The Pain Level and Discomfort on The Lower Extremities of Body Part

Mohamad Fitri Bin Azman
Engineering Student, School of Mechanical Engineering
Faculty Engineering
Universiti Teknologi Malaysia
Skudai, Johor, Malaysia
fitri@graduate.utm.my

Jafri Mohd Rohani
Senior Lecturer, School of Mechanical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia
Skudai, Johor, Malaysia
jafrimr@utm.my

Noorul Azreen Aziz
Executive, Ergonomic Excellence Centre
Southern Region
National Institute of Occupational Safety and Health
Skudai, Johor, Malaysia
noorulazreen.niosh@gmail.com

Ismail Abdul Rahman
Executive, Ergonomic Excellence Centre
Southern Region
National Institute of Occupational Safety and Health
Skudai, Johor, Malaysia
ismailabdulrahman.niosh@gmail.com

Abstract

The purpose of this study is to determine the prevalence of pain and discomfort in lower extremities of body part. Musculoskeletal Disease (MSD) is one of the problems faced by industrial worker in Malaysia. This study targets the industrial worker in Malaysia that required prolonged standing. This study uses survey to determine the pain on lower extremities of prolonged standing worker. The survey uses online medium which is Google form to collect the respondents' data. The lower extremities body parts involved are lower back, thigh, back leg, front leg, knee, and foot. Experiment conducted to validate the pain level reported from the survey. The experiment has three tasks that design based on the data analyzed from the survey. The body part rank based on the mean pain level from the survey and the experiment. Respondents indicate their pain level based on Likert scale used in the survey questionnaire. The

experiment assessment for using numerical pain rating scale (NPRS) to indicate pain level. The pain level mean from survey compared with the experiment and past study data. The most critical body part that reported high pain level are lower back, back leg, and foot. The best way to reduce pain are rest and do stretching on legs.

Keywords
MSD, Pain level, Lower extremities, Prolonged standing, Discomfort

1. Introduction
Many workers are required to stand over a long period of time when they are performing their work. Workers have a little time where they got to sit or rest when they are standing over a long period of time because of their work. Prolonged standing expose workers to risk of major health problems such as musculoskeletal disorders, musculoskeletal pain especially on lower back, back leg and feet, and some case spontaneous abortion. Lower extremity musculoskeletal disorders (LEMDs) in contrast of musculoskeletal disorder that focus on upper limb where lower extremity is lower limb of body where lower back, thigh, leg, and feet. Pain or fatigue on muscle is symptoms of Musculoskeletal Disease (MSD) and if ignored worker health could deteriorated. Discomfort closely associated with pain on muscle especially on lower extremities. Thus, to comply with the problem, this research had been made to study the prevalence of pain on lower extremities of the worker during standing activity. Based on the survey by Zein, R. M. et. al. (2015), shows that during prolonged standing activity, most of the industrial worker had suffered from muscular pain in the lower part of the body especially at the calf and the heel part of the foot. Jones et al. (2006) found that out of 1,012,000 people who reported suffering a work-related MSD,18% (185, 000) reported disorders that mainly affected the lower limb.

1.1 Objectives
The key objectives of this study are:
- Identify the body part that prevalence to muscle pain through survey.
- Validate the prevalence of muscle pain from the survey through experiment.
- Propose the practices to reduce muscle pain on lower extremities of body part.

2. Literature Review
According to the Occupational Disease and Poisoning Statistic (2018) published by DOSH, 85 confirmed cases out of 188 cases of OMSD had been reported 6 for the year of 2018. The article from Muller, J. (2021) had stated that the most common ergonomics problems arise in the person's neck, shoulder, back or extremities. The working condition of worker usually determine the symptoms of ergonomic injuries. Numb, cramp, and stiffness on the body part are the common symptoms of Occupational Musculoskeletal Disease (OMSD). Psychological fatigue study conducted using survey questionnaires, the most critical muscle which experience the most muscle fatigue is by the gastrocnemius muscle followed by erector spinae and the tibialis anterior (Halim I, et al., 2012). The findings from the survey shows that 83% of the respondents experienced work-related MSK symptoms. The most common location reported were low back (78%), neck (74%), and shoulder (30%) (Gautamn S, et al., 2021). The research also finds that the used of intervention is compulsory and effective to reduce the negative effect caused by prolonged standing (RB & TR, 2015). Increase in standing or walking time on the job was linked to lower extremity fatigue at the end of the workday (Nancy G, et al., 2010).

3. Methods
A full-blown survey and laboratory experiment will be conducted to determine the muscle pain and fatigue in the lower extremities of human body. A survey is conducted to gather the perception of the worker on the muscle pain in the lower extremities. The survey is conducted together with laboratory experiment so that the experiment can validate the survey finding.

3.1 Parameter
The control factor of the experiment is the body part involve and the activity done by the participant. For the survey the muscles involve are lower back, thigh, knee, leg, and foot. The survey will consist of questions on the pain level perceive by the respondents for lower back, thigh, knee, leg, and foot. The questions in the survey have five level of pain which are no pain, little pain, moderate pain, severe pain, and very severe pain. The laboratory experiment will be conducted to determine pain on muscle. The muscles that test on the experiment were same as the survey. For the

condition of the experiment, based on the guideline from National Institute of Occupational Safety and Health (NIOSH), the temperature of the room needs to be less than 35℃ as higher temperature can lead to reduce in productivity. For the ventilation, air can enter office building or space through both mechanical ventilation system as well as naturally through window, door etc. The ceiling is installed with PVC ceiling. Interior height should not be less than 2.5 m. Have general lighting that covered more than 300 lux.

3.2 Survey

The survey will be conducted online using Google form, so that the data gathered from the survey easier to analyse and manage. The data gather from using Google form survey easier to analyse and reduce the error when transferring the data from one medium to another. The respondents for this survey were selected among workers that attend training class at NIOSH Johor Bahru. The participants of NIOSH training class mostly workers from many industries around Johor. The raw data gather from the survey need to be analysed to help us determine the pain level perceive by respondents. The SPSS software will be used to perform analysis on the data. SPSS software is a software develop by IBM that can be used to do statistical analysis. From the pilot test conducted, reliability test was done to determine the validity of the survey instrument. Reliability Coefficient or Cronbach's α is used to determine the internal consistency. The α reliability coefficient of the Cronbach usually is between 0 and 1. All the parts in the questionnaire had Cronbach's α more than 0.8 which was good. This shows that the survey instrument was consistent and reliable. The structure of the survey is containing sixty-one questionnaire that was divided into eight parts which are Part A: Respondent Profile, Part B: Lower Back, Part C: Thigh, Part D: Back Leg, Part E: Front Leg, Part F: Knee, Part G: Foot, and Part H: Practice to Reduce Pain. All the questions only required only one answer for each question but there some questions where the respondents may choose more than one answer.

3.3 Experiment

The experiment conducted after the survey data analysed. There three tasks need to be completed by the participants. Each task consisted of different type of activity based on the data analysed from the survey. Five participants were chosen to be the subject for this experiment. All the participants involved in the experiment are male. All the participants chosen are male because based on survey data, 90% of respondents are male. The age range of the participants was 23-25 years old. The reason this age range was chosen because from the survey data, most of respondents were young adult which age range 17-35 years 18 old. The weight range of the participants was 65-78 kg, while the height range was 168-171 cm. The body mass index (BMI) of the participant were four participant normal BMI and only one participant overweight. All the participants do not sustained injury for past 12 months. The experiment consisted of three task which were task 1, task 2, and task 3. The activity used in the task based on a survey questionnaire that asked respondents about most activity done by them. The tasks were static standing, walking, and lifting heavy object for task 1, task 2, and task 3 respectively. Participants of the experiment given Numerical Pain Rating Scale (NPRS) assessment form before and after the experiment. The environmental parameter was controlled. The dry temperature ranges from 23.3°C to 26.8°C and the humidity average was 50.7%. The NPRS assessment form used for the participant to indicate their pain scale or level. The scale is from 0-10 which 0 mean no pain and 10 is the worst pain imaginable. The mean for pain level from the experiment compared with survey data and literature review. Practices to reduce muscle pain on lower extremities were proposed based on the survey findings. Figure 1 below shows the flowchart for the methodology of this study. (Figure 1)

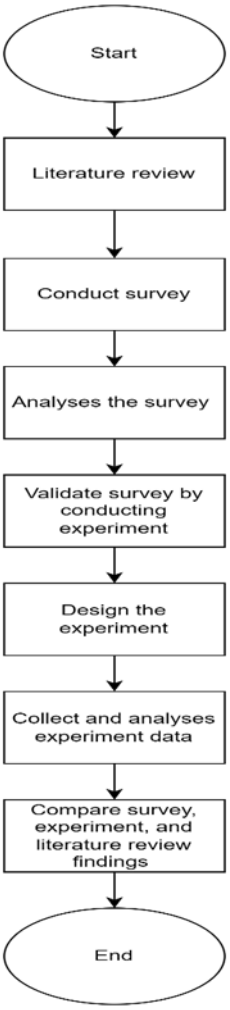

Figure 1 Flow Process of this study

4. Result and Discussion

The total respondents that answered this survey is 49 respondents and after screening process the valid data is 48 respondents only. From 48 respondents, 32 respondents (66.7%) are young adult which is age range from 18 to 35 years old. 16 respondents (33.3%) are middle-aged adult which is age range from 36 to 55 years old. 23 respondents (47.9%) are weight between 60 to 80 kg, while 12 respondents (25%) weight between 81 to 100 kg, 9 respondents (18.8%) weight below 60 kg, and 4 respondents (8.3%) weight more than 100 kg. 19 respondents (39.6%) work in manufacturing sector, 11 respondents (22.9%) work in construction sector, 7 respondents (14.6%) work in service sector, 5 respondents (10.4%) work in transportation, warehouse, and warehouse sector, 4 respondents (8.3%) work in utility sector and lastly, 1 respondent (2.1%) work in mining and quarry, and wholesale and retail sector respectively. 37.5% of respondents standing without walking and walking when working and 20.8% lifting heavy object. Figure 2 below shows the summary of respondent profile from the survey.

.

Description	Result
Age range	Most of respondents are young adult (18-35 years old)
Height range	Most respondents' height 161-170 cm
Weight range	Most respondents' weight 60-80 kg
Gender	90 % respondent are male
Economy sector	62.5% respondents work in construction and manufacturing sector
Working experience	75.0% respondents have 1-10 years working experience
Working time	90.0% respondents work normal time
Standing duration	45.8% respondents stand 8-10 hours a day
Activity done during work	Most activity done are walking and static standing
Total break time	81.3% respondents get 31-60 minutes break time

Figure 2 Summary of respondents' profile

From survey, lower back mean value for the pain level in lower back before work was 1.35 with standard deviation of 0.601. The mean for pain level in lower back during work was 2.44 with standard deviation of 1.109. The mean for pain level in lower back after work was 2.19 with standard deviation of 0.891. 38 respondents (79.2%) stated that they had aches discomfort on lower back. 10 respondents (20.8%) stated that they had no discomfort on lower back. The mean value for pain level on back leg before work was 1.33 with standard deviation of 0.630. The mean value for pain level on back leg during work was 2.29 with standard deviation of 0.849. The mean value for pain level on back leg after work 2.15 with standard deviation of 0.825. 33 respondents (68.8%) reported aches as discomfort on back leg while 12 respondents (25%) reported 37 no discomfort on back leg. The mean value for pain level on foot before work was 1.29 with standard deviation of 0.582. The mean value for pain level on foot during work was 2.10 with standard deviation of 0.831. The mean value for pain level on foot after work 1.90 with standard deviation of 0.722. 31 respondents (64.6%) reported aches as discomfort on foot while 16 respondents (33.3%) reported no discomfort on foot. The mean value for pain level on front leg before work was 1.13 with standard deviation of 0.393. The mean value for 39 pain level on front leg during work was 1.58 with standard deviation of 0.539. The mean value for pain level on front leg after work 1.40 with standard deviation of 0.536. 30 respondents (62.5%) reported no discomfort on front leg while 18 respondents (37.5%) reported aches as discomfort on front leg. The mean of pain level in thigh before was 1.19 with standard deviation of 0.491. The mean pain level in thigh during work was 1.56 with standard deviation of 0.580. The mean pain level in thigh after work was 1.48 with standard deviation of 0.618. 28 respondents (58.3%) stated that they had no discomfort on thigh. 19 respondents (39.6%) stated that they had aches as discomfort on thigh. 1 respondent (2.1%) stated that he or she had cramp as discomfort on thigh. The mean value for pain level on knee before work was 1.21 with standard deviation of 0.504. The mean value for pain level on knee during work was 1.42 with standard deviation of 0.577. The mean value for pain level on knee after work 1.40 with standard deviation of 0.574. 32 respondents (66.7%) reported no discomfort on knee while 15 respondents (31.3%) reported aches as discomfort on knee. 87.4% of respondents reported that their current practice to reduce pain on muscle during prolonged standing involved rest. For suggestion practice to reduce pain during prolonged standing, the highest suggestion was do stretching on legs. From results of survey, the rank from high to low pain level were as follow lower back, back leg, foot, front leg, thigh, and knee. High discomfort reported on the body parts that have high mean of pain level. Most discomfort reported was aches. The time that most respondents experienced pain on the body parts was during work compared to before and after work. Figure 3 below shows graph of the summary for mean pain level on all body parts before, during, and after work.

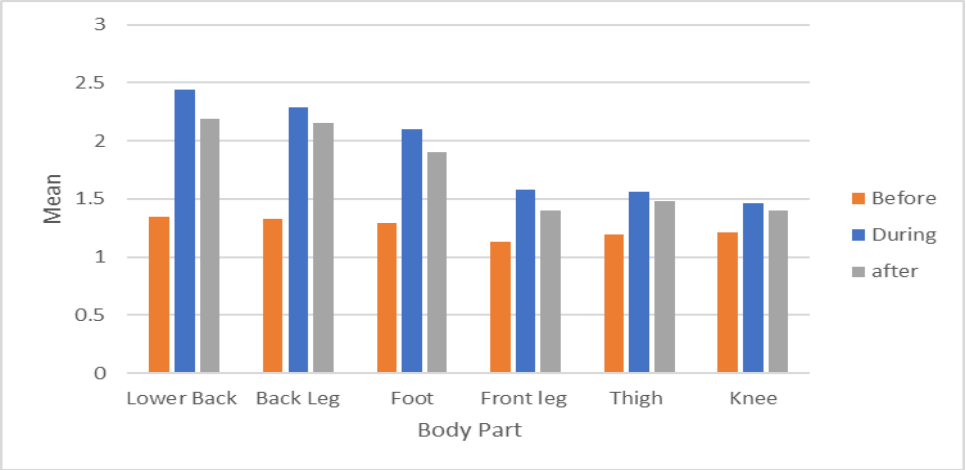

Figure 3 Mean pain level before, during, and after work

The experiment conducted to validate the survey findings by comparing the mean pain scale on the body parts. 5 males participated in this experiment ages 23-25 years old with BMI of normal and overweight. The experiment consisted of 3 tasks that need to be completed by the participants. All the participant in this experiment completed all the tasks. All participants reported that they do not experienced pain on the body parts involved in this experiment. Therefore, all mean pain level before doing the task will be 0. For task 1 The mean for pain scale or level on foot after task was 4.40 with standard deviation of 0.548. The mean for pain scale or level on lower back after task was 4.00 with standard deviation of 1.414. The mean for pain scale or level on back leg after task was 2.40 with standard deviation of 0.894. The mean for pain scale or level on front leg after task was 1.60 with standard deviation of 0.894. The mean for pain scale or level on thigh after task was 1.20 with standard deviation of 1.095. The mean for pain scale or level on knee after task was 0.80 with standard deviation of 0.837. Next for task 2, The mean for pain scale or level on lower back after task was 3.40 with standard deviation of 1.517. The mean for pain scale or level on foot after task was 3.40 with standard deviation of 0.894. The mean for pain scale or level on back leg after task was 3.20 with standard deviation of 1.304. The mean for pain scale or level on front leg after task was 1.40 with standard deviation of 1.517. The mean for pain scale or level on thigh after task was 1.20 with standard deviation of 0.837. The mean for pain scale or level on knee after task was 0.40 with standard deviation of 0.548. The mean for pain scale or level on lower back after task was 4.40 with standard deviation of 1.140. The mean for pain scale or level on foot after task was 2.80 with standard deviation of 1.789. The mean for pain scale or level on back leg after task was 2.60 with standard deviation of 2.074. The mean for pain scale or level on thigh after task was 1.20 with standard deviation of 0.837. The mean for pain scale or level on knee after task was 1.00 with standard deviation of 0.707. The mean for pain scale or level on front leg after task was 0.60 with standard deviation of 0.548. Figure 4 shows graph of the summary of mean pain level on all body parts on all tasks.

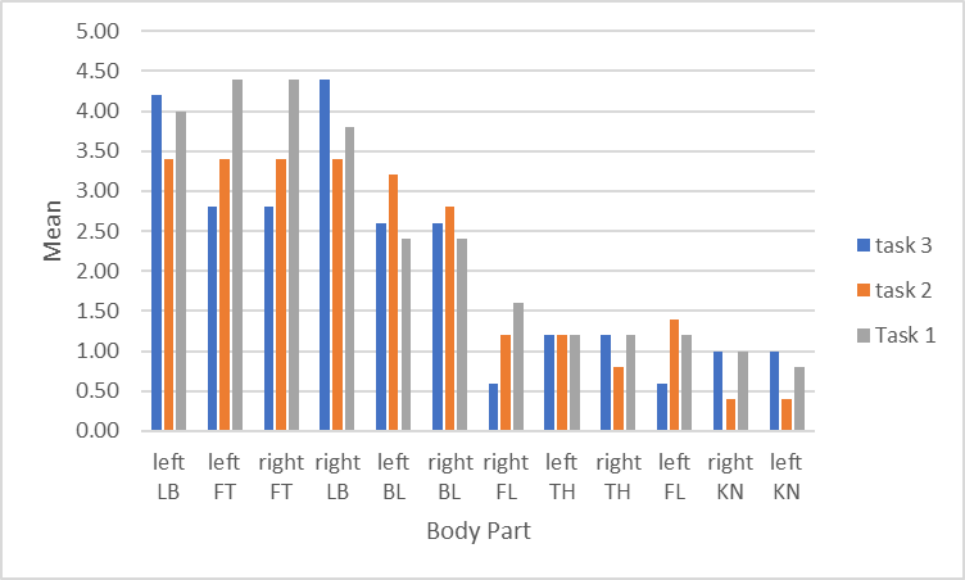

Figure 4 Mean pain level after tasks for all body parts

There 3 muscles that exceed the mean pain level of 2 which were lower back, back leg, and foot. The pain level during work chosen as the value to rank the muscle pain or fatigue because it was the time that highest pain or fatigue occur compared to before and after work. The experiment data analysis we concluded that based on task 1 the rank of muscle pain or fatigue were as follow foot, lower back, back leg, front leg, thigh, and knee. Based on task 2 the rank of muscle pain or fatigue were as follow lower back, foot, back leg, front leg, thigh, and knee. Based on task 3, the rank of muscle pain or fatigue were as follow lower back, foot, back leg, thigh, knee, and front leg. Comparing the result from the survey data, experiment data and literature review on the muscle pain or fatigue. From the survey data the three highest pain or fatigue reported during work were lower back, back leg, and foot. Meanwhile from experiment data the three highest pain or fatigue reported were lower back, foot, and back leg. Based on the survey and experiment we could see that the three highest pain or fatigue muscle reported was consistent. The least pain or fatigue muscle reported in survey and experiment was knee except in task 3 of the experiment. (Halim I, et al., 2012) Half of respondents complained of being very fatigue in the left and right gastrocnemius muscle (posterior legs), 5 subject complained being very fatigue in erector spinae muscle (lower back) and 11 subject complained being moderate fatigue in anterior muscle (anterior legs) [5]. From Assessment of Muscle Fatigue Associated with Prolonged Standing in the Workplace by Halim I, et al., (2012) from the survey the three muscle that had most complained of being fatigue were posterior legs, lower back, and anterior legs [5]. Lastly, to achieve the third objective of this study which was to propose the practices to reduce muscle pain on lower extremities of body part. We proposed that worker that required prolonged standing to get rest and do stretching on leg occasionally. This will help reduced the pain or fatigue on the lower extremities. Rest help muscle to recover form fatigue and stretching on leg help blood circulation on lower extremities.

5. Conclusion and Recommendation

5.1 Conclusion

Musculoskeletal Disease (MSD) is common and widely known among the industry workers that required prolonged standing. The most occurrence of MSD is in lower extremities of the worker body such as lower back and foot. Over the years many studies on risk of MSD were done by industrial researcher to improve the condition of industrial worker. The main objective of this project is to determine the muscle pain or fatigue for lower extremities region during standing activity which to validate whether the standing activity can cause the changes in muscle activity of a person and to see which part of muscle is the most critical during the standing activity. The project also was conducted an experiment to validate and support the finding on the survey. The results obtained from the project also will be compared with the existing research to see whether the results obtained from the research can be accepted. The study focused on lower extremities region of body part which are lower back, thigh, back leg, front leg, foot, and knee. Many

previous studies focused on certain part of lower extremities such as erecter spinae, and gastrocnemius muscle. This study included more body part in lower extremities such as knee and thigh muscles. This is because the study wants to get a broader view on the prevalence of muscle pain on lower extremities. An experiment in a controlled environment had been conducted to validate and support the finding from the survey. The activity done by the participants of the experiment determine by the finding of the survey. Both findings then compared to previous study or literature review to see whether the findings are true. 52 The conclusion of this study is muscle pain or fatigue is prevalence in the prolonged standing worker. The rank of reported body part that experienced the most pain is as follow lower back, back leg, foot, front leg, thigh, and knee. The three critical body parts are lower back, back leg, and foot as the experiment result and literature review show the similarities. The practice to reduce the pain in lower extremities also proposed which are rest and do stretching on legs based on finding from survey.

5.2 Recommendation

To improve the outcome of this research, a few suggestions for the overall research that could make:

- The respondents for the survey chosen from the industry sector that that required extensive amount of time standing.
- The survey conducted physically in the real industry environment.
- Use same subjects or participant for survey and experiment to maintain same perspective.

References

Gautamn, S., G, T., DC, T., JD, M., & YN, H. (2022). Survey of Canadian vascular surgeons and trainees finds work-related musculoskeletal pain and discomfort is common. *J Vasc Surg.*, 1431-1436.

Gell, N., RA, W., A, H., N, W., & WM, K. (March Risk factors for lower extremity fatigue among assembly plant workers. *Am J Ind Med.*, 216-230 2011).

Idris, N. F. *Statistik Penyakit dan Keracunan Pekerjaan sehingga September 2018 (Kes Disiasat)*. Retrieved from Laman Web Rasmi Jabatan Keselamatan dan Kesihatan Pekerjaan Malaysia: (2018). https://www.dosh.gov.my/index.php/ms/osh-info-2/occupational-health/138-statistik/statistik/2038-statistik-penyakit-dan-keracunan-pekerjaan-sehingga-september-2018-kes-disiasat

I, H., AR, O., AM, S., & I, O. Assessment of muscle fatigue associated with prolonged standing in the workplace. *Saf Health Work*, 31-42. (2012).

Jones, J.R., Huxtable, C.S. and Hodgson, J.T. Self-reported work-related illness in 2004/05: Results from the Labour Force Survey. Health and Safety Executive, National Statistics (2006)

Muller, J. *Common Workplace Ergonomic Issues and their Causes*. Retrieved from Ergonomic Trends: (7 June, 2021).https://ergonomictrends.com/common-workplace-ergonomic-issues/

TR, W., & RB, D. Evidence of health risks associated with prolonged standing at work and intervention effectiveness. *Rehabil Nurs.*, 148-65. (2015).

Zein, R. M., Halim, I., Azis, N. A., Saptari, A., & Kamat, S. R. A Survey on Working Postures among Malaysian Industrial Workers. *Procedia Manufacturing. Elsevier B.V.*, 450-459.. (2015).