



**UNIVERSITI PUTRA MALAYSIA**

***THE DEVELOPMENT OF SMART FRUIT BASKET FOR PINEAPPLE  
HARVESTING***

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FPSK4 2017 40**

## **ACKNOWLEDGEMENTS**

I would like to praise to Allah for His permission, this thesis could be completed on time. Without Him, I think that I will totally lose strength throughout the research process and could not able to complete my thesis.

Special thank to my research supervisor, Dr. Emilia Zainal Abidin for helping me throughout the process in completing this thesis. Without her assistance, supervision and dedicated involvement in every step throughout the process, this thesis would have never been completed. I would like to thank you very much for your support, advice, and understanding over these past two semesters. Thank you also for contributing me the financial support for producing the new prototype of the knapsack basket.

I would also like to show gratitude to my co-supervisor, Dr. Karmegam Karuppiah for assisting and guiding me through this research process. Thank you for your advice and patience with my knowledge gaps in this area.

Besides, I would like to thank En Rosli bin Piei for his cooperation and assistance in fabricating the prototype of pineapple knapsack basket for this research. Without his skill and knowledge, this prototype will not be able to be done.

Not to be forgotten to all the respondents those were willing to spend their precious time for this research. I am really appreciating your cooperation in fulfilling the data collection for this research.

Most importantly, none of this could have happened without my family. Thank you for all the encouragement and support. Every time I was ready to quit, you did not let me and I are forever grateful and blessed with all of your support.

Finally yet importantly, not to be forgotten for anybody that had directly and indirectly helped me here in Universiti Putra Malaysia for completing my undergraduate.

Thank you.

## ABSTRACT

### DEVELOPMENT OF SMART FRUIT BASKET FOR PINEAPPLE HARVESTING

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**Introduction:** Harvesting is one of the main tasks of the pineapple plantation workers that have contributed to the reporting of severe muscular skeletal symptoms (MSS) and other kinds of ergonomic risks. Harvesting is done manually using solid rattan baskets and workers need to carry cumulatively 500-600 kg of fruits per day. Harvesting task using existing basket exposes workers to excessive bending, pain and discomfort at various body area. This study is done to develop an improved basket to replace the existing basket in order to reduce MSS. **Objective:** The objective of this study is (a) to develop a conceptual design of an ergonomic knapsack basket, (b) to fabricate a prototype of an ergonomic knapsack basket, (c) to test the design of an ergonomic knapsack basket on the aspect of discomfort, physiological workload and perception of workers. **Methodology:** An experimental study was done. The development and testing of the design for the knapsack basket was done in the laboratory of Occupational Safety and Health at the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia while authorized party did the fabrication of the improved basket. A simulation on pineapple harvesting was done at the laboratory. A set of questionnaire was given to assess the discomfort of respondents using Borg scale CR-10 and perception of respondents. The physiological workload (heart rate and energy expenditure) of respondents was measured using polar heart rate monitor S610i. Energy expenditure of respondents was calculated using the average heart rate of the respondents using a formula by previous study. Data was analyzed using Statistical Packages of Social Sciences (SPSS) version 22.0. The ethical committee for human research had approved the protocol of this study. **Results:** The newly designed basket had ergonomic characteristics such as adjustable cushion strap, foaming back padded and latch for opening. A total of 12 respondents participated in this study. Mean discomfort of all body parts for improved basket was  $4.13 \pm 6.1$  while existing basket was  $12.26 \pm 11.2$  showing a significant reduction ( $p\text{-value}=0.012$ ). The physiological workload showed significant reduction ( $p\text{-value}=0.021$ ) as the average heart rate and energy expenditure for improved basket was 89.05 beats/min and 5 kJ/min while for the existing basket was 94.13 beats/min and 6 kJ/min. Respondents also preferred improved basket to existing basket for pineapple harvesting. **Conclusion:** Improved basket was better than existing basket and can reduced MSS if being used for a long run. However, improvement should be done to improved basket especially to change to lighter material.

**Keywords:** Musculoskeletal Symptoms (MSS), physiological workload, discomfort, heart rate, pineapple plantation workers, knapsack basket

## ABSTRAK

### PEMBANGUNAN BAKUL BUAH PINTAR UNTUK PENUAIAN NANAS

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**Pengenalan:** Penuaian adalah salah satu tugas utama pekerja ladang nanas yang telah menyumbang kepada pelaporan gejala otot rangka yang teruk (MSS) dan lain-lain jenis risiko ergonomik. Penuaian dilakukan secara manual menggunakan bakul rotan dan pekerja perlu mengangkat secara kumulatif 500-600 kg buah setiap hari. Penuaian menggunakan bakul sedia ada mendedahkan pekerja kepada lenturan berlebihan, kesakitan dan ketidakselesaan di pelbagai anggota badan. Kajian ini dilakukan untuk membina bakul yang lebih baik untuk menggantikan bakul yang sedia ada bagi mengurangkan MSS. **Objektif:** Objektif kajian ini adalah (a) untuk membangunkan reka bentuk konsep sebuah bakul bunttil ergonomik, (b) untuk mereka prototaip bakul bunttil ergonomik, (c) untuk menguji reka bentuk bakul bunttil ergonomik daripada aspek ketidakselesaan, beban kerja fisiologi dan persepsi pekerja. **Metodologi:** Satu uji kaji telah dilakukan. Pembangunan dan ujian reka bentuk bakul bunttil telah dilakukan di makmal Keselamatan dan Kesihatan Pekerjaan di Fakulti Perubatan dan Sains Kesihatan, Universiti Putra Malaysia manakala pihak yang dilantik membuat bakul baru. Satu simulasi penuaian nanas telah dilakukan di makmal. Satu set soal selidik telah diberikan untuk menilai ketidakselesaan responden menggunakan skala Borg CR-10 dan persepsi responden. Beban kerja fisiologi (kadar jantung dan penggunaan tenaga) responden diukur menggunakan pemantau kadar jantung kutub S610i. Penggunaan tenaga daripada responden telah dikira menggunakan purata kadar jantung responden menggunakan formula daripada kajian sebelumnya. Data dianalisis menggunakan Pakej Statistik Sains Sosial (SPSS) versi 22.0. Jawatankuasa etika penyelidikan manusia telah meluluskan protokol kajian ini. **Keputusan:** Bakul baru yang direka mempunyai ciri-ciri ergonomik seperti tali kusyen boleh laras, penyandar belakang yang empuk dan selak untuk membuka bahagian belakang bakul. Seramai 12 orang responden terlibat dalam kajian ini. Purata kadar ketidakselesaan semua bahagian badan untuk bakul baru adalah  $4.13 \pm 6.1$  manakala bakul sedia ada adalah  $12.26 \pm 11.2$  menunjukkan penurunan yang signifikan ( $p\text{-value} = 0.012$ ). Beban kerja fisiologi menunjukkan pengurangan signifikan ( $p\text{-value} = 0.021$ ) kerana kadar jantung dan purata tenaga bagi bakul baru adalah 89.05 denyutan / min dan 5 kJ / min manakala bagi bakul sedia ada adalah 94.13 denyutan / min dan 6 kJ / min. Responden juga lebih memilih bakul baru berbanding bakul sedia ada untuk penuaian nanas. **Kesimpulan:** Bakul baru adalah lebih baik daripada bakul sedia ada dan MSS boleh dikurangkan jika bakul baru digunakan untuk jangka masa yang panjang. Walau bagaimanapun, penambahbaikan perlu dilakukan terhadap bakul baru terutamanya menukar kepada bahan yang lebih ringan.

**Kata kunci:** Gejala otot rangka (MSS), beban kerja fisiologi, ketidakselesaan, kadar jantung, pekerja ladang nanas, bakul bunttil

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## **LIST OF ABBREVIATIONS**

<b>MSS</b>	<b>Musculoskeletal symptoms</b>
<b>MSD</b>	<b>Musculoskeletal disorder</b>
<b>MPIB</b>	<b>Malaysian Pineapple Industrial Board</b>
<b>NBOS</b>	<b>National Blue Ocean Strategy</b>
<b>HR</b>	<b>Heart rate</b>
<b>GTP</b>	<b>Government Transformation Program</b>
<b>BMI</b>	<b>Body Mass Index</b>
<b>RULA</b>	<b>Rapid Upper Limbs Assessment</b>
<b>REBA</b>	<b>Rapid Entire Body Assessment</b>
<b>HIRARC</b>	<b>Hazard Identification, Risk Analysis and Risk Control</b>
<b>WRMSD</b>	<b>Work-related Musculoskeletal Disorder</b>
<b>NABC</b>	<b>Need Approach Benefit Competition</b>

# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 Background**

In agricultural work, working in plantation requires a tremendous amount of energy to perform work thus highly expose the agricultural workers to ergonomic hazards. According to The University of Chicago (2017), ergonomic hazards are the workplace conditions that pose a risk of injury to the musculoskeletal system of the worker. Ergonomic hazards consist of vibration, temperature extremes, repetitive and forceful movements, and awkward postures due to improper work methods and improperly designed workstations, tools, and equipment. Ergonomic hazards lead to various musculoskeletal symptoms (MSS) that occurs at the neck, low back pain, hip, knee, and upper limb (Shan et al., 2011). Harris-Adamson et al., (2015) reported that the risks of getting MSS are much greater when a worker is exposed to several ergonomic risk factors simultaneously.

## **1.2 Cost of MSS to Workers**

Musculoskeletal symptoms can occur once ergonomic principles at work is not being considered thus provide spiritual and physical tensions, low productivity and unsuitable work life quality (Abarqhouei & Hosseini Nasab, 2011). Any work-related health impairment or disorders due to hazardous work environment can lead to sick absenteeism thus affect the productivity of work (Benavides, 2006). Various studies have stated that productivity loss as a consequent of health risks or problem in various industries (Alavinia et al., 2009). Ng et al., (2014) stated that those having MSD during the past week and yet went to work were almost three times to be less productive compared to their healthy or those who did not experience MSD counterparts. Besides that, MSD can cause disability, lost work time, and increase the production cost. The production costs increase due to worker absence, insurance and medical costs, decreased work capacity, and loss of employees from other less physically demanding industries (Kirkhorn et al., 2010).

## **1.3 Work Activities in Pineapple Plantations**

Malaysia is one of the world major producers for pineapple together with Indonesia, Hawaii, Thailand, Philippines, Kenya, Brazil, Ivory Coast, South Africa, India, Taiwan and Australia (Mohd Tamrin & Aumran, 2014). Working in the pineapple plantation involve repetitive and heavy tasks that give a lot of strain on the body, such as weeding, constant bending over to plant seeds, and harvesting the pineapples. This is because pineapple plants are spiky and are difficult to handle, as they grow low to the ground. Due to the environmental conditions and physical

demands in the plantation field, the unusual exposure has placed the pineapple workers at increased risk of injuries and MSS. The study conducted by Rani et al., (2016) in Pontian, Johor showing that the highest prevalence of MSS reported for the past 12 months was for the complaints of pain at lower back (63.0%) followed by knees (53.7%), shoulders (51.9%), ankles/feet (33.3%), elbow (18.5%), thigh (13%), upper back and wrists/hands (9.3%), and neck (7.4%) regions. While Rani et al., (2016) reported that the one-year prevalence of MSS among pineapple plantation workers was 87.0%.



Figure 1.1: Excessive bending to unload pineapples during harvesting process (Rani et al., 2016)

There are several steps required in the work tasks of a pineapple plantation. Rani et al., (2016) stated that the pineapple plantation workers prepare the land for pineapple plantation, cultivate the sucker of the pineapple, fertilize and weed the pineapple plantation, harvest the pineapple and spray pesticide at the pineapple plantation. The workers had to bend forward their trunk to prepare the land for pineapple plantation. The workers also had to bend their trunk to cultivate young sucker of pineapple into the holes on the ground. Sometimes they had to twist their

wrist from neutral position repetitively. Then, the workers sprinkled fertilizer manually with their hand.

The pineapple plantation workers involved in strenuous work that will increase the heart rate. According to Gaskell (2010) heart rate will increase and decrease depending on the amount of demand placed on the muscles. If the demand is high, heart pumps harder to deliver more oxygen to muscles for metabolism. However, a variation of cardiovascular stress index among workers might be due to the difference in the environmental conditions, degree of severity of job and also duration of activity (Dey et al., 2007). A number of studies have combined physiological and neurological measures to produce results more successful than those found using a single measure. Successful combinations include: heart rate variability and electro-dermal response (Haarmann et al., 2009); alpha band, blink rate and heart rate variability, heart rate and eye movement (Rusnock & Borghetti, 2015)

#### **1.4 Problem Statement**

From all the tasks performed at pineapple plantations, previous studies have shown evidence that harvesting of fruits is one of the tasks that give the highest risk factors for MSS. A research by Rani et al., (2016) shows that harvesting process gives a huge impact on MSS. Harvesting of fruit is done by carrying a knapsack basket on their back to collect all the fruits. During harvesting process, the pineapple plantation workers need to carry the knapsack basket on their back while collecting the pineapple fruits. The workers have to carry loads about 50 kg and if the existing

knapsack basket is modified can carry up to 70 kg for each session of pineapple collection. This activity will go on for more than 4 hours of the day making the cumulative load that the workers carry are about 500 kg to 600 kg of fruits per day. Figure 1.2 shows a worker collecting fruits using modified knapsack basket by adding on a wire at the knapsack basket to collect more load.



Figure 1.2: Modification on the existing knapsack basket using wire

Those workers involved in an awkward posture and forceful exertion while performing tasks due to workers were required to bend excessively for more than 60° especially during unloading of the pineapple to the ground. They also have to twist their wrist from neutral position repetitively (Rani et al., 2016). The workers take about 3 days to collect all the fruits from the plantation area that has the width for about one ha.

Mostly the workers only do one task only. For example, if the workers are involving in the harvesting process, the workers will only do that task only but this is only applicable in the big pineapple plantation area. If the workers work in a small

pineapple plantation area, the workers need to do all the tasks in the plantation area such as cultivation of sucker, fertilizing, land preparation, harvesting, weeding and pesticide spraying.

The knapsack basket used to carry the fruits is made of rattan as rattan has higher durability than other material. However, rattan gives more weight making the workers carry higher load together with the fruits as an empty solid rattan basket had already weight for 5 kg. Sometimes the workers make modification on the existing knapsack basket on their own by using wire so that they can carry more loads during the harvesting process. The workers also use a gunnysack to cover their back from the pineapple barb making them carry more loads.



Figure 1.3: Gunnysack is used as back support from the pineapples' barb

In addition, the workers' trunk will bend according to the weight of the load that they carried about  $20^{\circ}$  to  $60^{\circ}$  (Rani et al., 2016). The more loads that they carry; the more they have to bend their trunk. Rani et al., (2016) reported that weight of full load knapsack basket weighs approximately 50 kg or more that exceeded the

National Institute Occupational Safety and Health safe limit for ideal lifting load of 23 kg or 51 lbs (Kamarudin et al., 2013).

The workers also involved in excessive bending for more than 60° when they need to unload all the pineapples from the knapsack basket on the ground. The workers also involve in deviation and twisting of the wrist from neutral position repetitively for more than 20 times per minute (Rani et al., 2016). Pineapple plantation involve in working on soft ground or known as peat soil making the workers have to do the task manually to collect all the fruits. They cannot use any tools such as wheelbarrow due to unsuitable soil structure. The workers are local people and they have been working in the pineapple plantation for about 25 years making them be exposing with the ergonomic risk for a long time (Rani et al., 2016).

The research further shows that prevalence of MSS among pineapple plantation workers who reported discomfort or pain at any body part is 87.0% and 80.6% of the workers complained of MSS in 2 to 5 part of the body (Rani et al., 2016). As there is no innovative design of knapsack basket for pineapple harvesting, there is a need for inventing a new knapsack basket that can carry loads but give less health effect, reduce discomfort to body parts and may reduce MSS among pineapple workers if being used in a long run.

## **1.5 Research Justification**

Working at plantation involves numerous hazards related to work environment, the tools and equipment used, and the nature of the work (Cabrera, 2011). The pineapple-harvesting workers have no choice but to use the available rattan basket to perform their work. Unlike the palm oil industries, a limited number of innovative products has been created for tropical agricultural work tasks. For example, the development of new chisel for the oil palm harvester by Ng et al., (2014) that used the ergonomic principles in the chisel's designing. It is compulsory to invent the new ergonomic knapsack basket for the harvesting process in this specific agricultural sector. This is due to harvesting process was identified as a task that gave high risk to workers and workers involved in very high postural body risk while performing the task. Therefore, this study is designed to invent a new ergonomic knapsack basket that can carry the loads but give less health effect to the workers. This new ergonomic knapsack basket can reduce the MSS among the pineapple plantation workers if being used for a long run. This new ergonomic knapsack basket expected to reduce the discomfort of the workers while performing their tasks. The ergonomics risks factors while performing any activity can be overcome by developing safe and trustworthy design (Chakrabarti, 2009). Effective design application in agro-based industry is needed to improve productivity together with workers overall wellbeing (Chakrabarti & Bhattachheriya, 2012). This new invention can also be the first prototype of ergonomic knapsack basket for any other study to improve the existing knapsack basket for the pineapple plantation workers.

## **1.6 Research Questions**

- i. How to develop a conceptual design of an ergonomic knapsack basket?
- ii. How to fabricate the ergonomic knapsack basket?
- i. How to test the design of an ergonomic knapsack basket on the aspect of discomfort, physiological workload and perception of workers?

## **1.7 Research Objective**

### **1.7.1 General Objective**

- i. To design and develop an ergonomic knapsack basket for the pineapple plantation workers

### **1.7.2 Specific Objective**

- ii. To develop a conceptual design of an ergonomic knapsack basket
- iii. To fabricate a prototype of an ergonomic knapsack basket
- iv. To test the design of an ergonomic knapsack basket on the aspect of discomfort, physiological workload and perception of workers

## 1.8 Hypothesis

There is a significant difference of average working heart rate of the respondents when using the new ergonomic knapsack basket compared to the existing knapsack basket. Discomfort among body parts of the respondents also shows difference when using the new knapsack basket compared to existing basket. There is also a significant difference of perception of respondents when using the new knapsack basket compared to existing basket.

## 1.9 Conceptual Framework

The pineapple plantation workers involve in many tasks. One of the main tasks of the pineapple plantation workers is a harvesting process. They expose to many ergonomic risk factors such as carrying a heavy load and excessive bending when performing the harvesting process. They expose to excessive bending during the unloading of the fruits on the ground for about 60°. All these ergonomic risk factors will lead them to get MSS such as pain at the elbow, upper back, lower back, neck, shoulder, wrist, hip, knee, ankle, and feet if the risk factors are not controlled. In order to control and minimize the risk factors, an intervention is designed to tackle the problem by inventing an ergonomic knapsack basket for the workers. The strap of new knapsack basket is comfortable for the workers, a backrest to prevent from pineapples' barbs and there will be an opening for unloading of fruits. The usage of the new knapsack basket for a long run will reduce the distribution of MSS among the workers. In this study, the design of the knapsack basket is the independent

**variable while the level of discomfort and the heart rate of workers are the dependent variables due to different design of the knapsack basket that will affect the level of discomfort and heart rate of the workers.**



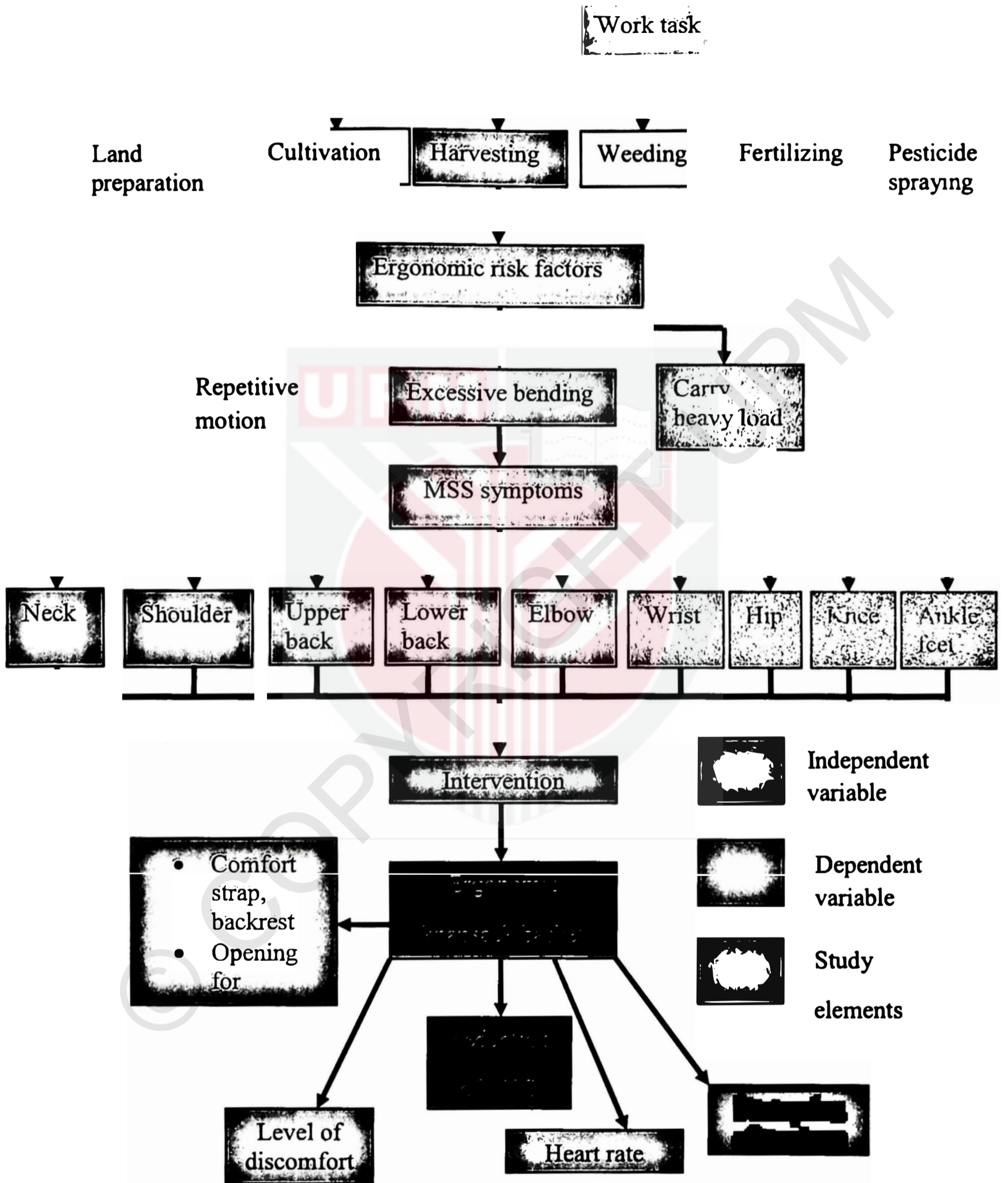


Figure 1.4: Conceptual framework

## **1.10 Definition of Term**

### **1.10.1 Sociodemographic factors**

**Conceptual definition:** The characteristic of population that is expressed as statistics distribution.

**Operational definition:** The sociodemographic factors of the respondents such as the age, gender, marital status and educational level get from the structured questionnaire.

### **1.10.1 Discomfort**

**Conceptual definition:** A painful feeling in part of body when have been hurt slightly or when have been uncomfortable for a long time.

**Operational definition:** The use of Borg Scale CR-10 by (Borg and Gunnar, 1998) to represent extreme intensities. It is a general intensity scale for most subjective magnitudes that can be used to measure exertion and pain.

### **1.10.3 Physiological workload**

**Conceptual definition:** Rusnock and Borghetti (2015) stated that workload is the amount of effort experienced by the workers when doing a task and workload can be estimated by physiological or neurological responses. The physiological workload is classified based on working heart rate (Borah, 2015). Heart rate is probably the most frequent measured variable in cardiovascular psychophysiology (Turner, 1994; Borah, 2015)

**Operational Definition:** Heart rate (beats/min) is measured with the help of polar heart rate monitor during the entire period of work every 5 minutes (Bhattacharyya & Chakrabarti, 2012) The workers need to use the existing knapsack basket for the first time of heart rate monitoring. The next monitoring the workers will use the ergonomic knapsack basket to get the heart rate measurement. The measurement of heart rate for both knapsack baskets will be compared. The energy expenditure (EE) of the respondents was calculated using the average values of heart rate (AHR) with the formulae given by (Varghese et al., 1994; Bhattacharyya & Chakrabarti, 2012) as below:

$$EE (Kj-min) = 0.159 \times AHR (\text{beats per min.}) - 8.72$$

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Pineapple plantation workers**

National Blue Ocean Strategy (NBOS) is one of the approaches inspired by the Prime Minister for the pineapple plantation workers based on Government Transformation Program (GTP). Work culture during the implementation of NBOS is to help the government find a new creative and innovative idea in providing comfort and well-being to the people. This project is a project for the cultivation of MD2 Pineapple involving area about a total of 16 acres. This NBOS offer program on pineapple cultivation under the supervision of Malaysian Pineapple Industry Board (MPIB) and the program get full support from the Ministry of Agriculture and Agro-Based Industry.

#### **2.2 Prevalence Rate on MSS in Malaysia**

The research done by Rani et al., (2016) shows that the most affected region of a body part by MSS is lower back (64.8%), feet and ankle (53.7%) and knee (52.8%). MSS are also reported for shoulder (38.0%), wrist (20.4%), neck (13.0%),

hips and thigh (11.1%), and upper back (9.3%) making MSS is common among pineapple plantation workers.

Ng et al., (2014) reported that the prevalence of total MSD in any body parts for the past 12 months were 93%. The highest prevalence of MSD reported among the nine body parts are lower back (58%) followed by knee (45.5%), shoulder (32.9%), neck (32.2%), upper back (28.0%), hand/arms (26.6%), ankle/feet (25.2%), thigh (21.0%) and elbow. The hazardous task in the past has been reported to be the cause of the high prevalence of musculoskeletal disorders (Ng et al., 2013).

A study by Ng et al., (2014) showed that the prevalence of MSD across individual body parts for the 12 months and 7 days were consistently the highest for lower back; 58.0% and 24.5% respectively. The finding was in line with the prevalence of low back pain in another locally published study that reported 12 months prevalence of low back pain at 67%.

Shan et al., (2011) reported that prevalence of MSDs among rubber workers was high (85.7%). During last 12 months, the prevalence of MSDs in different body region for rubber tappers are 59.9% for neck pain followed by low back pain (56.3%), shoulders pain (54.9%), knee pain (45.8%), ankles/feet pain (34.4%), elbow pain (33.2%), upper back pain (30.8%), wrists pain (30.1%) and hip/thighs pain (15.3%). This finding is similar to a study done by (Holmberg et al., 2003; Xiao et al., 2014) found out that 918 (90.6%) reported MSDs and the reporting musculoskeletal problems were 51% higher among farmers than non-farmers. The

highest prevalence of MSDs found in this study was neck pain (59.9%), followed by low back pain (56.3%) and shoulder pain (54.9%).

### **2.3 Ergonomic risk factors**

A study done by Bhattacharyya and Chakrabarti (2012) reported that the ergonomic risk factors in plucking operation are the awkward posture, pinch force with twisted movements and highly repetitive movement. The workers plucked tealeaves in standing posture with slight bending near the neck and low back. The arms needed to be outstretched to reach the leaves while finger moves repetitively to grab the leaves. The development of wrist disorders among the tealeaf pluckers was due to an awkward wrist or hand posture and when combine with other factors such as repetition, force, and duration (Bhattacharyya & Chakrabarti 2012).

According to Shan et al., (2011) the risk factors for neck pain in rubber field are twisted head, neck extension, awkward postures, flexion of neck, and repetitive moving of the head. Ergonomic risk factors cause various occupational related diseases among agriculture workers especially rubber plantation workers and need more exploration and research in Malaysia.

Rani et al., (2016) reported that the pineapple plantation workers are exposed continuously to the ergonomic risk factors as they perform all the tasks manually and repetitively. Physical activities such as excessive bending, twisting, and carrying heavy loads are common in the pineapple plantation. Therefore, the workers need to bend their body (awkward posture) at many job tasks such as cultivating, weeding,

harvesting and land preparation that will lead to muscle pain and feeling of discomfort (Mohd Tamrin & Aumran, 2014).

## **2.4 Physiological Workload**

Rusnock and Borghetti, (2016) stated that amount of effort experienced by the workers when performing a task is known as workload and the workload can be estimated by physiological or neurological responses. The physiological workload is classified based on working heart rate (S. Borah, 2015). In some cases, a workload can undergo a real-time evaluation. Turner (1994) and Borah (2015) stated that heart rate (HR) is the most frequent measured variable in cardiovascular psychophysiology.

Chung et al., (2001) reported that the effect of load, leg and trunk postures were significant on oxygen consumption, heart rate, and subjective rating. All the combined conditions showed high correlation with heart rate and subjective ratings. The physiological workload of the work tasks was influenced by the weight of a load, trunk posture, and leg posture. The average heart rate of the assembly workers when carrying heavy load was 98.46 beats/min, which was significantly higher than when carrying a light load (94.96 beats/min). The heart rate also increased significantly when the trunk bent and twisted compared to the trunk posture without such motion (98.76 vs. 94.66 beats/min).

Bhattacharyya and Chakrabarti (2012) reported that the energy expenditure of the tea-leaves pluckers while performing plucking by using improved cane basket was 6.57 kj/min but while using existing bamboo basket was found to be increased to 8.27kj/min. This made the workers considered plucking activity as light activity with improved basket compared to existing basket in which the plucking activity was considered as moderately heavy activity.

## **2.5 Ergonomic Product Specification**

Rhie et al., (2017) stated that ergonomic product specification include anthropometric design that has been widely used in designing products used for daily life. Physical comfort can be improved while reducing incidences of MSDs when designing specifications using anthropometric considerations (Rhie et al., 2017). A concept of ergonomics in any product design will produce a high quality product and the response from consumers will absolutely provide comfort and suitable to overcome the human physical capabilities (Hafizi et al., 2016). Besides that, the process of designing a product should considered human consumption factor to determine the function and role of a product (Hafizi et al., 2016).

Besides that, an innovation should have ergonomics characteristics, such as good human and machine interface with the work environment. Ergonomic aspects such as working posture, energy, conditions of environment, safety and usability need to be taken into account in designing a product (Hani et al., 2016). Any design should consider comfort, safety and functionality in the modification of the tools.

Reliability of agricultural tools can be greatly enhanced if the anthropometric dimensions were considered of target users when in designing.

An efficient use of agricultural farm machines require a good knowledge and proper design of equipment that capable of increasing work efficiency, safety and safeguarding when using the machines (Onuoha et al.,2013; Kumar et al., 2012). A study by Qutubuddin et al., (2013) revealed that designing each component of furniture with care and attention to user's need can result in user friendly design.

## **2.6 Designing Ergonomic Tools**

Aptel and Sécurité (2002) stated that factors involved in the ergonomic design process include the integration of ergonomics into the design process, definition of the different ergonomic stages involved, and the knowledge of the different factors involved in the tool design. The ergonomic tools were designed to improve efficiency, satisfactorily fulfill the task for which it had been designed, to fulfill the needs of the users, and to be as cheap as possible. The ergonomic design was designed to be safe, efficient and increase comfort, reduced biomechanical solicitation with regard to users' functional capacities thus reduced risk of WRMSD.

Design process involved different "models" such as language, technical experience, know-how and etc. The user, tool, workplace, environment, and the task itself were linked and had to be considered in the designing process. The users requirements and expectations after detailed observation of the work process and work context should be considered. While the users' characteristics such as

anthropometrics measurements was also defined during this phase. Then, the tool specifications finally emerged from the study of user needs and work processes (Aptel & Sécurité, 2002).

In addition, designing of a new tool prototype should be done based on tool specifications, laboratory simulation and study of the biomechanical solicitation. The the new tool produced must be compared with the tool previously used. This stage included all other phases, which were concept modeling, functionality modeling and functional prototyping. A test of prototypes by a large sample of users in real workplace situations should be done. The trial should be conducted over a sufficiently long period (several weeks) and feedback on the user's perception of the new tool should be regularly sought according to a procedure similar to that used in the first phase. If satisfactory results were obtained, the tool can be considered duly certified for those situations in which it has been tried and tested. Users must be trained and encouraged to use the prototypes over a sufficiently long period before final judgement is given (Aptel & Sécurité, 2002).

The design should also include the Need Approach Benefit Competition (NABC) method, a method that was used for the development, assessment and presentation of ideas especially for the specialists in their field of interest to explain their ideas to the world (Christian, 2012). This method enabled the idea-makers to present their ideas while assessing their value using a range of central parameters. Thus, preventing the ideas from being rejected by worlds due to any misunderstanding of the ideas.

## **CHAPTER 3**

### **METHODOLOGY**

#### **3.1 Study Design**

This study was classified as an experimental study in which the intervention of new ergonomic knapsack basket was being done to replace the existing knapsack basket. This intervention was done to reduce the discomfort and contact stress to body parts of workers, thus minimize the distribution of MSS among pineapple plantation workers.

#### **3.2 Study Location**

This study was done at Occupational Safety and Health Laboratory, Universiti Putra Malaysia. The development and testing of the new knapsack basket was done at the laboratory while a hired party did the fabrication.

### **3.3 Sampling**

#### **3.3.1 Sample Population**

The population of this study was male who aged 18 to 60 years old that had normal BMI (body mass index) and above. These age criteria was based on the Minimum Retirement Age Act 2012 while the BMI was depending on a study done by Rani et al., (2016) that reported 90% of the pineapple workers were having normal and above BMI.

#### **3.3.2 Sampling Unit**

The respondents were selected based on the selection criteria.

Exclusion criteria: UPM

- 1) Diagnosed respondents that had chronic disease such as heart disease because according to American Heart Association (2014), heart disease will lead to irregular heart beat.
- 2) Diagnosed respondents that had been diagnosed of musculoskeletal disorders (MSD) because MSD can affect the discomfort results obtained. This study wanted to know the discomfort due to different types of baskets not other factors (Harris, Chen, Janowitz, & Rempel, 2011)

### 3.4 Sampling Method

The sampling method for the respondent selection was purposive sampling and the respondents that fulfilled the criteria were being chosen.

### 3.5 Sample Size

The total sample size for the study was as follows using two means:

$$\text{Formula } n = \frac{2\sigma^2(Z_{1-\alpha/2} + Z_{1-\beta})^2}{(\mu_1 - \mu_2)^2}$$

Where:

$\sigma$  = estimated standard deviation (assumed to be equal to each group)

$\mu_1$  = mean of first population

$\mu_1 = 3$

$\mu_2$  = mean of second population

$\mu_2 = 2$

Bhattacharyya & Chakrabarti, 2012

$Z_{1-\alpha/2}$  = Standard error associated with confidential interval

(Choose 95% confidential interval = 1.96)

$Z_{1-\beta}$  = Standard error associated with power

(Choose 90% of power = 1.28)

$$n = \frac{2(1)^2(1.96+1.28)^2}{(3-2)^2}$$

$$n = 21$$

$$n = 21 + 20\% \text{ dropout rate}$$

The sample will be 25 subjects.

### **3.6 Study Instruments**

#### **3.6.1 Instruments**

The instrumentation that was used in this study were:

1. Structured questionnaire
2. Polar heart rate monitor S610i

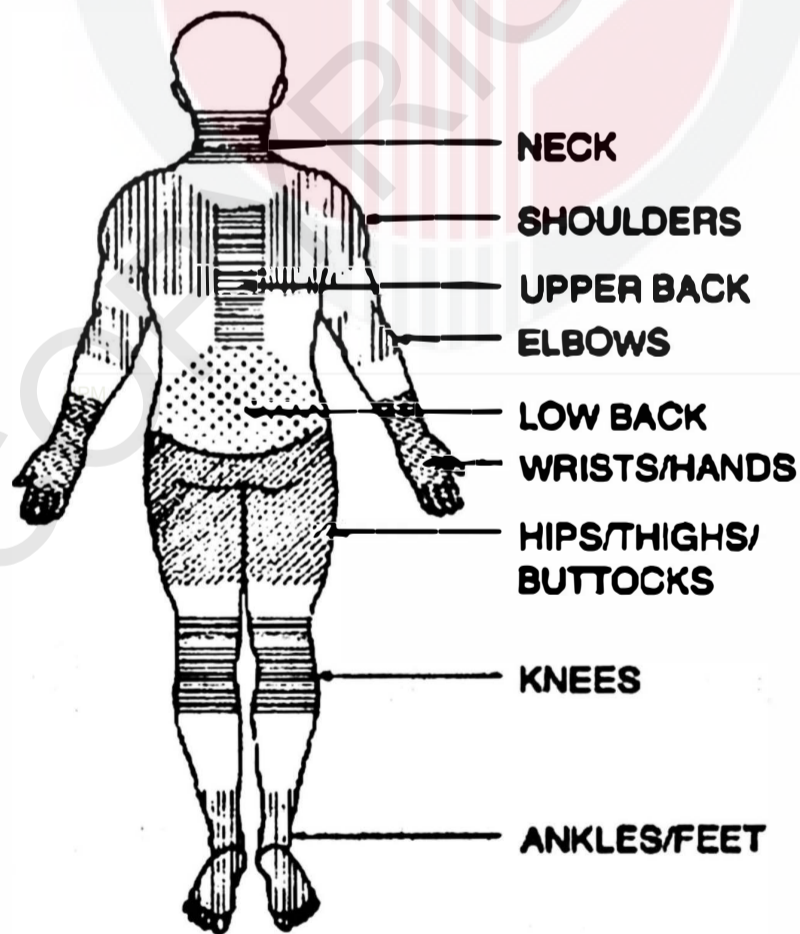
##### **3.6.1.1 Questionnaire**

The structured questionnaire was given in the Malay language and English language. The respondents could choose which language that they preferred to answer. The questionnaire consisted of four parts. Part A was the background information of the respondents such as age, height and weight, educational level and

marital status. Part B was the health information of the respondents and Part C was the respondents' response to discomfort when using both baskets measured using the Borg's CR-10. Part D was the respondents' perception when using the new knapsack basket. The Borg's CR-10 was shown in Figure 3.1.

**Borg Scale (Discomfort Rating)**

	Nothing at all		Extremly weak		Very weak		Weak		Moderate		Strong		Very strong			
	0	0.5	0.5	0.7	1	1.5	2	2.5	3	4	5	6	7	8	9	10
Neck																
Shoulder																
Upper Back																
Wrists/hands																
Low Back																
Hips/thighs/buttocks																
Knees																
Ankles/feet																
Elbows																



**Figure 3.1: Borg's CR-10**

(Borg and Gunnar, 1998)

### **3.6.1.2 Polar Heart Rate Monitor S610i**

Measurement of working heart rate was performed every one minutes during the entire period of simulation which were collecting and unloading of pineapples using the polar heart rate monitor S610i for both the existing and new basket. The respondents used the existing knapsack basket for the first experiment and the new knapsack basket for the second experiment. For every experiment, the simulation was repeated five times for both baskets. A simulation took about one minute to be done so when the simulation was repeated for five times, it took about five minutes to complete the simulation for every basket. The measurements of working heart rate for both knapsack baskets were compared after the experiment. The respondents wore the polar heart rate monitor at their wrist while the transmitter of the monitor was wore under the chest of the respondents and the connector was put at the middle.

### **3.7 Pineapple Simulation**

The pineapple simulation used 10 pineapple fruits that weighted about 1kg per fruit. Therefore, the total fruits used during the simulation were 10 kg. The fruits were arranged zig-zag and arranged 100 m from each other on the chair to simulate the actual pineapple plantation area. The height of the chair resembled the pineapple's trees due to workers did not have to bend their body to pluck the fruits. The pineapple tree was cultivated 100 m from each other and cultivated side by side. Figure 3.2 showed the zig-zag arrangement of the pineapple for simulation.



Figure 3.2: Zig-zag arrangement of pineapple for simulation

A questionnaire was distributed to collect information of the respondents before starting the experiment to determine whether the respondents fulfilled the criteria needed or not. The chosen respondents carried the existing basket for the first experiment after wearing the polar heart rate monitor and the simulation was repeated for five times. Heart rate of the respondents was measured every one minutes of the simulation. After the simulation, the respondents answered the discomfort rating for the existing basket.



Figure 3.3: Simulation on collecting pineapple fruits



Figure 3.4: Simulation on unloading of pineapple fruits

This procedure applied at the second experiment that using the new basket. The same respondents will do the second experiment using new knapsack basket after resting for an hour. The simulation of the new basket also repeated for five times and heart rate were measured every one minutes during the simulation. After the simulation, the respondents answered the discomfort rating together with a perception rating about the new knapsack basket.

The pre-test of the questionnaire was conducted among male respondents at Universiti Putra Malaysia by taking the respondents who were having same characteristics with the intended respondents of this study. The pre-test took about 10% from the total of intended sample size of the respondents.

The main material used for the new knapsack basket was iron, which was available on the market. This iron was used to replace the rattan that had been used for the existing knapsack basket and this iron could be welded to make the opening for the basket to prevent excessive bending more than 60° during unloading of fruits. The knapsack basket was designed in a rectangular trapezoid to replace the cone shape of the existing basket that gave contact stress to the back of respondents.

There was a latch at the left side of the basket to open the basket for unloading of fruits. The opening of the basket was at the back of the basket and to open the basket, the latch needed to be pressed up at the middle and for the closing of basket, the latch should be pressed at the back.

Adjustable polyester strap together with cushion was used to replace the raffia strap used for the existing basket. The polyester strap was used due to higher durability while the cushion was put to absorb sudden pressure during harvesting process. Before the respondents wore the basket, they could adjust the basket according to their height and size to make sure that the respondents were comfortable wearing the new basket. A foaming pad together with PVC polyester was used as the back support to replace the gunnysack used in the existing basket that was put by the workers at their back to prevent from the pineapples' barb. The foaming pad was used to give comfort to the respondents. The hired company did the fabrication of the new basket.

### **3.8 Procedure of Data Collection**

1. Approval from the ethical board committee of Universiti Putra Malaysia.
2. The methodology was based on the objectives.
3. For objective to develop a conceptual design of an ergonomic knapsack basket, the design was developed based on the problem arose from the existing harvesting basket. The design of the new knapsack basket was based on ergonomic principles focusing on to reduce the flexion of the trunk during the unloading of fruits onto the ground and gave comfort to workers.
4. For objective to fabricate a prototype of an ergonomic knapsack basket, cheap or low-cost material easily sourced was used as the material for the knapsack basket.
5. For objective to test the design of an ergonomic knapsack basket, field-testing was performed at the UPM laboratory by doing a pineapple harvesting simulation using male respondents. A structured questionnaire was given to

the respondents. The questionnaire consisted of personal background, health information, respondents' response on discomfort due to wearing different knapsack basket and perception of respondents when using new knapsack basket. The measurement of working heart rate was performed using a polar heart rate monitor S610i every one minutes during the simulation period. The simulation was repeated five times for both baskets.

6. Data was entered into a statistical software and was analyzed according to the objectives.

### **3.9 Statistical Analysis**

The data obtained was analyzed using IBM SPSS (Statistical Package for the Social Sciences) version 22. The types of analysis used in this study depend on the objectives of this study. The demographic information of the respondents and the respondents' perception when using new basket were analyzed using descriptive analysis. The average working heart rate and discomfort level for both knapsack baskets were analyzed using paired t-test.

\*From the average values of heart rate (AHR), energy expenditure (EE) was calculated with the formulae given by (Varghese et al., 1994; Bhattacharyya & Chakrabarti, 2012) as below:

$$EE (Kj-min) = 0.159 \times AHR (\text{beats per min.}) - 8.72$$

**Table 3.1 Data Analysis Methods Based on Study Objectives**

Objectives	Hypothesis	Data Analysis Methods
To develop a conceptual design of an ergonomic knapsack basket		
To fabricate a prototype of an ergonomic knapsack basket		
To test the design of an ergonomic knapsack basket		Descriptive analysis and Paired T-Test

### **3.10 Validity of Questionnaire**

Validity contents of the questionnaire were done in the pre-testing of the questionnaire on 10% of the intended total number of sample size among male respondents in UPM. The questionnaire was distributed to respondents who were having same characteristics with the intended respondents of this study. The pre-test was conducted among male at UPM. Any ambiguous term found from the pre-test were identified and amended in order to help the respondents understand the questionnaire better.

### **3.11 Reliability**

The reliability of questionnaire study was tested using Cronbach's Alpha. Adamson and Prion (2013) stated that the Cronbach's Alpha measured the internal consistency in a statistic and it was suitable for measuring the internal consistency in scales where items had more than two response options. The Cronbach's alpha can range from 0 to 1. The value of  $\alpha$  is value of 0 means there is no relation but when the value of  $\alpha$  is 1 means the perfect correlation. The value obtained was 0.85

### **3.12 Quality Control**

The quality control used in this study was the polar heart rate monitor was reset before taking any measurement and pre-test was done to the questionnaire before the experiment.

## **CHAPTER 4**

### **RESULTS**

#### **4.1 Sociodemographic Information**

The response rate was only 48% due to the data collection was done during the weekends so not many respondents were available. All respondents in this study were Malaysian male with an average age of  $22.4 \pm 2.2$  years old. The respondents had average weight of  $68.0 \pm 15.4$  kg and average height of  $1.7 \pm 0.1$  m. The respondents average BMI was  $23.8 \pm 5.0$ . All the respondents (100%) were single and received education up to university level. The information on sociodemographic background of the respondents was presented in Table 4.1.

**Table 4.1 Frequency distribution of sociodemographic characteristics of respondents (n=12)**

Variables	Sociodemographic		Mean (SD)
	Frequency	Percent (%)	
Age (Years)	20	1	8.3
	21	6	50.0
	23	2	16.7
	25	1	8.3
	26	2	16.7
Weight (kg)			68.0 (15.4)
Height (m)			1.7 (0.1)
BMI	Normal	9	75.0
	Overweight	1	8.3
	Obese	2	16.7
Marital status	Single	12	100.0
	Married		
	Divorced		
Educational level	Primary		
	Secondary		
	College		
	University	12	100.0
n= Frequency	SD= Standard deviation	BMI= Body mass index	

## 4.2 Musculoskeletal Systems (MSS) Information

### 4.2.1 Musculoskeletal symptoms (MSS) history among respondents

A few respondents reported having MSS history on certain body parts. The most affected region of body part was upper back (25%) followed by neck, shoulder

and knees (16.7%). The least affected region of body parts were elbow, lower back, wrist, hips and ankles which were (8.3%). The distribution of MSS history among respondents was tabulated in the Table 4.2.

**Table 4.2 Distribution of musculoskeletal symptoms (MSS) history among respondents (n=12)**

<b>Variables</b>	<b>Musculoskeletal symptoms</b>			
	<b>No</b>		<b>Yes</b>	
	<b>Frequency</b>	<b>Percent (%)</b>	<b>Frequency</b>	<b>Percent (%)</b>
Neck	10	83.3	2	16.7
Shoulder	10	83.3	2	16.7
Elbow	11	91.7	1	8.3
Upper back	9	75.0	3	25.0
Lower back	11	91.7	1	8.3
Wrist	11	91.7	1	8.3
Hips	11	91.7	1	8.3
Knees	10	83.3	2	16.7
Ankles	11	91.7	1	8.3

#### 4.2.2 Musculoskeletal symptoms (MSS) history among respondents within 7 days before experiment

Respondents that reported having MSS history as stated in Table 4.2 also reported MSS within 7 days before experiment being done. The most affected region of body part was upper back (16.7%) followed by elbow, lower back, wrist, hips, knees and ankles (8.3%). The result was tabulated in Table 4.3.

**Table 4.3 Distribution of musculoskeletal symptoms (MSS) among respondents within 7 days before experiment (n=12)**

Variables	Musculoskeletal symptoms		Yes Frequency	Percent (%)
	No Frequency	Percent (%)		
Neck	12	100.0		
Shoulder	12	100.0		
Elbow	11	91.7	1	8.3
Upper back	10	83.3	2	16.7
Lower back	11	91.7	1	8.3
Wrist	11	91.7	1	8.3
Hips	11	91.7	1	8.3
Knees	11	91.7	1	8.3
Ankles	11	91.7	1	8.3

### 4.3 Existing knapsack basket

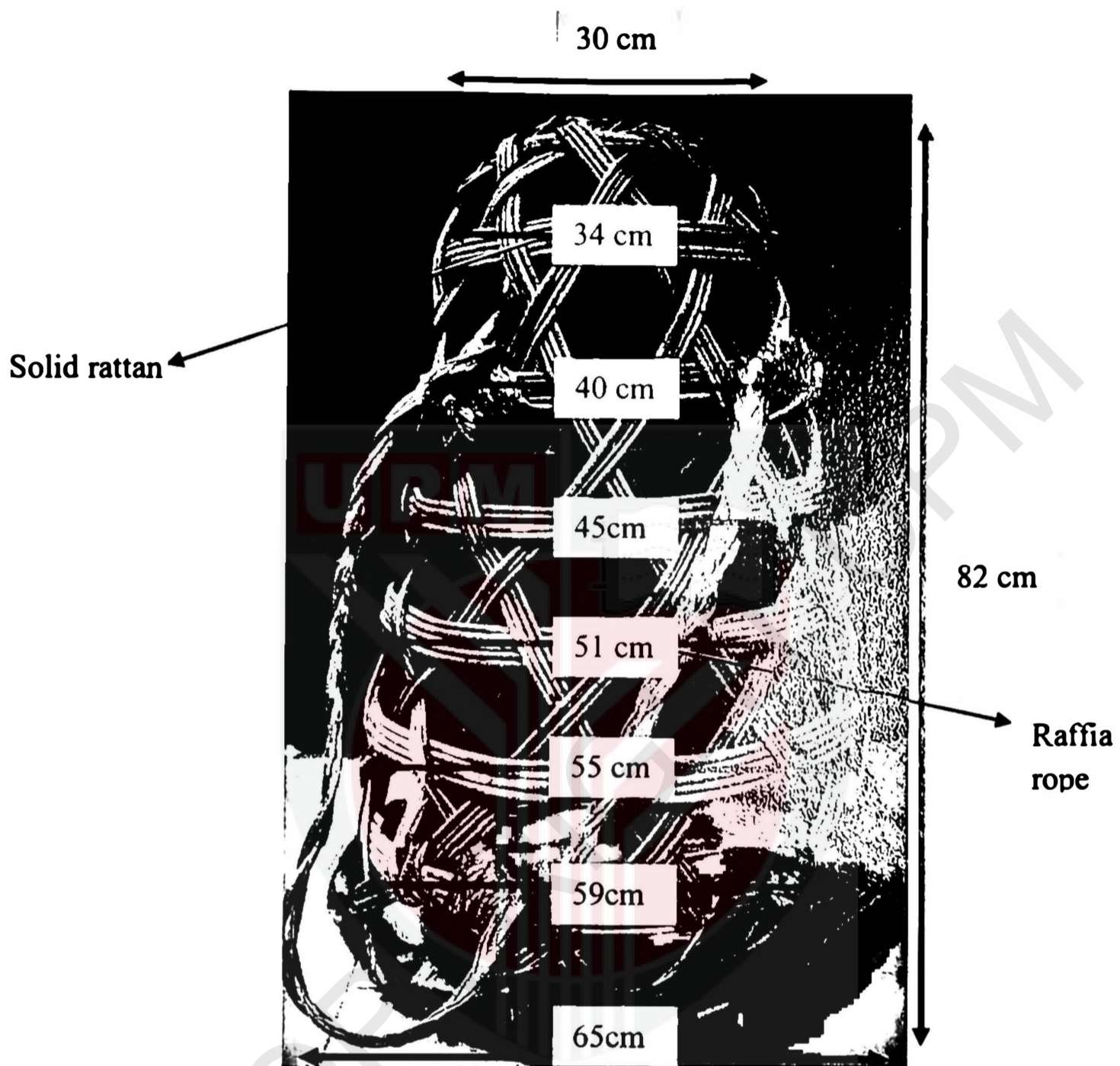


Figure 4.1: Design criteria of existing basket

#### Design criteria

The basket weighted about 5kg and had the following design criteria:

- A cylindrical shape basket without latch on the bottom. This made the workers expose to excessive bending when to unload fruits.
- Made of solid rattan material.
- A pair of non-adjustable shoulder strap made from raffia rope attached at one side of the basket gave higher contact stress to workers and did not fit the anthropometric dimensions of the workers.

#### 4.4 New knapsack basket prototype

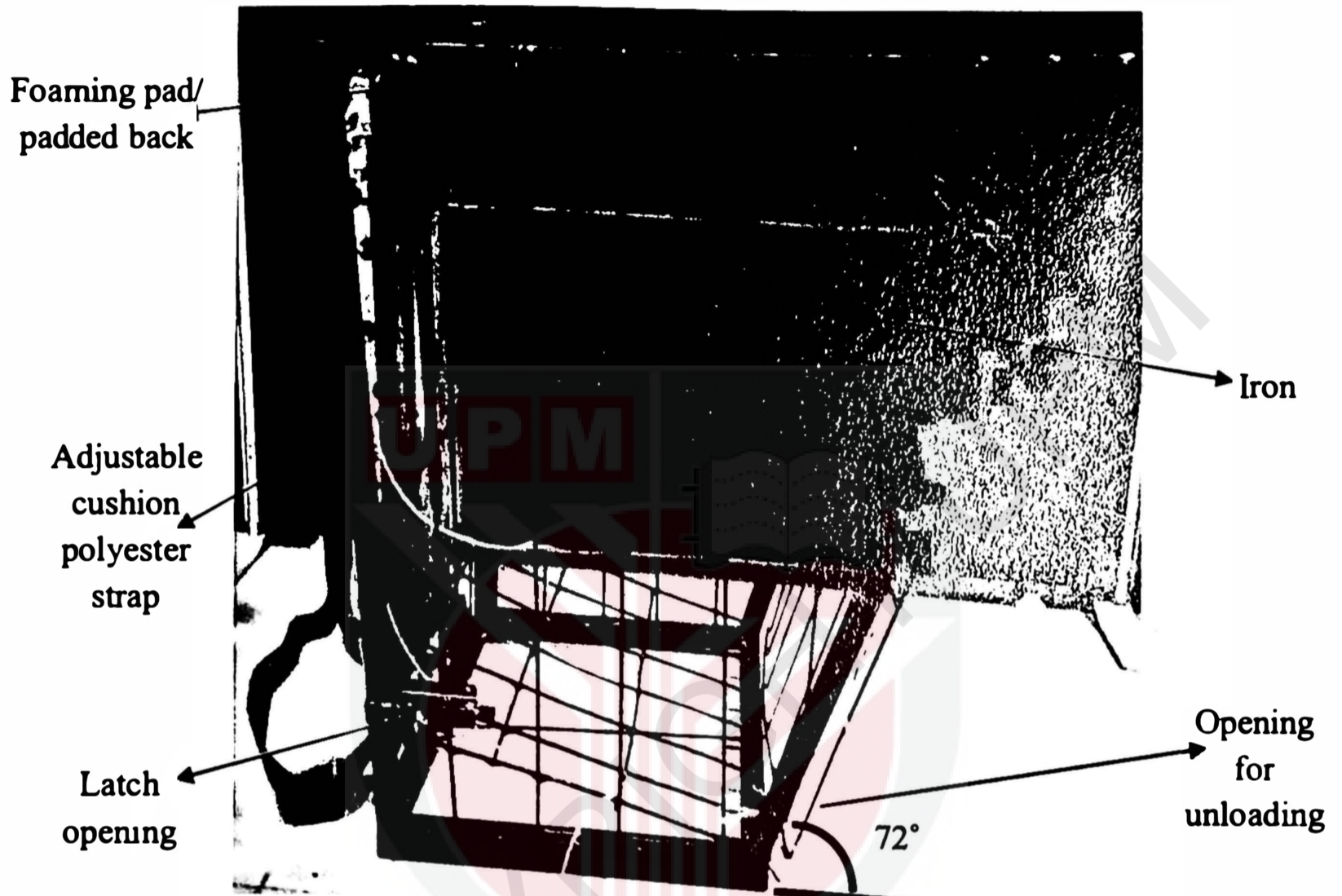


Figure 4.2: Design criteria of new basket

#### Design criteria

The basket weighted about 8kg and had the following design criteria:

- A rigid frame of rectangular trapezoid shaped pack basket with an open top suitable for adult harvester.
- Surface dimensions with rectangular holes, made from vertical and horizontal wire mesh.
- A pair of adjustable shoulder strap attached at one side of the basket.
- A latch opening connected to the front side of the rectangular fruits basket to tip out when latch is opened.

- The latch opening operated by a spring button mechanism, which needs to be pressed with thumb on the right side of the basket to close and to open.
- A spring attached at the right side of the basket to pull the door of the latch to close the latch.
- A foam padding on one side of the basket where it meets the user's back.

### Mechanism of the newly design basket

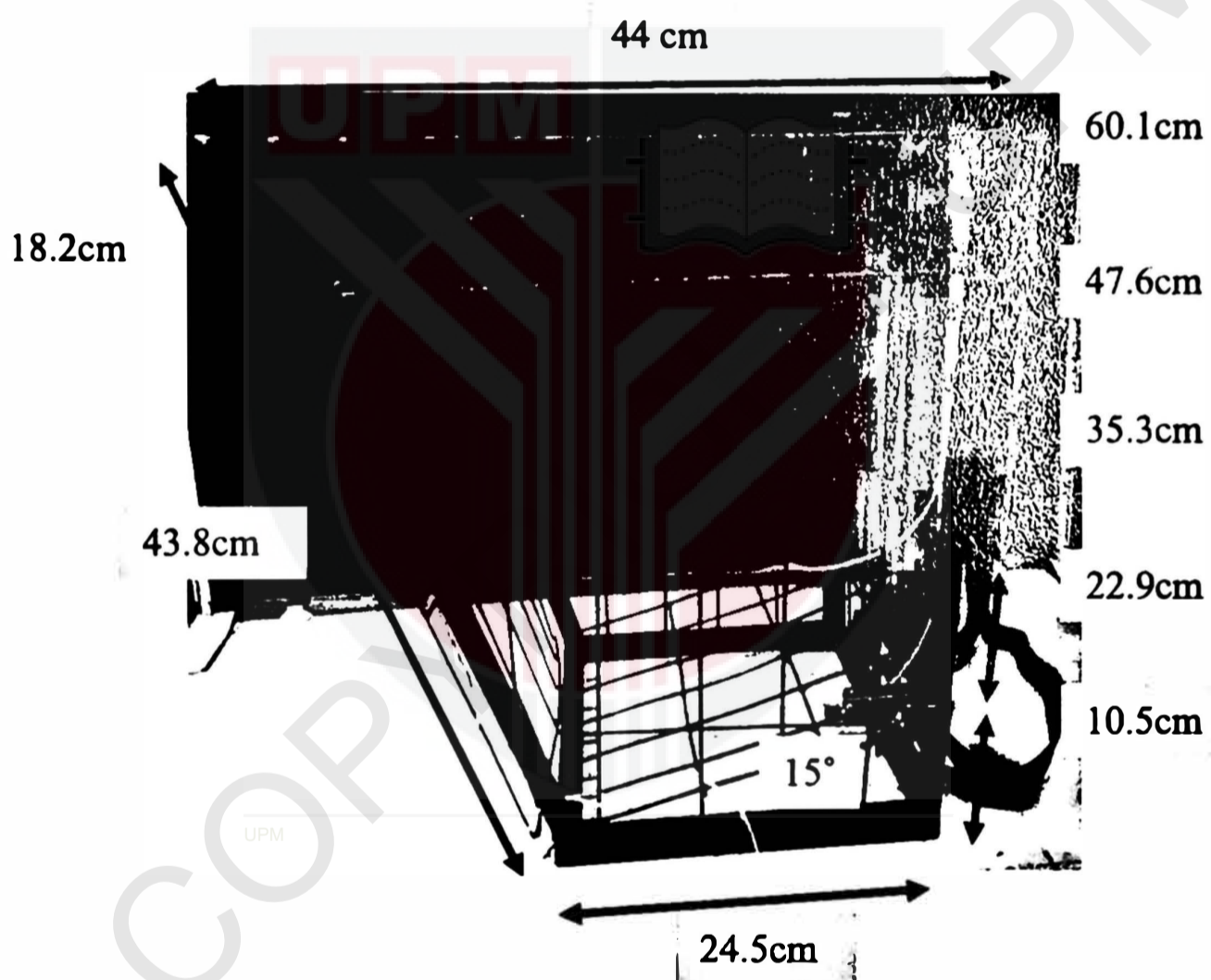


Figure 4.3: Measurement of new basket

### Modified shoulder straps

The new shoulder straps were made of polyester strap together with cushion. This new strap was used to replace the raffia rope used by workers to carry the basket. The cushion strap had wider width and with the cushion provided gave better

suspension thus minimized the impact of sudden downward forces. This strap helped to reduce musculoskeletal pain by giving even distribution of weight carried by workers. Abdominal muscle also helped to support as well due to wider strap.

Besides that, the shoulder straps with padding, helped to reduce contact stress. The adjustable shoulder straps also suited with anthropometric dimensions. All this mechanism helped to reduce level of discomfort among workers.

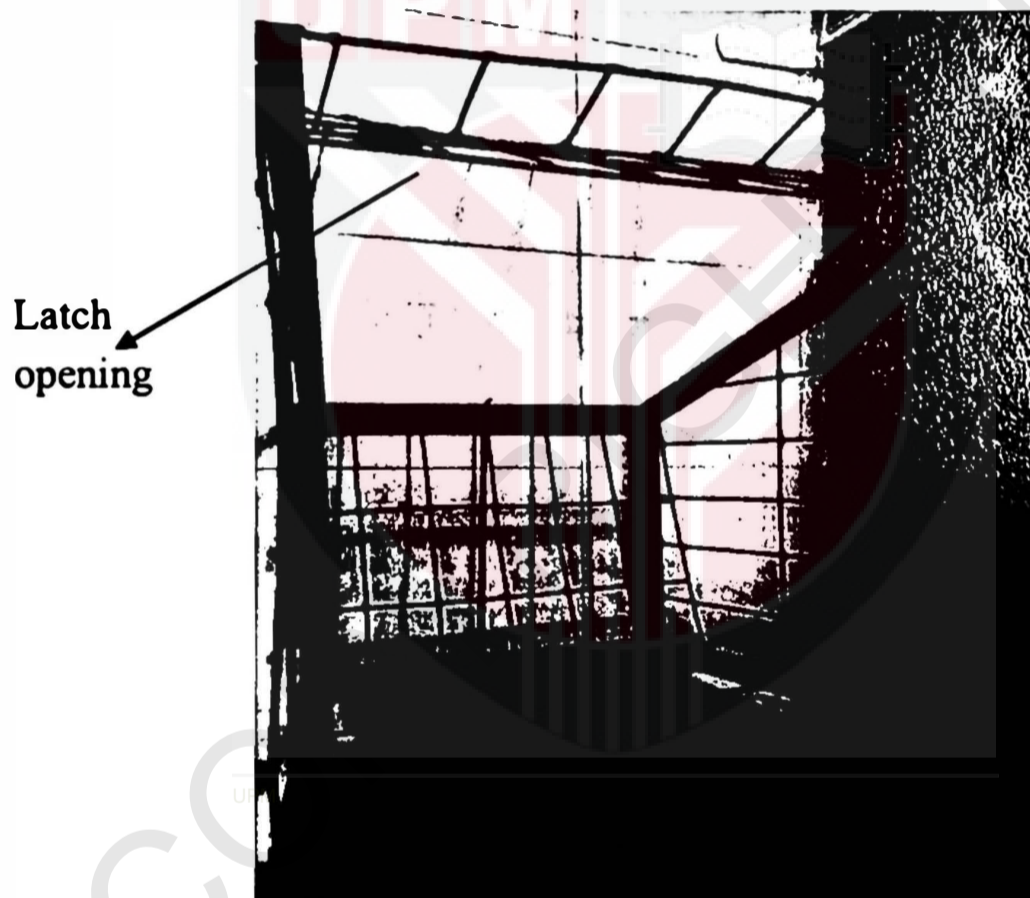


Figure 4.4: Opening for unloading

### Opening for unloading

This new knapsack basket had an opening for unloading or latch opening. This opening helped to reduce the physiological workload due to the opening allow unloading of fruits while standing. The workers did not need to bend their body to

unload fruits from the basket. This will eliminate the ergonomic risk factors of excessive bending during harvesting thus helped in reducing the MSS among workers.

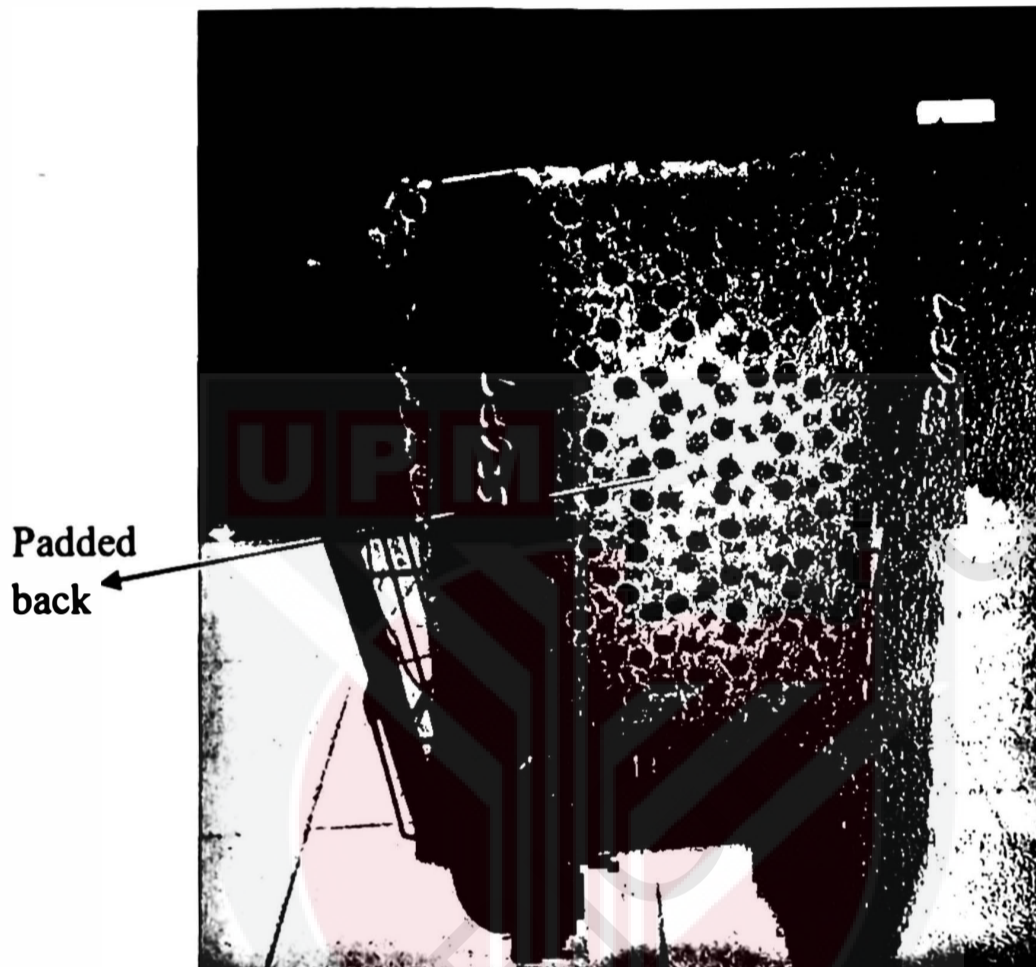


Figure 4.5: Padded back/ foam padding

#### **Padded back/ foam padding**

The padded back was made of foam, small plank and PVC leather. A small and light plank was used to support the back of knapsack baskets' users. Then, foam was put to give comfort to back of users. The foam was wrapped with PVC leather because this material is lighter than real leather, easy to clean and resist fading. The foam padding was used to replace gunnysack that being used by workers to cover back from pineapples' barbs. The foam helped to reduce barbs contact with back of workers.

#### 4.5 Evaluation of discomfort among respondents using different types of baskets

Result for overall distribution of discomfort among respondents when using different types of baskets was tabulated in Table 4.4. The result showed that there was a significant difference ( $p=0.012$ ) when using existing and improved baskets. Discomfort for every part of body of respondents using different types of baskets showed that there were significant for neck ( $p=0.032$ ), shoulder ( $p=0.004$ ), upper back ( $p=0.041$ ) and hips ( $p=0.048$ ). Distribution of discomfort for every part of body of respondents using existing and improved baskets was presented in Table 4.5. Figure 4.1 showed that the respondents reported discomfort more when they used the existing basket compared to new basket.

**Table 4.4 Overall distribution of discomfort of respondents using existing and improved baskets (n=12)**

Variable	Mean (SD) Existing basket	Improved basket	Mean difference (95%CI)	t-statistics (df)	p- value*
Discomfort all body parts	12.26 (11.2)	4.13 (6.1)	8.13 (2.13, 14.12)	2.98 (11)	0.012*

\*Significant at  $p<0.05$

**Table 4.5 Distribution of discomfort for all parts of body of respondents using existing and improved baskets (n=12)**

Variable	Mean (SD)		Mean difference (95%CI)	t-statistics (df)	p-value*
	Existing basket	Improved basket			
Neck	1.78 (2.1)	0.49 (0.8)	1.28 (-0.21, 0.89)	2.45 (11)	0.032*
Shoulder	2.33 (1.8)	0.92 (0.9)	1.42 (0.56, 2.27)	3.64 (11)	0.004*
Elbow	0.98 (1.6)	0.11 (0.1)	0.88 (-0.17, 1.92)	1.85 (11)	0.091
Upper back	2.04 (1.9)	0.91 (1.9)	1.13 (0.06, 2.21)	2.32 (11)	0.041*
Lower back	1.76 (1.7)	0.94 (2.0)	0.82 (-0.24, 1.87)	1.70 (11)	0.117
Wrist/ hands	1.42 (2.3)	0.51 (0.8)	0.91 (-0.46, 2.28)	1.46 (11)	0.172
Hips/ thighs/ buttocks	0.81(1.2)	0.13 (0.2)	0.68 (0.01, 1.36)	2.23 (11)	0.048*
Knees	0.48 (1.0)	0.08 (0.2)	0.39 (-0.26, 1.04)	1.33 (11)	0.210
Ankles & feet	0.67 (1.5)	0.05 (0.1)	0.62 (-0.33, 1.57)	1.43 (11)	0.181

\*Significant at  $p < 0.05$

\* Statistic test used was paired t-test

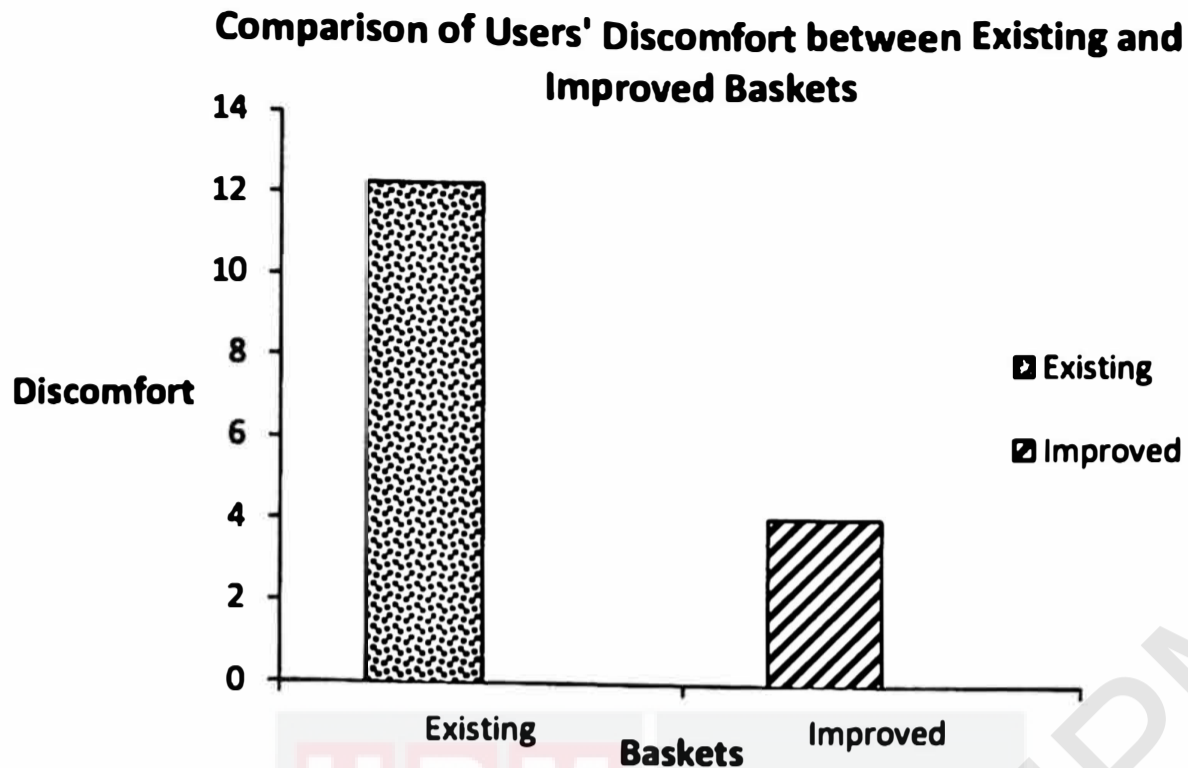


Figure 4.6: Comparison of users' discomfort between existing and improved baskets

#### 4.6 Physiological workload among respondents using different types of baskets

From Table 4.6, overall distribution of heart rate of respondents for five rounds showed a significant differences when using existing and improved baskets ( $p=0.021$ ). From Table 4.7, working heart rate for respondents were significant at third round ( $p=0.036$ ), fourth round ( $p=0.001$ ) and fifth round ( $p<0.001$ ) of experiments. Figure 4.2 showed that the working heart rate of respondents were slightly higher when using existing basket compared to new basket. Table 4.8 showed the overall distribution of energy expenditure of respondents using existing and improved baskets. From the table, it was reported that there were significant differences between energy expenditure for existing and improved baskets ( $p=0.021$ ).

**Table 4.6 Overall distribution of heart rate of respondents using existing and improved baskets (n=12)**

<b>Variable</b>	<b>Mean (SD) Existing basket</b>	<b>Improved basket</b>	<b>Mean difference (95%CI)</b>	<b>t-statistics (df)</b>	<b>p- value*</b>
Average heart rate for 5 rounds	94.13 (9.9)	89.05 (13.3)	5.08 (0.94, 9.22)	2.70 (11)	0.021*

\*Significant at p<0.05

\* Statistic test used was paired t-test

**Table 4.7 Distribution of heart rate of respondents using existing and improved baskets according to rounds of simulation (n=12)**

<b>Variable</b>	<b>Mean (SD) Existing basket</b>	<b>Improved basket</b>	<b>Mean difference (95%CI)</b>	<b>t-statistics (df)</b>	<b>p- value*</b>
Heart rate 1 <sup>st</sup> round	89.25 (9.6)	86.50 (11.3)	2.75 (-3.48, 8.98 )	0.97 (11)	0.352
Heart rate 2 <sup>nd</sup> round	92.25 (10.4)	91.83 (13.9)	0.42 (-6.07, 6.90)	0.14 (11)	0.890
Heart rate 3 <sup>rd</sup> round	94.75 (10.2)	89.25 (13.8)	5.50 (0.43, 10.57)	2.39 (11)	0.036*
Heart rate 4 <sup>th</sup> round	97.33 (11.8)	88.67 (14.7)	8.67 (4.32, 13.01)	4.39 (11)	0.001*
Heart rate 5 <sup>th</sup> round	97.08 (12.3)	89.00 (14.9)	8.08 (4.46, 11.70)	4.92 (11)	0.000*

\*Significant at p<0.05

\* Statistic test used was paired t-test

**Table 4.8 Overall distribution of energy expenditure of respondents using existing and improved baskets n=12**

Variable	Mean (SD)		Mean difference (95%CI)	t-statistics (df)	p-value*
	Existing basket	Improved basket			
Energy expenditure for 5 rounds	6.0 (1.6)	5.0 (2.1)	0.81 (0.15, 1.47)	2.70 (11)	0.021*

\*Significant at p<0.05

\* Statistic test used was paired t-test

\*From the average values of heart rate (AHR), energy expenditure (EE) was calculated with the formulae given by (Varghese et al., 1994; Bhattacharyya & Chakrabarti, 2012) as below:

$$EE \text{ (Kj-min)} = 0.159 \times \text{AHR (beats per min.)} - 8.72$$

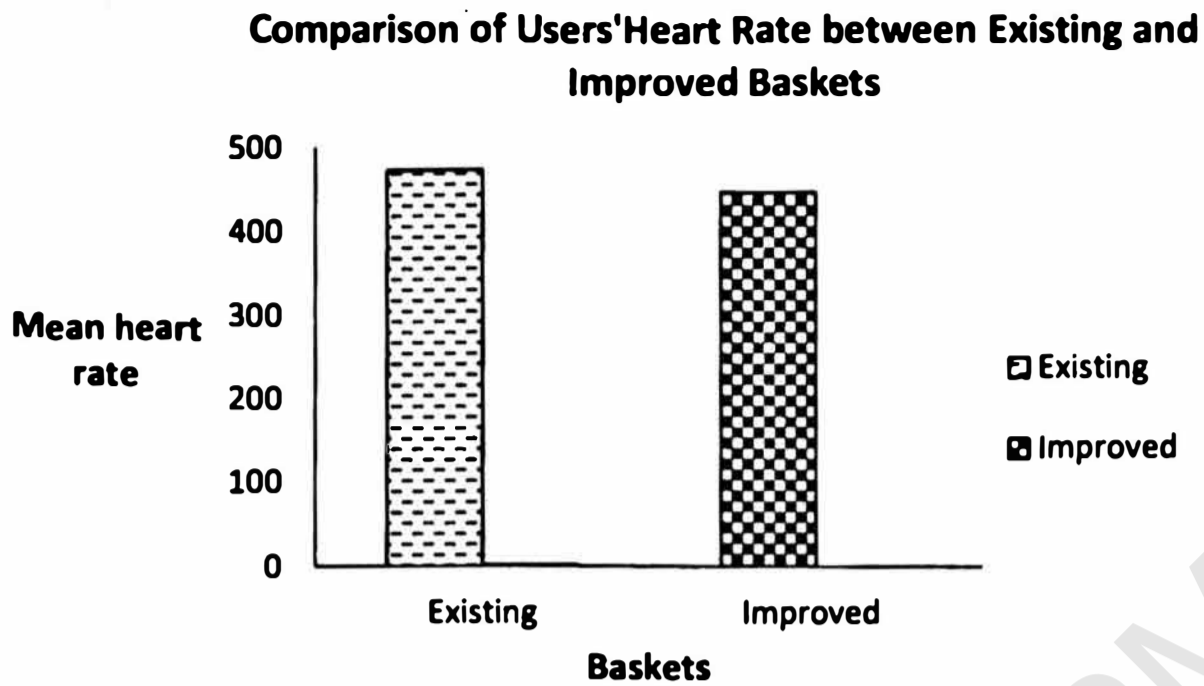


Figure 4.7: Comparison of users' heart rate between existing and improved baskets

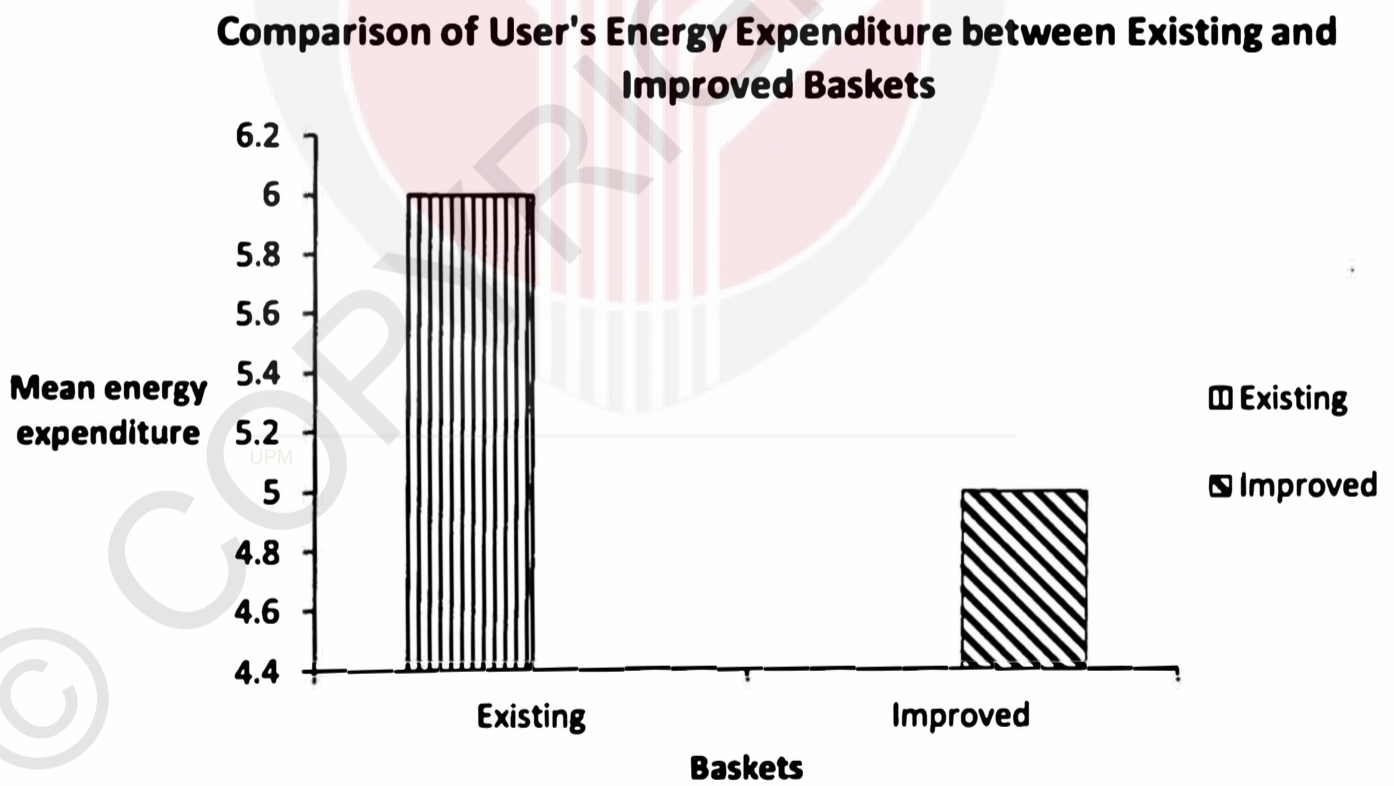


Figure 4.8: Comparison of users' energy expenditure between existing and improved baskets

#### **4.7 Perception of respondents using different types of baskets**

Approximately (8.3%) of the respondents strongly agreed that the material of the new knapsack basket was suitable than the existing basket while (33.3%) of the respondents strongly disagreed with the material used. About (50.0%) of respondents agreed that the new knapsack basket gave more comfort than the existing basket while (16.7%) disagreed. About (33.3%) of the respondents strongly agreed that the new knapsack basket was better than existing basket in terms of its functionality for pineapple harvesting while (16.7%) disagreed.

Approximately (40%) of respondents agreed that the new knapsack basket was suitable for pineapple harvesting in peat soil plantations while (8.3%) disagreed with the statement. About (50.0%) of the respondents strongly agreed that the functions of new knapsack basket (padded back, backrest, opening for unloading) could help to reduce musculoskeletal symptoms. About (42%) of the respondents were not sure whether the new knapsack basket could reduce the time required to collect the same amount of fruits as the old one.

In addition, about (67%) of the respondents agreed that the new knapsack basket was easier to be used than the existing basket. About (60%) of the respondents agreed that the new knapsack basket can be used to collect pineapple fruits. About (33.3%) of the respondents strongly agreed that they were willing to

use the new knapsack basket for work in the future. Table 4.9 showed the perception of respondents when using existing and improved baskets.

**Table 4.9 Distribution of perception of respondents using improved baskets (n=12)**

Variables	Perception		Mean (SD)	
	Frequency	Percent (%)		
The material for new knapsack basket is suitable than the existing basket.	Strongly agree	1	8.3	2.58 (1.4)
	Agree	2	16.7	
	Not sure	2	16.7	
	Not agree	3	25.0	
	Strongly not agree	4	33.3	
New knapsack basket give more comfort than existing basket	Strongly agree	4	33.3	3.00 (1.0)
	Agree	4	50.0	
	Not sure			
	Not agree	2	16.7	
	Strongly not agree			
New knapsack basket is better than existing basket in terms of its functionality for pineapple harvesting	Strongly agree	4	33.3	2.75 (1.1)
	Agree	3	25.0	
	Not sure	3	25.0	
	Not agree	2	16.7	
	Strongly not agree			
New knapsack basket is suitable for pineapple harvesting in peat soil plantations	Strongly agree	3	25.0	2.83 (0.9)
	Agree	5	41.7	
	Not sure	3	25.0	
	Not agree	1	8.3	
	Strongly not agree			
The functions of new knapsack basket (padded back, backrest, opening for unloading can help to reduce musculoskeletal	Strongly agree	6	50.0	3.17 (1.0)
	Agree	3	25.0	
	Not sure	2	16.7	
	Not agree	1	8.3	
	Strongly not agree			

symptoms	agree			
New knapsack basket can reduce the time required to collect the same amount of fruits as the old one	Strongly agree	2	16.7	
	Agree	4	33.3	
	Not sure	5	41.7	2.58
	Not agree	1	8.3	(0.9)
	Strongly not agree			
New knapsack basket is easier to be use than the existing basket	Strongly agree			
	Agree	8	66.7	
	Not sure	2	16.7	2.50
	Not agree	2	16.7	(0.8)
	Strongly not agree			
New knapsack basket can be used to collect pineapple	Strongly agree	4	33.3	
	Agree	7	58.3	
	Not sure	1	8.3	3.17
	Not agree			(0.8)
	Strongly not agree			
I am willing to use the new knapsack basket for work in the future	Strongly agree	4	33.3	
	Agree	3	25.0	
	Not sure	3	25.0	2.75
	Not agree	2	16.7	(1.1)
	Strongly not agree			

## **CHAPTER 5**

### **DISCUSSIONS**

#### **5.1 Conceptual design of new knapsack basket**

Rani et al., (2016) stated that pineapple plantation workers used solid rattan basket for pineapple harvesting due to unsuitable soil structure (soft peat soil). The workers could not use wheelbarrow because it was hard to push a wheelbarrow on the soft soil as the wheelbarrow that full of pineapple fruits might stuck in the soil. Instead of pushing, the workers might need to pull the wheelbarrow to collect all the fruits making workers to be involved in work that was more strenuous. Obviously, the workers will need to use more physiological workload to pull the wheelbarrow and the workers might get involved in more ergonomic risk factors due to awkward posture during pulling the wheelbarrow that full of fruits. Therefore, the only choice that the workers had was to carry the solid rattan basket to collect the fruits. However, the existing basket also did not suit to the workers' comfort ability due to improper design structure.

Usage of the rattan basket made the workers to bend excessively more than 60° (Rani et al, 2016) to unload all the fruits on the ground due to the basket did not have any opening at the bottom. The workers needed to collect many fruits due to

huge pineapple plantation area and they do the excessive bending repeatedly because the workers wanted to save time during the unloading of fruits. So, the workers tend to bend excessively repeated time that will finally involve them with MSS.

In addition, the rattan basket did not have proper strap and the workers tend to make their own strap using raffia rope. This raffia rope had a narrow diameter and width thus contributed the workers to contact stress at both of their shoulder and upper limbs. The raffia strap was also not adjustable and not fit with the workers' anthropometric dimensions. The workers also added a gunnysack at their back because they wanted to cover their back from the pineapple's barbs. This additional gunnysack contributed more on the existing load that the workers had to carry during the harvesting process.

Therefore, a new knapsack basket was designed and developed to overcome the problem of the existing basket. This new basket used iron as the main material to develop the basket because this iron could be welded to make an opening for the basket for pineapple loading. Other materials suggested which were wire mesh, aluminium, nylon streamers and bamboo could not be use even though the materials were lighter than the iron. This was due to the wire mesh melted during the welding session, the aluminium was brittle and expensive while both the nylon streamers and bamboo could not be welded to make the opening for unloading. This study wanted to eliminate the excessive bending during pineapple unloading so iron was the suitable material compared to others.

Polyester was used to make the adjustable strap of the new basket because polyester was used in harness manufacturing and suitable for anthropometric dimensions of the workers. This was due to the strap had wider width thus reduced contact stress on the workers' shoulder and upper limbs. Cushion was also added to the polyester strap and placed on the workers' shoulder. This additional cushion was used to absorb sudden force and reduce the strain on shoulder during the collection of fruits. For the padded back, a foaming pad was used and covered with PVC polyester to replace the gunnysack used for existing basket. The foaming pad gave comfort to workers while the PVC polyester was waterproof, anti abrasion and anti fading.

The new basket was designed as rectangular trapezoid because this design wanted to eliminate the contact stress to back of workers and ease the pineapple collection. The back of the new basket was designed as rectangular to get the straight structure so that the workers' back will not be in contact stress with the structure of the basket. In addition, the straight structure also designed to ease the installation of the backrest to replace the gunnysack used by workers to prevent from pineapples' barbs. This was due to existing basket was in cylindrical shape making the workers' back to be in contact stress with the basket during the pineapple collection. While the trapezoid structure of the new basket was designed to ease the pineapple collection. This was due to workers threw the fruits into the basket and if the structure of the new basket was small, the fruits will not get into the basket but ended up on the ground. Therefore, the structure of the basket was designed to be wider and longer to overcome the problem and the trapezoid design was suitable to solve the issue.

On the other hand, the new basket had an opening for unloading at the back thus eliminate the excessive bending for more than 60° during the unloading of the fruits on the ground. The workers only have to stand during the pineapple loading without doing any awkward posture. For the unloading, the workers only had to press a button that was located at the right side of the basket at the middle, and the basket will be opened for the unloading. If the workers wanted to close the back of the opening, the workers only needed to press the button at the back, and the opening will be closed.

## **5.2 Discomfort among respondents using existing and improved baskets**

This study reported that the discomfort of respondents reduced when using the improved basket compared to the existing basket. This may be due to additional design criteria of the improved basket to ease the process of harvesting of pineapple. There was significant reduction of discomfort of neck, shoulder, upper back, hips, thighs and buttocks of the respondents when using the improved basket compared to the existing basket. That finding was supported by a study done by Vanderwal et al., (2011) that demonstrated a longer hoe handle reduces back pain as the workers can work in an upright posture than with a short handled hoe. Improved working posture can have a significant impact on primary and particularly secondary prevention of low-back pain.

A study by Md Yusoff et al., (2014) about new chisel design for harvesting of oil palm fruits showed a significant reduction in the energy use at the right

Brachioradialis and left Deltoid muscle when using the newly designed tool. Besides, the right Biceps showed almost significant muscle activity reduction for the new tool. The trend indicated that the newly proposed chisel generated lower muscle activities compared to the current chisel.

Vanderwal et al., (2011) also stated that using the new long hoe reduced the discomfort of subjects in the lower back, hips and legs, and also an injury near miss compared to the traditional hoe. Usage of the new long hoe also reduced the discomfort of neck, shoulder, arm and hand discomfort. Compared to use of the new short hoe, the new long hoe significantly reduced discomfort in all body parts, as well as injury near misses. By using the new long hoe subjects were enabled to work with a more upright posture than with either the traditional or new short hoe. (Vanderwal et al., 2011).

Besides that, the finding of the study was supported with a study by Ojha and Kwatra, (2012) that reported new rice trans-planters could reduce drudgery by 36.1% and 69.8% in terms of physiological cost/ha as compared to traditional practice. The equipment used avoid the bending posture that is adopted during traditional method.

### **5.3 Physiological workload among respondents using different types of baskets**

In this study, the respondents did not need to bend their body excessively more than 60° (Rani et al., 2016) during unloading of fruits when using the new basket making the average heart rate was lower than using the existing basket, as the respondents need to bend excessively to unload fruits if they used the existing

basket. This finding was supported with Chung et al., (2001) that reported the heart rate increased significantly especially when the trunk was laterally bent and twisted, as compared to the trunk posture without such motion (98.76 vs. 94.66 beats/min).

A study by Yaacob et al., (2017) at the pineapple plantation area using Rapid Upper Limbs Assessment (RULA) showed that many workers (91.67%) obtained a score of seven for harvesting when using existing basket and was categorized as above action level 4. That means an immediate change was required on the workers work posture to be implemented to avoid serious physical damage due to workers involved in lifting of more than 30 kg of loads, awkward body posture and repetitive movement (Yaacob et al., 2017).

Another study by Rani (2016) using Rapid Entire Body Assessment (REBA) to the pineapple workers showed that harvesting was categorized as high and very high risk when using the existing basket due to workers obtained score of 8 to 10 (23.8%) and more than 10 (76.2%). While when Hazard Identification, Risk Assessment and Risk Control (HIRARC) on harvesting was done, the result reported that the harvesting using the existing basket was categorized as medium risk due to workers involved in carrying heavy load and awkward postures.

Besides that, the average heart rate of the respondents when using existing basket increased significantly during each carrying trip. This finding was supported by Chung et al., (2005) that stated the mean heart rates of workers carrying soft drink beverages increased to 164 and 156 beats/min, respectively, as the number of trips increased.

The average heart rate (94.13 beats/min) when using improved basket was considered as a very light physiological workload while when using the existing basket, the average heart rate (89.05 beats/min) was considered light in this study. This finding was supported by Borah and Kalita (2016) that stated the physiological workload will be considered as very light if the heart rate was 90 beats/min and below while considered as light physiological workload if the heart rate was 91 to 105 beats/min. Vanderwal et al., (2011) reported that maximum heart rate of subjects lowered to 5% when using the new short hoe, compared to the traditional hoe. This statement proved that usage of improved basket was better than existing basket due to significant reduction of the physiological workload.

The energy expenditure in this study showed that when using new basket, the energy expenditure needed was lower than the energy expenditure when using existing basket. This finding was supported with a study by Bhattacharyya and Chakrabarti (2012) that designed a new basket for tea-leaf plucking. The finding of the tea-leaf study showed that, the energy expenditure needed for new basket (6.57 kJ/min) was lower than the energy expenditure when using existing basket (7.07 kJ/min). The tea-leaf workers considered the plucking activity as light activity when using the new basket but moderately heavy activity when using existing basket.

Another study by Borah and Kalita (2016) stated that the energy expenditure 5 kJ/min and below was considered as a very light physiological workload while the energy expenditure of 5.1 to 7.5 kJ/min was considered as a light physiological workload. That study supported the finding of this study that reported about the new basket was better than the existing basket. This was due to significant differences of

the physiological workload, as the energy expenditure when using the improved basket (5 kJ/min) was considered as a very light physiological workload while energy expenditure when using the existing basket (6 kJ/min) was considered a light physiological workload. This study might be categorized as very light when using the new basket and light when using existing basket because the total of load carried was not the same as the actual load carried by the pineapple workers. However, the study by Borah and Kalita (2016) supported that new basket was better than existing basket.

#### **5.4 Perception of respondents using improved basket**

About half of the respondents strongly agreed that the functions of improved basket (padded back, backrest, opening for unloading) can help to reduce musculoskeletal symptoms. This finding was supported by a study done by Earle-richardson et al., (2005) that stated about the enthusiasm for a hip belt, a perception of the hip belt as both a support for the back (even when detached from the bag) and a means of displacing some of the bag weight during the apple harvesting. That intervention redistributed weight from the upper back, neck and shoulders to the hips. An intervention idea for a mailbag research demonstrated that wearing one strap over the shoulder and one strap around the waist while carrying the load in front is effective at reducing load on the lower back. (Earle-richardson et al., 2005).

The respondents also agreed that the improved basket gave more comfort than existing basket due to additional design criteria such as modified shoulder strap and backrest. This study was in lined with a study conducted by Earle-richardson et

al., (2005) about the orchard workers that reported the hip belt had greater comfort than the existing equipment. This was due to the hip belt made the workers to feel good around the waist, took weight off the shoulder and kept the weight steady. The workers felt differences at the neck, shoulder and back after using the improved basket.

Besides that, the respondents strongly agreed that the improved basket was better than existing basket in terms of its functionality for pineapple harvesting. This finding was supported by a study done by Earle-richardson et al., (2005) as the orchard workers mostly agreed that the improved equipment for apple harvesting was better than the existing one. A study by Ex et al., (2016) also reported that the rate of perceived opinion for improved sickle was highly acceptable compared to simple sickle due to improved sickle reduced the physical tiredness from medium to low.

The respondents were also strongly agreed and willing to use the improved basket for work in the future. This statement was supported by a study done by Earle-richardson et al., (2005) that reported that over three-quarters of workers interviewed said they would use the modified bag in the future, due to a perceived advantage in terms of reducing load on the upper back if the equipment were available.

In addition, the respondents agreed that the improved basket was easier to be use than the existing basket and this statement was in lined with a study by Earle-

richardson et al., (2005) as the orchard workers stated that the improved equipment helped in working better during the apple harvesting.

Most of the respondents also said that the improved basket could reduce the time required to collect the same amount of fruits as the old one. This perception was supported with a study done by Earle-richardson et al., (2005) that reported half of the workers did not think that the improved equipment would slow them down although the workers used the equipment every day. This was due to the intervention did not appear to change work practices thus would not affect picking speed, since picking speed was a component of work activity.

Ex et al., (2016) reported that the rate of perceived opinion for improved sickle was highly acceptable compared to simple sickle due to time saving when doing work about 12 to 20 per hour/ ha. The study was in lined with a study by Vanderwal et al., (2011) that stated the use of the long-handled hoe reduced the time required to prepare a specified area of land, without increasing the effort required (heart rate) compared to the traditional or new short hoe, thus improving worker productivity.

However, most of the respondents strongly disagree that the material for new knapsack basket is suitable than the existing basket. This was due to the material used for building the basket, which was iron that made the basket heavier than the existing basket. The material for the basket should be sturdy to withstand the weight of the fruits and this study wanted to eliminate excessive bending more than 60° during pineapple loading (Rani, 2016). Although iron material used was heavier than

the existing basket, but this new basket managed to eliminate excessive bending more than 60° during pineapple loading.

Other lighter materials such as aluminium, wire mesh and bamboo could not be used due to aluminium were too expensive and this study had money constraint. The wire mesh and bamboo could not be welded to make the opening for loading so could not eliminate excessive bending more than 60° during pineapple loading (Rani, 2016). Therefore, iron material was chosen even though the material was heavier but with other ergonomic criteria added helped to reduce discomfort and MSS among the workers.

Nevertheless, most of the respondents agreed that improved basket was suitable to collect pineapple and for pineapple harvesting in peat soil plantations. This finding was supported with a study by Pandey et al., (2013) that reported the use of Naveen sickle reduced physiological work load and decreased the drudgery of women in harvesting of paddy even though Naveen sickle was the heaviest weight 229g followed by Baibhav 202g and Deshi 178g.

### **5.5 Weakness of study**

The weakness of this study was selection bias as the respondents used were not the actual pineapple plantation workers that experienced the MSS due to harvesting process. Due to not using the pineapple workers, the amount of load carried also not resembled the actual load carried by the workers using the existing basket. Thus, could not determine the actual discomfort and physiological workload

of workers when using the new basket. The study location also did not resemble the actual plantation area due to simulation was being done at the UPM laboratory. The floor was hard and smooth compared to actual area that was soft due to soft peat soil that made the workers to use more energy to walk on the soil. Besides that, the material used for new basket was also heavier than the existing basket due to lighter material that was aluminium was expensive and due to money constraint, the material could not be used.

The testing of the new basket also did not use the same assessment done by previous study which were RULA and REBA to the actual workers. This should be done to compare the posture of workers when using existing and new basket to identify any other improvement to be done to the new basket. However, due to money constraint, the assessment using RULA and REBA could not be done to the actual workers in Pontian, Johor.

Improvement and modification should also be done to the new basket as sometimes the latch of the basket might not be opened and stucked due to force exerted on the basket or the latch opened by itself during the harvesting process making the fruits to fall off along the passage. The design criteria of the latch were a good idea in preventing the excessive bending during unloading of fruits but improvement should be done to ease the process.

## **CHAPTER 6**

### **CONCLUSION AND RECOMMENDATIONS**

This study concluded that the new designed basket was better than the existing basket because there was a significant reduction of physiological workload of the respondents using the improved basket compared to existing basket. The energy expenditure needed by respondents using improved basket also less than the energy expenditure needed for the existing basket. Usage of the improved basket not only reduce the discomfort of body parts but also helped in reducing MSS and gave comfort during working. Thus, could increase the productivity of the workers if the improved basket is being used in a long run to replace the existing basket.

For recommendation, there is need to do more improvement to the improved basket. More ergonomic design criteria should be added such as using lighter material than the iron and choose material that has smooth surface so that the latch will not be stuck during unloading of the fruits. The base of the improved basket should be design steeper and the gap of the basket should be minimized to ease the process of unloading of fruits. The improved basket should add on the hip belt as the belt help to redistribute weight from the upper back, neck and shoulders to the hips (Earle-richardson et al., 2005).

Besides that, the respondents used for the research should be the pineapple plantation workers that used the basket for harvesting process. The research should be done at the pineapple plantation farm during the working time of the workers and the total weight of the fruits carried should be the same as the one collected during the harvesting. This is to make sure that the actual physiological workload, discomfort and perception of workers when using the improved basket and the existing basket can be compared to get the most accurate result.



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**FOR RESEARCH INVOLVING HUMAN SUBJECTS  
(JKEUPM)  
UNIVERSITI PUTRA MALAYSIA**

<b>Research title</b>	<b>: The Development of Smart Fruit Basket</b>
<b>Study Site</b>	<b>: MAEPS, Serdang</b>
<b>JKEUPM Ref No.</b>	<b>: FPSK(EXP16-OSH)U031</b>
<b>Researcher</b>	<b>: Nurul Shahida bt Mezlan</b>
<b>Supervisor</b>	<b>: Dr. Emilia Zainal Abidin</b>

Documents received and reviewed with reference to the above study:

1. Ethics Application Form, Version 1 dated 18/10/2016
2. Respondent Information Sheet & Consent (English) Version 2 dated 25/11/2016
3. Respondent Information Sheet & Consent (Malay) Version 2 dated 25/11/2016
4. Proposal (English), Version 2 dated 24/2/2017
5. Questionnaire (English), Version 1 dated 18/10/2016
6. Questionnaire (Malay), Version 1 dated 18/10/2016
7. Curriculum Vitae of:
  - a. Dr. Emilia Zainal Abidin
  - b. Dr. Karmegam a/l Karuppiah

The University Research Ethics Committee, Universiti Putra Malaysia (JKEUPM) operates in accordance to the ICH-GCP Guidelines.

Decision by JKEUPM:

- Approved
- Permission MUST BE OBTAINED from the respective hospitals/ institutions before conducting the research**
- Disapproved

Please note that the approval is valid until 6 Mac 2018

Researchers should comply with the following:

- I. Complete a Study Final Report upon study completion (Form D).
- II. Ethical approval is required in the case of amendments/ changes to the study documents/ study sites/ study team.



**JAWATANKUASA ETIKA UNIVERSITI UNTUK  
PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)  
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,  
SELANGOR, MALAYSIA**

## **FORM B1: RESPONDENT'S INFORMATION SHEET AND CONSENT**

Please read the following information carefully and do not hesitate to discuss any questions you may have with the researcher.

### **1. STUDY TITLE :**

**The Development of Smart Fruit Basket**

### **2. INTRODUCTION:**

Harvesting is one of the main tasks of the pineapple plantation workers. However, the harvesting process has led to muscular skeletal symptoms due to the workers has to carry heavy load and involve in excessive bending when performing the task. This study is to develop new ergonomic knapsack basket to replace the existing knapsack basket used by the workers to reduce the muscular skeletal symptoms.

### **3. WHAT WILL YOU HAVE TO DO?**

You need to answer the questionnaire that will be distributed as to get the information on personal background, health information and muscular skeletal symptoms.

### **4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?**

The workers that already diagnosed of chronic disease such as heart disease.

### **5. WHAT WILL BE THE BENEFITS OF THE STUDY:**

#### **(a) TO YOU AS THE SUBJECT?**

This study will develop the new knapsack basket for the comfortness of the workers. The usage of the new knapsack basket will reduce the muscular skeletal symptoms and increase the health status of the workers.

#### **(b) TO THE INVESTIGATOR?**

This study will help the investigator to determine the appropriate design and material for the development of the new knapsack basket.

**6. WHAT ARE THE POSSIBLE RISKS?**

**There is no risk available in this study.**

**7. WILL THE INFORMATION THAT YOU PROVIDE AND YOUR IDENTITY REMAIN CONFIDENTIAL?**

**The information and identity used in this study will remain confidential.**

**8. WHO SHOULD YOU CONTACT IF YOU HAVE ADDITIONAL QUESTIONS DURING THE COURSE OF THE RESEARCH?**

**If you have any queries, you may contact the researcher Nurul Shahida binti Mezlan at**

**013-9373293 or email at [nsnurulshahida@gmail.com](mailto:nsnurulshahida@gmail.com) or Supervisor of the study research Dr Emilia binti Zainal Abidin at 03-89472643 or email at [za\\_emilia@upm.edu.my](mailto:za_emilia@upm.edu.my).**



*Please initial here if you have read and understood the contents of this page \_\_\_\_\_*

**9. CONSENT**

I ..... Identity Card No. ....  
address.....

.....hereby voluntarily agree to take part in the research stated above \*(clinical /drug trial/video recording/ focus group/interview-based/ questionnaire-based).

I have been informed about the nature of the research in terms of methodology, possible adverse effects and complications (as written in the Respondent's Information Sheet). I understand that I have the right to withdraw from this research at any time without giving any reason whatsoever. I also understand that this study is confidential and all information provided with regard to my identity will remain private and confidential.

I\* wish / do not wish to know the results related to my participation in the research

I agree/do not agree that the images/photos/video recordings/voice recordings related to me be used in any form of publication or presentation (if applicable)

\* delete where necessary

Signature ..... Signature .....  
(Respondent) (Witness)

Date : ..... Name : .....  
I/C No. : .....

I confirm that I have explained to the respondent the nature and purpose of the above-mentioned research.

Date ..... Signature .....  
(Researcher)



**JAWATANKUASA ETIKA UNIVERSITI UNTUK  
PENYELIDIKAN MELIBATKAN MANUSIA (JKEUPM)  
UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG,  
SELANGOR, MALAYSIA**

## **BORANG B1: PENERANGAN DAN PERSETUJUAN RESPONDEN**

Sila baca maklumat berikut dengan teliti. Sekiranya anda mempunyai sebarang pertanyaan, sila kemukakan kepada penyelidik.

### **1. TAJUK KAJIAN**

**Pembangunan Bakul Buah Pintar**

### **2. PENGENALAN**

Penuaian adalah salah satu tugas utama pekerja ladang nanas. Walau bagaimanapun, proses penuaian ini telah membawa kepada gejala gangguan otot rangka disebabkan oleh pekerja membawa beban berat dan tunduk berlebihan apabila melakukan tugas. Kajian ini adalah untuk mencipta bakul bunttil ergonomik baru untuk menggantikan bakul bunttil yang sedia ada digunakan oleh pekerja untuk mengurangkan gejala gangguan otot rangka.

### **3. APAKAH YANG PERLU ANDA LAKUKAN?**

Anda perlu menjawab soal selidik yang akan diedarkan untuk mendapatkan maklumat mengenai latar belakang peribadi, maklumat kesihatan dan gejala gangguan otot rangka.

### **4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?**

Para pekerja yang telah disahkan menghidap penyakit kronik seperti penyakit jantung.

### **5. APAKAH FAEDAH MENYERTAI KAJIAN INI?**

#### **a) KEPADA ANDA SEBAGAI PESERTA?**

Kajian ini akan membangunkan bakul bunttil baru untuk keselesaan para pekerja. Penggunaan bakul bunttil baru ini akan mengurangkan gejala gangguan otot rangka dan meningkatkan taraf kesihatan para pekerja.

#### **b) KEPADA PENYELIDIK?**

Kajian ini akan membantu penyelidik untuk menentukan reka bentuk yang sesuai dan bahan untuk pembangunan bakul bunttil baru.

### **6. ADAKAH IA BERISIKO?**

Tiada risiko dalam kajian ini.

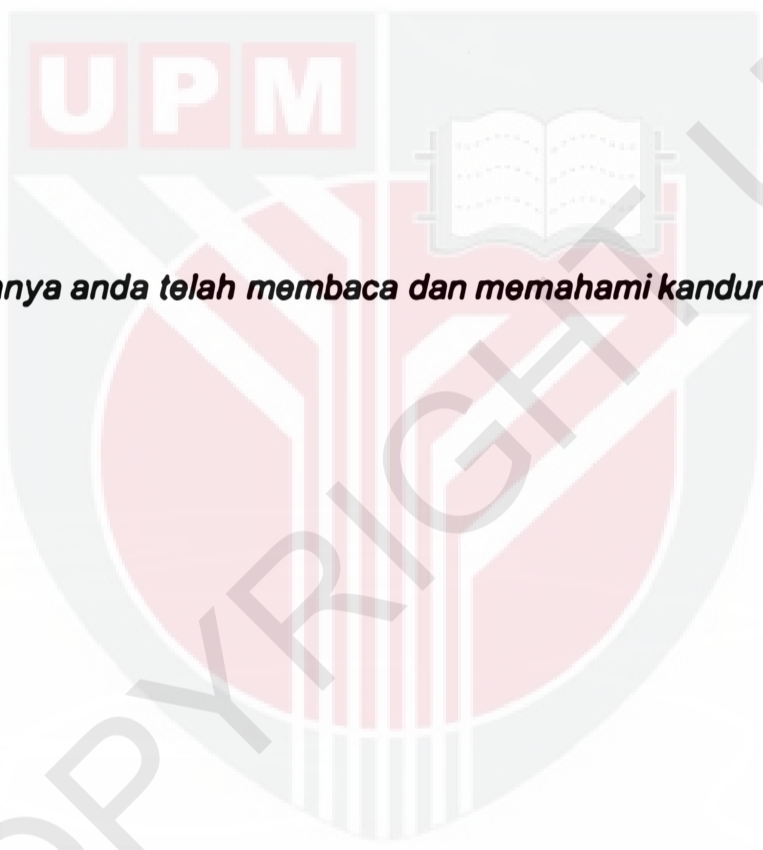
**7. ADAKAH MAKLUMAT DAN IDENTITI SAYA KEKAL RAHSIA?**

Maklumat dan identiti yang digunakan dalam kajian ini akan kekal sulit.

**8. SIAPA YANG SAYA PERLU HUBUNGI SEKIRANYA SAYA MEMPUNYAI SOALAN TAMBAHAN SEMASA MENGIKUTI PENYELIDIKAN INI?**

Jika anda mempunyai sebarang pertanyaan, anda boleh menghubungi penyelidik iaitu Nurul Shahida binti Mevlan di 013-9373293 atau emel di [nsnurulshahida@gmail.com](mailto:nsnurulshahida@gmail.com) atau Penyelia kajian penyelidikan iaitu Dr Emilia binti Zainal Abidin di 03-89472643 atau emel di [za\\_emilia@upm.edu.my](mailto:za_emilia@upm.edu.my).

*Sila tandatangan di sini sekiranya anda telah membaca dan memahami kandungan halaman ini \_\_\_\_\_.*



**9. PERSETUJUAN**

Saya..... No Kad Pengenalan. ....  
beralamat.....  
.....dengan ini bersetuju untuk mengambil bahagian secara sukarela dalam penyelidikan yang tersebut di atas \*(kajian klinikal/percubaan ubat-ubatan/rakaman video/kumpulan sasaran/temuduga/ soal selidik).

Saya telah diberi penjelasan secara menyeluruh mengenai penyelidikan ini dari segi metodologi, risiko dan komplikasi (seperti tertulis pada Helaian Penerangan Responden). Saya memahami bahawa saya berhak menarik diri dari penyelidikan ini pada bila-bila masa tanpa memberi sebarang alasan.Saya juga memahami bahawa sebarang maklumat yang berkaitan identiti saya akan dirahsiakan.

..ya\* berminat / tidak berminat untuk mengetahui keputusan kajian yang melibatkan saya.

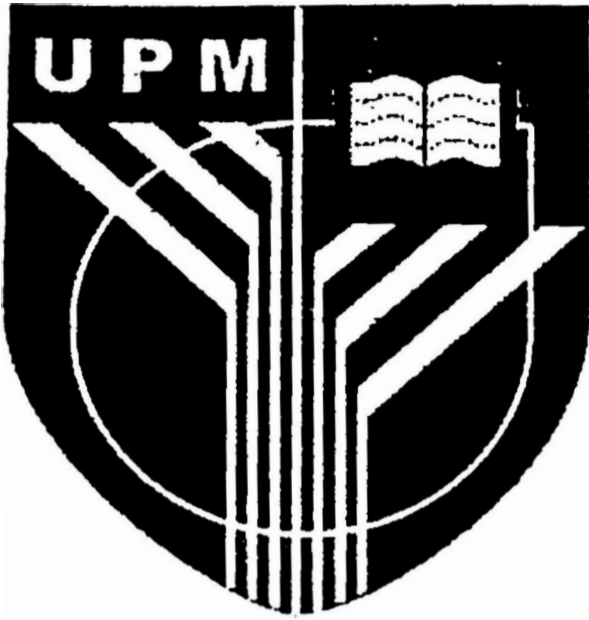
setuju/tidak bersetuju untuk imei/gambar/rakaman video/ rakaman suara digunakan dalam apa jua bentuk penerbitan atau pembentangan. (sekiranya berkaitan).

Tandatangan ..... Tandatangan .....  
(Responden) (Saksi)

Tarikh :..... Nama :.....  
No. K/P: .....

Saya mengesahkan bahawa saya telah menerangkan kepada responden ini sifat dan tujuan penyelidikan yang tersebut di atas.

Tarikh ..... Tandatangan .....  
(Penyelidik)



**TITLE:**

**DEVELOPMENT OF SMART FRUIT BASKET FOR PINEAPPLE HARVESTING**

**Questionnaire**

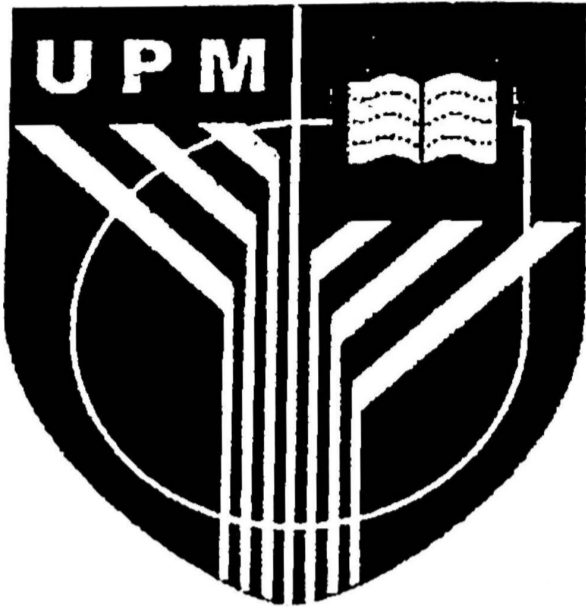
**Respondent's ID :**

**Date :**

**Signature**

All responses will be treated as confidential. No one beyond the study team will have access to your details. Any summary results will be presented in an anonymous format so that no one will be able to recognize you from the results.

There are FOUR sections to this questionnaire and it should take about 5 to 10 minutes to complete answering the questionnaire. Please answer the question by TICKING or WRITING in the spaces provided.



**TITLE:**

**DEVELOPMENT OF SMART FRUIT BASKET FOR PINEAPPLE HARVESTING**

**Questionnaire**

**Respondent's ID :**

**Date**

**Signature :**

All responses will be treated as confidential. No one beyond the study team will have access to your details. Any summary results will be presented in an anonymous format so that no one will be able to recognize you from the results.

There are FOUR sections to this questionnaire and it should take about 5 to 10 minutes to complete answering the questionnaire. Please answer the question by TICKING or WRITING in the spaces provided.

## PRESURVEY QUESTIONNAIRE

This page contains questions that will provide your personal information, Please answer each question completely.

### Part A: Background Information

1. Age: \_\_\_\_ years

2. Weight: \_\_\_\_ kg

3. Height: \_\_\_\_ cm

4. Educational level:  Primary  Secondary

College  University

5. Marital status:  Single  Married  Divorce

### Part B: Health Information

1. Do you have the following disease?

Heart disease

Hypertension

Diabetes

Asthma

Others. Please state \_\_\_\_\_

2. How many years do you have those diseases? \_\_\_\_\_ years

3. Are you taking medicine for that disease?

Yes  No

**Part C: Musculoskeletal Disorders Information**

Parts of body

i) Do you ever feel pain, aches, burning or discomfort on the part of the body below?

ii) Do you ever feel pain, aches, burning or discomfort on the part of the body below within 7 days lately?

Neck

Yes  No

Yes  No

If Yes, answer questions ii. If not continue to the next question

Shoulder

Yes  No

Yes  No

If Yes, answer questions ii. If not continue to the next question

Elbow

Yes  No

Yes  No

If Yes, answer questions ii. If not continue to the next question

Upper back

Yes  No

Yes  No

If Yes, answer questions ii. If not continue to the next question

Lower back

Yes  No

Yes  No

If Yes, answer questions ii. If not continue to the next question

Wrist

Yes  No

Yes  No

If Yes, answer questions ii. If not continue to the next question

Hips

Yes  No

Yes  No

If Yes, answer questions ii. If not continue to the next question

Knees

Yes  No

Yes  No

If Yes, answer questions ii. If not continue to the next question

Ankles

Yes  No

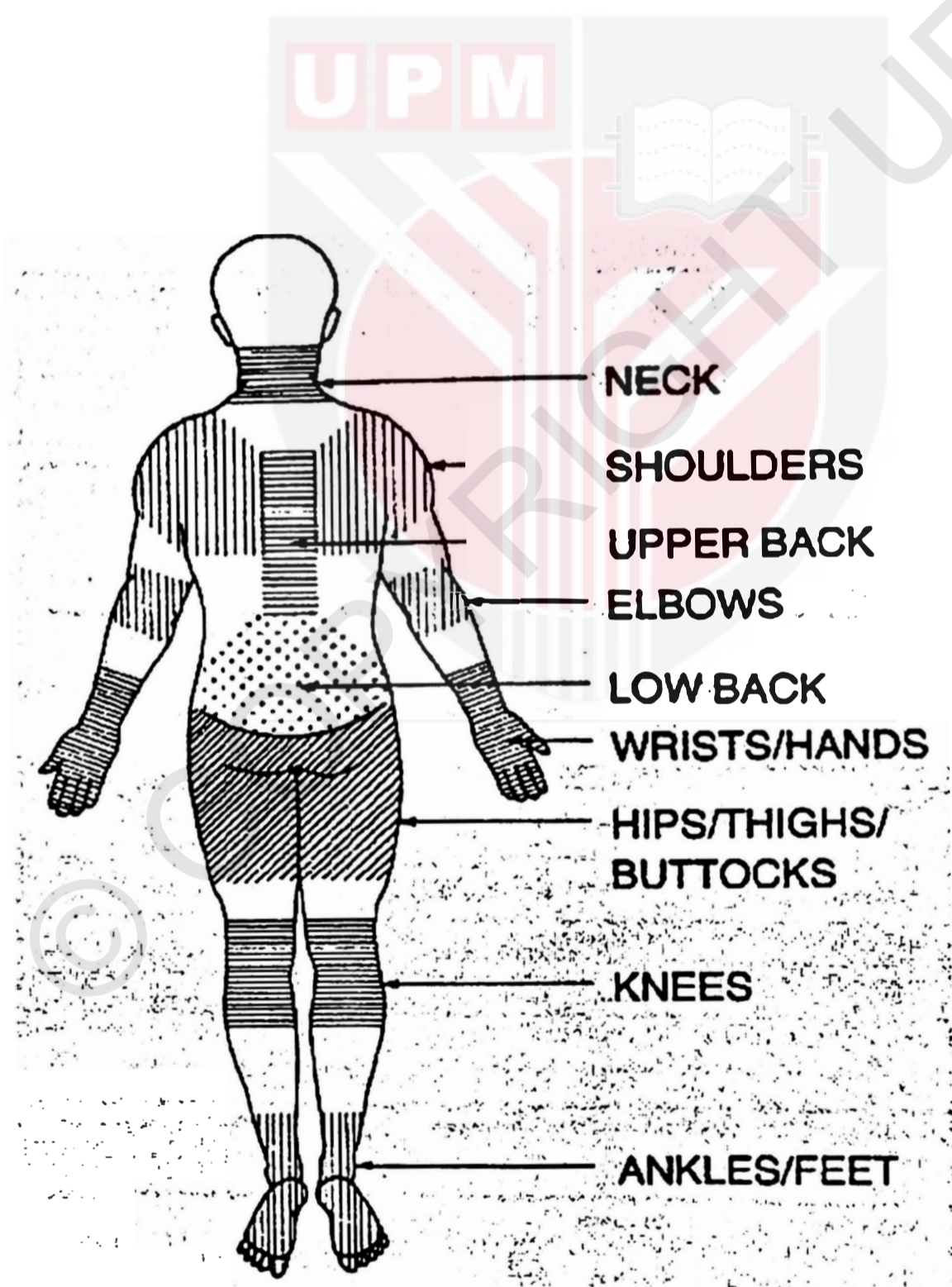
Yes  No

If Yes, answer questions ii. If not continue to the next question

**Part D: Borg Scale (Discomfort Rating)**

Nothing at all		Extremely weak				Weak		Moderate		Strong		Very strong								
0	0.3	0.5	0.7	1	1.5	2	2.5	3	4	5	6	7	8	9	10					

- Neck
- Shoulder
- Upper Back
- Wrists/hands
- Low Back
- Hips/thighs/buttocks
- Knees
- Ankle & feet
- Elbows



**Diagram 1**

## **PERCEPTION OF RESPONDENTS**

Please answer all the questions by ticking (✓) according to the following scale.

4 – Strongly agree

3 – Agree

2 – Not sure

1 – Not agree

0 – Strongly not agree

No	Question	4	3	2	1	0
1.	Do you think that the material for the new knapsack basket is suitable than the existing basket?					
2.	Did the new knapsack basket give you more comfort than the existing basket?					
3.	Do you think that the new knapsack basket is better than the existing basket in terms of its functionality for pineapple harvesting?					
4.	Do you think that the new knapsack basket is suitable for pineapple harvesting in peat soil plantations?					
5.	Do you think that the functions of the new knapsack basket (padded back, backrest, opening for unloading can help to reduce the musculoskeletal symptoms?					
6.	Do you think that the new knapsack basket can reduce the time required to collect the same amount of fruits as the old one?					
7.	Do you think that the new knapsack basket is easier to be use than the existing basket?					
8.	Do you think that the new knapsack basket can be used to collect pineapple?					
9.	Are you willing to use the new knapsack basket for your work in the future?					



**TAJUK:**

**PEMBANGUNAN BAKUL BUAH PINTAR UNTUK PENUAIAN BUAH NANAS**

**Soal Selidik**

ID Responden

Tarikh :

Tandatangan

Semua maklum balas akan dianggap sebagai sulit. Tiada siapa di luar pasukan kajian akan mempunyai akses kepada maklumat anda. Apa-apa keputusan ringkasan akan dibentangkan dalam format tanpa nama supaya tiada siapa yang akan dapat mengenali anda berdasarkan keputusan.

Terdapat EMPAT bahagian untuk soal selidik ini dan ia perlu mengambil kira-kira 5 hingga 10 minit untuk menjawab soal selidik. Sila jawab soalan dengan MENANDA atau MENULIS di dalam ruang yang disediakan.

### Bahagian C: Maklumat Gangguan Otot Rangka

Bahagian tubuh badan	i) Adakah anda pernah merasa sakit, pedih atau rasa tidak selesa di bahagian badan di bawah?	ii) Adakah anda pernah merasa sakit, pedih atau rasa tidak selesa di bahagian badan di bawah dalam tempoh 7 hari kebelakangan ini?
Leher	Ya <input type="checkbox"/> Tidak <input type="checkbox"/> Jika Ya, jawab soalan ii. Jika tidak terus ke soalan seterusnya	Ya <input type="checkbox"/> Tidak <input type="checkbox"/>
Bahu	Ya <input type="checkbox"/> Tidak <input type="checkbox"/> Jika Ya, jawab soalan ii. Jika tidak terus ke soalan seterusnya	Ya <input type="checkbox"/> Tidak <input type="checkbox"/>
Siku	Ya <input type="checkbox"/> Tidak <input type="checkbox"/> Jika Ya, jawab soalan ii. Jika tidak terus ke soalan seterusnya	Ya <input type="checkbox"/> Tidak <input type="checkbox"/>
Belakang atas	Ya <input type="checkbox"/> Tidak <input type="checkbox"/> Jika Ya, jawab soalan ii. Jika tidak terus ke soalan seterusnya	Ya <input type="checkbox"/> Tidak <input type="checkbox"/>
Belakang bawah	Ya <input type="checkbox"/> Tidak <input type="checkbox"/> Jika Ya, jawab soalan ii. Jika tidak terus ke soalan seterusnya	Ya <input type="checkbox"/> Tidak <input type="checkbox"/>
Pergelangan tangan	Ya <input type="checkbox"/> Tidak <input type="checkbox"/> Jika Ya, jawab soalan ii. Jika tidak terus ke soalan seterusnya	Ya <input type="checkbox"/> Tidak <input type="checkbox"/>
Peha	Ya <input type="checkbox"/> Tidak <input type="checkbox"/> Jika Ya, jawab soalan ii. Jika tidak terus ke soalan seterusnya	Ya <input type="checkbox"/> Tidak <input type="checkbox"/>
Lutut	Ya <input type="checkbox"/> Tidak <input type="checkbox"/> Jika Ya, jawab soalan ii. Jika tidak terus ke soalan seterusnya	Ya <input type="checkbox"/> Tidak <input type="checkbox"/>
Buku lali	Ya <input type="checkbox"/> Tidak <input type="checkbox"/> Jika Ya, jawab soalan ii. Jika tidak terus ke soalan seterusnya	Ya <input type="checkbox"/> Tidak <input type="checkbox"/>

## Skala Borg (Kadar Ketidakselesaan)

	Tiada		Tersangat lemah		Sangat lemah		Lemah		Sederhana		Kuat		Sangat kuat		Tersangat kuat	
	0	0.3	0.5	0.7	1	1.5	2	2.5	3	4	5	6	7	8	9	10
Leher																
Bahu																
Belakang atas																
Pergelangan tangan / tangan																
Belakang bawah																
Pinggul/ paha																
Lutut																
Buku lili/ kaki																
Siku																

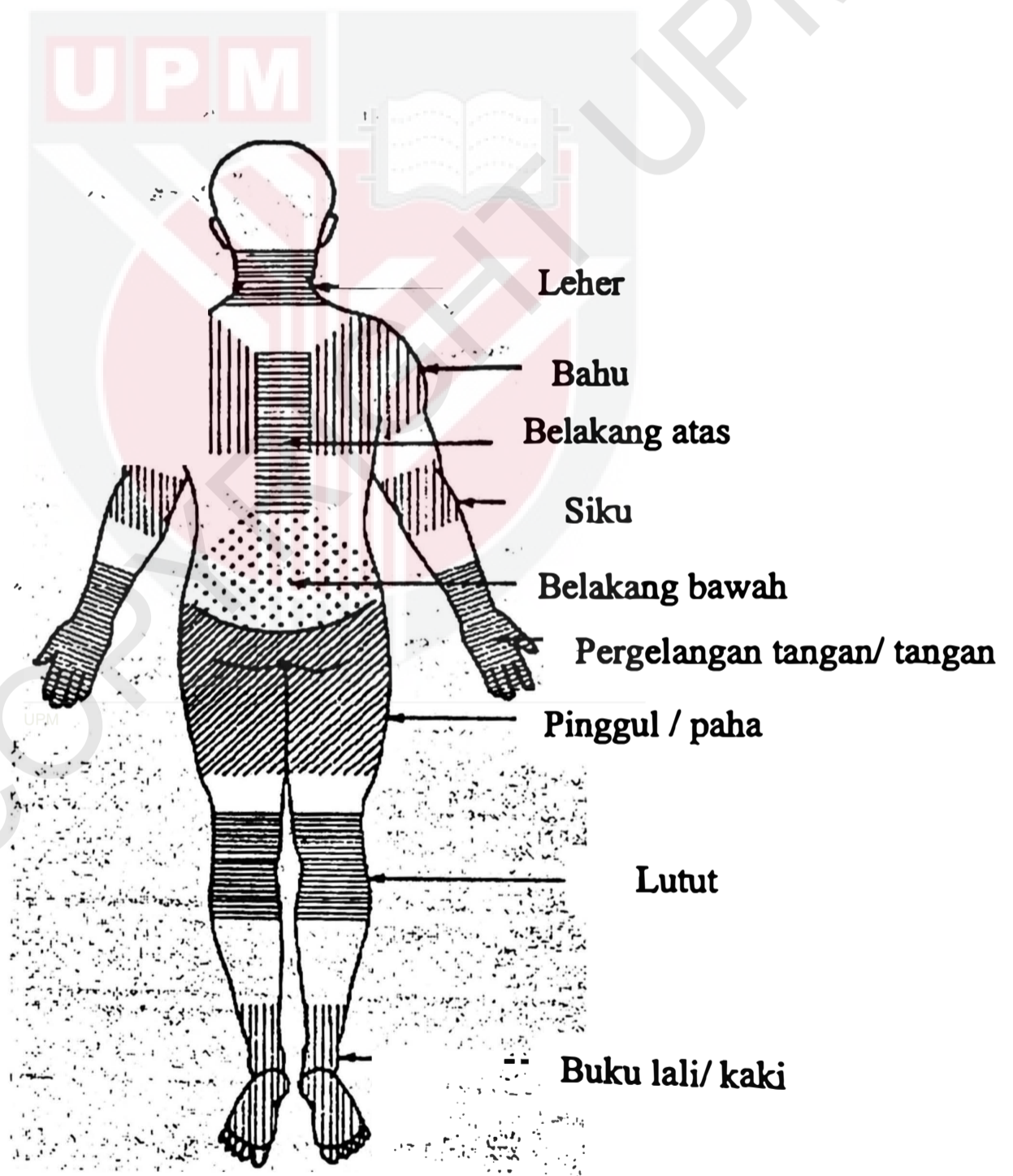


Diagram 1

## PERSEPSI RESPONDEN

Sila jawab soalan-soalan di bawah dengan menanda (/)skala di bawah.

4 – Sangat setuju

3 – Setuju

2 – Tidak pasti

1 – Tidak setuju

0 – Sangat tidak setuju

No	Soalan	Skala				
		4	3	2	1	0
1.	Adakah anda rasa bahan yang digunakan untuk bakul baru lebih sesuai berbanding bakul lama?					
2.	Adakah bakul baru lebih selesa berbanding bakul lama?					
3.	Adakah bakul baru lebih berguna untuk penuaian nanas berbanding bakul lama?					
4.	Adakah anda rasa bakul baru lebih sesuai digunakan untuk penuaian nanas di tanah gambut?					
5.	Adakah kriteria (penyandar belakang, bukaan untuk buah) yang ada pada bakul baru dapat mengurangkan simptom gangguan otot kerangka?					
6.	Adakah bakul baru dapat mengurangkan masa untuk mengutip jumlah bilangan nanas yang sama seperti bakul lama?					
7.	Adakah anda rasa bakul baru lebih mudah digunakan berbanding bakul lama?					
8.	Adakah anda rasa bakul baru boleh digunakan untuk mengutip nanas?					
9.	Adakah anda sanggup untuk menggunakan bakul baru ini untuk kerja anda pada masa hadapan?					