

**A STUDY OF ERGONOMIC RISK ON WORKERS PERFORMING
MATERIAL MANUAL HANDLING OF ACTIVITY AT MANUFACTURING
INDUSTRY**

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ABSTRACT

Assembly, Test and Manufacturing (ATM) primarily is automated process. During ATM, the finish product need to be checked thru series of tight procedure to ensure good quality deliver to customer. During testing, most of the activity required human assistance. Manual Material Handling (MMH) consist of activity that utilizing human capability to perform lifting, carrying, pushing and pulling. The aim of the study is to identify all manual material handling area and identify which area is the highest risk based on RULA. RULA (Rapid Upper Limb Analysis) is being used as an assessment method to investigate significant risk of MSDs at ATM. Then all workers at selected area will be evaluated using RULA and from there the most affected body part in term of working posture especially will be identified. If MMH is performed excessively it will create Musculoskeletal Disorders (MSDs). MSDs risk refers to damage of nerves, tendons, muscles and supporting structures of the body. After RULA conducted, survey form of body discomfort level is being issued to workers to understand level of discomfort among workers. The proposed recommendation will be based on improvement to prevent injury related to MSDs. In the nutshell the highest risk of work area is HDMT. The most risky body part posture based on RULA are upper arm and neck. The factors contributed for ergonomic risk are varies based on individual such as height of employee, working method, duration of standing, experience or inexperience , design of workstation and life style of workers.

ABSTRAK

Perusahaan, Pemasangan dan Ujian (ATM) adalah kebanyakannya menggunakan proses automatik. Semasa ATM process, produk akhir akan melalui beberapa siri proses pemeriksaan yang ketat untuk memastikan kualiti yang terbaik diterima oleh pelanggan. Semasa proses ujian dijalankan kebanyakannya dilakukan secara manual. Pengendalian Kerja Secara Manual (MMH) adalah seperti mengangkat, membawa, menolak atau menarik objek yang berat. Matlamat kajian ini adalah untuk menjalankan pemeriksaan untuk kawasan kerja yang melibatkan dan mengenalpasti kawasan yang didapati berisiko tinggi. RULA (Rapid Upper Limb Analysis) telah digunakan sebagai kaedah pemeriksaan untuk menyiasat risiko ketara MSDs. Jika MMH dilakukan secara berlebihan ia akan boleh menyebabkan MSDs. Risiko MSDs adalah kecederaan kepada saraf, tendon, otot dan struktur badan. Daripada kawasan yang telah dipilih, kesemua pekerja akan diberikan borang kaji selidik ringkas untuk mengetahui tahap ketidakselesaan tubuh badan mereka. Kemudian ringkasan daripada borang soal selidik akan di analisis untuk mengetahui bahagian anggota badan yang mempunyai risiko postur yang tinggi. Selain itu keputusan RULA akan dibandingkan dengan faktor yang lain seperti ketinggian pekerja, kaedah kerja, tempoh masa berdiri, dan pengalaman kerja. Langkah cadangan untuk penambahbaikan akan berdasarkan pencegahan kemalangan yang melibatkan MSDs. Secara kesimpulannya tempat kerja yang berisiko tinggi adalah HDMX, bahagian anggota badan yang terjejas adalah lengan atas dan leher. Faktor-faktor yang menyumbang risiko ergonomik adalah berbeza daripada setiap individu seperti ketinggian pekerja, kaedah kerja, masa diambil untuk berdiri dan tahap pengalaman.

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LIST OF SYMBOLS AND ABBREVIATIONS

ATM: Assembly Test Manufacturing

MMH: Manual Material Handling

MSDs: Musculoskeletal Disorder

HDMT : High Density Module Testing

DOSH : Department of Safety and Health

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LIST OF APPENDICES

Appendix A:

- 1) RULA worksheet

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Ergonomics is normally is related to human and job task. The job task that is not fit or adapt to human posture, capability and limitation will exposed employee to the high ergonomics risk. One of the common ergonomics risk at industry is related to manual material handling. The manual material handling (MMH) can be described as activity using hands to seize, holding grasping, lifting, lowering and carrying object. If the MMH done in excessive force, awkward postures and repetitive motion it will lead to injuries related to spine and muscles; namely musculoskeletal disorders (MSD). When workers performing MMH in the long period and not practising correct method, eventually the risk such as Lower Back Pain (LBP) and other MSD started to increase {Schaafsma, 2015 #16} .

This study is specifically conducted at production plan at Assembly Test Manufacturing (ATM) at Malaysia. Due to confidentiality of the company, the name of the company only stated as Assembly Test Manufacturing (ATM). ATM started in 1972 in Penang as Assembly Plant and developed as Global Shared Services in 2010. In 1996, Kulim campus was opened as System Manufacturing and 1999 as Board Design Center and Assembly/Test Plant. Now, ATM Malaysia not only focused on processors but also involved in data center, client (PCs and laptops), ultra-mobile (smartphones and tablets) and wearable/IoT.

Most of activities at ATM is automated but some activities are still requiring manual work force due to demand in flexibility and low cost. The activity that required MMH are Ball Attach Heller, Cart Mobilization, HDMT, Lifting RBP Board and Manual Flipping Tray. In order to identify which area is the highest risk, Rapid Upper Limb

Assessment (RULA) method have been used to investigate on posture and supported by Body Discomfort Survey to analyse further the affected body parts. The purpose of the study is to investigate significant risk of MSD such as low back pain and suggest recommendation program. Furthermore there is a need to improve any Musculoskeletal disorders due to it can cause impact significantly to finance cost such as medical treatment and lead to losses in productivity and higher turnover .Thus if the MSDs such case is not manage properly it will impact the productivity of organisation by increasing employee absenteeism.

1.2 Problem Statements

MMH caused lots of problem to huge different employee at workplace worldwide. However most of injuries related to MSD is lagging and employee only noticed the injury after the symptom worsen. That is the main reason identification of ergonomic significant risk should be carried out proactively instead of reactively. The body part affected by MMH are also varies from each employee. Thus investigation using RULA and Body Discomfort Survey able to determine the significant risk and which body part is affected is required. From the RULA result, recommendation for improvement can be suggested at specific working area.

1.3 Scope Of Study And Limitation Of The Research

In line with the current situation, top management direction and lack of resources, the scope of the study will be focusing pre-determined area that involved MMH activity. The work area involved are Ball Attach Heller, Cart Mobilization, HDMT, Lifting RBP Board and Manual Flipping Tray. All the working area mentioned will be assessed using RULA assessment tools in order to identify which area is the highest score. After identified which one is the highest, RULA assessment will be conducted for 20 workers at those specific area to assess further which part of the body affected and significant

risk of MSDs. The sampling involve 20 participants and all are male (only male working there) and age between 25 to 36 years old.

The study is hoped to contribute some input regarding the MMH common body part affected and enhance the growth of consciousness especially employer for ergonomic investment and employees who are directly or indirectly exposed will aware that performing job in the right technique will reduce injury. Proper mitigation measures and preventive actions are expected to be taken in order to reduce the risk of MSD at specific working area.

1.4 Study Objectives

1.4.1 General Objective

To study and identify which area is the highest level of risk based on Rapid Upper Limb assessment (RULA) and potential of musculoskeletal disorders among workers who perform the manual material handling works based on selected work area at Assembly, Test and Manufacturing Malaysia.

1.4.2 Specific Objective

1. To identify level of MSD risk of pre-determined MMH work area
2. To determine the common body part affected that can lead to musculoskeletal disorders among employee using RULA and Body Discomfort Survey
3. To suggest recommendation for improvement for the specific working area.

1.4.3 Flow Chart of Study

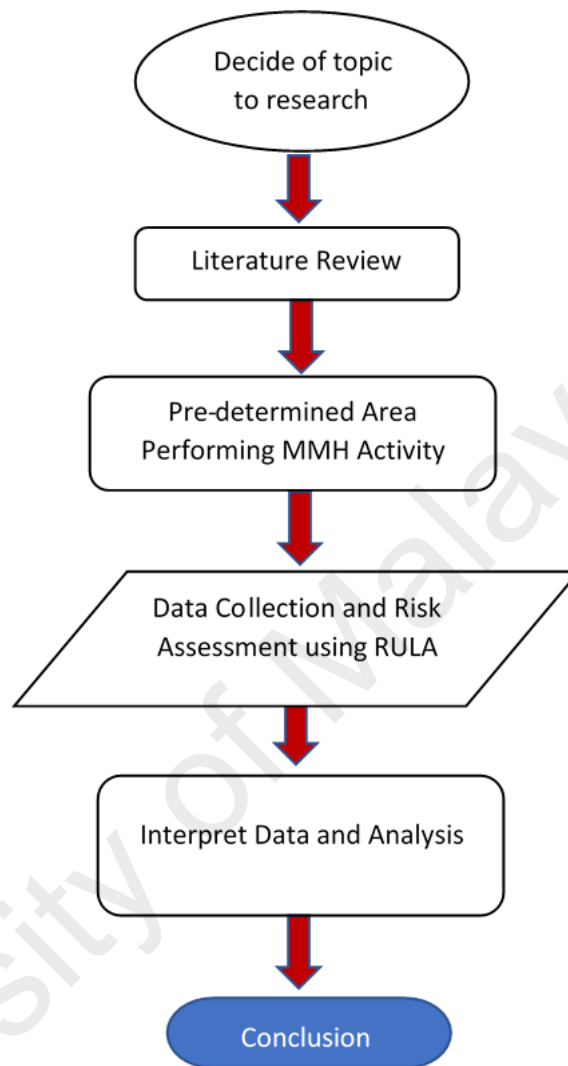


Figure 1.5.3 Flow Chart of Study

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Manual Material Handling (MMH) consist of activity that utilizing human capability to perform frequent lifting, lowering, carrying, pushing, pulling heavy equipment and it is usually associated with awkward posture, frequency of job, , tools, or material mobilization from one point to another point. By performing MMH it will create potential of ergonomic risk such as work-related musculoskeletal disorders (MSDs). In order to reduce the ergonomic, assessment should be done upfront using the available assessment method. Comprehensive approaches to physical ergonomic interventions work best to reduce the incidence of work-related MSDs.

Due diligence to maintain workers safety and health including ergonomic also stipulated clearly in legal requirement of Occupational Safety and Health Act (OSHA) 1994 that required management to ensure the work environment shall he adapted to the physiological and psychological needs of the workers (OSHA, 1994). The trending of accident shows increase of MSDs case year by year. Figure 1.2 Trend of MSD Reported case from 2005 to 2014 (Source from SOCSO) the MSD case reported to SOCSO from 2005 to 2014 was increased drastically from 10 cases to 657.

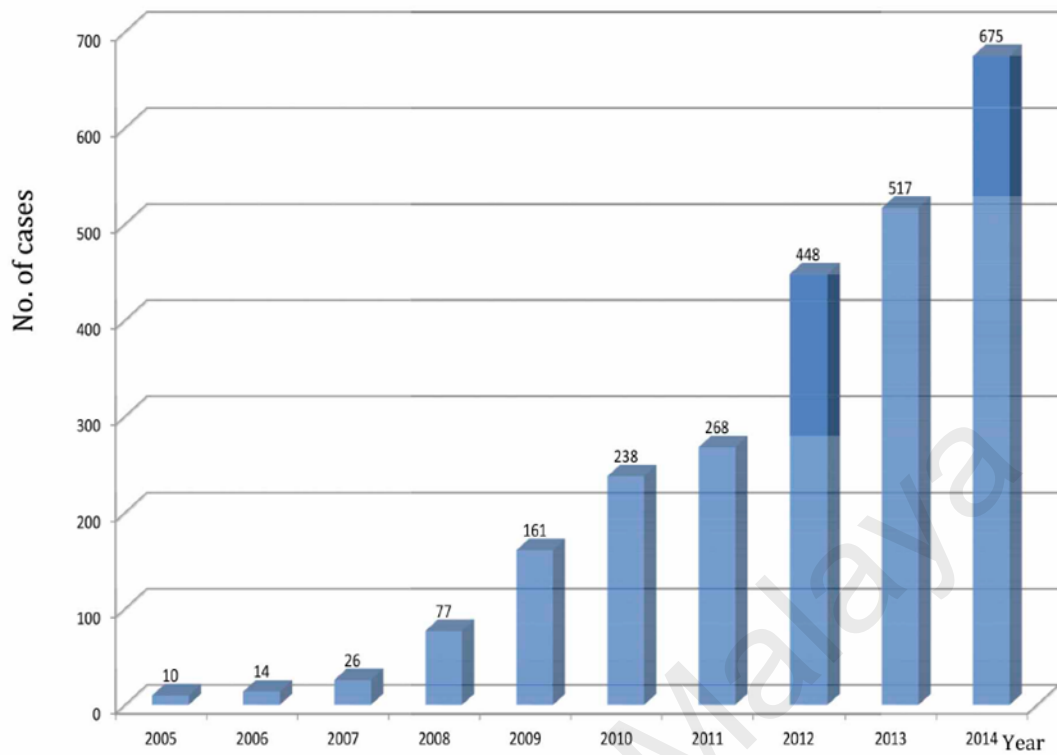


Figure 1.2 Trend of MSD Reported case from 2005 to 2014 (Source from SOCSO)

By comparing to ATM incident statistic, Figure 1.2 showed that 43 % from the case reported is related MSD compared to other incident. In the nutshell MSD case trending is trending and required action plan for improvement

Table 1.2 Assembly, Test and Manufacturing Incident Statistic Report 2017

Geographical Entity	Impact Severity	ILL/CT D/MSD	ILL/All Other Illness	ILL/Respiratory Condition	ILL/Skin disorder	Inj/Chemical/Contact Burn	Inj/contusion /bruise	inj/cut lacpuncture	inj/eye injury/illness	inj/other s	Inj/strain /spain	Inj/thermal/electrical burn	Total
Kulim 1	First Aid Case	0	0	0	0	0	0	0	0	0	0	0	1
Kulim 2	First Aid Case	3	0	4	0	0	1	0	0	0	0	1	14
Kulim 3	First Aid Case	0	0	0	1	0	0	0	0	0	0	0	1
Kulim 5	First Aid Case	25	0	1	1	3	1	0	0	8	1	1	44
	Days Away	1	0	0	0	0	0	0	0	0	0	0	1
Kulim 6	First Aid Case	5	0	0	0	0	2	0	1	0	1	1	10
	Recordable	1	0	0	0	0	0	0	0	0	0	0	1
	Day away	0	0	0	0	0	1	0	0	0	0	0	1
Penang 10 Warehouse	Recordable	1	0	0	0	0	0	0	0	0	0	0	1
Penang 12	First Aid Case	19	0	0	0	0	1	0	1	0	0	0	22
	Recordable	1	0	0	0	0	0	0	0	0	0	0	1
	Days away	0	0	0	0	0	0	0	0	0	0	0	1
Penang 2.1	First Aid Case	3	0	0	0	0	0	0	0	0	0	4	
Penang 7	First Aid Case	2	0	0	0	0	0	0	0	0	0	0	3
	Recordable	1	0	0	1	0	0	0	0	0	0	0	2
	Days Away	0	0	0	1	0	0	0	0	0	0	0	1
Penang 8	First Aid Case	40	1	8	3	28	7	13	0	14	10	1	126
	Recordable/w/restrictions	0	0	0	1	0	0	0	0	0	0	0	1
	Recordable	1	0	0	0	0	0	0	0	1	0	0	2
	Days Away	1	0	1	1	0	0	2	0	0	1	0	6
Penang 9	First Aid Case	0	0	0	0	0	1	0	0	0	0	1	

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Apart from company policy or procedure, by doing ergonomic assessment it is also demonstrate that management care about workers to gain healthier and safe and working environment. Commonly management get used to understand that safety injury is not related to ergonomic. Thus ergonomics aspects are always being ignored by the organization in the workplace design and improvement {Fernandes, 2015 #46}. In Malaysia, there is still a lack in the awareness of MSD related to work. The issue is considered new in Malaysia compared to other developed countries, and it is still being promoted by the professionals to enhance the awareness level to all Malaysia especially the OSH practitioners.

Others issue that need to consider is the cost, figure 1.2.1, SOCSO (Social Security Organisation) has reported the trend of compensation of occupational diseases either temporary or permanent is increased from RM 2.65 million in 2009 to RM 14.05 million in 2014. From the total compensation, the compensation due to MSD also showing increasing trend from 2009 to 2014.

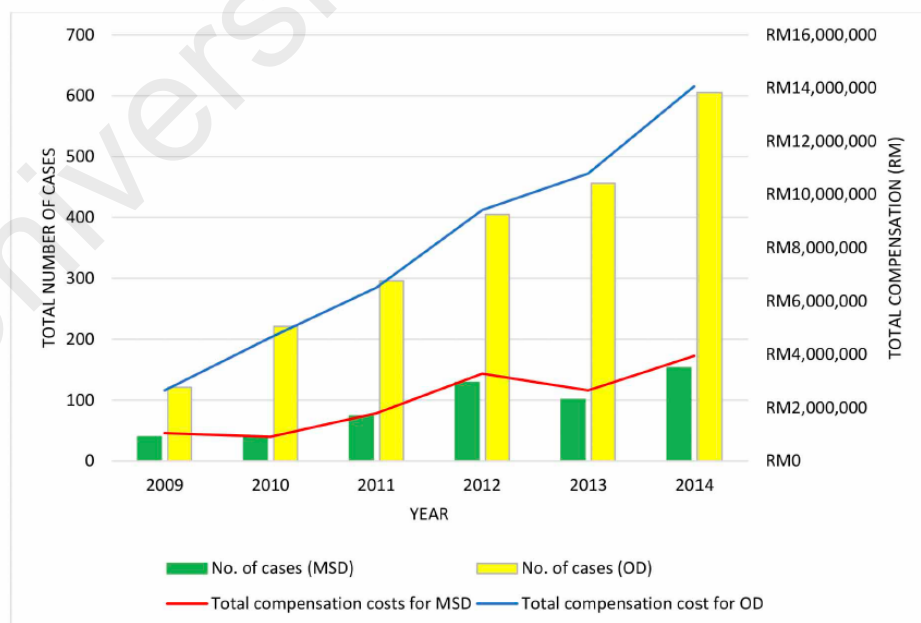


Figure 1.2.1 Trend of recorded MSDs relative to occupational diseases cases and compensation reported for permanent disability from 2009 to 2014.

Ignoring the MSD not only causing employee injury, absenteeism but it is also direct related to cost. This study is very important to investigate significant risk of manual handling works in the manufacturing field to the increment of MSD trend in the industry. It is also beneficial to other companies to find the root cause of the MSD and to further improves the state of the working environment in the factory.

2.2 Ergonomics and Work Design

Ergonomics of human factor is mainly referring to fitting the task to the human and not fitting the human to the task, (Dennerlein 2017). The purpose of ergonomic can be describe as maintaining body neutral posture when performing any task. The risk of ergonomic started to presence when the workers deviate from body neutral position while performing any task. The deviation of body neutral happening when the ergonomic principle not being considered when designing workplace and not fit with the interaction between human and physical environment. The interaction between human and physical environment will help to optimising the performance of human and also overall system that interact to human capability. When the ultimate performance achieved it will lead to prevention of work-related musculoskeletal disorders (MSDs).

2.3 MSDs And Manual Material Handling

Musculoskeletal Disorders refers to conditions that involve the nerves, tendons, muscles, and supporting structures of the body (Bernard, 1998). Musculoskeletal disorders, or MSDs, account for a significant portion of the injuries/illness experienced by most work organizations. Ranging from back strains to carpal tunnel syndrome, it is common for the employers to find MSDs accounting for 40% or more of their injury cases, and 60% of their workers compensation costs (Adams, 2002). Musculoskeletal disorders are always being associated with manual material handling. MSDs related to MMH attribute from the following activity high repetitive and heavy lifting, frequency for repetition of

bending and twisting, uncomfortable working position, exerting too much force, duration of work, adverse working environment, psychosocial factors (time pressure), late responding upon MSDs symptom and awkward or extreme joint motions. Symptom of MSDs varied from individual, however knowledge of the symptom will help to identify the risk before worsen.

Table 2.3 MSD Common Problem

No.	Type of MSDs/CTD	Cause
1	Carpal Tunnel Syndrome	Compression of median nerve travel to carpal tunnel
2	Tendinitis	Overuse of tendon e.g. athlete, aging
3	tenosynovitis	Overuse muscle or tools that cause inflammation of tendon sheaths
4	White Fingers	Excessive vibration
5	Trigger Finger	Exercise used of operating finger
6	Back Pain	Frequent bending, lifting, carrying heavy load

Based on survey on postures practise at Malaysia, Industrial workers were frequently exposed to injury at work due to an incorrect working posture. Improper working posture such as bending, twisting, overreaching, repetitive task and uncomfortable posture contribute to musculoskeletal disorder (MSD). Moreover common factors associated with MSD and low back pain is contributed by MMH activities. Thus if the MSD case is not manage properly it will impact the productivity of organisation by increasing employee absenteeism (Baba Md Deros, e.t all 2015). Low back pain is impact associated with improper posture, technique, frequent bending, twisting, awkward position, exertion muscle and sudden movement of our body in certain time frame that eventually

producing low back pain (Baba Md Deros, et al 2015). LBP is a symptom, not a disease, and it has many causes (Suhaimi 2018). From the medical perspective, Low back pain (LBP) is defined as pain occurring in the lumbosacral region with radiation limited to above the knee, without signs of nerve root compromise (Du, Hu et al. 2017).

The identification of risk will be followed by an improvement program. The improvement will be based on a hierarchy of control such as elimination, substitution, isolation, engineering control, administrative control and last but not least is personal protective equipment.

Manual Material Handling scope is broad not limited to lifting, lowering and carrying, it also covers activities using electronic devices such as computers, games consoles and mobile phones. A study located at Hong Kong found that from the total of 503, 251 (49.9%) respondents reported upper limb musculoskeletal symptoms, particularly in the neck and shoulder regions. Among these, 155 (61.8%) indicated that their discomfort was related to electronic device usage. The impact of MSDs varies based on individual anthropometry, biomechanics and type of activity but what is the same is which body part is affected by the activity. A comparison of MSD discomfort between Malaysia and Australia found that the hazard and exposure are the same and significant, however the impact on people in Australia is minimised due to their better focus on work-life balance (Maakip, Keegel et al. 2017).

Based on research, MSDs are the leading cause of work disability, sickness absence from work and loss of productivity across all European Union (EU) countries. The total estimated lost cost of productivity caused by MSDs among people of working age in the EU could be as high as 2% of gross domestic product (Bevan, 2015 #47). By improving policy such as clinical and employment practices, it probably will improve work performance and decrease the economic and social costs of MSDs (Bevan 2015). Other countries such as the US also have an increase in the cost due to MSDs, this study has indicated

that from 2003 until 2007 the average cost for medical and associated per case went up even the total cost of work related MSD declined from 2003 to 2007 (Bhattacharya 2014).

Among industries the more manual the activity and process, the higher the incident case reported related to MSD risk including back pain. According to study, 90% of adult will experiencing LBP at least once in their adult life (Costa-Black, Loisel et al. 2010). Thus ergonomic improvement should be consider while designing products, jobs, material-handling systems, machine-tool interfaces, workplace layouts, process-control interfaces and machine tool layouts (Nurmianto, Ciptomulyono et al. 2015). Decision either the ergo risk is low, medium or high will also consider the severity and probability of occurrence of ergonomic incident or accident. The severity of ergonomic risk is depend on frequency, intensity, and duration to perform pushing, pulling, lifting, carrying, heavy load repetitive movement, prolonged sitting or standing, awkward position, vibration, as well as factors related environment such as lighting, noise humidity and temperature (Otto and Battaia 2017). The risk is varies from each individual that involves heavy labor or manual material handling may be in a high-risk category. Manual material handling entails lifting, but also usually includes climbing, pushing, pulling and pivoting, all of which pose the risk of injury to the back (Nancy et al; 2006).

2.4 Human Spine

The spine is one of the most important parts of our body. Spine gives body structure and support, and protects spinal cord. The spinal cord. The spinal cord is the column of nerves that connects the brain with the rest of the body, and organs could not function. That is why keeping our spine healthy is important if we want to live an active life. Spine anatomy is significant combination of strong bones, flexible ligaments and tendons, large muscles and highly sensitive nerves. Spine anatomy can be divided into four segments such as cervical spine, thoracic spine, lumbar spine, and sacrum.

Spine is incredibly strong, protecting the highly sensitive nerve roots, yet highly flexible, providing for mobility on many different planes. Most of us take this spine for granted in our everyday lives until something goes wrong. Until then, people will be more aware about how to protect the spine and prevent the recurrent to happen. The functions of spine are to maintain structure of trunk and body movement, to protect the spinal cord and acts as shock absorber. Anatomy of the spine is showed in Figure 2.4.

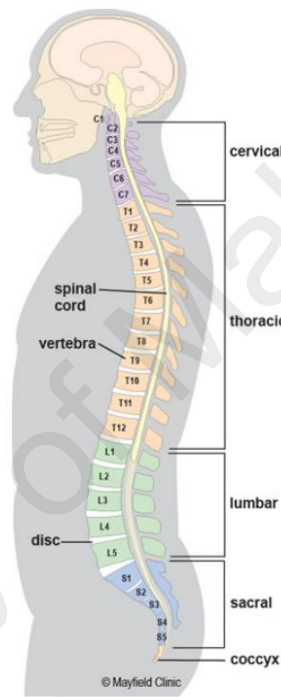


Figure 2.4: The anatomy of human spine (source: mayfieldclinic.com)

2.5 Back Pain

Back pain is a complex symptom that is a very common condition nowadays. Back pain can be categorized into acute back pain and chronic back pain. Acute back pain last less than 6 weeks whereas chronic back pain lasts for more than 12 weeks (Khan and Siddiqui, 2005).

According to Shaw et al., (2001), low pain is the most prevalent musculoskeletal disorder, and it associated with significant distress and lost productivity among workers. Low back pain which is one of the musculoskeletal disorders is a multifactor in origin and many be associated with occupational and non-work related factor and characteristic. (Haynes and William, 2006). A study done by Feldman et el., (2001), were considered possible risk factors such as a growth spurt, muscular flexibility, poor abnormal strength and increased level of physical activity and work. Study done by Reeves et al., (2005) showed that risk factor for low back pain in the study were muscle activity, posture shift and gender effect. The study showed that female having significant musculoskeletal than male.

2.6 Ergonomic Assessment Method

In order to evaluate MMH risk selection of assessment tools is important for accuracy and to avoid bias measurement. There are many ergonomics assessment tools that have been created for task analysis, equipment as well as environment (Roman-Liu 2014). In this study the ergonomic risk RULA is used as assessment tools. The RULA have been used due to its flexibility, cheap and not required advance experts in ergonomics and expensive equipment. Table 2.6 are guideline from DOSH to select the best ergonomic assessment method.

Table 2.6 Method for Assessing Ergonomics Risk Factor (DOSH Ergonomic Guideline 2017)

Risk Factor	Assessment Methods
Posture	<ul style="list-style-type: none"> i) Rapid Upper Limb Assessment (RULA)* ii) Rapid Entire Body Assessment (REBA) iii) Ovako Working Posture Analysis System (OWAS) iv) Biomechanics Analysis v) Etc
Forceful Exertion	<ul style="list-style-type: none"> i) Manual Handling Assessment Chart (MAC)* ii) Borg Scale iii) Liberty Mutual Manual Material Handling Tables (Snook Table) iv) Revised NIOSH Lifting Equation v) Etc
Repetitive Motion	<ul style="list-style-type: none"> i) Assessment of Repetitive Tasks (ART) ii) Occupational Repetitive Action (OCRA) Checklist* iii) OCRA Index iv) Etc
Workstation design	<ul style="list-style-type: none"> i) Rapid Office Strain Assessment (ROSA)* ii) Anthropometry Analysis iii) Etc

This chapter have presents various of significant research method to investigate on MSDs at workplace but the most prominent is RULA due to its flexibility, cost effective, rapid and not required expensive equipment or tools. In the nutshell there are opportunity to extend the study to identify which measurement tool is the best for certain task for better result and improvement in the future.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The ergonomic assessment is mainly used Rapid Upper Limb Assessment (RULA). Due to almost activity at ATM are automated, working area that performing Manual Material Handling was identified by referring to manufacturing process flow. The pre-determined working area are Ball Attach Heller, Cart Mobilization, HDMT, Lifting RBP Board and Manual Flipping Tray .All the area will be screen thru using RULA to identify which area has the highest score of MSD risk. After identification of focus area, RULA assessment will conducted to all workers working at specific area to identify which body part affected. The last step is to identify level of discomfort towards body part by using Body Part Discomfort Survey.

3.2 Study Sampling

The subject sampling was choose are consist of 20 people that representing all the workers working at selected area that was identified high risk by RULA. In this study age and sex was not considered as confounding factor.

3.3 Rapid Upper Limb Assessment (RULA)

RULA is a survey method developed for use in ergonomic assessment or investigations of workplace where work related to upper limb is reported. RULA is a tools that able to screen biomechanical and postural loading requirement of job, task or demands on the neck, trunk and upper extremities. The RULA assessment is conducted by using one single page of worksheet, the body posture (McAtamney and Nigel Corlett 1993).

RULA divided the body into two segments which are segment A and B. Figure 3.3 shows RULA Employee Assessment Worksheet. Segment A is to assess upper and

lower arm and wrist, while B for neck, trunk and legs. Each body segmented is scored individually based on posture position diagram.

ERGONOMICS P.L.L.S. **RULA Employee Assessment Worksheet** Task Name: _____ Date: _____

A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position:

Step 1a: Adjust...
 If shoulder is raised: +1
 If upper arm is abducted: +1
 If arm is supported or person is leaning: -1

Upper Arm Score: 3

Step 2: Locate Lower Arm Position:

Step 2a: Adjust...
 If either arm is working across midline or out to side of body: Add +1

Lower Arm Score: 2

Step 3: Locate Wrist Position:

Step 3a: Adjust...
 If wrist is bent from midline: Add +1

Wrist Twist Score: 2

Step 4: Wrist Twist:

If wrist is twisted in mid-range: +1
 If wrist is at or near end of range: +2

Wrist Score: 4

Step 5: Look-up Posture Score in Table A:

Using values from steps 1-4 above, locate score in Table A

Upper Arm	Lower Arm	Wrist Score				
		1	2	3	4	
1	1	1	2	2	3	3
1	2	2	2	2	3	3
1	3	2	3	3	3	4
1	4	2	3	3	3	4
2	1	2	3	3	3	4
2	2	3	3	3	3	4
2	3	3	3	3	3	4
2	4	3	3	3	3	4
3	1	3	4	4	4	5
3	2	3	4	4	4	5
3	3	4	4	4	4	5
3	4	4	4	4	4	5
4	1	4	4	4	4	5
4	2	4	4	4	4	5
4	3	4	4	4	4	5
4	4	4	4	4	4	5
5	1	5	5	5	5	6
5	2	5	5	5	5	6
5	3	5	5	5	5	6
5	4	5	5	5	5	6
6	1	6	6	6	6	7
6	2	6	6	6	6	7
6	3	6	6	6	6	7
6	4	6	6	6	6	7

Posture Score A: 5

Step 6: Add Muscle Use Score

If posture mainly static (i.e. held >10 minutes), Or if action repeated occurs 4X per minute: +1

Muscle Use Score: 0

Step 7: Add Force/Load Score

If load < 4.4 lbs. (intermittent): +0
 If load 4.4 to 22 lbs. (static or repeated): +1
 If load 4.4 to 22 lbs. (static or repeated): +2
 If more than 22 lbs. or repeated or shocks: +3

Force / Load Score: 2

Step 8: Find Row in Table C

Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in Table C.

Wrist / Arm Score	Neck, Trunk, Leg Score		
	1	2	3
1	1	2	3
2	2	2	3
3	3	3	3
4	3	3	4
5	4	4	5
6	4	4	5
7	5	5	6
8	5	5	6

Wrist & Arm Score: 7

Scoring: (final score from Table C)
 1-2 = acceptable posture
 3-4 = further investigation, change may be needed
 5-6 = further investigation, change soon
 7 = investigate and implement change

RULA Score: 7

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:

Step 9a: Adjust...
 If neck is twisted: +1
 If neck is side bending: +1

Neck Score: 3

Step 10: Locate Trunk Position:

Step 10a: Adjust...
 If trunk is twisted: +1
 If trunk is side bending: +1

Trunk Score: 2

Step 11: Legs:

If legs and feet are supported: +1
 If not: +2

Leg Score: 1

Table B: Trunk Posture Score

Neck Posture Score	Legs					
	1	2	3	4	5	6
1	1	2	2	2	2	2
2	2	3	3	3	3	3
3	3	3	4	4	4	4
4	4	4	4	5	5	5
5	5	5	5	5	6	6
6	6	6	6	6	6	6

Step 12: Look-up Posture Score in Table B:

Using values from steps 9-11 above, locate score in Table B

Posture B Score: 3

Step 13: Add Muscle Use Score

If posture mainly static (i.e. held >10 minutes), Or if action repeated occurs 4X per minute: +1

Muscle Use Score: 0

Step 14: Add Force/Load Score

If load < 4.4 lbs. (intermittent): +0
 If load 4.4 to 22 lbs. (static or repeated): +1
 If load 4.4 to 22 lbs. (static or repeated): +2
 If more than 22 lbs. or repeated or shocks: +3

Force / Load Score: 2

Step 15: Find Column in Table C

Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in Table C.

Neck, Trunk, Leg Score	Wrist / Arm Score		
	1	2	3
1	1	2	3
2	2	2	3
3	3	3	3
4	3	3	4
5	4	4	5
6	4	4	5
7	5	5	6
8	5	5	6

Neck, Trunk, Leg Score: 5

Figure 3.3 RULA Employee Assessment Worksheet

The segment and grand score determine on action level dictate if further investigation for that task is necessary.

A composite posture score is determine for segment A and B by referring at individual posture score in table A (for arm & wrist) and Table C (for Neck, Trunk and Legs). Each group posture score is then adjusted for additional musculoskeletal load taking muscle use and force into consideration. Table 3.3 shows RULA score and Action Level for final score

Table 3.3 RULA Action Level

Action Level	RULA Score	Interpretation
1	1-2	The person working in the best posture with no risk of injury from their work posture
2	3-4	The person is working in a posture that could present some risk of injury, and this score most likely the result of the body that deviated and awkward position, so this be investigated and corrected.
3	5-6	The person is working in a poor posture which a risk of injury, and this reason need to be investigated and changed in near future to prevent injury
4	7+	The person working in the worst posture with an immediate risk of injury and the reason of this need to be investigated and changes immediately to prevent injury

3.4 Data Collection

Data were collected through 4 approaches which were, interview, direct observation at work area and quantify using RULA, Body Parts Discomfort Survey, referring to reliable sources such as ATM Incident Report, government data, company manual and procedure

3.5 Body Parts Discomfort Survey (BPDS)

Body Parts Discomfort Survey is used to determine level of discomfort among workers performing MMH. The RULA mainly determined the posture of the workers. In order to understand level of discomfort among workers, survey form was used. In this survey sheet, 12 body parts were identified to be evaluated by the workers to determine their body discomfort level. Refer Table 3.5.1 for more details. For RULA only one side posture of the body will evaluated, thus the survey data for discussion is focus mainly on the right hand side of the body. The body parts evaluated was was adapted from Cornell (<http://ergo.human.cornell.edu>) and amendment had been made to suit with the study needs. Table 3.5.1 shows Body Parts Discomfort Survey

Table 3.5.1 Body Parts Discomfort Survey Form

Name : _____ (Optional) Area : _____ Age : _____ (Optional)		if you experienced ache, pain discomfort, how uncom. Was this		
		Slightly Uncom	Moderate uncom	very Uncom
Neck				
Shoulder	Right			
	Left			
Upper Back				
Upper Arm	Right			
	left			
Lower Back				
Forearm	Right			
	left			
Wrist	Right			
	left			
Hip/Buttocks				
Thigh	Right			
Knee	Left			
	Right			
Lower leg	left			
	Right			
foot	left			
	Right			

3.6 Interview

Interview was conducted to validate whether the workers clearly understand and answer the survey correctly and transparent. In this session workers also was asked if they are experiencing any MSDs such as back pain and etc.

3.7 Data Analysis

All data collected were analysed using basic statistical. The data from RULA was collected and analyse as well as survey form. The data analyse to determine which working area is the highest MSD level and the body part affected.

3.8 Study Ethics

All respondents in this study were volunteers and all the information collected was treated as confidential and only used for the purpose of this study.

3.9 Study Limitations

The study scope only focus on the area that was determine using RULA. The sampling used for the study may not be able to determine a comprehensive and significant association of the specific workstation.

The Body Part Discomfort Survey sheet which provides columns for workers to tick their feeling at each of the body part identified, caused a tendency bias. During the data analysis period, it was found that there were a lot of missing data which the workers did not answer. The amount of missing data in the study may cause some effect to the results later.

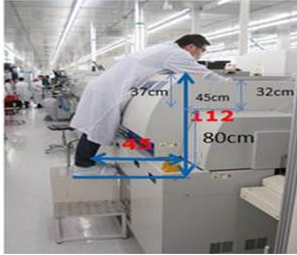


CHAPTER 4

RESULTS AND DISCUSSION


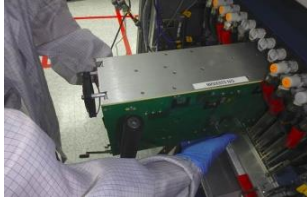

4.1 Introduction

In order to identify which area is the highest ergonomic risk, all the area that performing Manual Handling activity was listed down. Table 4.2 shows which work area contributed the highest level of MSD risk by using RULA. It can be concluded that HDMT was the highest score and the lowest is cart Mobilization. The medium risk area was cart Mobilization. In this study the work area that has highest level of MSD score is selected to identify the impact towards workers and what is improvement required.

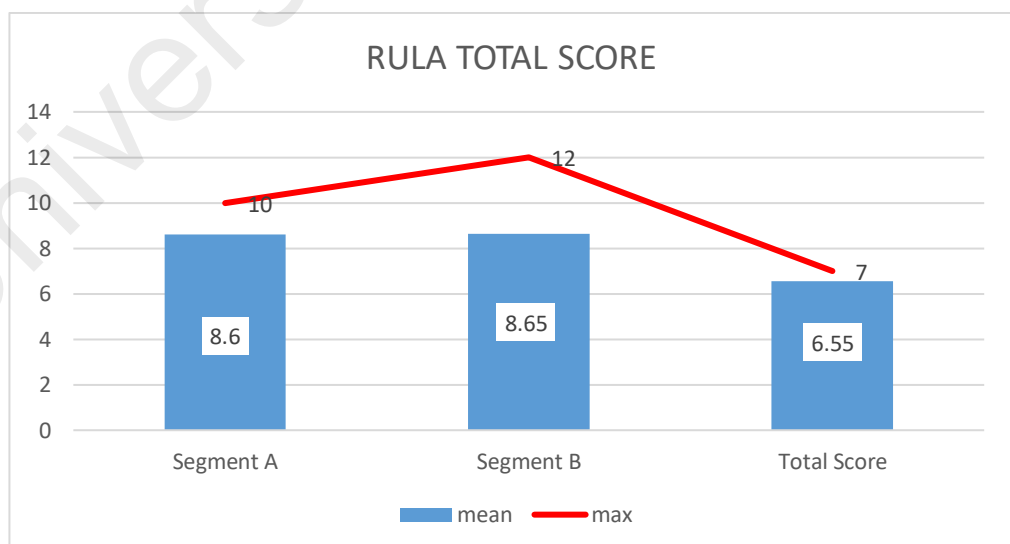
Table 4.1 Level of MSD Risk for Each Area

No	Work Area	Score of MSD Risk	Picture	Level of MSD Risk (RULA)
1	Ball Attach Heller	6		Medium Risk
2	Cart Mobilization	3		Low Risk
3	Digital Signature Algorithm	5		Medium Risk

Continue

5	HDMT	7		Very High Risk
6	RBP Board	5		Medium Risk
7	KM5 Manual Flipping	4		Low Risk

HDMT is new process setup to test the finish product. Refer Table 4.1 HDMT Process Flow for more details. Increasing of incident statistic in HDMT has shown study need to be done as proactive measure. The management not aware that the HDMT process is the one causing ergonomic risk towards employee. Thus, data collection was obtained from all 20 pax of workers from HDMT to find out workers MSD level of risk.



Score	Level of MSD Risk
1-2	negligible risk, no action required
3-4	low risk, change may be needed
5-6	medium risk, further investigation, change soon
6+	very high risk, implement change now

Figure 4.1 RULA Total Score

From figure 4.1, the result highlighted that 20 of total score is equal to 6.55 (93.57 %) compared to maximum value 7. The level of MSD Risk is very high risk and action is required to implement change immediately. However the improvement will be more effective if we are investing further on each body region. Identification of varieties of body region such as upper arm, lower arm wrist, neck, trunk and leg will allowed us to explore better control measures.

4.1.1 RULA Score for Different Body Region

In order to identify which body parts are affected, RULA method is being used to identify the mean score of each body region compared to the maximum MSD score of RULA method.

Table 4.1.1 RULA Scores for Each Body Region

	Upper Arm	Lower Arm	Wrist	Neck	Trunk	Leg
mean	3.35	0.38	0.53	0.92	0.38	2.000
min	2	1	1	1	1	2
max	4	2	3	4	2	2
std dev	0.59	0.44	0.64	1.18	0.44	0.00
%	83.75%	18.75%	17.50%	23.13%	18.75%	100.00%

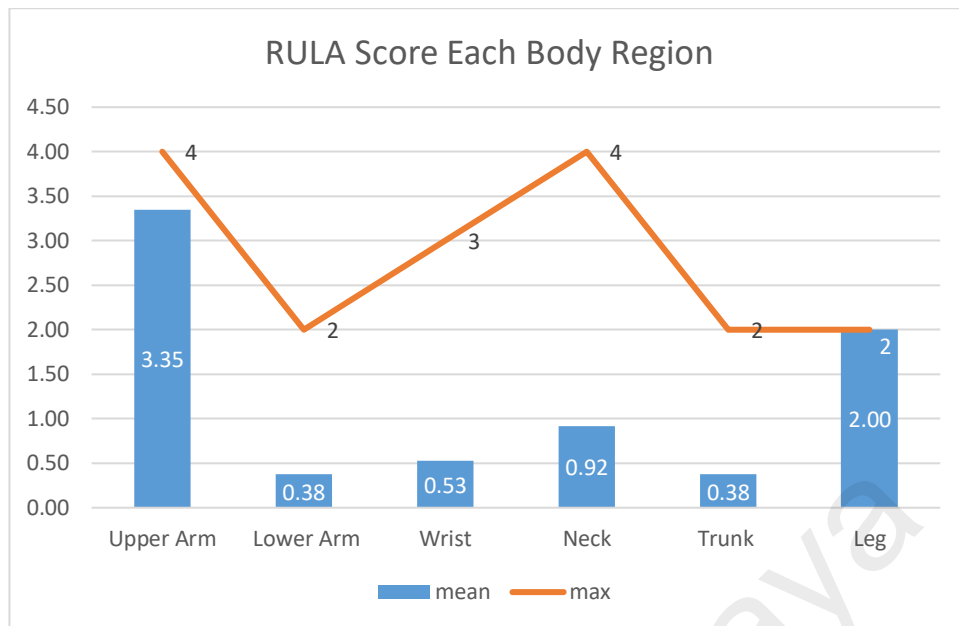


Figure 4.1.1 Mean RULA scores for each body region

The assessment of RULA shows the positioning of workers body region while performing the task whether neutral or extension. According to figure 4.3 the mean for leg position is equal to 2.00 (100%) compared to the maximum score is 2. This is significantly describe that the leg position is in the neutral position and most of the time is straight while performing manual handling. However for the upper arm position is equal to 3.35 (83.75%) which is apparently significant if compared to max score 4. Meanwhile the mean for neck is equal to 0.92 (23.13%) compared to maximum score 4. The upper arm and neck position while performing task can be concluded that were in extension position.

4.2 Limitation of RULA Assessment




Assessment of RULA mainly will describe generally workers body posture whether in neutral or extension. From RULA analysis, it can be concluded that the most Body Region in extension position are upper arm and neck. But the main limitation of RULA is, it will not able to describe the level of discomfort towards workers. Thus the survey was

conducted to all 20 workers using the question below to obtain more information on level of discomfort towards body part. Refer Table 3.5.1 to understand the question used for Body Parts Discomfort Survey

4.3 Overall Summary Result

HDMX is the highest level of MSD risk. In this score, the working area relatively fall under worst posture that will expose to immediate risk and in order to prevent injury, the root cause should be investigated and changes immediately.

Table 4.3 HDMX Process Flow at ATM

No	Activity	Illustration
1	Pull out Tester (using body force). *Tester (45 kg)	
2	Removal of Tester – push up and pull out the tester with body force (requires 2 manpower).	
3	Remove TIU – same method as tester *AP and TIU (15 kg)	

Continue



No	Activity	Illustration
4	Undock AP, removal is same method as Tester and TIU.	
5	Carry the TIU, AP and Tester and place at trolley to be sent to TRB room for repair	
6	Repair TIU, Tester and AP	Repair at TRB Room

Table 4.3.1 Summary Result

Body Part	RULA Score (Mean)	Max	Respondent Body Discomfort Survey (%)			
			Slight	Moderate	Very Uncom.	No Respond
Upper Arm	3.35	4	55	20	5	20
Lower Arm	0.38	2	40	25	28	7
Wrist	0.53	3	20	40	5	35
Neck	0.92	4	65	10	15	10
Trunk	0.38	2	45	20	1	34
Leg	2	2	25	40	15	20

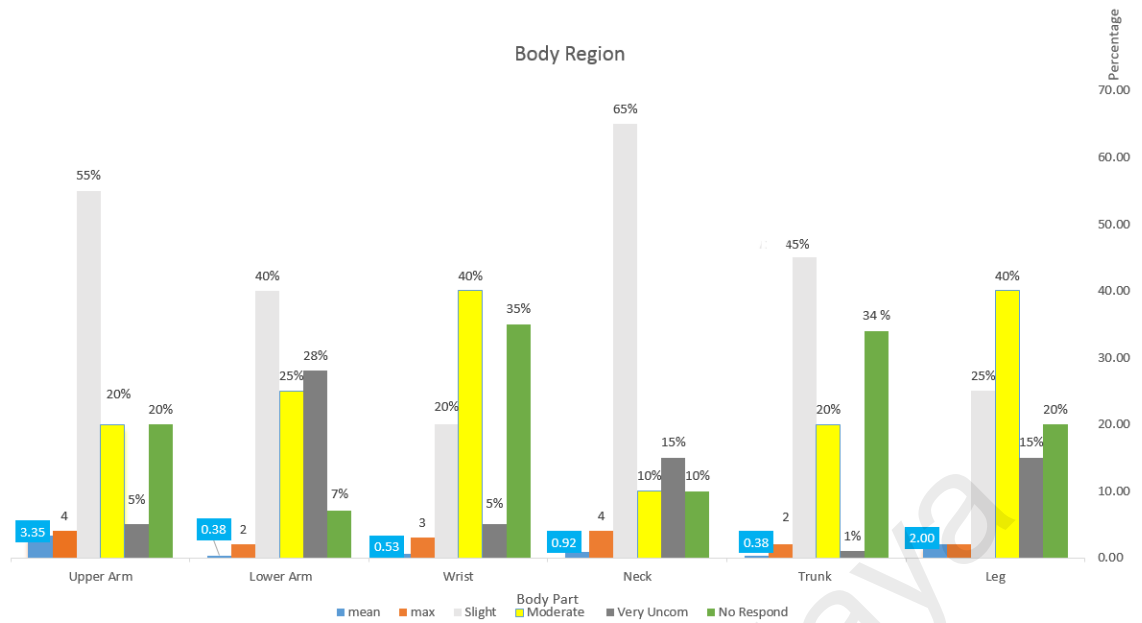


Figure 4.3 Overall Summary Result (Level of Discomfort)




4.4 Discussion

Based on the result of the discomfort survey among other body region, upper arm is the most high risk posture of the workers due to the body posture is deviated 83.75 % from the neutral position. However from the discomfort survey the respondent feedback that, 55 % are felt slightly comfortable followed by moderate is 20 %, very uncomfortable is 5 %, and 20 % not respond at all.

It is shows that even the risk of posture is high, it not directly represent that the level of discomfort among workers. Moreover moderate uncomfortable for Upper Arm Right is equal to 20%. This is showed that all the workers dominantly used right hand side compared to left hand. The more frequent the workers using their hand the more likely increase the level of discomfort. Table 4.4.1 shows awkward posture based on forearm pronation and forearm supination. By comparing neutral forearm with marked deviation and near extreme. It will help to indicate proactive measure to be taken towards working posture. Most of the posture observe during site visit are falling under either forearm

pronation (marked deviation) and supination (marked deviation) due to the common practise among workers. During interview most of the workers not aware the important of ergonomics. Most of them holding machine, tools or part based on convenient. There are not aware there is ergo technique while performing MMH.

Table 4.4.1 Awkward Posture for Hands

Body Segment	Awkward Posture	Comments	Illustration
Awkward Posture Definitions – Distal Upper Extremities			
4. Forearm pronation	Neutral: 0° - 30° Marked deviation: 30° - 60° Near extreme: > 60°	Pronation is "palm facing down." Measured from neutral (handshake) position. Note: Forearm pronation is less stressful than either supination or forearm rotation about the elbow.	 Neutral
			 4
5. Forearm supination	Neutral: 0° - 30° Marked deviation: 30° - 60° Near extreme: > 60°	Supination is "palm facing up". Measured from neutral (handshake) position.	 5

The over use of muscle, tendon, excessive vibration due tools usage are factor contribute to MSDs (Kadefors, Areskoug et al. 1993). The common MSDs related to fingers and hand such as tenosynovitis, white finger are occupational injury that should be prevented.

If any symptom of MSDs arise among workers, they should do early reporting to clinic for further investigation and prevention.





Let's compare for the most neutral or less deviated body part region which is leg. From the survey, 25 % felt slightly comfortable, while 40 % moderate, 15 % very uncomfortable and the rest 20 % not giving any respond. From this data analyse, the posture of body part is neutral but workers felt very uncomfortable. This is due to the capability of individual is different, certain people have certain pain threshold (Velásquez, Briceno et al. 2015). Doing work in standing with the same posture required different force towards backbone, leg and feet. If the person less force on his/her feet due to less weight, leg supported or using mechanical aid such as lifter or get help from other while doing lifting or lowering, the force is lesser to his/her feet and MSDs risk will be reduce.

MSDs due to prolong standing also related to the shoe. Shoe or place that we are standing also contributed to aggravation of MSD due to the foot pressure distribution, and impact force. Other than method of standing, duration or frequency of standing, break time and design of workstation, footwear also one of important in order to prevent MSDs related to leg and foot (Chiu and Wang 2007).

The second highest risk of body part according to RULA is neck. 23.13 % of posture of neck deviated very small from neutral position. However even it is only small, 15 % of respondent felt very uncomfortable, followed by 10 % moderate uncomfortable, 65 % felt slightly uncomfortable and the rest 10 % not giving any respond. If we combine the risk of very uncomfortable and moderate, 30 % or equal to half of workers are not comfortable with their position of neck. From the direct observation while collecting survey data, the position of neck related with the height of the workers.

Basically the parallel our head towards the object or items in front of us the lesser the risk of ergonomic. Table 4.4.2 shows awkward posture based on neck flexion, neck extension and next lateral flexion. Most of the posture observe during site visit are falling under either flexion or extension. Either flexion or extension is depend on the height of workers towards object or items in front of them. The tallest workers probably have issue with neck flexion and for shorter employee probably have issue with neck extension. If the activity conducted continuously either flexion or extension it will lead to MSDs related to neck (Charles, Ma et al. 2017). Thus we should address the concern from the workers in order to prevent any MSDs cases.

Table 4.4.2 Neck Awkward Posture





Body Segment	Awkward Posture	Comments	Illustration
Awkward Posture Definitions – Neck			
10. Neck flexion	Neutral: 0° - 20° Marked deviation: 20° - 45° Near extreme: > 45°	Neck flexion is bending the neck forward (e.g., looking downward).	 
11. Neck extension	Neutral: 0° Marked deviation: 0° - 30° Near extreme > 30°	Neck extension is bending the neck back (e.g., looking up).	
12. Neck lateral flexion	Neutral: 0° - 20° Marked deviation: 20° - 45° Near extreme: > 45°	Neck bent with the ear toward the shoulder.	 
13. Head rotation	Neutral: 0° - 20° Marked deviation: 20° - 45° Near extreme: > 45°	Neck rotation is turning the neck (e.g., looking to the side).	

55 % of respondent are mentioning that they felt slightly uncomfortable. It is shows that even the risk of posture is highly likely it is not directly represent that the level of discomfort.

Another body part that have significant risk of posture is wrist, the mean RULA score 0.53 (17.5 %) compared to max score 3. The wrist posture is deviate 17.5 % from neutral position. However based on body part level discomfort, 20% respondent felt slightly discomfort, followed by 40% respondent felt moderate, 5 % very uncomfortable and huge number of workers 35 % didn't respond at all. Based on the feedback, most of the workers didn't respond on the wrist portion due to, they felt that their discomfort of wrist not related to work. The wrist is being used extremely in our daily life such as using mobile phone to relate between work related or personal related when the wrist showing discomfort symptom. At HDMX process, apart from manual handling such as lifting, lowering, carrying, workers also need to used computer to key in data and checking data. Some of them need to use few monitor and keyboard in the same time. Using keyboard will cause wrist extension, ulnar deviation and forearm pronation between keyboard (Rempel, Barr et al. 2007). Table 4.4.3 shows wrist awkward posture based on wrist flexion, extension, ulnar deviation and radial deviation. Based on observation, the workers posture fall under wrist extension and radial deviation. Most of the workers

performing job based on convenient. Even some of them aware which method is correct, but they still used improper method just for convenient. The MSDs symptom not in acute affect, it is consider as chronic whereby it required longer time to detect. Usually people detect MSDs after the symptom worsen. Thus ergo awareness reduce over the time.

Table 4.4.3 Wrist Awkward Posture

6. Wrist flexion	Perfectly neutral: 0° - 5° Near neutral: 6° - 15° Non-neutral: 16° - 30° Marked deviation: 31° - 50° Near extreme: > 50°	Flexion is closing (reducing) the angle of the wrist.	
7 Wrist extension	Perfectly neutral: 0° - 10° Near neutral: 11° - 25° Non-neutral: 26° - 40° Marked deviation: 41° - 55° Near extreme: > 55°	Extension is opening (increasing) the angle of the wrist.	
8. Wrist ulnar deviation	Perfectly neutral: 0° - 10° Near neutral: 11° - 15° Non-neutral: 16° - 20° Marked deviation: 21° - 25° Near extreme: > 25°	Ulnar deviation is bending the wrist in the direction of the little finger.	
9. Wrist radial deviation	Neutral: 0° - 10° Marked deviation: 10° - 20° Near extreme: > 20°	Radial deviation is bending the wrist in the direction of the thumb.	

According to posture assessment related to RULA, lower arm and Trunk have the same RULA score equal to 0.38 (19 %) compared to max score 2. However among all body part, the lower arm is the highest workers responded as Very Uncomfortable, 28 % followed by leg and neck, both is 15 %, wrist and upper arm, 15 % respectively and trunk is the lowest only 1 %. Based on interview most of the feedback from the workers are complaining on the weight of HDMX tester is equal to 45 kg and AP and TIU, both is 15 Kg. Current procedure allocated 2 headcount, however during actual implementation workers have to do using one man power. This is also directly relate why lower arm has the highest level of discomfort. Furthermore some of the crew is new and not get used the new working environment. Experience workers contribute partially but now experience is one of important items because experience do influence performance of job when it is related work strategy and understanding of the risk.

The risk of developing MSDs for body part related to lower arm is tennis elbow, because experience influences work strategies, and consequently the risk of developing musculoskeletal disorders (MSDs). This study aimed to identify differences in work practices associated with tying rebar on slab, potentially relevant to back MSD development, in experienced and inexperienced workers. Figure 4.4 shows that Tennis Elbow is due to overuse of extensor muscles lead to pain at those area, the more pressure on the extensor the more pain occur. This MSDs cause not limited to work activity, but it is also contributed by others factors such aging, and poor blood (Velásquez, Briceno et al. 2015).

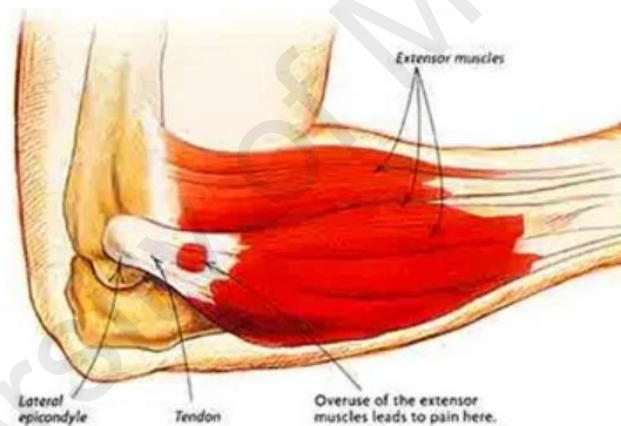


Figure 4.4 Tennis Elbow

From the overall summary result we can identify that, the most risky body part based on RULA are upper arm, followed by neck and then wrist and trunk have equal score. Finally the most neutral is leg. For body discomfort level result, based on discomfort survey (very uncomfortable feedback) the most body part feeling very uncomfortable are upper arm, followed by neck and leg shared equal score, then wrist and upper arm also have same value and finally trunk.

The ergonomic risk for each body part is caused by different factors such as height of employee, working method, duration of standing, experience or inexperience, design

of workstation and life style of workers. All of this factors was obtain and relate during interview and survey.

4.5 Mitigation Measure for HDMT Process

In order to prevent MSD injury caused by the damage of tendon, muscle ligament and joint. The issue faces by workers such as design workstation, awkward position, insufficient manpower, prolong standing, wrong working method, inexperience workers should be address immediately and ultimately to prevent the risk.

Referring to NIOSH (<https://www.cdc.gov>), effective control measure recommended to be based on hierarchy of control which are elimination, isolation, substitution, engineering control and last is PPE.

Design of workstation at HDMT not based on average height. It was observed that workers with low height required to bend their head more in order to looking up. Workers who is tall the risk is lower because they able to bend their knees proportion to the desired height. In order to increase the height, elevated platform either mobilise or fix can be design to install on the floor. By designing the elevated platform, it is also address awkward position.

According to working procedure, the task at HDMT shall be carried out by two people, however employee feedback that allocation of man power is not consistent and few times the workers need to work alone when changing the tester, AP and TIU board. Lifting heavy load, even though in the right posture will lead to MSDs issue. That is why it is a must to enforce buddy system while working with heavy load. Other than enforcement, mechanical aid or engineering control should be consider as improvement. Mechanical aid such as lifter can help to reduce MSDs by reducing the force while doing lifting, and carrying heavy load. Probably the lifter is expensive but the indirect cost that

we spent for recovery from accident much higher. Using mechanical aid it will also help to reduce time taken to complete the task and reduce as much as awkward or exertion posture.

Other issue highlighted is prolong standing, based on the observation, the HDMT process by nature is standing but there is no restriction to have micro break. Suggested to provide rest chair nearby workstation and recommended workers to rest frequently. Others improvement are by providing suitable shoes for employee and install standing mat on the floor. It will reduce force towards spine. Our muscle need to stretch for some time, introduce stretching program also one of the good approach.

Wrong working method and inexperience workers can be address by providing sufficient training to workers and monitor their implementation in daily task. From the interview lack of awareness is one of the major factor employee not practising right method even they have receive adequate training. Recognition, award and penalty should be one part of balance system in order to motivate and penalise the workers who is not adhere to procedure.

All the improvement should be consider as continual improvement and will not end by given time. All the hazard identification for any process should be review and revise accordingly to reflect the actual time and people.

CHAPTER 5

CONCLUSION AND RECOMENDATIONS

5.2 Conclusion

In the nutshell the RULA result highlighted upper arm is the most high risk body posture among the workers at HDMT. Upper arm deviated 83.75% from the neutral position and 20 % of respondent felt very uncomfortable. Upper arm is the worst body posture due to the workers need to raise their hand above shoulder and the position of palm facing up. The angle is more than 60 degree. The design of workstation contributed in this issue whereby the workers need to lift up tester and insert it on the top of shelf, when the workers height shorter than the slot, they need to raise upper arm above shoulder as much as they can. Moreover the tester is 45 kg, the force is huge. The effect of this posture will lead to MSDs related to upper arm that will causing pain from finger to shoulder. The neck is second highest risk and co-related to upper arm body posture, the neck deviated 23.13 % from neutral posture and 15 % out of 20 workers felt very uncomfortable with the posture. As the same factor with upper arm, the shorter the workers the higher the risk of neck posture due to the workers need to bend their neck at the back in order to looking up, and the angle of bending is up to 30 Degree. The frequent of neck bending will lead to MSDs such as cervical spondylosis and cervical disc space narrowing. In order to address upper arm and neck posture issue, installing elevated platform will be one effective improvement.

The lowest body part score based on RULA is Leg. The leg is the most neutral posture among others body part, However significant risk related to ergo not related to posture but the force received. This is due to the force distribution from lifting heavy object was distributed the most at the leg. According to survey result 40 % felt moderate uncomfortable towards leg. Observation found that the tester weight is the main factor of

the discomfort .The tester weight is 45 kg and the longer the workers standing the more they felt discomfort. The MSDs related to force is back pain. The best control measure is by using mechanical aid such as lifter or buddy system. Others control is increase the micro break time by providing the rest chair near work station.

5.3 Recommendations

This study suggests some recommendations:

- To establish proactive ergonomic assessment program for plant wide for incident prevention awareness campaign and introduce stretching program for intervention (Robertson, Huang et al. 2017)
- To establish ergo related training program based on the know-how of a group of all new and experienced workers and demonstrated while performing job. The development of training content will be helping in achieving goal to prevent musculoskeletal disorders (Ouellet and Vézina 2014),
- To plan and coordinate a comprehensive program or ergonomics plant wide which involves all levels including the top management and the workers.
- To increase the awareness level among workers through trainings and promotions such campaign. The awareness are very important especially among management as decision maker for the company. The best design of ergo will be initiated without approval by management and this required effort and high level of awareness among management. (Deros, Daruis et al. 2015)
- To incorporate the ergonomics factors (including the layout and SOP) in the new projects as a proactive approach. To promote and implementing collaboration between ergo design and human factor in designing workplace that fitting task to the workers and not fitting workers to the task (Hassall, Xiao et al. 2015)

- To improve the current workstations which involved MMH especially lifting task, and have high risk of backache and MSD.
- Further study is required to find out the association of MSD and MMH with the use of purposive sampling with specific location and task, and with more respondent to get the overall view of the problem.

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Abstract Low back pain is perhaps the most common affliction of mankind, second to headache. In this chapter, the basics of lower back anatomy are visited, specifically potential back pain generators, the cascade of degenerative changes that leads to widespread back pain, and factors that propagate an acute back pain to become chronic. Next, a system of approach to this multifactorial condition is offered by classifying etiologies based on its predominant clinical presentation. The chapter ends with Clinical Pearls, summing up the current understanding and approach to low back pain.

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