experimental Group for Hand.

From the graph of Borg Scale of Discomfort Rating between control and experimental group in this study shows that there was no 'break point' of discomfort ≥5. The line graph in Figure 4.4 shows that the upward trend of hand discomfort rating during 120 minutes testing period. The line graphs compare the level of Borg's scale discomfort rating in two groups (control group and experimental group). However, discomfort rating in experimental group always lower level than control group. There was a big decreased in hand discomfort between control and experimental groups. Overall, from the graphs, it was clear that the highest peak of discomfort rating at the end of session in control group was over 0.66 on the 10 points scale while 0.03 out of 10 points for experimental groups.

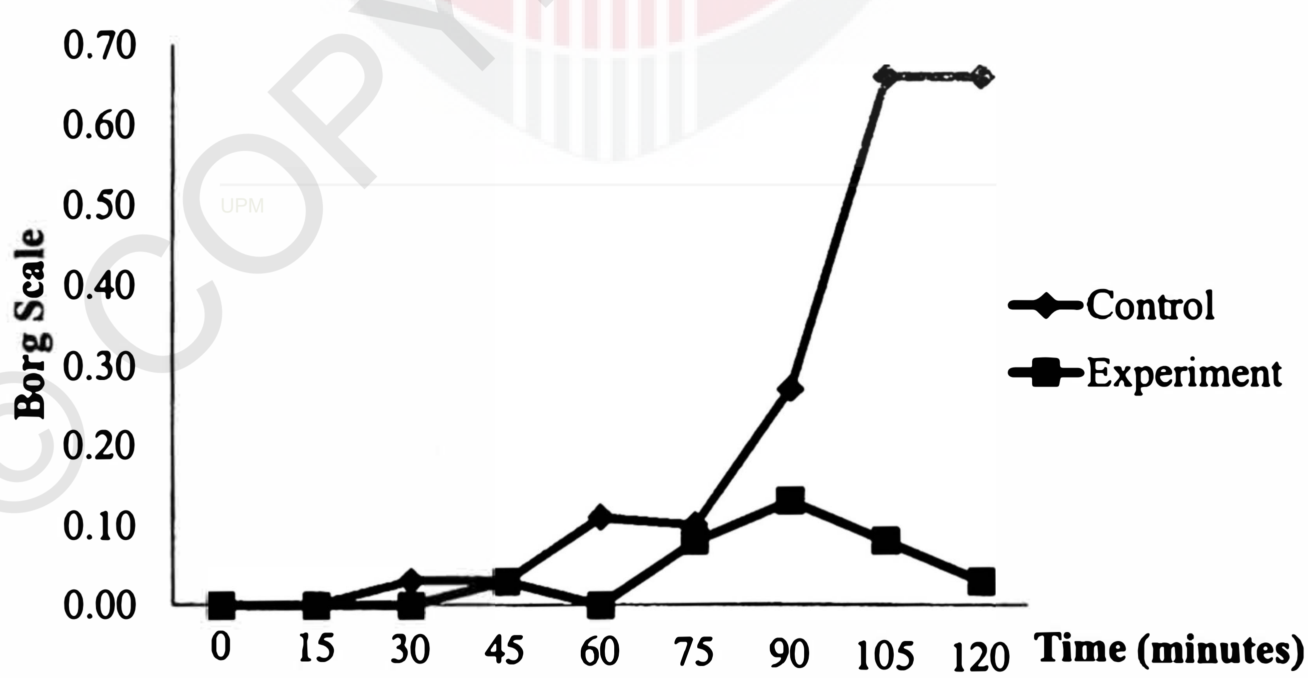


Figure 4.4: Graph of Borg Scale of Discomfort Rating between the control and experimental group for hand

From Table 4.5, the data shows that the comfort level has increased when the respondents used anti-fatigue mat (experimental group) compared without anti-fatigue mat (control group). By using independent t-test this study shows that there was a significant ($p<0.05$) difference of hand discomfort between control and experimental group only at minutes 30, 60, 90,105 and 120.

Table 4.5: Independent T-test of hand discomfort between control and experimental group

Time	Mean (SD)		Mean Difference (95% CI)	t-value (df)	p-value
	Control	Experiment			
30	0.03 (0.0909)	0 (0)	0.03 (0.0042,0.0558)	2.333 (49)	0.024*
45	0.03 (0.0909)	0.03 (0.0909)	0 (-0.0361,0.0361)	0.000 (98)	1.000
60	0.11 (0.1776)	0 (0)	0.11 (0.0595,0.1605)	4.380 (49)	< 0.001*
75	0.10 (0.2020)	0.08 (0.1678)	0.02 (-0.0537,0.0937)	0.538 (98)	0.591
90	.0.27 (0.4239)	0.13 (0.2073)	0.14 (0.0069,0.2731)	2.098 (71.162)	0.039*
105	0.66 (1.1877)	0.08 (0.1678)	0.58 (0.2394,0.9206)	3.419 (50.956)	0.001*
120	0.66 (1.1877)	0.03 (0.0909)	0.63 (0.2916,0.9684)	3.740 (49.574)	< 0.001*

* Significant difference p-value <0.05

4.3.5 Comparison of Borg Scale of Discomfort Rating between Control and Experimental Group for Lower Back.

From the graph of Borg Scale of Discomfort Rating between control and experimental group in this study shows that there was no 'break point' of discomfort ≥5. The line graph in Figure 4.5 shows that the upward trend of lower back discomfort rating during 120 minutes testing period. The line graphs compare the level of Borg's scale discomfort rating in two groups (control group and experimental group). However, discomfort rating in experimental group always lower level than control group. Overall, from the graphs, it was clear that the highest peak of discomfort rating at the end of session in control group was over 2.29 on the 10 points scale while 1.78 out of 10 points for experimental groups.

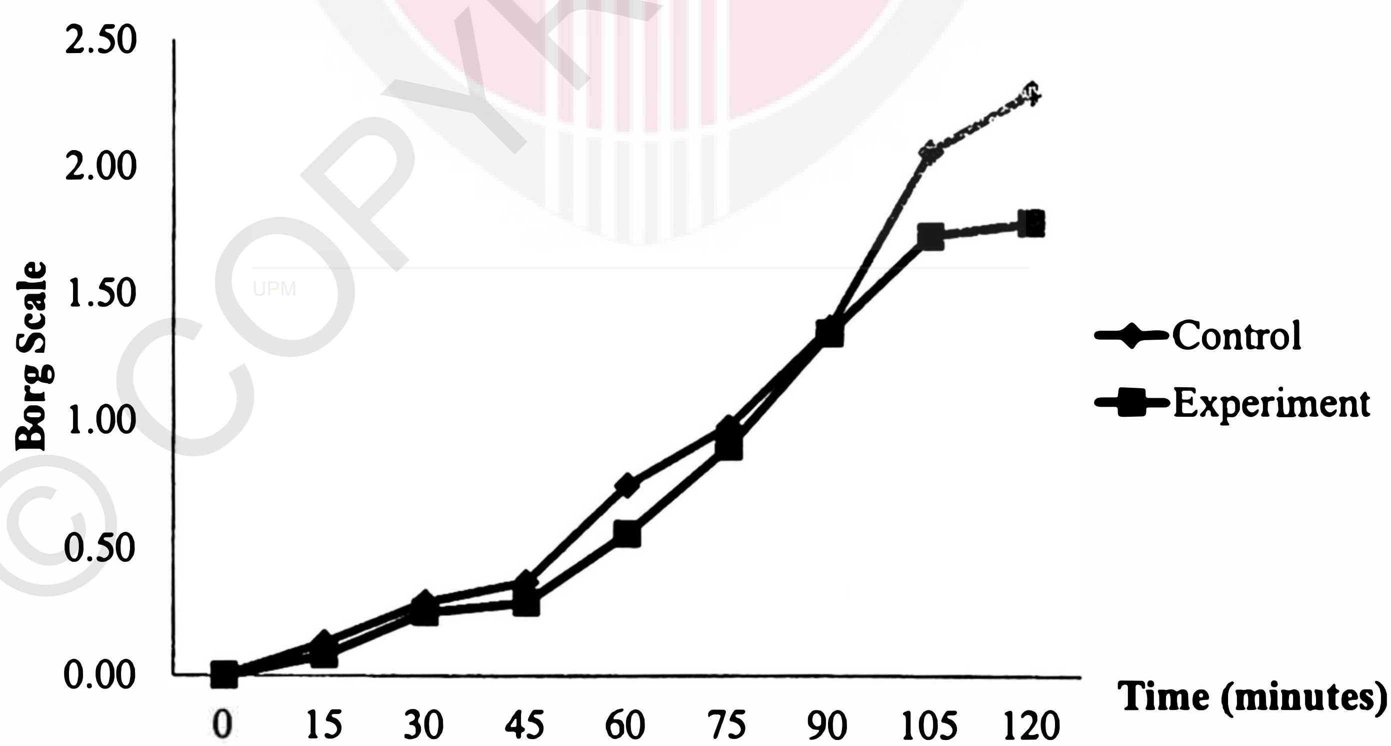


Figure 4.5: Graph of Borg Scale of Discomfort Rating between the control and experimental group for lower back

From Table 4.6, the data shows that the comfort level has increased when the respondents used anti-fatigue mat (experimental group) compared without anti-fatigue mat (control group). By using independent t-test this study shows that there was not a significant ($p<0.05$) difference of lower back discomfort between control and experimental group at every minute.

Table 4.6: Independent T-test of lower back discomfort between control and experimental group

Time	Mean (SD)		Mean Difference (95% CI)	t-value (df)	p-value
	Control	Experiment			
30	0.29 (0.3079)	0.25 (0.2901)	0.04 (-0.0787,0.1587)	0.669 (98)	0.505
45	0.37 (0.3382)	0.29 (0.4437)	0.08 (-0.0766,0.2366)	1.014 (98)	0.313
60	0.75 (0.6929)	0.56 (0.8526)	0.19 (-0.1183,0.4983)	1.223 (98)	0.224
75	0.98 (1.3871)	0.90 (1.4128)	0.08 (-0.4757,0.6357)	0.286 (98)	0.776
90	1.37 (1.4393)	1.35 (1.7527)	0.02 (-0.6165,0.6565)	0.062 (98)	0.950
105	2.06 (1.8975)	1.73 (2.2642)	0.33 (-0.4991,01.1591)	0.790 (98)	0.432
120	2.29 (2.1138)	1.78 (2.4061)	0.51 (-0.3888,1.4088)	1.126 (98)	0.263

* Significant difference p-value <0.05

4.3.6 Comparison of Borg Scale of Discomfort Rating between Control and Experimental Group for Buttocks.

From the graph of Borg Scale of Discomfort Rating between control and experimental group in this study shows that there was no 'break point' of discomfort ≥5. The line graph in Figure 4.6 shows that the upward trend of buttocks discomfort rating during 120 minutes testing period. The line graphs compare the level of Borg's scale discomfort rating in two groups (control group and experimental group). However, discomfort rating in experimental group always lower level than control group except at minutes 90. Overall, from the graphs, it was clear that the highest peak of discomfort rating at the end of session in control group was over 1.46 on the 10 points scale while 0.77 out of 10 points for experimental groups.

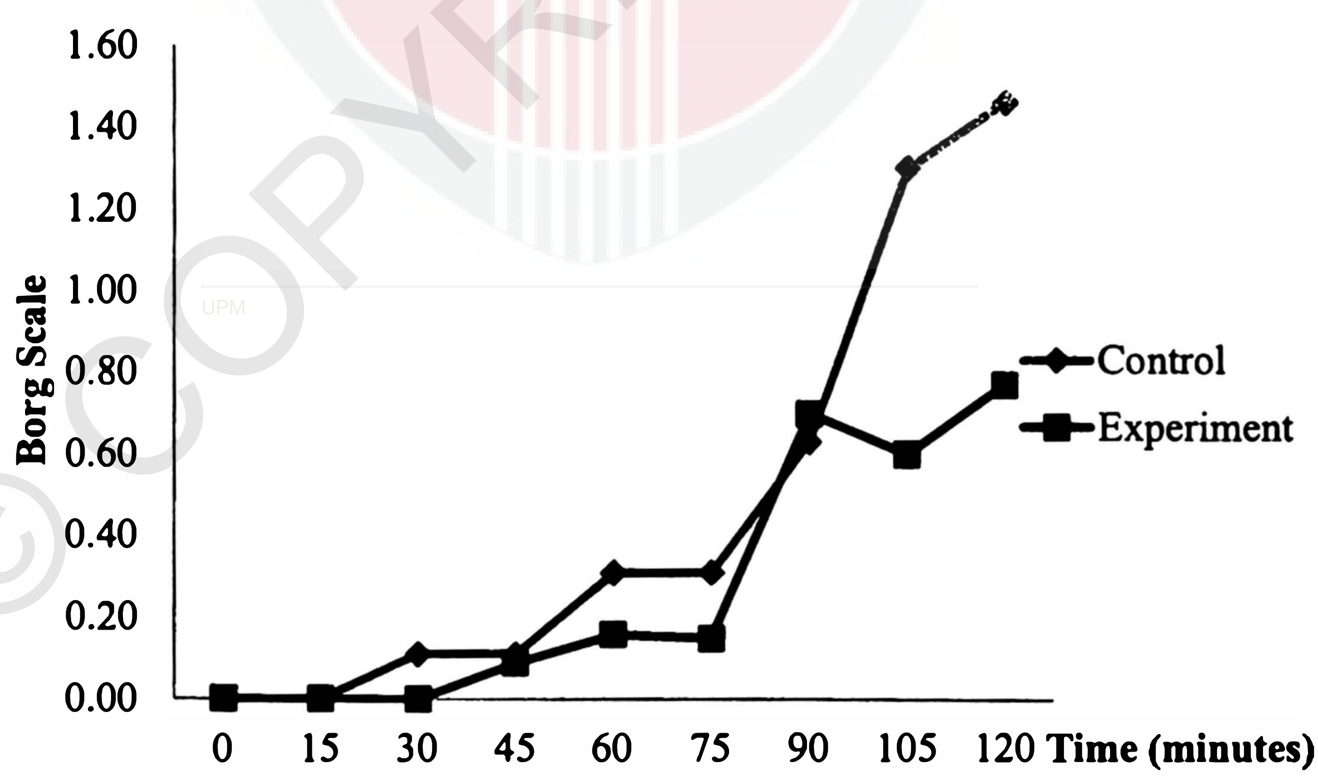


Figure 4.6: Graph of Borg Scale of Discomfort Rating between the control and experimental group for buttocks

From Table 4.7, the data shows that the comfort level has increased when the respondents used anti-fatigue mat (experimental group) compared without anti-fatigue mat (control group). By using independent t-test this study shows that there was a significant ($p<0.05$) difference of buttocks discomfort between control and experimental group only at minutes 30, 60, 75, 105 and 120.

Table 4.7: Independent T-test of buttocks discomfort between control and experimental group

Time	Mean (SD)		Mean Difference (95% CI)	t-value (df)	p-value
	Control	Experiment			
30	0.11 (0.1776)	0 (0)	0.11 (0.0595,0.1605)	4.380 (49)	0.000*
45	0.11 (0.1776)	0.09 (0.1389)	0.02 (-0.0433,0.0833)	0.627 (92.622)	0.532
60	0.31 (3.144)	0.16 (0.2080)	0.15 (0.0440,0.2560)	2.813 (84.99)	0.006*
75	0.31 (0.3144)	0.15 (0.2485)	0.16 (0.0475,0.2725)	2.823 (98)	0.006*
90	0.63 (0.9148)	0.70 (1.5017)	-0.07 (-0.5635,0.4235)	-0.281 (98)	0.779
105	1.30 (1.8947)	0.60 (0.9302)	0.70 (0.1049,1.2951)	2.345 (71.325)	0.022*
120	1.46 (1.8611)	0.77 (1.0420)	0.69 (0.0893,1.2907)	2.287 (76.973)	0.025*

* Significant difference p-value <0.05

4.3.7 Comparison of Borg Scale of Discomfort Rating between Control and Experimental Group for Thigh.

From the graph of Borg Scale of Discomfort Rating between control and experimental group in this study shows that there was no 'break point' of discomfort ≥5. The line graph in Figure 4.7 shows that the upward trend of thigh discomfort rating during 120 minutes testing period. The line graphs compare the level of Borg's scale discomfort rating in two groups (control group and experimental group). However, discomfort rating in experimental group always lower level than control group. Overall, from the graphs, it was clear that the highest peak of discomfort rating at the end of session in control group was over 2.32 on the 10 points scale while 1.32 out of 10 points for experimental groups.

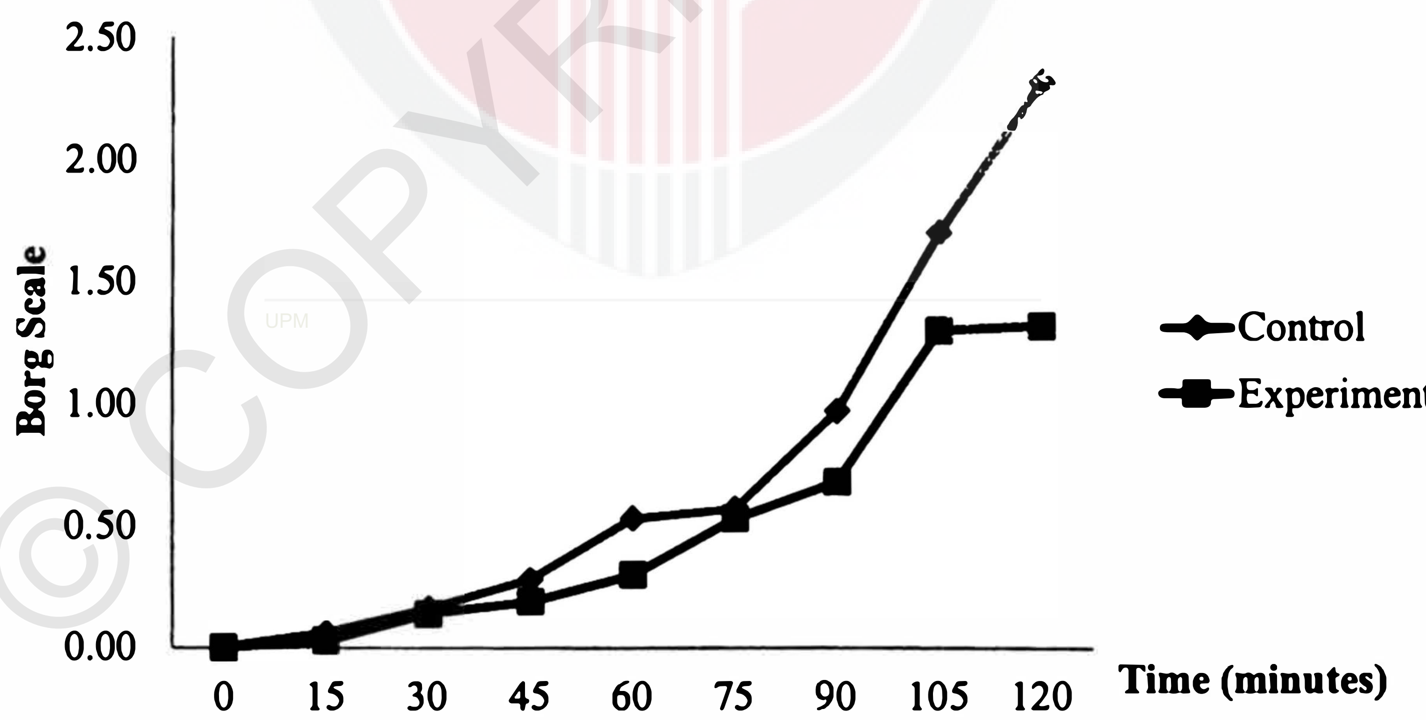


Figure 4.7: Graph of Borg Scale of Discomfort Rating between the control and experimental group for thigh

From Table 4.8, the data shows that the comfort level has increased when the respondents used anti-fatigue mat (experimental group) compared without anti-fatigue mat (control group). By using independent t-test this study shows that there was a significant ($p<0.05$) difference of thigh discomfort between control and experimental group only at minutes 60 and 120.

Table 4.8: Independent T-test of thigh discomfort between control and experimental group

Time	Mean (SD) Control	Mean (SD) Experiment	Mean Difference (95% CI)	t-value (df)	p-value
30	0.16 (0.2080)	0.14 (0.1818)	0.02 (-0.0575,0.0975)	0.512 (98)	0.610
45	0.28 (0.2548)	0.19 (0.2234)	0.09 (-0.0051,0.1851)	1.878 (98)	0.063
60	0.53 (0.3099)	0.30 (0.3350)	0.23 (0.1019,0.3581)	3.564 (98)	0.001*
75	0.57 (0.3032)	0.53 (0.5856)	0.04 (-0.1459,0.2259)	0.429 (73.510)	0.669
90	0.97 (0.7600)	0.68 (0.8581)	0.29 (0.0069,0.2731)	1.789 (98)	0.077
105	1.70 (1.4701)	1.30 (1.5017)	0.40 (-0.1898,0.9898)	1.346 (98)	0.181
120	2.32 (1.7472)	1.32 (1.7443)	1.00 (0.3071,1.6929)	2.864 (98)	0.005*

* Significant difference p-value <0.05

4.3.8 Comparison of Borg Scale of Discomfort Rating between Control and Experimental Group for Knee.

From the graph of Borg Scale of Discomfort Rating between control and experimental group in this study shows that there was no 'break point' of discomfort ≥5. The line graph in Figure 4.8 shows that the upward trend of knee discomfort rating during 120 minutes testing period. The line graphs compare the level of Borg's scale discomfort rating in two groups (control group and experimental group). However, discomfort rating in experimental group always lower level than control group. Overall, from the graphs, it was clear that the highest peak of discomfort rating at the end of session in control group was over 3.10 on the 10 points scale while 1.85 out of 10 points for experimental groups.

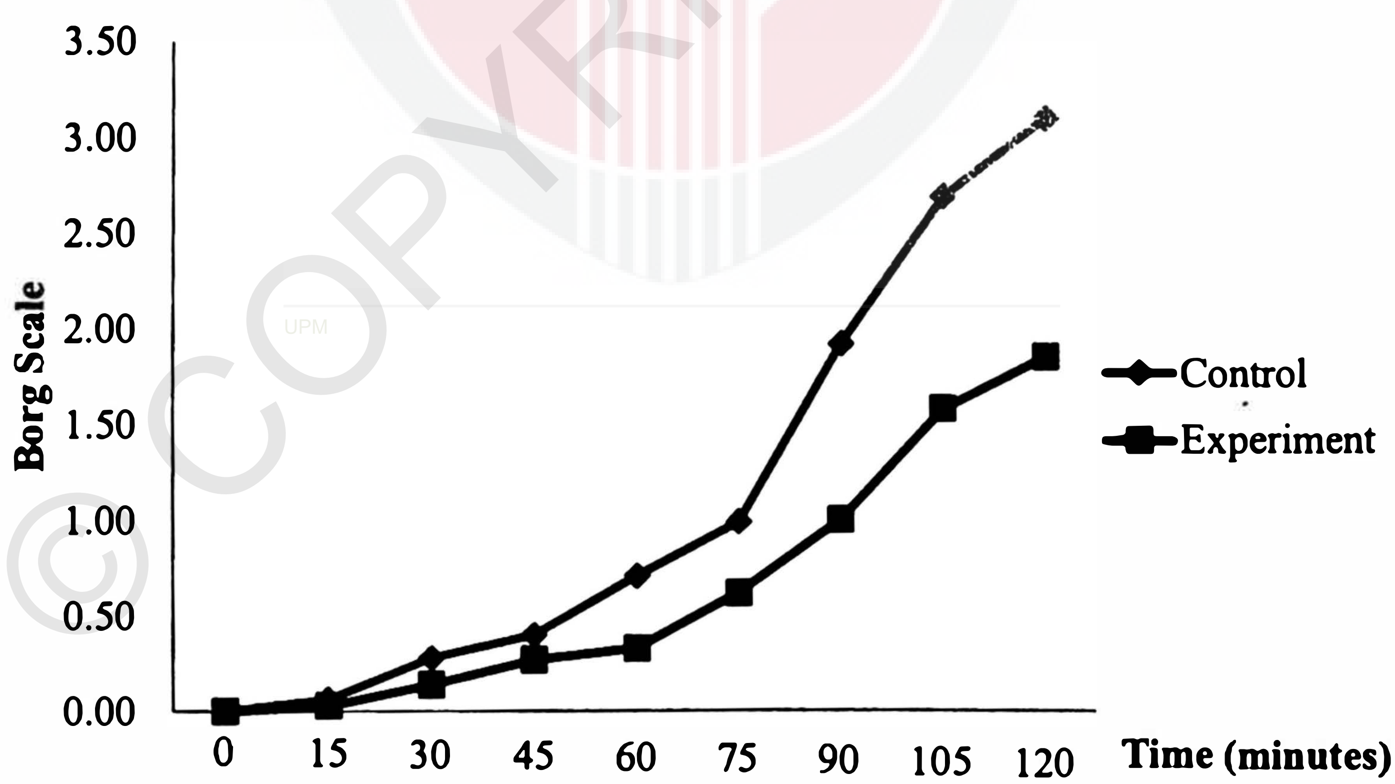


Figure 4.8: Graph of Borg Scale of Discomfort Rating between the control and experimental group for knee

From Table 4.9, the data shows that the comfort level has increased when the respondents used anti-fatigue mat (experimental group) compared without anti-fatigue mat (control group). By using independent t-test this study shows that there was a significant ($p<0.05$) difference of knee discomfort between control and experimental group at every minute.

Table 4.9: Independent T-test of knee discomfort between control and experimental group

Time	Mean (SD)		Mean Difference (95% CI)	t-value (df)	p-value
	Control	Experiment			
30	0.28 (0.2548)	0.14 (0.1818)	0.14 (0.0520,0.2280)	3.163 (88.638)	0.002*
45	0.40 (0.2556)	0.27 (0.2929)	0.13 (0.0209,0.2391)	2.365 (96.228)	0.020*
60	0.71 (0.3079)	0.33 (0.3196)	0.38 (0.2555,0.5045)	6.055 (98)	< 0.001*
75	0.99 (0.5541)	0.62 (0.6058)	0.37 (0.1396,0.6004)	3.187 (98)	0.002*
90	1.92 (1.1238)	1.00 (1.1066)	0.92 (0.4774,1.3626)	4.125 (97.977)	< 0.001*
105	2.69 (1.9131)	1.58 (1.7165)	1.11 (0.3886,1.8314)	3.054 (98)	0.003*
120	3.10 (1.9272)	1.85 (1.9568)	1.25 (0.4792,2.0208)	3.218 (98)	0.002*

* Significant difference p-value <0.05

4.3.9 Comparison of Borg Scale of Discomfort Rating between Control and Experimental Group for Calf.

From the graph of Borg Scale of Discomfort Rating between control and experimental group in this study shows that there was no 'break point' of discomfort ≥5. The line graph in Figure 4.9 shows that the upward trend of calf discomfort rating during 120 minutes testing period. The line graphs compare the level of Borg's scale discomfort rating in two groups (control group and experimental group). However, discomfort rating in experimental group always lower level than control group. Overall, from the graphs, it was clear that the highest peak of discomfort rating at the end of session in control group was over 4.10 on the 10 points scale while 2.54 out of 10 points for experimental groups.

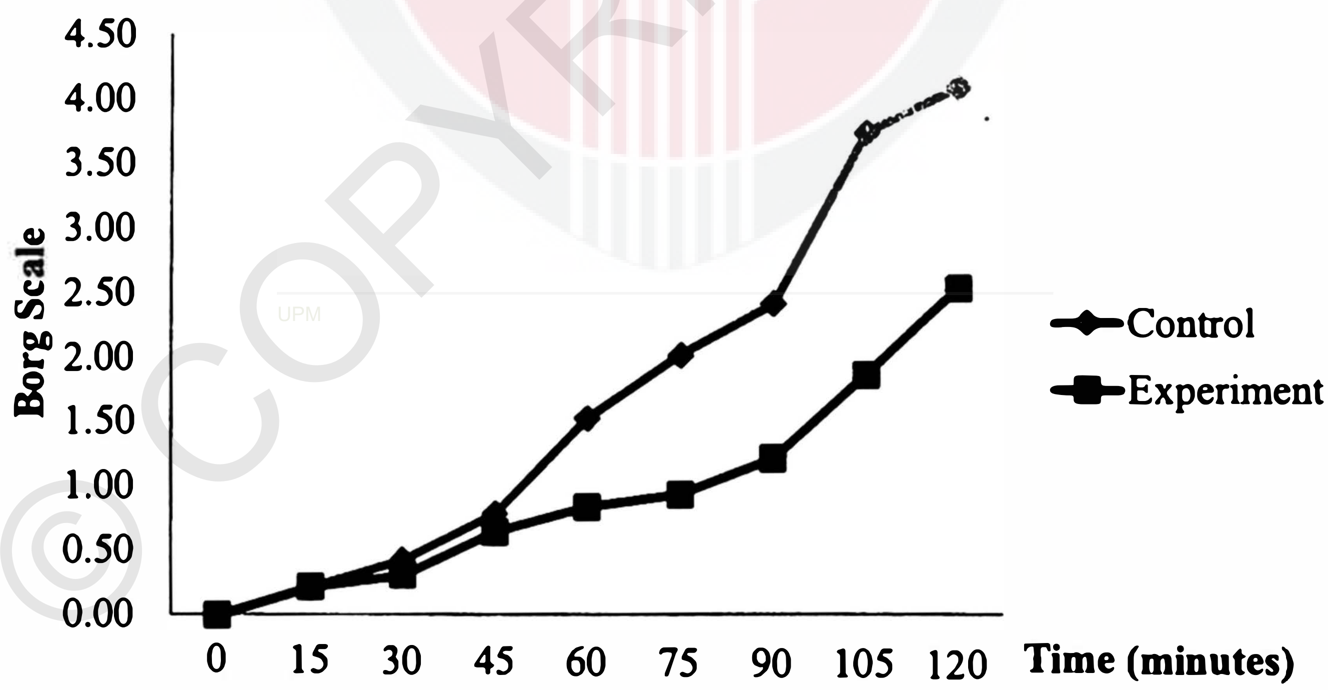


Figure 4.9: Graph of Borg Scale of Discomfort Rating between the control and experimental group for calf

From Table 4.10, the data shows that the comfort level has increased when the respondents used anti-fatigue mat (experimental group) compared without anti-fatigue mat (control group). By using independent t-test this study shows that there was a significant ($p<0.05$) difference of calf discomfort between control and experimental group only at minutes 30, 60, 75, 90, 105 and 120.

Table 4.10: Independent T-test of calf discomfort between control and experimental group

Time	Mean (SD)		Mean Difference (95% CI)	t-value (df)	p-value
	Control	Experiment			
30	0.43 (0.3032)	0.31 (0.2367)	0.12 (0.0120,0.2280)	2.206 (98)	0.030*
45	0.79 (0.6035)	0.65 (0.5156)	0.14 (-0.0828,0.3628)	1.247 (98)	0.215
60	1.53 (1.3477)	0.84 (1.0797)	0.69 (0.2051,1.1749)	2.825 (93.546)	0.006*
75	2.02 (1.8052)	0.94 (0.7643)	1.08 (0.5265,1.6335)	3.896 (66.018)	< 0.001*
90	2.42 (1.6805)	1.22 (1.3686)	1.20 (0.5914,1.8086)	3.915 (94.141)	< 0.001*
105	3.75 (2.1695)	1.87 (1.9060)	1.88 (1.0694,2.6906)	4.603 (96.401)	< 0.001*
120	4.10 (2.1285)	2.54 (2.3897)	1.56 (0.6619,2.4581)	3.447 (98)	0.001*

* Significant difference p-value <0.05

4.3.10 Comparison of Borg Scale of Discomfort Rating between Control and Experimental Group for Feet.

From the graph of Borg Scale of Discomfort Rating between control and experimental group in this study shows that there was no 'break point' of discomfort ≥5. The line graph in Figure 4.10 shows that the upward trend of feet discomfort rating during 120 minutes testing period. The line graphs compare the level of Borg's scale discomfort rating in two groups (control group and experimental group). However, discomfort rating in experimental group always lower level than control group. Overall, from the graphs, it was clear that the highest peak of discomfort rating at the end of session in control group was over 4.50 on the 10 points scale while 2.77 out of 10 points for experimental groups.

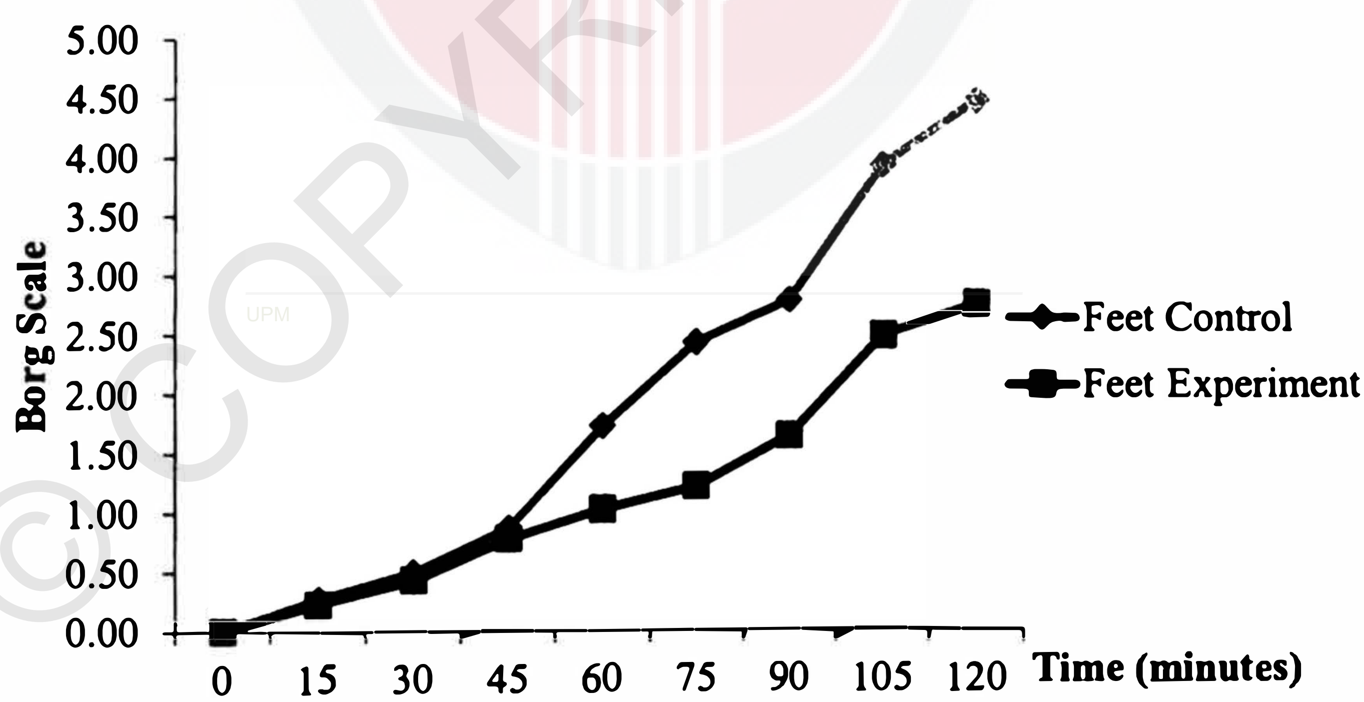


Figure 4.10: Graph of Borg Scale of Discomfort Rating between the control and experimental group for feet

From Table 4.11, the data shows that the comfort level has increased when the respondents used anti-fatigue mat (experimental group) compared without anti-fatigue mat (control group). By using independent t-test this study shows that there was a significant (p<0.05) difference of feet discomfort between control and experimental group only at minutes 60, 75, 90, 105 and 120.

Table 4.11: Independent T-test of feet discomfort between control and experimental group

Time	Mean (SD) Control	Mean (SD) Experiment	Mean Difference (95% CI)	t-value (df)	p-value
30	0.50 (0.1807)	0.43 (0.4404)	0.07 (-0.0645,0.2045)	1.040 (65.042)	0.302
45	0.87 (0.6390)	0.78 (0.7770)	0.09 (-0.1923,0.3723)	0.633 (98)	0.528
60	1.73 (1.6061)	1.03 (1.1057)	0.70 (0.1519,1.2481)	2.538 (86.926)	0.013*
75	2.44 (2.0811)	1.22 (1.4083)	1.22 (0.5136,1.9264)	3.433 (86.097)	0.001*
90	2.80 (1.8925)	1.65 (1.5520)	1.15 (0.4631,1.8369)	3.322 (98)	0.001*
105	3.95 (2.2974))	2.50 (2.4011)	1.45 (0.5174,2.3826)	3.085 (98)	0.003*
120	4.50 (2.5951)	2.77 (2.8183)	1.73 (0.6548,2.8052)	3.193 (98)	0.002*

* Significant difference p-value <0.05

4.4 Correlation between age, heavy work and sleep hours with all body part discomfort among two groups.

From Table 4.12, most of the data showed that there were a moderate positive correlation between the sleep hours with all body parts discomfort level among control and experimental group. The result also showed that there were statistically significant ($p<0.05$) differences of most of body parts and sleep hours. For correlation between age and body parts discomfort, most of the data showed there were weak positive correlations between age and body parts discomfort level in the two groups. The result showed only some of the body showed that there were significant differences between age and body parts in the two groups which were in control group hand ($r = 0.298$, $p<0.05$), knees ($r = 0.3367$, $p<0.05$), and feet ($r = 0.516$, $p<0.05$), while in experimental group only hand ($r = 0.875$, $p<0.001$). For the correlation between body mass index (BMI) and body parts, most of the data showed positive weak correlation but there were statistically significant ($p<0.05$) differences of most of body parts and body mass index (BMI)..

Table 4.12: Correlation between age, body mass index and sleep hours with all body part discomfort among two groups.

Group	Variables	Age		Body mass index		Sleep hours	
		r-value	p-value	r-value	p-value	r-value	p-value
Control group	Head	0.208	0.147	0.524*	<0.001	0.464*	0.001
	Shoulder	0.196	0.173	0.490*	<0.001	0.569*	<0.001
	Upper back	0.188	0.191	0.460	0.001	0.578*	<0.001
	Hand	0.298*	0.036	0.294*	0.038	0.512*	<0.001
	Lower back	0.111	0.444	0.329*	0.020	0.610*	<0.001
	Buttocks	0.165	0.252	0.280*	0.049	0.569*	<0.001
	Thigh	-0.032	0.826	0.551*	<0.001	0.344*	0.014
	Knees	0.337*	0.017	0.409*	0.003	0.436*	0.002
	calf	0.269	0.059	0.418*	0.003	0.598*	<0.001
	Feet	0.516*	<0.001	0.317*	0.025	0.567*	<0.001
Experimental group	Head	-0.076	0.600	-0.560*	<0.001	0.464*	0.001
	Shoulder	0.148	0.306	0.435*	0.002	0.569*	<0.001
	Upper back	0.055	0.706	0.474*	0.001	0.578*	<0.001
	Hand	0.875*	<0.001	-0.283*	0.046	0.512*	<0.001
	Lower back	-0.040	0.781	0.473*	0.001	0.610*	<0.001
	Buttocks	-0.088	0.541	-0.050	0.728	0.569*	<0.001
	Thigh	0.052	0.719	0.653*	<0.001	0.344*	0.014
	Knees	0.216	0.132	0.482*	<0.001	0.436*	0.002
	calf	-0.154	0.286	0.398*	0.004	0.598*	<0.001
	Feet	0.113	0.435	0.320*	0.023	0.567*	<0.001

*Correlation is significant at the 0.05 level (p-value).

4.5 Correlation between feet and body parts discomfort among control and experimental group.

Pearson correlation coefficients were calculated between each of body parts discomfort to determine the strength of their relationships. From Table 4.13, the data shown that there were a strong positive correlation ($r > 0.76$) between the feét discomfort level with the knees and calves discomfort level ($r = 0.791$, $p < 0.05$ and $r = 0,873$, $p < 0.05$ respectively) that associated with floor condition for control group and for experimental group there were strong positive correlation between the feet discomfort and calves ($r = 0.95$), knees ($r = 0.859$), lower back ($r = 0.933$), upper back ($r =0.739$), thigh ($r = 0.714$) and shoulder ($r = 0.752$). There is also week positive correlation between feet discomfort and the shoulder ($r = 0.463$), upper back ($r = 0.388$), hand ($r = 0.25$), and buttocks($r = 0.116$) discomfort during standing on the mat in control group. For experimental group showed weak positive correlation between the feet discomfort and the head, hand and buttocks discomfort level ($r = -0.172$, $p> 0.05$, $r = 0.027$, $p > 0.05$ and $r = -0.031$, $p > 0.05$ respectively). Majority of the data showed that they were positive strong correlation between lower extremities. The results showed there are significant differences in relationship between each body parts except between the feet discomfort and buttocks discomfort.

Table 4.13: Correlation between feet and body parts discomfort among control and experimental group.

Others body part	Feet			
	Control Group		Experimental group	
	Coefficient, (r)[a]	p-value	Coefficient, (r)[a]	p-value
Head	0.623*	< 0.001	-0.172	0.231
Shoulder	0.463*	0.001	0.752*	< 0.001
Upper back	0.388*	0.005	0.739*	< 0.001
Hand	0.250	0.080	0.027	0.850
Lower back	0.448*	0.001	0.933*	< 0.001
Buttocks	0.116	0.422	-0.031	0.833
Thigh	0.465*	0.001	0.714*	< 0.001
Knees	0.791*	< 0.001	0.859*	< 0.001
Calves	0.873*	< 0.001	0.950*	< 0.001

Table 4.14: Correlation between each body parts discomfort.

Others body part	Feet		Calves		Knees		Thigh		Buttocks		Lower Back		Hand		Upper Back		Shoulder	
	Coefficient, (r)	p-value	Coefficient, (r)	p-value	Coefficient, (r)	p-value	Coefficient, (r)	p-value	Coefficient, (r)	p-value	Coefficient, (r)	p-value	Coefficient, (r)	p-value	Coefficient, (r)	p-value	Coefficient, (r)	p-value
Head	0.335*	0.001	0.331*	0.001	0.506*	>0.01	0.503*	>0.01	0.680*	>0.01	0.425*	>0.01	0.646*	>0.01	0.387*	>0.01	0.651*	>0.01
Shoulder	0.564*	>0.01	0.571*	>0.01	0.786*	>0.01	0.825*	>0.01	0.603*	>0.01	0.798*	>0.01	0.603*	>0.01	0.853*	>0.01		
Upper back	0.599*	>0.01	0.619*	>0.01	0.803*	>0.01	0.855*	>0.01	0.403*	>0.01	0.886*	>0.01	0.36*	>0.01				
Hand	0.260*	0.009	0.325*	0.001	0.421*	>0.01	0.507*	>0.01	0.792*	>0.01	0.415*	>0.01						
Lower back	0.712*	>0.01	0.733*	>0.01	0.832*	>0.01	0.870*	>0.01	0.505*	>0.01								
Buttocks	0.123	0.224	0.197*	0.050	0.330*	0.001	0.495*	>0.01										
Thigh	0.628*	>0.01	0.666*	>0.01	0.899*	>0.01												
Knees	0.842*	>0.01	0.768*	>0.01														
Calves	0.924*	>0.01																

*Correlation is significant at the 0.05 level (p-value

CHAPTER 5

DISCUSSION

5.0 Discussion

5.1.1 Subject and Methods

In the study, all respondents have normal Body Mass Index (BMI) that average between 18.5 and 24.9 and this factor are being considered since the previous study stated that there were strong correlation between the variables of height and discomfort was found that associated with various body parts and the condition of the standing surface. The shorter respondents reported greater general fatigue, and greater discomfort especially at the lower leg, knees, and upper back during long standing on the hard surface (King, 2002). American Podiatric Association has been reported that in the United States there were 83% of industrial workers experienced lower back pain and feet pain and discomfort associated with prolonged standing (Zander, King and Ezenwa, 2004). The result showed there were statistically significant ($p<0.05$) different of correlations between hand, knees and feet discomfort level with age. The finding was significant as the previous study done by Orlando & King (2004) whereas there was a correlation between the demographic information (age, height, weight) and subjective rating in discomfort, fatigue, and firmness associated with other body parts.

From the previous study, improper design of workstation with insufficient rest period during standing, not only can cause muscle fatigue and discomfort but can even lead to occupational injuries in the long-term (Halim et al., 2012). The average sleep amount, doing heavy work and playing sport have been reported from the questionnaire. The average sleep amounts of majority of the respondents were 6.78±1.083 hours daily. The respondents do not do heavy work (70%) and playing sport (70%), which showed that all the respondents in physically active and have enough sleep. The result showed there were significant ($p<0.05$) different of correlations between some of the body parts discomfort level with sleep hours as shown in Table 4.12 above. It was supported by previous study done by Hembecker et al. (2016) stated that the sleep disorder could indicate another musculoskeletal problem among the workers. The less amount of sleep can cause a lot of muscle been used and can lead to muscle discomfort and fatigue. Therefore, it will give an effect to the result because of time for muscle recovery not enough.

Physically active is very important in maintaining the muscle cell structure and functioning. When muscles not used, the structure of the cell muscle will increase with the fibrous material and fat that will affect the strength of the muscle. Therefore, the result affected when the respondents not physically active because their muscle easily discomforts and fatigue when cannot adapt with the study environment (Bogdanis, 2012).

5.1.2 Determination of discomfort rating' (Borg's Scale) between experimental and control groups for every body parts.

The data have showed that the comfort level of respondents increased when used the anti-fatigue mat (experimental group) compared without anti-fatigue mat (control group) during 120 minutes. A study by Lin, Chen and Cho (2012), stated that the respondent was standing on the mat while wearing sports shoes or barefoot was more comfortable than standing on the hard floor. The previous studies gave much conflict information about the effectiveness of anti-fatigue mat in reducing the muscle discomfort but many of the employees gave positive feedbacks which are the softer surface of floor give more comfortable than the hard surface (King, 2002). Another study also stated that the comfort level can be increased by standing on the soft mat compared to the hard surface in a long time (Cham & Redfern, 2000). This is because the anti-fatigue mat has soft surface that can reduced the pressure on leg during standing and provided better circulation of the body parts. The highest discomfort rating of body parts among control group was feet, calf, knee and thigh respectively which was near with the break point (>5). The hypothesis is not rejected.

5.1.3 Determination of the discomfort 'break point' (Borg's Scale) between control and experimental groups for every body parts.

The Borg scale of discomfort rating of all body parts has showed that there was no 'break point' of discomfort which was the scale not more than 5 out of 10 between control and experimental group. Even though they do not reach the breakpoint line, the graphs line of the discomfort level in upward trend. There were high possibilities for the break points exceeded when the time exposure increased. The possible reasons for disagreement in the result were because of limited times exposure. Many previous studies found that the impacts of floor condition on muscles discomfort were not significantly differences have been detected until 3rd and 4th hours of standing (Cham & Redfern, 2000). Other study supported that the mean subjective ratings of lower extremity discomfort were significantly higher at 4 hours than those at 3 hours, 2 hours and 1 hour (Lin, Chen and Cho, 2012). The result showed differences in some of body part discomfort ratings because of individual influences of various factors during standing. The hypothesis is not rejected.

5.1.4 Comparison of the Borg Scale of discomfort rating between control group and experimental group.

The respondents stood for two hours while sorting mixed objects. Every 15 minutes, they evaluated the level of discomfort for every body parts using Borg scale. The environmental factors that influenced the rating have been controlled. The result showed that there was a statistically significant different comparison between the body muscle discomfort (knees) and the Borg scale discomfort rating in control group and experimental groups at every minute. The result was supported by the previous study that stated when the workers perform standing tasks in a long duration without insufficient rest, the workers may feel discomfort and fatigue especially in the shoulder, neck/head and lower limb (Halim & Omar, 2011). The result was slightly different because of the variables between these two studies were not same. The respondents that been used were different; this study used students while the other study used workers as their respondents.

During prolonged standing, the load from upper body has been transferred to lower part of body. The result of other body parts showed there were significantly differences of discomfort level at certain minutes only among control group and experimental group. The result showed there was a statistically significant different of neck discomfort at minutes 15 and the result became not significant at minutes 30. Based on interview session with the respondents, the comfort level of neck part increased at minute 15 when used anti-fatigue mat because the muscles do not pressure to support the neck posture but at minutes 30, the muscle became discomfort in order to maintain the posture. The previous study supported that the development of discomfort can cause at first 15 minutes of standing when people tend to stand in a long times, awkward twisting, bending and reaching on the hard surface (Gregory & Callaghan, 2008).

The result in head, shoulder, hand, buttocks, thigh, calf and feet part showed there were a statistically significant different of discomfort level at minutes 90 and above between control and experimental group. The previous study supported that the discomfort level of all body parts increased over time. The mean of perceived discomfort increased between the first 30 minutes and after 90 minutes of standing especially at hip (217%). upper leg (179%), lower leg (126%), ankles (127%), and feet (137%) (Sartika & Dawal, 2010). The result showed there was no consistency in significant value of these body parts for every minute because of many external factors that can influenced the data. These factors can be the type of respondents that been used because the students tend to feel greater discomfort compared to the workers. This is because the student muscle not very strong compared to experienced workers. Moreover, the discomfort rating questionnaire was too subjective to identify the exactly minutes that respondents feel discomfort. That is the limitation for this study and for the further study, electromyography (EMG) is suggested to be used to identify the muscle activity.

The result in lower back part showed there was no a significant difference of discomfort level at every minute which was contradictory with some of other studies that stated that the lower back discomfort significantly increased over two hours ($p < 0.0001$) (Gregory & Callaghan, 2008). The result of every body part showed there were a significant difference of discomfort level between control and experimental group except for lower back. The hypothesis is not rejected.

5.1.5 Correlation between each body parts discomfort among two groups.

During standing in a long period of time on a hard surface gave cumulative effect to the human body such as discomfort in the legs, lower back and feet with increased overall body fatigue (Redferen and Cham, 2000). There were strong positive correlations found between the feet discomfort and the knees and calves discomfort during prolonged standing. When the feet discomfort, the other parts of lower extremities also feel discomfort because the pressure that related with body mechanism will affect the vascular and muscular areas. A study by Antle & Cote (2013) stated that the blood volume of foot showed a significant increase during prolonged standing and there was a significant strong association between lower limb and foot discomfort. Many studies stated that prolonged standing can lead muscle discomfort in the knees, lower leg, ankles and especially feet (Chester, Rys and Kon, 2002). The result showed weak positive correlation between the feet discomfort and buttocks discomfort during standing in a long period of time. The previous study also stated that the discomfort level higher in lower limb part rather than in the back (Antle & Cote, 2013). The hypothesis is not rejected.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

6.1.1 Determination of discomfort rating' (Borg's Scale) between experimental and control groups for every body parts.

It can be concluded that the anti-fatigue mat has possible to reduce the discomfort level compared without used it.

6.1.2 Determination of the discomfort 'break point' (Borg's Scale) between control and experimental groups for every body parts.

There was no 'break point' in each of body parts, however the precaution step should be taken because the risk still there.

6.1.3 Comparison of the Borg Scale of discomfort rating between control group and experimental group.

There was a statistically significant different between body muscle discomfort (knees) and Borg Scale rating in control group and experimental groups at every minutes. But, the result of some body part showed there was significant difference of body discomfort level (head, shoulder, hand, buttocks, upper back, thigh, calf and feet) at certain minutes only between control group and experimental group.

6.1.4 Correlation between each body parts discomfort among two groups.

There were strong positive correlations between the feet discomfort and the knees and calves discomfort during standing on the mat. As conclusion, the intervention (anti-fatigue mat) is engineering improvement that gives the effectiveness and relaxation for prolonged standing workers.

6.2 Study Limitation

These listed limitations were considered in this study:

i. The validity of each respondent answers or responds that will be given while answering questionnaire cannot be proved clinically, therefore, the researcher can only assume that the respondents will answer truthfully and all data that will be given is valid.

ii. The researcher cannot control the sleep adequacy of the respondents, however researcher can only remind the respondents to take note to get adequate sleep and rest before the day the experiment will be conducted.

iii. The researcher cannot control type of daily activities each respondent did that may contribute to factors of muscle fatigue. This may lead to bias or affecting outcome of data collected.

6.3 Recommendation

The further study needs to use electromyography (EMG) in order to determine the muscle activity especially in lower extremities area. Moreover, the changes of skin temperature, leg volume and leg circumferences need to be recorded and analyzed in the study to measure the effect of prolonged standing on the workers. A comparison study between male and female should be investigated to determine the effect of anti-fatigue mat on different gender. Other than that, the further studies should study a comparison to determine the effect of anti-fatigue mat between prolonged standing in controlled room and real situation. Further investigation is needed before definitive conclusion can be made about the effect of anti-fatigue mat on comfort and muscle activity including a much bigger population and more variation in measurements.

7.0 References

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Appendix 1:

Ethical Approval

ETHICS COMMITTEE FOR RESEARCH INVOLVING HUMAN SUBJECTS (JKEUPM) UNIVERSITI PUTRA MALAYSIA

Research title	:	**Influence Of Flooring Condition On Leg Muscle Discomfort And Muscle Activity Due To Prolonged Work In Upright Position Among Workers**
Study Site	:	**UPM**
JKEUPM Ref No.	:	**FPSK(EXP16-OSH)U040**
Researcher	:	**Zutiqa Aqmar Binti Yazuli**
Supervisor	:	**Dr. Karmegam Karuppiah**

Documents received and reviewed with reference to the above study:

1. Ethics Application Form, Version 1 dated 18/10/2016
2. Respondent Information Sheet & Consent (English) Version 1 dated 18/10/2016
3. Proposal (English), Version 1 dated 18/10/2016
4. Questionnaire (English) Version 1 dated 18/10/2016
5. Curriculum Vitae of:
    a. Dr. Karmegam Karuppiah

The University Research Ethics Committee, Universiti Putra Malaysia (JKEUPM) operates in accordance to the ICH-GCP Guidelines.

Decision by JKEUPM:

[X] Approved

[ ] **Permission MUST BE OBTAINED from the respective hospitals/ institutions before conducting the research**

[ ] Disapproved

Please note that the approval is valid until 29 November 2017

Researchers should comply with the following:

I. Complete a Study Final Report upon study completion (Form D).

II. Ethical approval is required in the case of amendments/ changes to the study documents/ study sites/ study team.

Appendix 2:

Consent Form

JAWATANKUASA ETIKA UNIVERSITI UNTUK PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM) UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG, SELANGOR, MALAYSIA.

FORM B1: RESPONDENT'S INFORMATION SHEET AND CONSENT

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

1. **STUDY TITLE**
   EFFECT OF ANTI-FATIGUE MAT ON LEG AND BODY MUSCLE DISCOMFORT DUE TO PROLONGED WORK IN UPRIGHT POSITION AMONG STUDENTS
2. **INTRODUCTION**
   We would like to invite you to participate in a research project on study of the evaluation of leg and body muscles discomfort among prolonged standing students. Before you decide to take part, it is very important for you to understand why this research is being done and what it will be involving. Prolonged standing has been identified as one of the risk factors which associated with occupational injuries (Halim I et al. 2012). Installing an anti-fatigue mat under the standing workstation allowed the workers to change their posture and resulted in relieving pain and fatigue (Sartika and Dawal, 2012). This study will be focusing on finding out the effectiveness of anti-fatigue mat on muscle discomfort and fatigue due to prolonged standing. Participation is voluntary and you can withdraw from the study at any time. Please take time to read the following information carefully and discuss it with others if you wish. Please do ask us if there is anything that is not clear of if you would like to gain more information.

3. **WHAT WILL YOU HAVE TO DO?**
   If you already agree to take part in this study, we will ask you to complete the questionnaire enclosed with this sheet. The questionnaire will need to be filled with information regarding your background information, your daily activities, your health

information and your musculoskeletal disorder information. Then, you will be instructed to stand for 2 hours with and without anti-fatigue mat. You will be asking to stand on anti-fatigue mat in a quiet room in the laboratory. You need to attend experimental sessions on two different days (with a minimum of three days interval between them). Each session will lasts for 2 hours. Meanwhile, you need to sort the mixed items and separate them in three different boxes on table based on color of the items during 2 hours period. Besides that, you need to complete the discomfort rating (Borg's scale) for every 15 minutes.

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

Respondents are not selected based on these criteria:

i. Female.
ii. Age out of range between 18 – 35 years old.
iii. Respondents are not within normal range of Body Mass Index (BMI) (18.5 – 24.9.
iv. Have history regarding Musculoskeletal Disorders (MSD).
v. Have immediate complaints of Musculoskeletal Disorders (neck, head, shoulder, upper back, arms, hands, low back, buttocks, thighs, knees, calf, ankles or feet regions).
vi. Inadequate of sleep and rest.

5. WHAT WILL BE THE BENEFITS OF THE STUDY:

(a) TO YOU AS THE SUBJECT?

There are individual benefits in taking part in this research study. The token will be given if individual participates in the study.

(b) TO THE INVESTIGATOR?

However, by volunteering you can help us to gain more understanding and determine the effect of anti-fatigue mat on muscle discomfort in prolonged standing.

6. WHAT ARE THE POSSIBLE RISKS?

If you decide to take part in this study, standing for more than 2 hours increases the discomfort level due to prolonged standing (Wong & Callaghan, 2010). Therefore, participants who have previous history cardiovascular, musculoskeletal disorder or any chronic illness are not recommended to take part in this study. Besides that, there is a limitation of movement from respondents as it may affect the data collected. Participation is voluntary and you can withdraw from the study at any time.

7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?

Yes, all the information gathered will be kept strictly confidential. Any information which related to you such as personal information and results of sampling will not be identifiable in published material. Your data will not be disclosed to any regulatory body and it is for research purpose only.

8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?

If you have queries regarding your involvement in this study, please feel free to contact the researcher with the number and email address provided below:

Zutiqa Aqmar binti Yazuli

B.S (Environmental and Occupational Health),

Faculty of Medicine and Health Sciences,

University Putra Malaysia.

Tel: 013-6443954

Email: zutiqa94@yahoo.com

Dr. Karmegam Karuppiah (Supervisor)

Department of Environmental and Occupational Health,

Faculty of Medicine and Health Sciences,

University Putra Malaysia.

Tel: +603-8947 2643

Email: megam@upm.edu.my

9. CONSENT FORM

I …………………………………… Identity Card No. ………………………………
address……………………………………………………………………………………………
………… ……………………………………………………….hereby voluntarily agree to take part in the research stated above *(clinical /drug trial/video recording/ focus group/interview-based/ questionnaire-based).

I have been informed about the nature of the research in terms of methodology, possible adverse effects and complications (as written in the Respondent's Information Sheet). I understand that I have the right to withdraw from this research at any time without giving any reason whatsoever. I also understand that this study is confidential and all information provided with regard to my identity will remain private and confidential.

I* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me be used in any form of publication or presentation (if applicable)

* delete where necessary

Signature ……………………………………
(Respondent)

Signature …………………………………….
(Witness)

Date :……………………………………………

Name :…………………………………………..

I/C No. :………………………………………..

I confirm that I have explained to the respondent the nature and purpose of the above-mentioned research.

Date …………………………………

Signature …………………………………….
(Researcher)

Appendix 3:

Questionnaire

QUESTIONNAIRE FOR PRE-SURVEY

TITLE OF PROPOSAL:

EFFECT OF ANTI-FATIGUE MAT ON LEG AND BODY MUSCLE DISCOMFORT DUE TO PROLONGED WORK IN UPRIGHT POSITION AMONG STUDENTS

SUPERVISOR NAME:

DR. KARMEGAM KARUPPIAH

(Department of Environmental and Occupational Health)

PREPARED BY:

ZUTIQA AQMAR BINTI YAZULI

175122

DEPARTMENT OF ENVIRONMENTAL AND OCCUPATIONAL HEALTH

FACULTY OF MEDICINE AND HEALTH SCIENCE

UNIVERSITY PUTRA MALAYSIA

2016

ID:

PRE-SURVEY QUESTIONNAIRE

This page contains questions that will provide your personal information. Please answer each question completely.

SECTION A: BACKGROUND INFORMATION

1. Age: _____________ year
2. Weight: ___________ kg
3. Height: ___________cm
4. Total Body Mass Index (BMI) __________________

SECTION B: DAILY ACTIVITIES

5. On average, how many hours do you sleep per day? ____________ hours
6. Are you doing heavy work activities?

   ☐ Yes ☐ No

   If yes, how often do you do heavy work activities in a week? ____________

7. Do you play sports?

   ☐ Yes ☐ No

   If yes, how often do you play sports in a week? ____________

SECTION C: HEALTH INFORMATION

8. Have you ever experienced any health problems that have been diagnosed by a doctor?

   ☐ Yes ☐ No

If yes, please tick the list below, if not proceeds to question 10.

Illnesses are as stated below:

Cardiovascular disease ☐

Musculoskeletal disease ☐

Others: Please state ____________

9. At present, do you take any medical treatment from doctor?

☐ Yes ☐ No

If yes, please specify the type of medicine below:

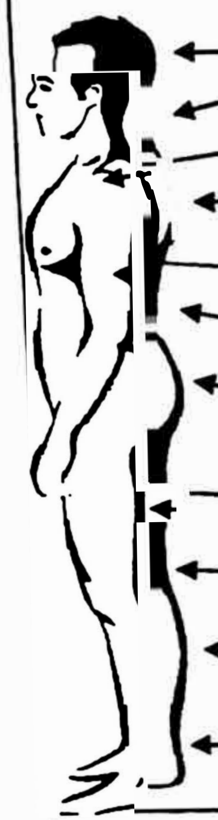
____

SECTION D: MUSCULOSKELETAL DISORDERS INFORMATION

Parts of body	i. Do you ever feel pain, aches, burning or discomfort on the part of the body below?	ii. Do you ever feel pain, aches, burning or discomfort on the part of the body within 7 days lately?
1 Lower back	Yes ☐ No ☐ If yes, answers question ii. If not continue to the next question.	Yes ☐ No ☐
2 Knees	Yes ☐ No ☐ If yes, answers question ii. If not continue to the next question.	Yes ☐ No ☐
3 Feet	Yes ☐ No ☐ If yes, answers question ii.	Yes ☐ No ☐

BORG'S SCALE DISCOMFORT RATING (Karmegam. et. al, 2012)

ID ....



	Nothing at all		Extremely weak			Very weak	Weak		Moderate		Strong		Very strong			Extremely strong
	0	0.3	0 5	0 7	1 0	1 .5	2 0	2 5	3 0	4.0	5 0	60	7.0	8 0	9 0	10
Neck or head																
Shoulder																
Upper back																
Arms & hands																
Low back																
Buttocks																
Thigh																
Knees																
Calf (less below knee)																
Ankle & feet																