DEVELOPMENT OF MATHEMATICAL MODEL FOR MUSCLE ACTIVITY, PSYCHOPHYSICAL EXPERIENCE AND HEART RATE DURING MANUAL LOAD CARRYING

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A thesis submitted

in fulfillment of the requirements for the degree of Master of Science

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DECLARATION

I declare that this thesis entitled “Development of Mathematical Model for Muscle Activity, Psychophysical Experience and Heart Rate during Manual Load Carrying” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Manufacturing Engineering.

Signature : .....

Supervisor Name : .....

Date : .....

DEDICATION

Dedicated to my beloved husband, Mohd Hazman bin Marinamarican, my kids Muhammad Aniq and Hana Humaira, and my mother Che Esah binti Che Mat.

ABSTRACT

Manual materials handling (MMH) were categorized as highly risk physical activities if improperly conducted. As found in previous research, numbers of work-related musculoskeletal disorder (WRMSD) increased among the industrial workers caused by MMH. Hence, this research aims to find risk factors and its effect towards changes in muscle activity, heart rate, and psychophysical experience which specifically associated with manual load carrying activities. Mathematical models were develop to express the relationship between the risk factors towards muscle activity, heart rate, and psychophysical experience. Thirty subjects were asked to carry a load mass of water bottles while walking on certain distances on flat and inclination surfaces. Results revealed that load mass had significantly affected muscle activity and increased rating of perceived exertion on Trapezius (TRAP) and Erector Spinae (ES) muscle. On the other hand, walking inclination had significantly affected both right and left ES as well as increased heart rate but decrease psychophysical experience for TRAP and Right ES. Unlike TRAP muscle activity, the subjects rated that their working intensity increased with increasing of walking inclination on ES. The development of mathematical model described that with the increase in load mass, walking distance, and walking inclination, they might increase muscle activity and heart rate as well as psychophysical experience. These results provided guidance to predict the intensity of workers' muscle activity, heart rate, and psychophysical experience and to create safe working condition as they performed the asymmetrical manual load carrying.

ABSTRAK

Pengendalian bahan secara manual adalah dikategorikan sebagai aktiviti fizikal yang berisiko tinggi jika dikendalikan dengan salah. Kajian lampau mendapati bahawa penyakit bekaitan otot meningkat dalam kalangan pekerja industri disebabkan oleh aktiviti ini. Tujuan kajian ini adalah untuk mengenalpasti faktor risiko dan mengkaji kesan faktor risiko tersebut terhadap perubahan dalam aktiviti otot, kadar jantung dan pengalaman psikofizikal pekerja semasa melakukan aktiviti membawa beban secara manual. Model matematik juga dihasilkan untuk menyatakan hubungan antara faktor risiko terhadap aktiviti otot, kadar jantung dan pengalaman psikofizikal. Tiga puluh orang peserta menjalankan eksperimen dengan membawa botol air dengan berat yang berbeza sambil berjalan pada jarak yang berbeza di permukaan rata dan permukaan condong. Hasil kajian mendapati berat beban memberi kesan kepada aktiviti otot dan pengalaman psikofizikal pada otot Trapezius (TRAP) dan Erektor Spina (ES). Sebaliknya, berjalan pada permukanan rata dan menaiki tangga memberi kesan kepada kedua-dua belah kanan dan kiri ES, di samping meningkatkan kadar denyutan jantung. Berbeza dengan aktiviti otot TRAP, intensiti pekerjaan peserta meningkat pada otot ES semasa menaiki tangga. Berdasarkan model matematik yang dihasilkan, peningkatan jisim beban, jarak perjalanan dan menaiki tangga dapat meningkatkan aktiviti otot dan kadar jantung serta pengalaman psikofizikal. Hasil kajian ini dapat dijadikan panduan untuk meramalkan aktiviti otot pekerja, kadar jantung dan pengalaman psikofizikal di samping dapat mewujudkan keadaan persekitaran bekerja yang selamat.

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LIST OF ABBREVIATIONS

AD	-	Anderson-Darling
ANOVA	-	Analysis of Variance
DOE	-	Design of Experiment
ES	-	Erector Spine
L	-	Load
LES	-	Left Erector Spinae
LPG	-	Liquid Petroleum Gas
MANOVA	-	Multivariate Analysis of Variance
MMH	-	Manual Material Handling
NIOSH	-	National Institute for Occupational Safety and Health
OSH	-	Occupational Safety and Health
R-Sq	-	R Squared
REAT	-	Rehabilitation and Assistive Technology
REC	-	Research Ethic Community
RES	-	Right Erector Spinae
sEMG	-	Surface Electromyography
SOCSO	-	Social Security Organization
TRAP	-	Trapezius

VIF	-	Variance Inflation Factor
WD	-	Walking Distance
WI	-	Walking Inclination
WRMSD	-	Work-Related Musculoskeletal Disorder

LIST OF PUBLICATIONS

Al Amin,M., Nuradilah,Z., Isa H., Nor Akramin,M., Febrian,I and Taufik. A Review in Ergonomics Risk Factors and Health Associated with Manual Materials Handling. Advanced Engineering Forum Vol. 10 (2013) pp 251-256.

CHAPTER 1

INTRODUCTION

1.0 Introduction

News on occupational injuries involving industrial workers has widely spread all over the countries in Malaysia. Most of the researchers played their roles by investigating the causes and effects for the incidents to occur among the workers. Every aspects associated with the incidents were being focused on their investigation. In this research, the aspects related to both physiological and psychological were investigated. Generally, physiology is defined as a scientific study of normal functions of living things, including ways of human bodies functioning. On the other hand, psychophysical is the study of the relationship between the physical stimuli and the effect they has interpreted in mind. This research focused on finding the physiological effects such as how muscle activities of the workers reacted while they were performing the physical activities. In continuity, the study tended to find how human heart rates were affected by performing the physical activities. Psychophysical experiences of workers were evaluated other than of physiology study. Their perception upon performing the physical tasks were evaluated which was parallel to direct measurement of muscle activity and heart rate. An occupational injury often occurs among the workers who are involved in manufacturing industries and service sectors. This is due to the frequency of involvement in direct physical work such as manual materials handling. Manual material handling (MMH) activities in the industry refers to activities such as lifting, carrying, holding, lowering, pushing, and pulling. This research was mainly focusing on occupational problems among