ASSESSMENTS OF AWKWARD POSTURES ASSOCIATED WITH BIOMECHANICAL FORCES AND MUSCLE ACTIVATIONS DURING COLLECTING OIL PALM FRESH FRUIT BUNCHES

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LIST OF ABBREVIATIONS

MSDs	Musculoskeletal Disoders
FFBs	Fresh Fruit Bunches
SOCSO	Social Security Organization
NIOSH	National Institute for Health and Safety
RULA	Rapid Upper Limb Assessment
REBA	Rapid Entire Body Assessment
OWAS	Ovako Working Posture Analysis System
EMG	Electromyography
WMSDs	Work-related Musculoskeletal Disorders
GBD	Global Burden of Disease
IMU	Inertial Motion Unit
MTw	Wireless Motion Trackers
GRF	Ground Reaction Forces
3DSSPP	3D Static Strength Prediction Program
SENIAM	Surface Electromyography for the Non-Invasive Assessment of Muscles
MVIC	Maximum Voluntary Isometric Contraction

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PENILAIAN POSTUR JANGGAL YANG DIKAITKAN DENGAN DAYA BIOMEKANIKAL DAN PENGAKTIFAN OTOT SEMASA MENGUMPUL TANDAN BUAH SEGAR KELAPA SAWIT

ABSTRAK

Tujuan kajian ini adalah untuk membentangkan risiko ergonomik dalam mengumpul buah sawit dengan penilaian tulang belakang lumbar yang berkaitan dengan membongkokkan dan putaran badan, kemudian membandingkannya dengan kesusasteraan yang sedia ada. Eksperimen direka dalam pelbagai jenis teknik memuatkan bauh sawit termasuk menggunakan cara manual badan berpintas dan badan bengkok ke hadapan, alat tradisional digunakan untuk menilai risiko dalam aktiviti memuatkan pada ketinggian yang berbeza, dan tugas memunggah kereta sorong yang telah dimuatkan sepenuhnya akan dinilai. Risiko ergonomik telah dinilai menggunakan skor REBA dan perisian 3DSSPP. Pendekatan ini digunakan untuk merangsang keputusan untuk postur yang berbeza dalam setiap tugasan. Perbandingan antara badan berpintas dan lenturan menunjukkan perbezaan tekanan cakera L5/S1 di mana badan berpintas lebih berbahaya berbanding lenturan. Ia disebabkan oleh bengkokkan dan putaran badan yang membawa kepada daya mampatan dan hacih. Walaupun bengkokkan badan pada lenturan teknik adalah lebih tinggi daripada teknik berpintas, ia tidak begitu berbahaya kepada badan kerana ia hanya melibatkan bengkokkan badan berbanding dengan badan berpintas yang melibatkan kedua-dua bengkokkan dan putaran badan. Selain badan berpintas dan lenturan, postur mencangkung dan separuh mencangkung juga dalam risiko ergonomik yang tinggi. Walaupun memuatkan FFB menggunakan pancang pemunggahan, semakin tinggi ketinggian yang dikenakan lebih banyak usaha untuk mengangkat FFB. Justeru, meningkatkan risiko ergonomik sejak melibatkan angkat bahu. Kedua-duanya merekrut aduan subjek bahawa mereka merasakan ketidakselesaan dan kesakitan di bahu, lengan dan belakang yang lebih rendah.

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ABSTRACT

The purpose of this study is to present the ergonomic risks in collecting fresh fruit bunches (FFBs) with the assessment of the lumbar spine related to trunk flexions and rotations, then comparing them to the existing literature. The experiments of different types of FFBs loading were designed including the manual loading of twisted body and bent forward body, the loading spike was used to evaluate the risks in loading activities at different heights, and the unloading fully loaded wheelbarrow task. The ergonomic risks had been evaluated using REBA score and 3DSSPP software. These approaches were used to stimulate the results for different postures in each task. The comparison between the twisting and bending torso showed a pressure difference of disc L5/S1 where the twisted body more harmful compared to bending body. It was due to the trunk flexion and rotation that lead to the compression and shear forces. Even the trunk flexions of bending torso were higher than the twisted, it did not very harmful to the body since it only involved the trunk flexion compared to the twisted body which involved both trunk flexions and rotations. Besides twisting and bending torso, the squatting and half-squatting posture also in a high ergonomic risk. While loading FFBs using loading spikes, the higher the heights exerted more effort to lift the FFBs. Hence, increasing the ergonomic risk since involving the over shoulder lifting. Both recruited subject complaint that they felt discomfort and pains on the shoulder, arm and lower back.

CHAPTER 1

INTRODUCTION

1.1 Chapter Introduction

This chapter provides a brief overview of biomechanics, ergonomic and musculoskeletal disorders (MSDs), which will be frequently mentioned in this research. This chapter also offers an overview of the problems facing in the oil palm industry especially for FFBs' loaders and collectors that are related to the MSDs. The specific objectives for this study are also presented in this chapter.

1.2 Research Background

Biomechanics is generally defined as an analysis of life, while mechanics is an analysis of movements and the forces used which cause that movement [1]. The analysis of movements which are in response to applied forces is the forces working on life that can create movement, stimulate growth and expansion, or cause injury through overloading tissues [2]. However, biomechanics is considered as the expansion and application of mechanics to clearly understand the effect of mechanical loads on life that are related to structure, properties, and functions. Biomechanics further addresses several health problems, as well as ailments, afflictions, and their treatments for life [1]. Biomechanics has two main applications. These are for improving human locomotion and treating or preventing lesions [2], as shown in Figure 1.1.

Figure 1.1 The application of the biomechanics in sports industry [2].

Ergonomic is a study that focuses on the characteristics of humans as a consideration to produce an appropriate design of living and work environment that their characteristics which will enhance their comfort level [3]. There are two main strategies that can be applied, which are adapting the individual to the work or adapting the work to the individual. Individuals are adapted to work by selecting individuals who can perform specific tasks and training these individuals to perform their tasks better and safer than others. Furthermore, adapting work to the individual is a scenario in which the task, equipment, and work organization have been modified to accommodate human abilities, limitations, and preferences. Even so, adapting work to the individual has become the highest priority in the industry [3].

Moreover, ergonomics can be an important element in the design, production and use of products. It is vital to acknowledge the analysis of anthropometry, posture, repetitive movement, and the design of the workspace since it will affect ergonomic understanding in relation to the end-user's needs [4]. Anthropometry takes account of the measurement and description of the dimensions of the human body, as shown in Figure 1.2, and its involvement in the design of the work system. Meanwhile, movement analysis focuses on developing a better work method. Thus, anthropometric, posture, and motion analysis considerations in the design of a working system will improve system performance and efficiency together with safety, comfort and prevent injuries or occupational accidents [4, 5].

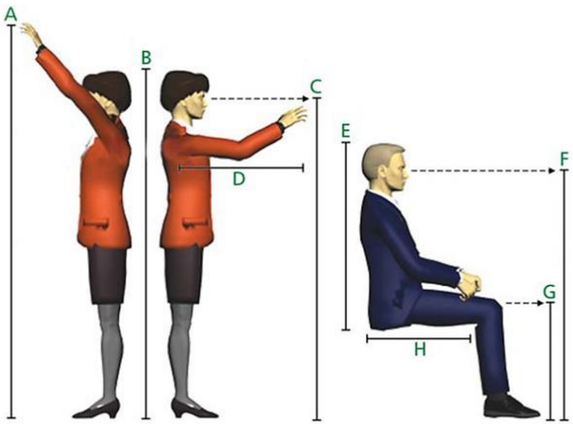

Figure 1.2 Common office environment posture measurements [4].

Ergonomics provides information to match the work with the operator and to identify and train suitable operators. Ergonomics therefore facilitates people and makes their work efficient. The use of ergonomic knowledge guarantees prudential use of human capabilities and abilities and protects individuals against excessive stress and undue strain [3].

Musculoskeletal disorders (MSDs) are among the most common chronic conditions and a major global cause of discomfort and pain among workers. MSDs include a wide range of incendiary and deteriorating conditions related to the musculoskeletal system, such as arthritis, osteoporosis, spinal disorders, soft tissue disorders, and musculoskeletal trauma and injury [6, [7]. Furthermore, pain and problems that are related to body parts like the neck, shoulders, arms, hands, buttocks, and knees are also known as MSDs [8].

MSDs is a term that relates to a range of pain or adverse conditions involving muscles, nerves, tendons, joints, and other soft tissues in the body. They constitute a broad range of disorders that differ in intensity from mild, severe, chronic, and enervative [9]. There are two basic types of lesions: (i) severe and painful, and (ii) chronic and long-lasting. The sudden structural and functional failure caused by the short-term heavy load such as muscle tearing due to lift a heavy load. When there are continual in permanent overload, the pain and dysfunctional of the muscles become worst. Next, the workers may be neglected the chronic injuries caused by long-term loading since it appears to recover without causing any lasting disability. Chronic injuries to muscles, tendons, ligaments, nerves, joints, bones and supporting vasculature, which are related to MSDs, are the most frequently reported cases among workers from many different occupations [10].

Since Malaysia is developing and the requirements are also increasing for physical workers in construction and plantation, the number of MSDs reported to the Social Security Organization (SOCSO) has also increased and it becomes one of the typical and major occupational health problems among workers [11], [12]. These disorders are often seen among workers performing manual handling works and that has been demonstrated in an abundance of studies which related to improper use of manual handling tools [13]. Those activities also can affect the productivity of workers and absenteeism [9], [13]. Occupations that involving the activities of high repetitions, high force exerts, kneeling, lifting heavy loads, vibration and awkward postures are the risk factors that may lead to MSDs [13] as shown in the Figure 1.3. Eventually, MSDs are a common medical reason for stopping work and seeking medical attention [12].

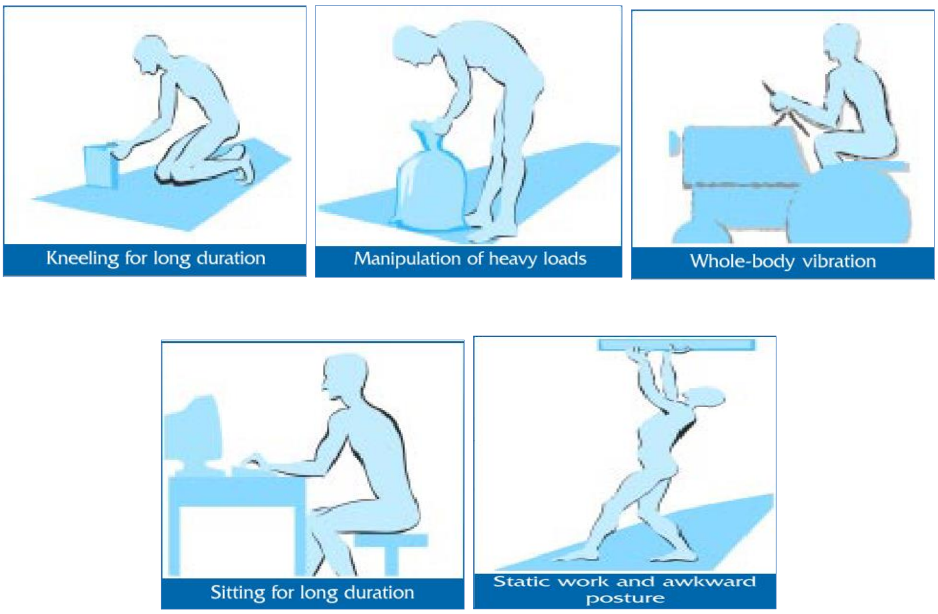

Figure 1.3 Examples of physical loads at work that are potentially dangerous for health [10].

Besides, MSDs are identified as a priority and the National Institute for Health and Safety of Work (NIOSH) strongly recommends reducing the prevalence and incidence of MSDs in work [13]. Ergonomic risks include various musculoskeletal issues like neck pain, back pain, buttock joint pain, knees, entire body, and arm vibration syndrome. The main cause of back pain is usually because of unintentionally lifting the objects or loads heavier than 51 pound or 23 kg [8, 14]. Lower back pain is caused primarily by distress, elevation, driving and other psychosocial factors [8].

1.3 Problem Statement

Ergonomic hazards and the associated MSDs have become increasingly recognisable in agricultural production. The problems of MSDs are inevitable as workers used manual handling when collecting the FFBs especially by using the manual techniques and conventional loading spikes. The task of manually lifting heavy FFBs could increase workers' health risk factors [15]. Thus, many previous studies showed that lifting of FFBs onto a wheelbarrow or lorry is typically a vital activity in the palm oil industry. These activities can lead to MSDs especially lower back pain among the workers since the workers exposed to the awkward postures, repetitiveness and require forceful exertion. The widely used measurement method in estimating the risk of MSDs among the FFBs' collectors and loaders by previous researchers was indirect, usually using questionnaires and traditional ergonomic assessment tools. Hence, the extreme postures, lumbar forces and muscle activation patterns of the recruited subjects while performing the FFBs loading and unloading tasks are assessed and computed using direct measurement equipment. It can be done by equipping the subjects with the surface electromyography (EMG) and inertial motion units (IMU). The findings can be valuable for intervention in reducing the MSDs risk of FFBs loading and unloading tasks.

1.4 Research Objectives

There are three specific objectives of the study, which are:

i. To analyse the extreme working postures during FFBs loading and unloading in relation to variation of lifting technique.
ii. To quantify the biomechanical forces of the lumbar spine that are imposed on the workers using the same postures during collecting and unloading the FFBs.
iii. To evaluate the muscle activation of the selected muscle for each posture during FFBs collecting and unloading in relation to variation of lifting technique.

1.5 Chapter Summary

The fundamental of the MSDs has been clearly discussed generally in this chapter and the risk factors also discovered. The MSDs among the FFBs' loaders and collectors can be explored and quantified by using the surface EMG for muscle activation patterns and IMU for extreme postures and lumbar forces. The main purposes of this study are also described in the three listed objectives.

CHAPTER 2

LITERATURE REVIEW

2.1 Chapter Introduction

This chapter review the current literature, which start with the review of MSDs in manual handling activities. Then, the review is narrow to the risk of MSDs related to collecting FFBs. It continued with the design technology to detect human movement and used of ergonomic assessment tools to determine MSDs prevalence from the selected awkward postures. Subsequently, the biomechanical modelling software used to create model to simulate the task as to calculate the lumbar forces and the fundamental of the EMG are also presented. At last, an overview of the review literature concluded the chapter.

2.2 Musculoskeletal Disorders in Manual Handling Task

Manual lifting had been widely used in various fields, specifically manufacturing and agricultural. The approaches taken in performing the manual lifting tasks required extreme working postures and high physical exertion, which increased the prevalence of MSDs. Manual lifting is an action that takes an object with one or two hands and moves it vertically without using a mechanical device. Manual lifting is a prevailing choice in industrial workplaces and an essential method of handling materials despite mechanised and automated technology [14]. Physical aspect is one of the factors that contributed to the prevalence of the MSDs. Physical factors, such as work methodology, equipment, and the environment, have been linked to the most clinical syndromes, including tendon inflammation and related conditions (tenosynovitis, epicondylitis, bursitis), nerve compression disorders (carpal tunnel syndrome, sciatica), and osteoarthrosis [16].

The previous studies had covered the ergonomic tasks involving a tremendous forces applied [17–19], prolonged static postures, awkward postures [18, 20–23], vibration [24–26], repetitive tasks [17–19, 23], working with arms above shoulder [23, 27–29], and handling heavy load manually [17–22, 27, 28, 30]. Manual tasks with strenuous force and awkward postures that performed by workers caused pain in lumbar spinal. An extreme forward flexion of trunk leads to the high torque coming