UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MARI – A PRACTICAL SOLUTION FOR MINIMIZING MUSCLE FATIGUE ASSOCIATED WITH PROLONGED STANDING AT INDUSTRIAL WORKPLACE

Submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

by

EUNICE NG XIN HUI

B051820035

981001-05-5128

FACULTY OF MANUFACTURING ENGINEERING

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Disahkan oleh:

Alamat Tetap
386 Taman Satelite,
72100 Bahau,
Negeri Sembilan.
Tarikh: 25 Jan 2022

Cop Rasmi: DR. ISA BIN HALIM
Lecturer
Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka

Tarikh: 25 Jan 2022

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DECLARATION

I hereby, declared this report entitled "MARI– A Practical Solution For Minimizing Muscle Fatigue Associated With Prolonged Standing At Industrial Workplace" is the results of my own research except as cited in the reference.

Signature:

Author's Name: EUNICE NG XIN HUI

Date: 17 JUNE 2021

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfillment of the requirements for the Bachelor Degree of Manufacturing Engineering (Hons.). The member of the supervisory committee is as follows

DR. ISA BIN HALIM
Lecturer
Faculty of Manufacturing Engineering
Universiti Teknikal Malaysia Melaka

.....

Principal Supervisor- Signature and Stamp

ABSTRAK

Dalam industri pembuatan dan sektor perkhidmatan, postur kerja ergonomik adalah penting untuk meningkatkan kesihatan pekerjaan dan kecekapan kerja. Bekerja dalam posisi berdiri adalah perkara biasa di kebanyakan tempat kerja kerana postur ini memberikan fleksibiliti dan mobiliti kepada pekerja. Bekerja dalam keadaan berdiri lama boleh menyebabkan masalah kesihatan seperti ketidakselesaan, keletihan otot pada bahagian bawah kaki dan penurunan produktiviti pekerjaan. Kajian ini bertujuan untuk menentukan tahap kesedaran pekerja daripada industri terpilih di Malaysia mengenai kesan ergonomik dan penyelesaian yang berkaitan dengan kedudukan berpanjangan di tempat kerja. Tinjauan atas talian yang melibatkan 55 responden telah dijalankan. Semua responden sedar bahawa berdiri lama menyebabkan ketidakselesaan dan keletihan otot. Tambahan pula, lebih separuh daripada responden sedar bahawa berdiri berpanjangan membawa kepada bengkak kaki (tiga puluh enam responden) dan vena varikos (tiga puluh responden). Konsep penyelesaian praktikal yang dinamakan "Moving- Alternate- Rest- Insoles- (MARI)" telah dicadangkan dan disahkan untuk menyelesaikan kesan ergonomik yang disebabkan oleh berdiri berpanjangan. MARI dilaksanakan dalam dua kajian kes: kajian kes di tempat kerja industri sebenar dan kajian kes simulasi di makmal. Subjek hendaklah mengisi borang soal selidik versi 1 sebelum kajian kes dan versi 2 selepas kajian kes. Tinjauan ini mendapati peningkatan besar dalam tahap keletihan, kekerapan sakit di bahagian bawah badan, dan keadaan kasut selepas melaksanakan MARI. Kesemua responden dan seorang jurutera dari industri menyatakan bahawa mereka sanggup melaksanakan MARI di tempat kerja mereka kerana MARI meningkatkan kesihatan pekerjaan dan produktiviti pekerjaan. Kajian masa yang dijalankan dalam kajian kes industri simulasi jelas menunjukkan pemasangan soket menunjukkan penurunan sehingga 25% apabila subjek mengamalkan MARI. Daripada keputusan EMG, didapati bahawa MARI membantu mengurangkan keletihan otot dengan merendahkan pengecutan otot sehingga 95%. Secara ringkasnya, dapat disimpulkan bahawa MARI terbukti dapat meningkatkan kesihatan pekerjaan dan prestasi kerja.

ABSTRACT

In the manufacturing industry and service sector, ergonomic work position is vital to improve occupational health and work efficiency. Working in a standing position is common in many workplaces as this posture provides greater flexibility and mobility to workers. However, working in prolonged standing can exhibit occupational health and productivity issues such as discomfort, muscle fatigue in the lower extremities, and decreased work performance. Thus, this study aims to determine the awareness level of workers from selected industries in Malaysia regarding ergonomics effects and solutions associated with prolonged standing at the workplace. An online survey that involved 55 respondents was carried out. All respondents are aware that prolonged standing causes discomfort and muscle fatigue. Furthermore, more than half of the respondents were aware that prolonged standing leads to swollen feet (thirty-six respondents) and varicose veins (thirty respondents). A concept of practical solutions called Moving- Alternate- Rest- Insoles (MARI) was proposed and validated to solve the ergonomics effects caused by prolonged standing. MARI is implemented in two case studies: a case study at an actual industry workplace and a simulated case study at the laboratory. The subject must fill in the questionnaire form version 1 before the case study and version 2 after the case study. This survey found a massive improvement in the level of fatigue, frequency of pain in lower body parts, and shoes' condition after implementing MARI. All respondents and one engineer from the industry mentioned that they were willing to implement MARI in their workplace due to MARI improving occupational health, work concentration, work productivity and work motivation. The time study carried out in simulated industrial case study clearly shows assembling the socket shows a significant decrease where the percentage of improvement is up to 25% in assembly time when the subject practised MARI. The EMG results found that MARI helps reduce muscle fatigue by lowering muscle contraction up to 95 %. In a nutshell, it can be concluded that MARI was proven to improve occupational health and work performance.

DEDICATION

Only

my beloved father, Ng Yoon Ping

my appreciated mother, Moo Lian Hiong

my brothers and sister, Stephen, Esther, and Daniel

for giving me moral support, money, cooperation, encouragement, and also understandings

Thank You So Much & Love You All Forever

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LIST OF ABBREVIATIONS

WRMSD	-	Work-Related Musculoskeletal Disorder
SOCSO	-	Social Security Organization
MARI	-	Moving-Alternate-Rest-Insole
EMG	-	Electromyography
CNS	-	Central Nervous System
CVI	-	chronic venous insufficiency
OWAS	-	Ovako Working Posture Analysing System
AC	-	action categories
IDC	-	Industrially Developing Countries
SIRIM	-	Standard and Industrial Research Institute of Malaysia
SENIAM	-	Surface Electromyography for the Non-Invasive Assessment of Muscles
CAM	-	Computer- Aided- Manufacturing
BW	-	Bodyweight
LBP	-	Low Back Pain
EVA	-	Ethylene vinyl acetate
MCR	-	Micro Cellular Rubber
GRF	-	Ground Reaction Forces
AM	-	Additive Manufacturing
ABS	-	Acrylonitrile Butadiene Styrene
PPRI	-	Plantar Pressure Redistribution Insoles
MVC	-	Maximum Voluntary Contraction
BMFG	-	Bachelor of Manufacturing Engineering
FKP	-	Faculty of Manufacturing Engineering
UTeM	-	Universiti Teknikal Malaysia Melaka
GA	-	Gastrocnemius
VL	-	Vastus Lateralis
TA	-	Tibialis Anterior
UiTMP	-	University Technology of MARA, Penang

OSH	-	Occupational Safety and Health
MSDs	-	Musculoskeletal Disorders
LPD	-	Local perceived discomfort
SUS	-	System usability scale
RPE	-	Rating of Perceived Exertion
LVL	-	Left Vastus Lateralis
RVL	-	Right Vastus Lateralis
LTA	-	Left Tibialis Anterior
RTA	-	Right Tibialis Anterior
LGA	-	Left Gastrocnemius
RGA	-	Right Gastrocnemius
IoT	-	Internet of Things
Kg	-	Kilogram

LIST OF SYMBOLS

%	-	Percentage
°	-	Degree

CHAPTER 1
INTRODUCTION

1.0 Overview

This chapter included the study's background related to the manufacturing industry's prolonged standing position. Most manufacturing industries have faced this issue as most of the process is impossible to perform in a seated position. The study's problem statement, which is the effect of the prolonged standing on the human body and productivity and efficiency during the manufacturing process, has been elaborated. The three objectives of this study are listed down in this section. Furthermore, the study's scope is presented and followed by the significance of the study. Lastly, this chapter summary is also included in the last part of the chapter.

1.1 Background of study

Working posture in the manufacturing industry is vital to reduce occupational injuries and increase working efficiency (Nico J. Delleman, Christine M. Haslegrave, 2004). The operators can perform the jobs in standing or sitting, or both positions in their workplace. The working posture is based on the operators' human characteristics, the type of workstation, and the process. Therefore, the working posture must be suited to the operators to ensure that they can perform the task in good condition.

In the manufacturing industry, the most common working posture is standing due to its ability to fulfil the human operator's requirement in the manufacturing process, which is a large degree of physical freedom and mobility (Mohd Noor et al., 2013; Zein et al., 2015). Standing posture is classified into static standing and dynamic standing. Static standing means the operator does not move; no lower body movement is available but stands still in

an upright position. On the other hand, dynamic standing means the operator performed intermittently walking while doing his job. It allows operators to have a reciprocal weight shift, flexion, and extension of the muscle in an upright position.

Figure 1.1 shows the operators' standing posture during the manufacturing process.

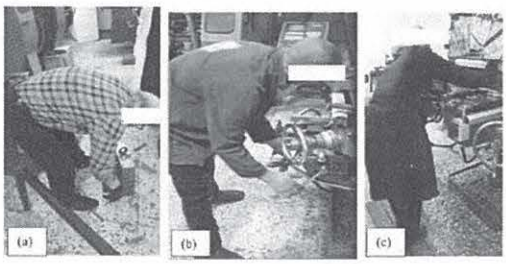

Figure 1.1: Standing position in the manufacturing industry (Boulila et al., 2018)

Besides, most manufacturing industries require operators who perform jobs to stand for a long time as they need to carry heavy products and machinery equipment, push and pull the excessive load, and others (Halim et al., 2012a; Zein et al., 2015). Therefore, prolonged standing is an occupational risk factor that brings discomfort on the operator's leg, muscle fatigue, and work-related musculoskeletal disorder (WRMSD) may occur if the long-term situation occurs (Yazuli et al., 2019). Based on a previous study, a work task can be classified as prolonged working posture when the operator spends over 50% of his work shift in a standing position (Halim et al., 2012a). On the other hand, prolonged standing is also defined as the worker standing within the one-meter square with more than 80% of his working day (Tomei et al., 1999). Furthermore, prolonged standing is also defined as the worker performing his job in standing for more than one hour without any movement or more than four hours a day (Nicolien de Langen, n.d.-b).

According to the study, muscle fatigue has happened in the lower back and legs after 90 minutes of prolonged standing (Sari Julia Sartika, 2010). Besides, based on the study, muscle discomfort has arisen within 15 minutes of standing in an awkward position, such as bending or twisting (Gregory & Callaghan, 2008). In Malaysia, the operator's regular working hours are 8 to 12 hours. Thus, the operator's risk of experiencing muscle fatigue due to prolonged standing is high.

Although prolonged standing effects are pretty severe, most of Malaysia's operators and industries do not consider it essential. Malaysia has started the concept and principles of ergonomic decades ago but still lacks awareness in prolonged standing as the management believe that they have given enough break to the operators without considering workload