THE EFFECTIVENESS OF NAPIER HARVESTING MACHINE IN REDUCING POSTURAL RISK AMONG NAPIER HARVESTERS IN PERLIS

by

MOHD KHAIRUL FAIZI BIN ABD RAHMAN
(0930610336)

A thesis submitted in fulfillment of the requirements for the degree of Master of Science in Mechanical Engineering

School of Mechatronic Engineering
UNIVERSITI MALAYSIA PERLIS

2015

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ACKNOWLEDGEMENTS

The research work which led to this thesis was conducted at School of Mechatronic Engineering, Universiti Malaysia Perlis. I wish to acknowledge Center of Excellent Unmanned Aerial System (UAS), Universiti Malaysia Perlis for providing the financial and facilities support during this research conducted.

My special thanks go to Associates Professor Dr. Hazry Desa for his guidance and continual support throughout the course of this work. I equally appreciated his wisdom, tolerance, patience, and challenging criticism. I would also like to thank Dr. Ruslizam Daud and Dr. Shahriman Abu Bakar for their expert views, advice, and fruitful discussions throughout this project.

I am very grateful to all staff and colleagues at School of Mechatronic Engineering, Universiti Malaysia Perlis especially to skillful carpenters and technicians at Mechanical Workshop 1, who help with fabrication work and for dealing with all of my last minute requests with great professionalism.

And most importantly, the unconditional love, support and care from, my beloved wife Ros Syammimi Hamid, my cute little girl Eisya Nur Adra, my parents and all my family have been unsurpassed at all times, and for this, I am eternally indebted.

KEBERKESANAN MESIN PENUAIAN NAPIER DALAM MENGURANGKAN RISIKO POSTUR DIKALANGAN PENUAI NAPIER DI PERLIS

ABSTRAK

Kebanyakkan pekebun di industri kecil dan sederhana menggunakan kaedah konvensional untuk membuat kerja-kerja penuaian. Mereka sangat terdedah kepada risiko sakit belakang bawah (LBP) dimana ianya salah satu masalah gangguan muskuloskeletal (MSDs). Merujuk kepada penilaian bahagian badan atas pantas (RULA), dan penilaian seluruh bahagian badan pantas (REBA), kerja-kerja penuaian konvensional berisiko tinggi untuk terjadinya LBP disebabkan oleh postur menunduk yang ekstrem dan beban biomekanikal belakang bawah yang tinggi. Berdasarkan keputusan kaji selidik bahagian badan, 95% responden mengalami LBP. Oleh itu, objektif kajian ini adalah untuk mengenalpasti postur kerja yang betul seterusnya untuk merekabentuk alatan penuaian Napier dengan penerapan ergonomik bagi memastikan penggantian penggunaan parang dalam kaedah konvensional. Kajian makmal yang komprehensif telah dibuat dengan fokus adalah kepada postur menunduk dengan menggunakan elektromyografi (EMG). Tiga jenis kondisi postur menunduk telah disiasat: menunduk dengan bebas beban; dengan beban mununduk 10 kg; menunduk dengan pemegang penyokong. Sebelas subjek lelaki telah dipilih untuk mendemonstrasi tiga jenis kondisi menunduk dengan empat tahap bongkokan yang berbeza dan isyarat EMG direkodkan. Isyarat data EMG kemudiannya telah dianalisa menggunakan ANOVA dengan α (0.05) dan telah diplotkan kepada plot taburan, dan kemudian regrasi lurus telah dibina untuk menghasilkan persamaan matematik lurus. ANOVA telah menunjukkan perbezaan ketara dengan *p-value* (0.001) dan plot kotak telah membuktikan bahawa membongkok dengan pemegang penyokong memberikan keputusan yang lebih baik. Alatan penerapan ergonomik telah dibangunkan secara prototaip dengan berbantu motor dan sistem separa automatik. Satu penilaian tapak kepada prototaip telah dibuat untuk mengawasi aktiviti-aktiviti otot dengan memberi fokus pada kawasan belakang bawah menggunakan EMG. Isyarat data EMG kemudiannya telah dianalisa menggunakan *t-test* dengan α (0.05). Sepuluh pekebun sukarela dipilih secara rawak untuk mensimulasi proses penuaian terbabit. Keputusannya menunjukkan berlaku pengurangan aktiviti otot belakang dibandingkan dengan kaedah konvensional disebabkan oleh penambahbaikan kepada postur kerja. Penggunaan prototaip telah menunjukkan perbezaan yang ketara pada aktiviti-aktiviti otot dengan *p-value* (0.00034). Disamping itu, RULA dan REBA juga menunjukkan skor yang lebih baik sebagai bukti kukuh dalam menambahbaik postur badan semasa menuai dengan kaedah baru ini. Tambahan lagi, pusingan masa menuai telah ditambah baik sebanyak 70.2% dimana ianya mendapat output pengeluaran yang lebih baik. Analisa *t-test* juga telah menunjukkan perbezaan ketara *p-value* (0.0000373) dan berdasarkan plot kotak, penggunaan prototaip menunjukkan pusingan masa yang lebih baik. Sebagai rangkuman, bantuan daripada prototaip ini dalam proses menuai Napier adalah dicadangkan memandangkan data kajian yang diberikan ianya mampu mengurangkan risiko sakit belakang bawah.

THE EFFECTIVENESS OF NAPIER HARVESTING MACHINE IN REDUCING POSTURAL RISK AMONG NAPIER HARVESTER IN PERLIS

ABSTRACT

Most farmworkers in the small and medium Napier industry are using conventional method for harvesting works. Therefore, they are extremely exposed to the risk of low back pain (LBP) disease which is one of the musculoskeletal disorders (MSDs) typical problems. Referring to the Rapid Upper Limb Assessment (RULA), and Rapid Entire Body Assessment (REBA), conventional harvesting works was highly risk to undergo LBP due to extreme stooped posture and high of low back biomechanical loading. Based on the body score survey result, there were 95% of respondents suffering of LBP. Hence, the objective of this project is to identify proper working posture thus to design the Napier harvesting ergonomics engineering intervention in order to replace the use of machetes in conventional harvest. The comprehensive laboratory studies were conducted by focusing on stooped posture by using electromyography (EMG). Three kinds of stooped posture condition were investigated: free load stooped; with 10 kg load stooped; with support holder stooped. Eleven male subjects were selected to demonstrate these stooped conditions with four difference flexion levels. The EMG signal data then was analyzed by ANOVA with α (0.05) and plotted into scatterplot, and then linear regression was constructed to generate the linear mathematical equation. The ANOVA showed the significant difference with p-value (0.001) and the boxplot proved that stooped with support holder give better result. By the laboratory experiment findings, the ergonomics engineering intervention was properly designed. The intervention was developed in prototype with motorizes assistance and semi-automated system. A prototype field evaluation has been conducted to monitor the muscle activities with focusing on the lower back region by using EMG. The EMG data then was analyzed by the *t-test* with α (0.05). Ten volunteered farmworker is randomly picked to simulate the harvesting process. Based on the boxplot, the results shown reduction of back muscle activities as compared to the conventional method due to working posture improvement. The intervention prototype had a significant difference in the muscle activities with p-value (0.00034). Besides, the RULA and REBA also shows better score as concrete evidence in improving body posture during harvesting work with this new method. Furthermore, the harvest cycle time was improved about 70.2% where it's getting better production outputs. The *t-test* analysis also shown the significance difference with p-value (0.0000373) and based on boxplot, the intervention harvest depicted better cycle time. As conclusions, optimized working posture along with the assistance of intervention prototype in the Napier harvesting process is suggested since the data provided in this project show that it could decrease the risk of low back pain. Apparently, this study also encourage of generating the innovation in designing new tools to increase the agriculture workers' performance.

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CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter describes the general background of the present study. It starts by discussing the research motivations which discuss about the ergonomics awareness in Malaysian's agriculture industry and current issues in conventional Napier harvest works. Then, problem statements are addressed mainly on farmworkers stooped posture and biomechanical back load handling issues. Research objectives are outlined and followed by research scope.

1.2 Research Motivations

1.2.1 Ergonomics Awareness in Malaysian's Agricultural Sustainability

An ergonomics application in human daily works becomes the basic matter to the successfulness of the certain field including the agriculture industry. In line with this, the Malaysian government took the drastic initiative in developing their agriculture focus by applying ergonomics approaches. Due to this, the depth understanding of the ergonomics is important in order to apply optimizations in this kind of industry and even in various human daily works.

Based on the Agriculture Ministry of Malaysia (2011), agriculture land in Malaysia managed to cover 20% of total land area and approximately 33 million hectares which are included by three major activities: crops; livestock; fisheries. For that, the government has put the agricultural area as one of the main areas in National Key Economic Areas (NKEA) under the Economic Transformation Programs (ETP). In relation to that, Department of Statistics (2011) has published the Gross Domestic Product (GDP), it provides the detailed investigation of the agriculture sectors and labor forces for 2005 until 2010 period. Details of information are presented in Table 1.1 below.

Table 1.1: Malaysia GDPs and Employment in Agriculture Sector (2005-2010), published by the Malaysian Department of Statistic (2011).

	2005	**2006**	**2007**	**2008**	**2009**	**2010**[e]
***GDP (RM Million)**						
Total	449,250	475,526	504,919	528,311	521,095	558,382
Agriculture	35,524 (7.9%)	37,375 (7.9%)	37,846 (7.5%)	39,392 (7.5%)	39,579(7.6%)	40,680 (7.3%)
***Labor Force - Employment ('000 person)**						
Total	10,045.4	10,275.4	10,538.1	10,659.6	10,897.3	11,517.2
Agriculture	1,470.4 (14.6%)	1,503.5 (14.6%)	1,437.3 (13.6%)	1,558.2 (14.6%)	1,470.1 (13.4%)	1475.1 (12.8%)
†Vacancies (person)						
Agriculture	39,450	185,271	220,120	269,272	223,890	N.A

With very encouraging and promising profits in the national agricultural sector, greater involvement of ergonomics is required to ensure the continuity and effectiveness of crop productivity, labors health and safety. The lack of ergonomics approach has been contributed to poor consequences to this industry in Malaysia (Loo and Stanley, 2012). According to the Department of Safety and Health (DOSH) (2009), agriculture sectors consistently recorded as second higher occupational injuries and accidents by 2007 until 2009. By the year 2007, it contributed 22.3% of injuries whereby the worst case ever been reported to DOSH compared with the following years. By the year 2008 and 2009, it only contributed 16.5% and 20.6% of injuries and accidents respectively as shown in Table 1.2 below.

Table 1.2: Occupational Injuries and Accidents According to Types of Injuries and Sectors Reported to DOSH, 2007 – 2009 (Department of Safety and Health, 2009).

	2007				**2008**				**2009**			
	NPD	PD	Fatal	Total	NPD	PD	Fatal	Total	NPD	PD	Fatal	Total
Manufacturing	2094	133	63	2290	1585	136	79	1800	1419	90	63	1572
Mining and Quarrying	5	1	9	15	4	0	9	13	2	1	3	6
Construction	76	10	95	181	54	3	73	130	38	6	71	115
Agriculture	**712**	**14**	**30**	**756**	**368**	**7**	**43**	**418**	**440**	**8**	**44**	**492**
Utilities	51	4	10	65	83	12	20	115	116	3	23	142
Transport, Storage and Communication	7	0	2	9	18	1	8	27	21	0	18	39
Wholesale and Retail Trade	11	1	3	15	2	0	0	2	0	0	0	0
Hotels and Restaurants	11	2	0	13	13	1	1	15	18	0	0	18
Finance, Insurance, Real Estate and Business Services	25	0	4	29	2	1	4	7	0	0	1	1
Public Services and Statutory Body	16	3	3	22	3	1	2	6	0	0	1	1
Total	**3008**	**168**	**219**	**3395**	**2134**	**162**	**239**	**2535**	**2054**	**108**	**224**	**2386**

There is difference of injury data recorded by the Department of Labor and Social Security Organization (SOCSO) through the Ministry of Human Resource Malaysia (2009) where the number is increased, but the percentage showed a reduction in the year 2007, 2008, and 2009 as shown in Table 1.3. The contribution percentage of accident and injuries recorded 6.7%, 6.2%, and 4.7%, respectively.

Table 1.3: Occupational Injuries and Accidents by Sectors Reported to Labor Department and SOCSO, 2004 – 2009 (Ministry of Human Resource Malaysia, 2009).

Types of Industry	2004	2005	2006	2007*	2008	2009
Agriculture, Forestry and Hunting	**7,875**	**5,923**	**5,604**	**2,631**	**3,467**	**4,106**
Fishing	109	72	135	N.A	127	45
Mining and Quarrying	772	615	541	328	368	404
Manufacturing	31,372	28,454	27,066	19,228	19,041	20,747
Electricity, Gas and Water Supply	501	469	515	493	524	548
Construction	5,086	4,973	4,500	3,931	3,814	4,527
Wholesale and Retail Trade, Repair of Motor Vehicles, Motorcycles and Personal and Household	13,194	12,220	11,783	12,298	9,741	9,425
Transport, Storage and communication	4,194	3,676	3,653	3,639	3,305	3,732
Financial Intermediation	5,903	5,157	5,386	542	718	796
Hotel and Restaurant	29	53	39	13,248	1,601	1,953
Real Estates, Renting and Business Services	93	157	174	N.A	4,405	4,861
Public Administration and Defense, Compulsory Social Security	16	19	25	N.A	3,912	4,173
Education	1	0	2	N.A	239	246
Health and Social Work	0	1	2	N.A	849	918
Other Community, Social and Personal Service Activities	8,524	8,869	8,469	N.A	272	488
Private Household with Employed Person	0	3	5	N.A	3,551	4,386
Ex-territorial Organization and Bodies	1	3	4	N.A	155	144
Other activities inadequately defined	8	9	120	N.A	6	12
Total	**77,742**	**70,690**	**68,008**	**56,339**	**56,095**	**61,511**

In fact, the ergonomics approach is actually more geared to reducing injuries hence avoiding accident at the workplace. Apart from the accidents that come in many different ways, while the most common injuries are coming with, related to the musculoskeletal disorders (MSDs). MSDs contribute to the disruption of agricultural sector's productivity. Fig. 1.1 shows the number of MSDs cases that reported to the SOCSO by the year 2000 until 2009. The data show the exponential trend of reporting

MSDs cases particular from year 2007 - 2008 and in year 2008 - 2009 by the increasing percentage 196% and 109% respectively. This trend is expected to worsen due to the greater employment opportunity in the national future agriculture sector.

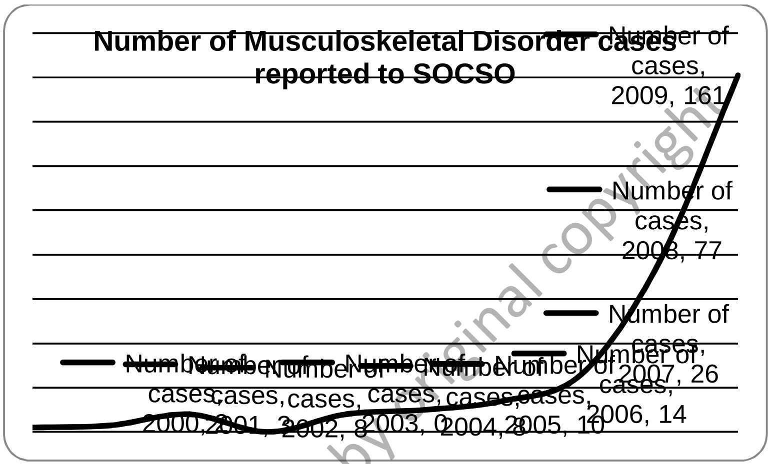

Figure 1.1: Number of Musculoskeletal Disorder Cases Reported to SOCSO, 2000 – 2009 (Department of Labor and Social Security Organization, 2009).

As a conclusion, ergonomics approach is a basic requirement in the development of the national agricultural sector. The awareness should be touted and the government and farmers alike have to take responsibility to ensure for the conducive and ideal working environment in order to optimize the agriculture productivity into global markets.

1.2.2 Napier Harvesting Process

Napier grass (*Pennisetum purpureum*) is the most popular fodder grass that contained high in nutrition such as fiber, mineral, vitamin, and protein, which is essential for livestock (Muinga et al., 1990). Napier was very suited to growing in

Malaysia due to its high rainfall areas and found that it is also grown well in drier areas.

Napier grass could be first harvested when it attains a height of 1-1.2 meters in 3-4 month after planting period. Napier was in good quality and sufficient dry matter at that time. Thereafter, the grass should be harvested in 6-8 weeks interval when it attains the same height. The grasses will undergo further processes after cut in the first time, whereby it will chop into pieces about 20-50 mm long by chopping machine and mixed thoroughly before feeding that suggested by Muinga et al. (1990).

According to Anim (2012), the Napier harvest process in Malaysia for most small and medium entrepreneur (SME) is done conventionally and totally manually by man power. The machete is a typical tool in the Napier harvesting work due to its low cost method and no high skill workers is required. Since the Napier grass is still not a primary agriculture industry and small scale dairy farm in Malaysia, there is no automated system require yet for the particular harvester machine.

The machete is used to swing the Napier stem about 2 inches from the bottom in order to let the remaining stem can be efflorescing as shown in Fig. 1.2. There are no specific techniques in cutting process in terms of body posture, hand side to use, cutting direction, and even the tools (Anem, 2012). It is all depending on subjective judgment as long as it may remove the stem from the plant root. The worker's awkward posture during harvesting was potentially increasing the risk of low back pain. Furthermore, biomechanical load handling might cause high stress on lower extremity region.

Figure 1.2: The conventional Napier harvesting using a machete.

1.3 Problem Statement

Based on observation, the current Napier harvesting technique is not practical ergonomics due to stooped posture of farmworkers and utilizes total manpower without assistant equipment. In line with above observation, Anem (2012) mentioned that common Napier harvesting in Malaysia was implemented manually by using machete which is experienced extreme and repetitive stooped posture of farmworkers. The stooped posture has been increased high back muscle activities so that it can increase the injury probability (Oudenhoven et al., 1982; Ghista et al., 1998; and Meng and Meng, 2010). Since the back muscle injury might cause low back pain (LBP) disease, it is also can be a main source of vertebrate disc damage

(Kristen, 2006; Lars and Carlo, 2003; Dedering et al., 2000, and Lariviere et al., 2000). It was found that the conventional technique was never considered the proper handle of the back biomechanical load and low back muscle fatigue can occur (Anem, 2012). Furthermore, this current practice of harvesting work was experienced repetitive of stooped posture which might promote the rapid of LBPs (Ulrey and Fathallah, 2011). In long duration of stooped working posture, movement activities of farmworkers are slowing down and required the frequent rest during harvesting work interval. Thus, this will contribute to the decreasing of productivity rate.

Better solution must be pursued to overcome the biomechanical factor which is its proven influenced by working posture and back load handle. The need of harvesting work evaluation and optimum working posture instead of conventional method may help to decrease lower back pain disease risk in Napier grass industry. This study aims to improve the human posture during Napier harvesting by using ergonomics engineering interventions in order to reduce lower back pain (LBP) disease.

1.4 Objectives

This project aims to investigate the human working posture and back load handling during harvesting work in relation to low back pain (LBP) disease. Therefore, the objectives of this study are:

i) To examine the human posture during conventional Napier harvesting works through ergonomics software and tools.

ii) To examine the suitable human stoop posture during Napier harvesting works through comprehensive laboratory experiments.

iii) To propose the improved engineering ergonomics intervention with optimum handle height for Napier harvesting.

iv) To evaluate and validate the proposed body posture with the assistance of an ergonomics engineering intervention.

1.5 Scopes

The main purpose of this project is to improve the body posture and come out with the prototype of ergonomics engineering intervention for Malaysia Napier farming conditions. Some consideration takes during implementing this study and some of the research scopes are determined.

The whole experiments are accounts of laboratory and real field based in order to provide the reliable and comparable data. These experiments are appointed by suitable subjects with considering good condition of nerve health, non-smoking, excellent physical and young. Most of the subjects consist of volunteered students for laboratory experiments and volunteered Napier farmworkers for field experiments. As for simulation purpose, the data are accounted by Human Activity Analysis (HAA) which provided in CATIA software. Entire laboratory experiments, field experiments, and simulation are focused on human stooped posture analysis.

1.6 Thesis Organization

This thesis consists of five chapters as follows:

Chapter 1: This chapter provides the brief introduction of study, deliberation of issues that mapped the study foundation: the research motivations; the statement of research problems; the research objectives to achieve; the research scopes; and the thesis organization.

Chapter 2: This chapter describes the literature surveys related to the theory reinforcement elements as the continuity to the project. It includes reviews of comprehensive investigation on Napier harvesting technique, ergonomics awareness in Malaysians agriculture industries, knowledge of musculoskeletal disorders (MSDs), the importance of Body score survey, the study of human biomechanics on the agricultural field by previous researchers, as well as knowledge of anthropology and anthropometry.

Chapter 3: This chapter provides discussion detail explanation about the whole figure and the methodology of the study. There are three steps of the main phases to be completed; investigation of existing systems, stoops posture analysis, and intervention development. Each phase is divided by main and sub activity. The investigation of the existing system is essential to identify, gathered and classified the real problem to be solved comprehensively.

Chapter 4: This chapter provides the details about entire postural laboratory experimental work, including their methods and implementations. These experiments