



UNIVERSITI PUTRA MALAYSIA

***THE ASSOCIATION BETWEEN WORK-RELATED
MUSCULOSKELETAL DISORDERS AND REPETITIVE TASKS
AMONG AIR-CONDITIONING PRODUCTION LINE WORKERS IN
BANGI, SELANGOR***

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DISORDERS AND REPETITIVE TASKS AMONG AIR-CONDITIONING
PRODUCTION LINE WORKERS IN BANGI, SELANGOR**



BY

NUR SYAZADINI BINTI NOR AZMI

**Thesis submitted in fulfilment of the requirement for the degree of Bachelor
Science (Environmental and Occupational Health) from the Faculty of Medicine
and Health Sciences, Universiti Putra Malaysia**

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ABSTRACT

Introduction: Work-related musculoskeletal disorder (WMSD) is one of the occupational threats to all the workforces globally, especially manufacturing workers. In the manufacturing industry, production line assembly workers are the most exposed to repetitive manual handling tasks. Repetitive movements among the workers can lead to the risk of developing WMSDs injury. **Objective:** The primary objective of this study is to determine the association between Work-related Musculoskeletal Disorders (WMSDs) and repetitive tasks among production line workers. **Methodology:** This study was conducted among production line workers in a selected manufacturing company. The selection of workstations was done by a purposive sampling method to determine the workstations with the most exposure towards repetitive tasks. A total of 118 respondents participated in this study. A self-administered and pretested questionnaire was used to collect data on socio-demographic, working conditions and job content while a Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) was used to assess musculoskeletal discomfort level of the respondents. Occupational Repetitive Action (OCRA) checklist method has been done based on the selected job tasks from the assembly line cycle to analyze the risk level of repetitive tasks exposed to the representative workers. **Result:** The results of the study found that the lower back (60.17%) has the highest prevalence of WMSDs complaint followed by neck complaint (55.93%), both shoulders (52.54%, 50.85%) on the left and right side respectively. The overall WMSDs from this study have shown a very high prevalence of 70.3%. The assessment of the repetitive task risk level indicated that most of the job tasks at assembly line cycle were at medium risk level. The chi-square test showed a significant association ($p < 0.05$, $\chi^2 = 4.348$) between WMSDs and repetitive task among production line workers. Another chi-square test results revealed that prevalence of WMSDs among workers in assembly cycle ($p < 0.05$) and final packing ($p < 0.05$) work units have a significant association with repetitive tasks. **Conclusion:** Production line workers especially those in assembly line cycle were likely to be exposed to repetitive hazards that contribute to the formation of WMSDs. Therefore, the findings from this study suggest the need for the management to increase ergonomics awareness and training among production line employees performing their daily repetitive job tasks to reduce the prevalence of WMSDs.

Keywords: Work-related musculoskeletal disorders, Repetitive task, OCRA, Production line workers

HUBUNGAN ANTARA GANGGUAN MUSKULOSKELETAL YANG BERKAITAN DENGAN PEKERJAAN DAN TUGAS BERULANG DI KALANGAN PEKERJA BAHAGIAN PENGELUARAN PENGHAWA DINGIN DI BANGI, SELANGOR

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ABSTRAK

Pendahuluan: Gangguan muskuloskeletal yang berkaitan dengan pekerjaan (WMSD) adalah salah satu ancaman pekerjaan kepada semua tenaga kerja di seluruh dunia, terutama pekerja perkilangan. Dalam industri pembuatan, pekerja pemasangan lini pengeluaran paling terdedah kepada tugas pengendalian manual secara berulang. Pergerakan berulang di kalangan pekerja boleh menyebabkan risiko kecederaan WMSD. **Objektif:** Objektif utama kajian ini adalah untuk menentukan perkaitan antara Gangguan Muskuloskeletal (WMSD) yang berkaitan dengan Pekerjaan dan tugas berulang di kalangan pekerja barisan pengeluaran. **Metodologi:** Kajian ini dilakukan di kalangan pekerja barisan pengeluaran di satu syarikat pembuatan yang terpilih. Pemilihan stesen kerja dilakukan dengan kaedah persampelan bertujuan untuk menentukan stesen kerja dengan pendedahan paling banyak terhadap tugas berulang. Sebanyak 118 responden telah mengambil bahagian dalam kajian ini. Soal selidik yang dikendalikan sendiri telah digunakan untuk mengumpulkan data-data sosio-demografi, keadaan kerja dan kandungan pekerjaan, sementara soal selidik Cornell Musculoskeletal Discomfort (CMDQ) digunakan untuk menilai tahap ketidakselesaan muskuloskeletal responden. Kaedah senarai semak Occupational Repetitive Action (OCRA) telah dilakukan berdasarkan tugas-tugas yang dipilih untuk menganalisis tahap risiko tugas berulang yang terdedah kepada pekerja. **Keputusan:** Hasil kajian menunjukkan bahawa bahagian bawah belakang (60.17%) mempunyai kelaziman tertinggi gangguan WMSD diikuti dengan aduan leher (55.93%), kedua-dua bahu (52.54%, 50.85%) di sebelah kiri dan kanan. Keseluruhan WMSD dari kajian ini menunjukkan kelaziman yang sangat tinggi iaitu 70.3%. Penilaian tahap risiko tugas berulang menunjukkan bahawa kebanyakan pekerjaan berada pada tahap risiko sederhana. Ujian chi-square menunjukkan hubungan yang signifikan ($p < 0.05$, $\chi^2 = 4.348$) antara WMSD dan tugas berulang di kalangan pekerja barisan pengeluaran. Hasil ujian chi-square lain menunjukkan bahawa kelaziman WMSD di kalangan pekerja dalam unit kerja kitaran pemasangan ($p < 0.05$) dan pembungkusan akhir ($p < 0.05$) mempunyai hubungan yang signifikan dengan tugas berulang. **Kesimpulan:** Pekerja barisan pengeluaran cenderung untuk terdedah kepada bahaya berulang yang menyumbang kepada pembentukan WMSD. Oleh itu, penemuan dari kajian ini menunjukkan perlunya pihak pengurusan meningkatkan kesedaran dan latihan ergonomi di kalangan pekerja yang melakukan tugas berulang untuk mengurangkan kelaziman WMSD.

Kata kunci: Gangguan muskuloskeletal yang berkaitan dengan pekerjaan, Tugas berulang, OCRA, Pekerja barisan pengeluaran

TABLE OF CONTENTS

			Page
DECLARATION			i
SIGNATURE OF SUPERVISOR			ii
ACKNOWLEDGEMENT			iii
ABSTRACT			iv
ABSTRAK			v
CONTENTS			vi
LIST OF TABLES			ix
LIST OF FIGURES			xi
LIST OF ABBREVIATIONS			xiii
CHAPTER			
1.0	INTRODUCTION		
	1.1	Study Background	1
	1.2	Problem Statement	3
	1.3	Study Justification	4
	1.4	Research Question	5
	1.5	Research Objectives	7
	1.6	Research Hypothesis	8
	1.7	Conceptual Definitions	8
	1.8	Conceptual Framework	10
2.0	LITERATURE REVIEW		
	2.1	Overview of Musculoskeletal Disorders (MSDs) 2.1.1 Work-related Musculoskeletal Disorders (WMSDs) 2.1.2 Upper Limbs Disorders (ULDs)	13
	2.2	Factors Contribute to Repetitive Task of Upper Limbs 2.2.1 Repetitiveness 2.2.2 Force 2.2.3 Awkward Posture 2.2.4 Additional Factors 2.2.5 Duration of Work 2.2.6 Movement Frequency 2.2.7 Recovery Period	20
	2.3	Review of Repetitive Task in Manufacturing Industries in Malaysia	28
	2.4	Association between Repetitive Task and Work-related Musculoskeletal Disorders (WMSDs)	32
	2.5	Cornell Musculoskeletal Discomfort Questionnaire (CMDQ)	33
	2.6	Repetitive Task Assessment Tools 2.6.1 Occupational Repetitive Action (OCRA) 2.6.1.1 OCRA Checklist 2.6.1.2 OCRA Index 2.6.2 Assessment of Repetitive Task (ART) 2.6.3 Job Strain Index (JSI)	34

		2.6.4 American Conference Governmental Industrial Hygienists (ACGIH) Hand Activity Level (HAL)	
3.0	MATERIALS AND METHODS		
	3.1	Study Design	40
	3.2	Study Location	40
	3.3	Study Duration	40
	3.4	Study Process Flow	41
	3.5	Sampling	46
		3.5.1 Sampling Procedure	46
		3.5.2 Study Population	48
		3.5.3 Study Sample	48
		3.5.4 Sampling Frame	48
		3.5.5 Sampling Unit	48
		3.5.6 Sample Method	49
		3.5.7 Sample Size	50
		3.5.7.1 Sample Size Calculations	50
	3.6	Study Instrumentations	51
		3.6.1 Questionnaires	51
		3.6.1.1 Pre-survey questionnaire	
		3.6.1.2 Questionnaire on socio-demography and working conditions	
		3.6.1.3 Questionnaire on Job Content	
		3.6.1.4 Questionnaire on Work-related Musculoskeletal Disorders	
		3.6.1.5 Rating Perceived Exertion Borg Scale (CR-10)	
		3.6.2 Occupational Repetitive Action (OCRA) Checklist	55
		3.6.2.1 Video Observations	
	3.7	Data Collection	67
	3.8	Statistical Analysis	69
	3.9	Quality Control	70
	3.10	Study Ethics	71
4.0	RESULTS		
	4.1	Socio-demographic and Occupational Information of The Production Line Workers	72
	4.2	Prevalence of WMSDs among Production Line Workers	75
	4.3	Risk Level of Repetitive Task according to Job Tasks	79
	4.4	The Association between prevalence of WMSDs and repetitive tasks among production line workers	84
5.0	DISCUSSION		
	5.1	Background Information	86
	5.2	Prevalence of WMSDs among Production Line Workers	86
	5.3	Risk Level of Repetitive Task	88
	5.4	The Association between prevalence of WMSDs and repetitive tasks among production line workers	89

6.0	CONCLUSION AND RECOMMENDATION		
	6.1	Conclusion	91
	6.2	Study Limitation	92
	6.3	Recommendation	94
	REFERENCES		96
	APPENDICES		105



LIST OF TABLES

TABLE NO.	TITLE	Page
2.1	Exposure score of ART tool	42
3.1	Task labelled according to job tasks	49
3.2	Frequency score according to rating score	60
3.3	Brief description of Task P	64
3.4	Net duration of repetitive work calculation in OCRA Checklist	64
3.5	Net total time of repetitive task cycle in OCRA Checklist	65
3.6	OCRA checklist score exposure level	74
3.7	Types of statistical tests used for each objectives	76
3.8	Questionnaire reliability testing	77
3.9	OCRA reliability testing	78
4.1	Socio-demographic information of production line workers	80
4.2	Prevalence of WMSDs among production line workers	83
4.3	Overall WMSDs prevalence in any complaints (timeline)	84
4.4	Discomfort score of any body parts	85
4.5	Checklist OCRA score according to job tasks (Right side)	87
4.6	Checklist OCRA score according to job tasks (Left side)	88
4.7	Summary risk level of repetitive tasks according to job task (Both sides)	89
4.8	Association between prevalence of WMSDs and repetitive task among production line workers	91



LIST OF FIGURES

FIGURE NO.	TITLE	Page
1.1	Occupational Diseases and Poisoning (Reported and Investigated) 2009-2019 in Malaysia by DOSH	4
1.2	Conceptual framework	12
2.1	Number of Workers Compensated by SOCSO with musculoskeletal diseases and NIHL problems	17
2.2	Repetitive Strain Injury (RSI) (MFMER, 2020)	19
2.3	Occupational Diseases and Poisoning Statistics by DOSH, 2017	31
3.1	Overall General Working Process at selected E&E manufacturing company	45
3.2	Work unit 1 (Assembly Cycle)	46
3.3	Work unit 2 (Internal Assembly)	46
3.4	Work unit 3 (Computer Test Room)	47
3.5	Work unit 4 (Final Packing)	48
3.6	Flowchart of Sampling Procedure	52
3.7	Task P (Loading unit to pallet job task)	63
3.8	The duration multiplier based on net duration of repetitive work (minutes)	66
3.9	Assessment of work periods without adequate recovery time in the full workday	66
3.10	Value of recovery factor based on number of working hours with inadequate recovery time	67
3.11	Work frequency score according to existence of brief interruptions	68
3.12	Force percentage of time and value exposure	69

towards force factors

3.13	Awkward posture score on shoulder, elbow, hand and wrist according to percentage of the full cycle time of work	70
3.14	Awkward posture score for each joint segment with higher precision	71
3.15	Assessment of additional factors in OCRA checklist	72
3.16	Flowchart of data collection	75
4.1	Risk mapping for the risk level of repetitive task in assembly line cycle (Right side)	90
4.2	Risk mapping for the risk level of repetitive task in assembly line cycle (Left side)	90

LIST OF ABBREVIATIONS

ACGIH	- American Conference Governmental Industrial Hygienist
ART	- Assessment of Repetitive Task
BLS	- Bureau of Labour Statistics
BMI	- Body Mass Index
CCOHS	- Canadian Centre for Occupational Health and Safety
CDC	- Centers for Disease Control and Prevention
CMDQ	- Cornell Musculoskeletal Discomfort Questionnaire
CTR	- Computer Test Room
DAFW	- Days Away from Work
DOSH	- Department of Occupational Safety and Health
DOSM	- Department of Statistics Malaysia
E&E	- Electrical and Electronic
ERA	- Ergonomics Risk Assessment
GDP	- Gross Domestic Product
HAL	- Hand Activity Level
IEA	- International Ergonomics Association
JSI	- Job Strain Index
MITI	- Ministry of International Trade
MSD	- Musculoskeletal Disorders
NIHL	- Noise Induced Hearing Loss
OCRA	- Occupational Repetitive Action
RAC	- Room Air Conditioning
RSI	- Repetitive Strain Injuries
SOCISO	- Social Security Organization
SOII	- The Survey of Occupational Injuries and Illness
ULDs	- Upper Limbs Disorders
WHO	- World Health Organization
WMSDs	- Work-related Musculoskeletal Disorders
WRULDs	- Work-related upper limbs disorders

CHAPTER 1

INTRODUCTION

1.1 Study Background

Nowadays, the manufacturing industry is one of the most important and powerful economic sectors that contributes to the country's development. It plays a crucial role in growth of economic and expanding the gross domestic product (GDP). Department of Statistic Malaysia (DOSM, 2020) reported that GDP from manufacturing industry in Malaysia averaged RM 6.3052.74 Million from 2010 until 2020 while the monthly manufacturing sales as in September 2020 reached at RM 121.2 billion, increased 3.7% as compared to previous year in 2019. In the third quartile of 2020, the manufacturing industries have shown the highest increment of production growth rate (3.30%) among the other industries such as services, agriculture, mining & quarrying and construction (DOSM, 2020). The electrical & electronics (E&E) industry is one of the largest contributors of industrial development in Malaysia that have set the fastest growing towards the country's exports, 27.2% and employment, 32.8% in manufacturing sector in 2013 (UKEssays, 2018). Up until now, Malaysia has more than 50 major electronics companies, including Western Digital, Panasonic, Intel, Samsung, Flextronics, Inari Technology and considerably more (Nordin et al., 2018). This indicates that the increasing in demands of the manufacturing products from the consumers have a slight implicit association with the additional of manufacturing workers to fulfil manufacturing needs.

However, the addition of manufacturing workers along with the increasing workload caused by the consumers' demands are one of the major contributions towards the rising of occupational diseases in Malaysia. In 2016, occupational diseases and poisoning have recorded the highest number from 2005 until 2020 with 7820 cases reported in Malaysia and manufacturing sectors are one of the major contributors towards the mass recorded numbers for occupational diseases and poisoning from 2017 until 2020 with 3349, 5198, 6040 and 1495 cases were recorded respectively (DOSH, 2020).

Work-related musculoskeletal disorder (WMSD) is one of the occupational diseases and poisoning occurred in the industries. It includes a wide range of health issues, including discomfort, minor wounds, and pain caused by work-related conditions. These health issues, on the other hand, can progress to more serious medical illnesses, which could result in permanent impairment. According to United States (U.S.) Centers for Disease Control and Prevention (2020), soft tissues of the musculoskeletal system, such as tendons, ligaments, cartilages, and spinal discs, are likely to be affected by musculoskeletal illnesses. These conditions can be worsened by extended exposure or abrupt exertion to physical factors for instance repetitive motion, forceful and sustained exertion, awkward posture, static and sustained posture, vibration, contact stress and environmental factors (DOSH, 2017). Industrial tasks which require repetitive movements of the upper limbs such as shoulder, neck and arms are common in a manufacturing industry. Upper limb risk factors include repetitive duties, uncomfortable work postures, and powerful exertions, all of which are strongly linked to the risk of Upper Limb Disorders (ULDs) (Rahman et al., 2017).

WMSD poses a major threat to everyone on the country, particularly the health of the workforce. It may occur when a human body is subjected to a mechanical workload that surpasses their physical capacity. WMSDs affect millions of workers throughout the world every year. It is an occupational health issues that seriously being discussed over the world including Malaysia as the trend of the cases is rapidly increase over the years, particularly in manufacturing sectors (Shamsudin et al., 2016).

1.2 Problem Statement

Manufacturing employees are hired to work hard in order to meet the needs of a variety of clients as well as the needs of the manufacturing organisation (Jovane et al., 2008). As a result, workplace accidents, injuries, illnesses, and diseases continue to be a serious problem in the manufacturing company, with an upward trend year after year (Hamalainen, Takala & Saarela, 2006). Based on Figure 1.1, according to Department of Occupational Safety and Health (DOSH) Report (2019), nearly 10,000 occupational diseases and poisoning cases have been reported to DOSH in 2019, increased 31.33% from previous year in 2018 (6500 cases) and 5907 cases were investigated.

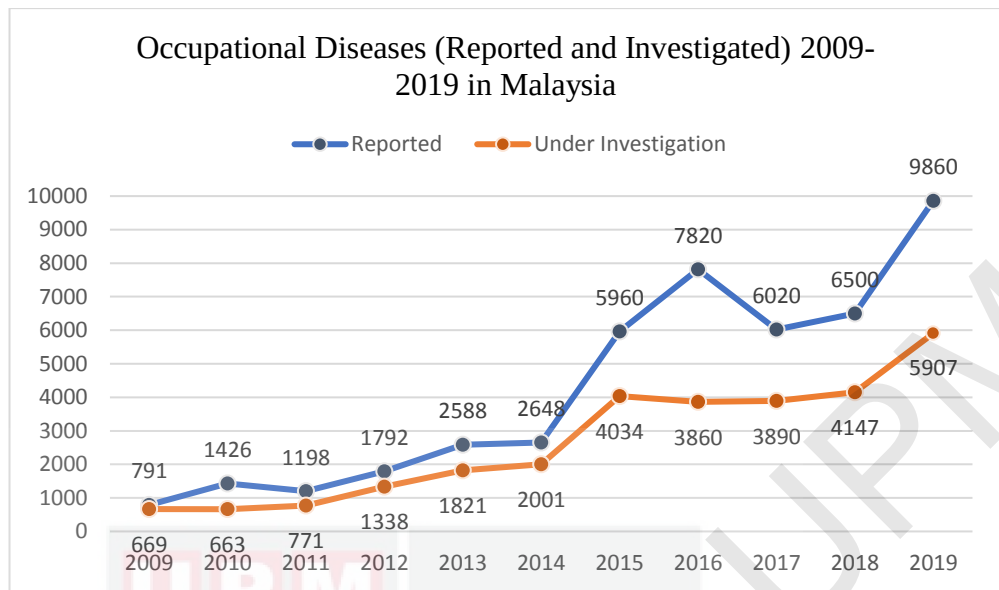


FIGURE 1.1: Occupational Diseases and Poisoning (Reported and Investigated) 2009-2019 in Malaysia by DOSH

Work-related musculoskeletal disorders (WMSDs) ranked as the second highest reported occupational diseases cases in 2019 after Occupational Hearing Loss with an increasing of 58.75% WMSDs cases from 2018. WMSDs are highly prevalent among workers in manufacturing sector. In a past study, 79% of the total sample among manufacturing workers have been assessed with pain in different parts of the body which almost 90% of them suffered from upper pain part and more than 10% had discomfort in the lower half of the body (Ayub & Shah, 2018).

Work-related musculoskeletal disorders (WMSDs) are highly associated with several ergonomics risk factors such as awkward posture, strenuous and prolonged exertions, repetitive motion, static and sustained posture, vibration, contact stress, and environmental risk factors (DOSH, 2017) which are directly connected to musculoskeletal discomfort (Chiasson et al., 2015). Many occupations in the manufacturing industry still require personnel to do manual handling that involve repetitive movements and 95% of them were exposed to

the moderate risk injury due to WMSDs by performing repetitive manual handling tasks (Shamsudin, Vijayakumar & Daud, 2017).

Repetitive task can be classified as repetitive when the individual performs at least 50% of the cycle time to perform the same technical action or when one cycle time of job task is done in less than 15 seconds (Hedge et al., 2004). Furthermore, a past study have shown that repetitive task involving movement of upper limbs is one of the risk factors that could lead to upper limbs injury where the highest prevalence symptoms was imposed on shoulder with 24.8% followed by elbow and forearm with 15.5% as well as wrist and hand with almost 20% other than contribution from awkward work postures and forceful exertions which eventually lead to the development of ULDs (Hembecker et al., 2017). In another previous study, Akter, Maruf & Chowdhury (2015) examined several risk factors that have been associated with musculoskeletal symptoms among metal manufacturing industry workers with 92.68% of them experienced awkward posture, 97.29% with repetitive movement, 91.66% of force exertion and 89.74% with environmental condition factors. In that way, repetitive task has been recorded as the highest occupational risk factor and a major significant that are likely to cause WMSDs (Mehta et al., 2020). A study by Pavlovic-Veselinovic (2013), the development of musculoskeletal discomfort on fingers, forearm/wrist, upper arm/elbow and shoulder caused by repetitive task that could lead to WMSDs can impose a very high risk with more than 4 hours of exposure daily. Most manufacturing workers in Malaysia spend an estimated of 8 to 12 hours in the workplace. Therefore, it is necessary to study Work-related Musculoskeletal Disorders (WMSDs) associated with repetitive tasks among manufacturing workers.

1.3 Study Justification

In this research study, it will provide the prevalence of Work-related Musculoskeletal Disorders (WMSDs) among employers in the E&E manufacturing industry. It is very important as it could aid in identifying the risk factors that lead to the development of WMSDs among manufacturing workers. In order to overcome WMSDs issues related to repetitive tasks of manufacturing workers, the risk factors associated to it should prior be identified to see the relation between both WMSDs and its risk factors.

This study will also supply evidence regarding exposure and evaluation of repetitive task involving upper limbs region. By having this, it could give awareness and increase ergonomics knowledge among workers especially employers. In a previous study, high level of awareness regarding knowledge as well as appropriate level of attitude and practice related to ergonomics could further lowering the risk of having WMSDs among manufacturing workers (Deros et al., 2015). This could help to open the eyes of the employers and management to put effort in improving ergonomics issues appeared among the manufacturing workers which indirectly could assist the company in reducing WMSDs cases among them.

Factors contributing to repetitive task such as duration and frequency of work, work pace, machine pacing, works demand at peak periods, recovery period and work arrangements can be overcome in order to reduce repetition risk that could contribute to the formation of WMSDs (Hong Kong Occupational Safety and Health Labour Department, 2020). Furthermore, a study by Bergamasco et al. (1998), the occurrence of WMSDs related to the upper limbs can be reduced by redesigning jobs featuring repetitive task where all the contributing factors

are taking into consideration and being control. Hence, ergonomics intervention such as redesign jobs training program, control of job demands and social support can achieve 100% of the workers' satisfaction and motivation (Morken et al., 2002).

According to U.S. Centers for Disease Control and Prevention (CDC, 2020), company's ergonomics program could eliminate or reduce worker exposure to WMSD risk factors which aim to prevent or control injuries and illnesses by implementing suitable engineering and appropriate administrative controls. In past literatures, there is no significant difference between WMSDs with physical ergonomics risk factor when almost 85% of the workers in production plant is comfortable with their job task and job design (Ravindran, 2019). Middlesworth (2020) mentioned that by implementing ergonomics interventions in workplace, it reduced 59% of musculoskeletal disorders, increase 25% productivity, improved employees' engagement by 48% reduction in employee turnover an almost 60% reduction in employee absenteeism as well as increase quality of the product to meet demand of customers by reducing scrap or errors by almost 70%. Hence, good ergonomics implementation and interventions increase workers' productivity, performance as well as reduce absenteeism which eventually meet the product quality and high demand of the customers.

1.4 Research Question

Is there any significant association between Work-related Musculoskeletal Disorders (WMSDs) and repetitive tasks among air-conditioning production line workers in Bangi, Selangor?

1.5 Research Objectives

1.5.1 General Objectives

The main objective of this study is to determine the association between Work-related Musculoskeletal Disorders (WMSDs) and repetitive tasks among air-conditioning production line workers in Bangi, Selangor.

1.5.2 Specific Objectives

The specific objectives as below:

- i. To determine socio-demographic characteristics of air-conditioning production line workers in Bangi, Selangor.
- ii. To determine the prevalence of WMSDs among air-conditioning production line workers in Bangi Selangor..
- iii. To determine the risk level of repetitive tasks among air-conditioning production line workers in Bangi, Selangor..
- iv. To study the association between prevalence of WMSDs and repetitive tasks among air-conditioning production line workers in Bangi, Sleangor.
- v. To study the association between prevalence of WMSDs and repetitive tasks among air-conditioning production line workers in Bangi, Selangor in every work unit.

1.6 Research Hypothesis

Research hypothesis of the study are as follows:

There is a significance association between WMSDs and repetitive tasks among air-conditioning production line workers in Bangi, Selangor..

1.7 Conceptual Definitions

This section discussed on the conceptual and operational definitions of several study variables applied in this study. As for the conceptual definitions, it is

obtained from experts from this research field while the operational definitions are applied according to relevant concepts to be used in the context of this study.

1.7.1 Musculoskeletal Disorders (MSDs)

Conceptual: Musculoskeletal disorders (MSDs) are injuries or disorders that affect the muscles, tendons, joints, nerves, cartilage, and supporting structures of the upper and lower limbs, neck, and lower back. Extended or abrupt exposure to physical variables such as improper posture, force recurrence, or vibration might worsen these disorders. (Bernard et al., 1997).

Operational: MSDs can result from a quick exertion, such as carrying a large object (Kumaraveloo et al., 2018), or they can result from repeating the same actions, such as repetitive strain, force, vibration exposure, or uncomfortable posture (Centers for Disease Control and Prevention, 2016).

1.7.2 Work-related Musculoskeletal Disorders (WMSDs)

Conceptual: Work-related Musculoskeletal Disorders (WMSDs) is a musculoskeletal disorder which affect human musculoskeletal system such as muscles, ligaments or other soft tissues and body joints caused by occupational risk factors (U.S. CDC, 2020).

Operational: WMSDs can be arisen from repetitive arm and hand movements along with a forceful and speedy manner as well as lack of recovery time before the next repetitive job task (Canadian Centre for Occupational Health and Safety [CCOHS], 2020).

1.7.3 Repetitive Tasks

Conceptual: Repetitive task which commonly known as repetitive motion is a high risk task which involves too frequent, too fast and over a long duration of repeated movements of the same groups of joints and muscle (CCOHS, 2020).

Operational: The threat of repetitive tasks of the upper limbs ranging from upper arm, lower arm, and wrist can be assessed by occupational repetitive action (OCRA), which is developed to assess the risk of repetitive duties (Occhipinti, 1998).

1.8 Conceptual Framework

Figure 1.2 shows the research conceptual framework of this study. Based on Figure 1.2, the independent variable is the repetitive task done by the production workers while dependent variable is the development of work-related musculoskeletal disorders (WMSDs). Production workers from manufacturing company tend to be exposed to repetitive task contributing factors such as repetitiveness, force, awkward posture and movements, duration, recovery multiplier, movement frequency as well as additional factors such as mechanical, environmental and organizational factors (Occhipinti, 1998). All these factors related to repetitive task are also known as upper limbs injury risk factors (Occhipinti & Colombini, 1996) that could lead to the development of upper limbs disorders (ULDs) (Hedge et al., 2004). ULDs are one type of WMSDs (Nur et al., 2014). Development of WMSDs could also be influenced by several other individual risk factors such as age, gender, educational level, marital status and working experience of a worker (Lotter et al., 2020). As for the indicator, blue filled boxes indicate the

variables under study while uncoloured boxes consider the variables that are not being study.



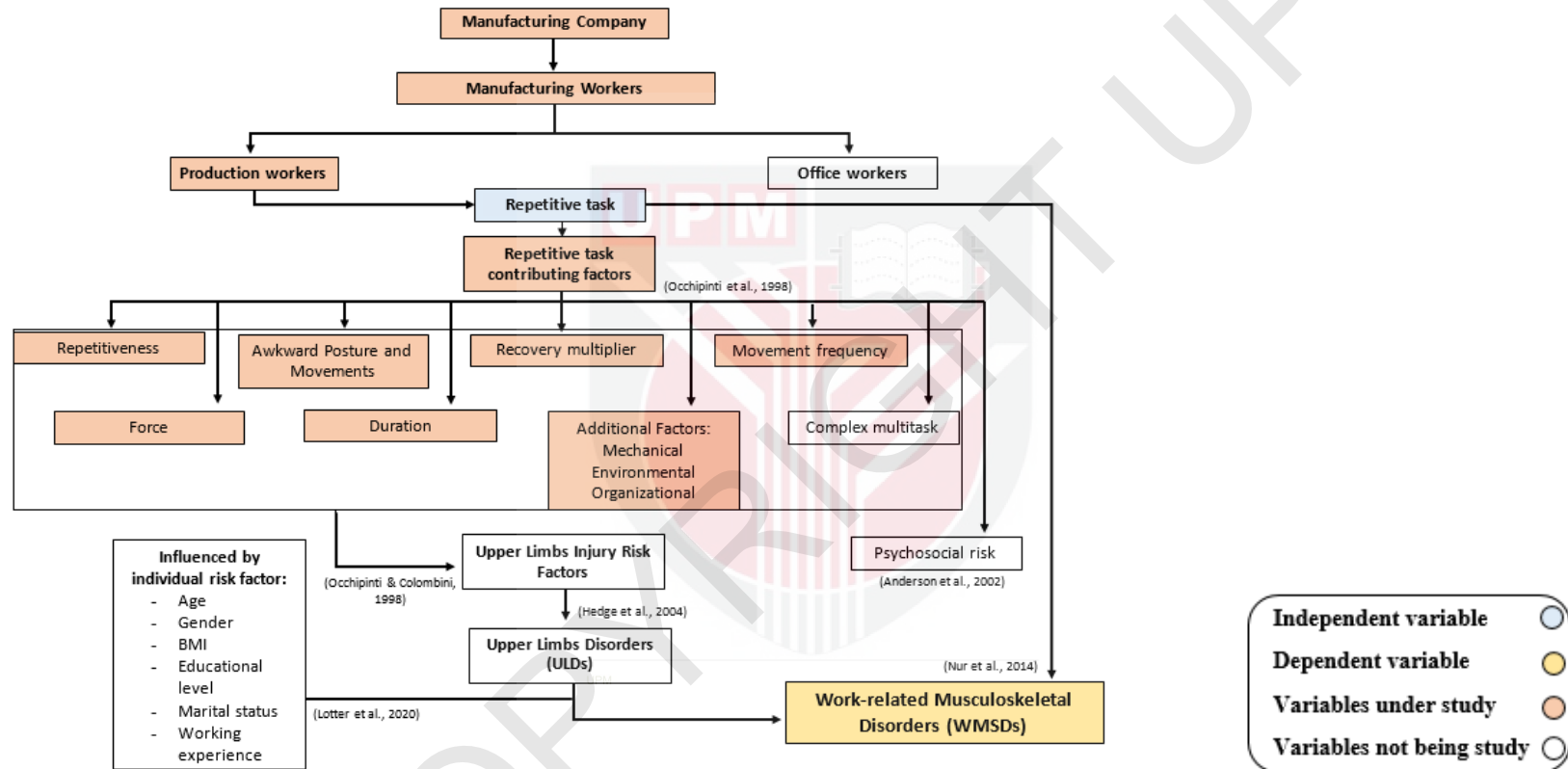


Figure 1.2: Conceptual framework

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Musculoskeletal Disorders (MSDs)

Musculoskeletal diseases (MSDs) are injuries that are the major cause of disability worldwide. According to Middlesworth (2020), there are a variety of risk factors that can lead to the development of musculoskeletal disorders (MSDs), which are divided into two categories: work-related ergonomic risk factors involving force, repetition, and posture, and individual-related risk factors such as poor work practises, poor fitness, and poor health habits. The predisposing factors that could contribute to the musculoskeletal conditions and development of MSDs could also be divided into ergonomics, psychosocial and individual risk factors (Bz et al., 2018). World Health Organization (WHO, 2019) stated a study from The Global Burden of Disease (GBD) regarding musculoskeletal conditions were proven as the highest causes to global disability with about more than 15% of all years imposed by disability and back pain at the lower parts maintained as the single contributing cause of disability since 1990s (James et al., 2017).

Musculoskeletal disorders affect numerous musculoskeletal systems, including the joints, bones, muscles, the spine, and connective tissues (DOSH, 2017). MSDs can also be defined as musculoskeletal system of the human body that have been affected by any injuries or disorders particularly on muscles, tendons, ligaments, nerves, discs and blood vessels (WHO, 1985). It is a very significant health problem and mostly affected the workers as it is also considered as the costly occupational problem with the negative outcome on

the public or government workers, employers as well as community (Bz et al., 2018). Musculoskeletal disorders (MSDs) can also be varied with several terms such as Occupational Overuse syndrome, Repetitive Strain Injury, Repetitive Stress Injury, Repetitive Motion Injuries, Cumulative Trauma Disorders, Upper Limb Disorders and Upper Extremity Musculoskeletal Disorders (DOSH, 2017) which greatly impacted on certain parts of the body including neck, shoulders, upper back, elbows, lower back, wrists/hands, hips, knees and ankles/feet (World Health Organization [WHO], 2019).

The development of MSDs could appear from the feeling of pain at those musculoskeletal system that have been developed for a longer period of time with lack of recovery period from repetitive motion, heavy workloads, awkward work postures and other related risk factors either occupational risk factor or individual risk factor (WHO, 2019). The aftereffects of musculoskeletal pain on the musculoskeletal systems could show impact towards the work performance of the workers (Bz et al., 2018) as in the European Union, absenteeism, early retirement and payments on disability are contributed from a single case of MSD.

In Malaysia, musculoskeletal disorders (MSDs) are increasing years by years. According to Social Security Organization (SOCISO, 2014), the number of MSD cases that have been stated in SOCISO annual report 2014 have increased dramatically with 34 times of increments within 2006 until 2013. MSDs is also one of the occupational diseases that have been listed under Factory and Machinery Act 1967 in third schedule. It is a musculoskeletal disease that can be compensable the claims with SOCISO and the cases happened in the workplace need to be reported to Department of Occupational Safety and

Health (DOSH), Malaysia to be recorded. Up until now, there is still no treatment for MSDs, but these musculoskeletal disorders can be managed by referring to a specialist or surgical care as they can be controlled with a mix of exercise, body weight control, psychological, and pharmaceutical therapy in primary care (Middlesworth, 2020).

2.1.1 Work-related Musculoskeletal Disorders (WMSDs)

Work-related musculoskeletal disorders (WMSDs) are a group of painful disorders which includes muscles, tendons, and nerves for example carpal tunnel syndrome, tendonitis, thoracic outlet syndrome, and tension neck syndrome (Canadian Center for Occupational Health and Safety [CCOSH], 2019). WMSDs is an employment-related musculoskeletal disorders that are caused or worsened by work and mostly affect the lower back, neck, and upper and lower extremities (CDC, 2020). It is among the most frequently reported causes of lost or restricted work time. According to the Bureau of Labour Statistics (BLS) (2020) from The Survey of Occupational Injuries and Illnesses (SOII), there were 30% of the MSDs cases occurred out of almost 10 million thousand days away from work (DAFW) that have been examined among the U.S private sector workers in 2018.

WMSDs are similar to musculoskeletal diseases, but they are more closely linked to injuries caused by employees as a result of their regular activities at their workplace or workstation. WMSDs are situations in which the work environment and workers' performance of work play a substantial role in the condition, and the condition worsens with prolonged exposure to poor work design and an unsuitable working environment (Nordin et al., 2018). In Malaysia manufacturing industries, there are still a lot of works need a manual

handling by the production workers along with the prolonged exposure of repetitive movements, awkward work postures and heavy workload (Deros et al., 2010) involving the use of musculoskeletal system especially shoulder with 74% of the prevalence assessed from a past study and arm with 89% (Shamsudin et al., 2017). Hence, upper limbs region are commonly affected by WMSDs risk factors with a higher prevalence on shoulder and arm other than wrist, elbows and neck.

In Malaysia, prevalence of musculoskeletal ache especially among labourers from a manufacturing industry is a serious issue as they are still prone to manual labour (Abdullah et al., 2017). According to DOSH (2019), WMSDs cases have manifested an increasing trends years by years where almost 50% of the spike have shown from 2018 to 2019. WMSD is one of the occupational diseases listed under the Fifth Schedule of Employees' Social Security Act 1969 which are eligible for Social Security Organization (SOCSO) compensation from workers. In 2016, compensation rate of WMSDs cases found to be higher than other occupational diseases (DOSH, 2016).

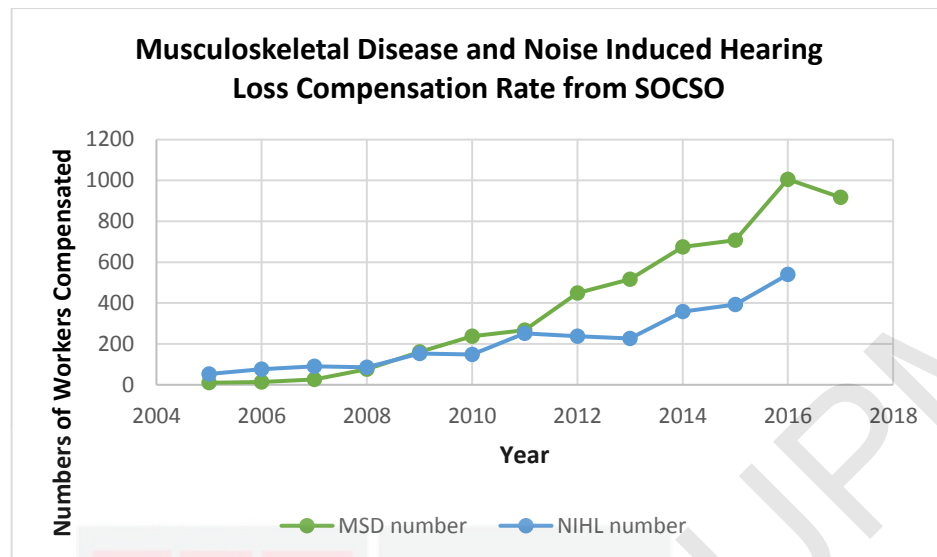


Figure 2.1 Number of Workers Compensated by SOCSO with musculoskeletal diseases and NIHL problems

Based on Figure 2.1, DOSH (2016) has reported ergonomic issues such as musculoskeletal disorders related to occupational have been reported to SOCSO with the highest compensation rate among other occupational diseases caused by noise and chemicals. The trends of WMSDs compensated statistics also keep on increasing from 2005 until 2017 with 1006 MSDs cases were recorded the highest in 2016. Work-related musculoskeletal disorders and Noise Induced Hearing Loss (NIHL) are occupational diseases that contribute the major cases each year. WMSDs ranked the second highest occupational diseases that have been reported by DOSH after NIHL from 2016 until 2019 (DOSH, 2019).

WMSDs can arise as a result of recurrent stress of various injuries associated with muscle injury, tendon injury, and nerve injury. It can be harmful because muscle contractions can restrict blood flow. According to CCOHS (2020), when a substance is being produced by the muscles, it will not be removed right away thus will accumulate the substance in the muscles. The substances

will eventually irritate the muscles and cause discomfort. Tendon damage is caused by repetitive or frequent work, as well as incorrect postures, causing inflammation and swelling of the tendon area, particularly around tendons with sheaths, such as the hand and wrist, and tendons without sheaths, such as the elbow, shoulder, and forearm. Finally, nerves are a crucial aspect of the body's system because they transport messages from the brain that control muscle activity.

As the nerve is surrounded by muscles, tendons and ligaments, repetitive work and unnatural postures can cause the tissues adjacent to the nerve to swell, squeeze, and compress. Figure 2.2 below shows an example of compression caused by Repetitive Strain Injury (RSI) of median nerves that can lead to carpal tunnel syndrome that affects the surrounding area including the fingers, hand and wrist caused by highly repetitive movements (Mayo Foundation for Medical Education and Research [MFMER], 2020) which several range of sensation felt by those affected area from chronic tingling to sharp and stabbing pain.

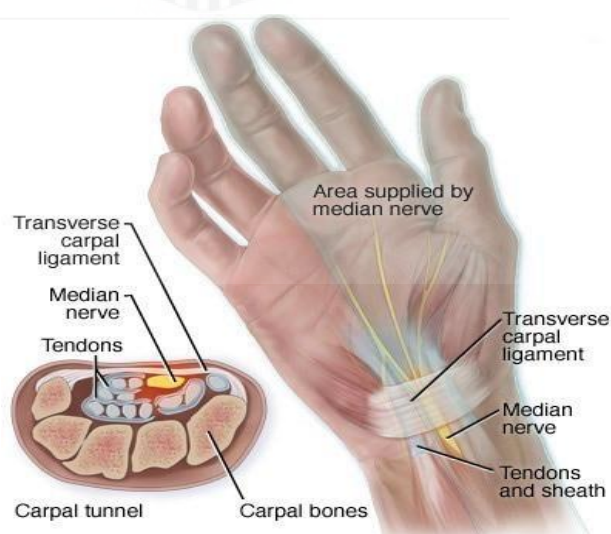


Figure 2.2: Repetitive Strain Injury (RSI) (MFMER, 2020)

WMSDs are formed from a consistent damaged with lack of recovery period in tissues of the musculoskeletal system (Kim & Hong, 2013). It can, however, be detected using laboratory and electronic procedures that are designed to detect any nerve or muscle damage. Other than that, WMSDs symptoms can also be screened and assessed by using questionnaire approach such as Cornell Musculoskeletal Disorders Questionnaire (CMDQ). It is used specifically to evaluate musculoskeletal discomfort among office workers (Hedge et al., 1999).

2.1.2 Upper Limbs Disorders (ULDs)

The upper limbs or upper extremity can be divided into three regions consisted of the upper arm, forearm and hand which begins at the shoulder point and contains 30 bones from the shoulder joints to the fingers. In a manufacturing industry, production workers have a high prevalence to experience the risk of work-related musculoskeletal disorders involving the upper limbs also have been known by few other terms such as Occupational Overuse syndrome, Repetitive Strain Injury, Repetitive Stress Injury, Repetitive Motion Injuries, Cumulative Trauma Disorders, Upper Limb Disorders and Upper Extremity Musculoskeletal Disorders (DOSH, 2017).

Work-related upper limbs disorder (WRULD) is a type of musculoskeletal disorders which are highly associated with upper limbs region work task posed by any workers. Hembecker et al. (2017) stated that the upper limbs region was the major overworked part among manufacturing workers with prevalence of almost 25.0% on shoulder, 15.5% on elbow or/and upper arm, 19.0% on lower arm part. In another study, the assessment on risk level of repetitive movement of the upper limbs by using Occupational Repetitive Action (OCRA) index

method revealed that the manual handling tasks were found to impose a very high-risk zone for both right and left upper limbs of the workers (Kaushal & Kanda, 2016).

In a past study, Deros et al. (2017) stated that workers in a manufacturing industry are prone to overuse the upper limbs region as they are still required to deal with a lot of manual handling tasks that are not done by machines such as carrying, lifting, pushing and moving loads mainly can be done by using the hands involving the movement of shoulder, upper arm and forearm. Inappropriate ways of handling the manual tasks along with repetitive movements could increase the ergonomic risks of the upper limbs injury and directly contribute to WMSDs. Upper limb disorders (ULDs) involved the pain and feeling of aches around the upper limb region such as wrist, shoulder, hand, upper arm and forearm. Industrial task involving biomechanical factors such as repetitive movements and other psychological and individual factors could contribute to the formation of ULDs when upper region body part is the major use.

2.2 Factors Contribute to Repetitive Task of Upper Limbs

Department of Occupational Safety and Health (DOSH, 2017) defined repetitive task as a high-risk job task which are commonly known as repetitive motion that involve too frequent, too fast and over a long duration of repeated movements of the same groups of joints and muscle. Repetitive task is one of the occupational risk factors fall under biomechanical group which can cause to the development of WMSDs without a proper way of working practice over a long period of time. However, the contributing factors of repetitive task could be from a combination of other biomechanical occupational risk factors such

as force, awkward work posture, repetitiveness, lack of recovery period and other additional risk factors which are coming from biomechanical, environmental and organization factors (Hedge et al., 2004).

The risk of developing WMSDs could be affected by muscle fatigue and discomfort experience by any workers caused by manual handling of repetitive and prolonged lifting task (Antwi-Afari et al., 2017). Manual material handling (MMH) is often associated with the risk of WMSDs. In the past literatures, repetitive task have been shown as one of the most capable risk factors of WMSDs for upper limbs (Antwi-Afari et al., 2017) that could lead to the formation of cumulative trauma disorders or known as repetitive strain injury (RSI)(Kumar, 1996). Apart from that, forceful exertion of load can also be the risk factor contributing to upper limbs injury other than lack of recovery and, duration of exposure toward repetitive movement task (Antwi-Afari et al., 2017). Hence, the combination of repetitive tasks contributing factors from biomechanical exposure can be the major risk factor to the precipitation of WMSDs of the upper limbs (National Academy Press, 2001).

2.2.1 Repetitiveness

Repetitiveness of a task can be defined as a form of cycle that is done repetitively in a short period of time. Because of the rising demand of jobs, neck and shoulder pain is usually related with repetitive work in a short cycle of time (Chiang et al., 1993). The prevalence of repetitive strain injuries (RSI) on hand and wrist can be increased by having a repetitive task under short cycle time period (Silverstein et al., 1986). According to a previous study by Nur et al. (2014), workers performing repetitive tasks have a high prevalence of work-related musculoskeletal disorders (WMSDs), with nearly half of them putting

their hands and wrists at risk, which could have a significant relationship with the short cycle of time and high production volume.

Repetitive tasks can be hazardous and serious if there are several involvements of the same muscle and joints over the same part accompanied by too frequent, too fast movements and lasts for a longer period. Lack of recovery time that adding up to the repetitive activity can be one of the contributing factors towards upper limbs injury that could lead to WMSDs. Repetitive task can be analysed by the steps or cycles involve in a specific task done by the workers. According to Hedge et al. (2004), the task is considered repetitive when the individual required at least 50% of the cycle time to perform the same technical action or when one cycle time of job task is done in less than 15 seconds.

2.2.2 Force

Forceful and sustained exertions can be exerted by musculoskeletal system such as muscle, ligaments, tendons and joints of the upper limb that will match the required workload which involve handling of heavy objects, fast movement or excessive force produced by the body muscle, any compression or stress of the equipment that come into contact on the parts of the upper limb and usage of hand tool that can cause impact or shock (DOSH, 2018). The force is considered high force when there is anti-gravity and heaviness exerted onto the body of the workers. Force is a necessary repetitive task contributing factors as it pictures a direct representation of biomechanical dedication (Hedge et al., 2004). High and overload force on workers while performing their repetitive task can lead to fatigue and if sustained, it can contribute to injury such as repetitive strain injury (RSI) or several effects caused by repeated use of such force. According to Gallagher and Heberger (2012), repetition can be increased

either from a risk of low-force tasks or a risk of high-force tasks and this might be caused by presence of fatigue failure in the affected tissues.

2.2.3 Awkward Posture

Awkward posture along with repetitive work task have a significant association with the risk of musculoskeletal disorders (Ezugwu et al., 2020). It can be divided into prolonged standing and standing along with slouching backs for several hours (Bogaeret et al., 2016) as well as awkward seating posture such as lordosed or kyphosed, overly arched or slouched that can lead to injury of spinal posture caused by higher pressure on the internal disc (Pynt et al., 2002). Hedge et al. (2004) stated that awkward posture is one of the repetitive tasks contributing factors as the posture will be represented when the repetitive task is being done.

Classification of awkward and sustained posture can be done by looking at the implementation of every action taken for at least one over third of the cycle time where the joint segment reaches more than 50% of the joint radius. Punnett et al. (2000) mentioned in a study that risk of shoulders could be increased by having a movement or maintained of the arms above the shoulder level where there is an extreme radius between arm and body with involvement of at least 10% of the cycle time. Furthermore, the chances of developing back and lower limbs pain can increase due to an awkward standing position (Kaka et al., 2016). Muscle fatigue and discomfort can be developed within 15 minutes of having an awkward working posture either while standing or seating in an uncomfortable twisting or bending posture (Gregory and Callaghan, 2008).

2.2.4 Additional Factors

U.S National Academy of Sciences (2001) mentioned that repetitive task contributing factors could also be caused by additional elements such as mechanical, environmental and organizational factors. The additional factors apart from the other risk factors that have been discussed can also contribute to the development of WMSDs (Colombini et al., 2001). These factors are classified as additional because it might or might not be presented on the repetitive task activity. Factors such as the vibration impacts, the surrounding environmental temperatures, the use of Personal Protective Equipment (PPE), working pace are those that can be categorized as additional context (Hedge et al., 2004).

2.2.4.1 Mechanical Factors

Mechanical factor is commonly associated with vibrations as it is an oscillatory motion produced from equipment or machine used by the workers and exposed the vibrations on their affected body parts. Hand-arm vibration and whole-body vibration are the two types of vibration. Mechanical variables can also include other aspects that may add to the impacts of vibrations. According to Colombini et al. (2001), there are several possible factors that can be classified as mechanical such as vibrations of hand-arm, use of gloves, extreme precision in positioning objects, rapid or shock wrenching movements of the upper limbs, shock exertion such as use of hammer on hard surfaces and constrained compression on upper limbs body parts. In a previous study, mechanical exposures such as vibration have shown a greater association with the risk of forearm injury caused by repetitive movements of the upper limbs (Charles et al., 2018).

2.2.4.2 Environmental Factors

Environmental factors can be defined as factors that can directly or indirectly affect the workers' behaviour while performing their repetitive task. Environmental elements such as chilly or hot environments, as well as the surrounding environment, can contribute to the development of WMSDs in people who perform repeated tasks (Colombini et al., 2001). Furthermore, factors such as annoying noise and too dim or too bright lighting are also examples of environmental factors. Environmental elements such as temperature, noise, and lighting, according to Magnavita et al. (2011) in a previous study, have a substantial relation with the development of upper limb disorders (ULDs).

2.2.4.3 Organizational Factors

Working at a machine's pace and on a moving item (Colombini et al., 2001) are two examples of organisational characteristics that can lead to the creation of WMSDs. According to U.S. CDC (2020), changing of organizational factors in workplace can help to prevent and further reduce the formation of WMSDs. In a previous study, organizational factors such as working pace plays an important role in the prevalence of WMSDs as a result from repetitive work task (Lu et al., 2015). It is an important factor within the organization to ensure the health of the workers and prevent them from exposing to diseases such as musculoskeletal disorders that will eventually lead to disability retirement (Knardahl et al. 2017).

2.2.5 Duration of Work

Duration of repetitive work can be concluded as the number of total hours spent in the working shift without recovery period (Occhipinti, 1998). Working shift is one of the important factors contribute to repetitiveness as well as to calculate the risk level of repetitive task as to determine the overall exposure. In Malaysia, normal working shift is range from 6 to 8 hours. According to Boenzi et al. (2013), adequate breaks or duration of period with enough recovery conditions can reduce the duration of work exposed to the task featuring repetitive motions. Furthermore, job rotation practices can be one of the appropriate strategies to reduce the duration of working on the repetitive task by switching the workers performing repetitive work with another type of job task with less repetitive motion and usage of different body parts to do the task to prevent the usage of the same muscles, joints and tendons (Paul et al., 1999). By having these, they can prevent the development of WMSDs, increase job satisfaction and morale of workers performing industrial job task (Boenzi et al., 2013).

2.2.6 Movement Frequency

Frequency can be defined as the number of mechanical activities of complex movements of one or more body parts needed to perform an operation in a particular time unit (Colombini et al., 2001). Movement frequency also have a limit value to not be considered of over limit of frequency actions where the range is from 10 to 25 actions per minute. According to Hedge et al. (2004), in the workplace surrounding, the action frequency of 30 actions per minute is applicable after having been practically considered. Movement frequency is commonly associated with repetition task. According to Silverstein et al.

(1987), the repetitive work task can be considered as critical when the repetition of the same joints used to perform one work task exceeds 50% of the cycle time or the work cycle is less than 30 seconds despite of the angle of movements. In order to reduce the frequency and repetition movement, the number of repetitive movements and the rate involving the combination of force and awkward posture need to be reduced by revise the method of repetitive task to include a variety of movement (U.K. HSE, 2020).

2.2.7 Recovery Period

Recovery period involves a period with breaks or non-repetitive task (Occhipinti, 1998). Recovery period is the time when the musculoskeletal system affected are given such a rest and it can be classified as recovery periods when there is a break from work including the lunch break, task that implied visualisation controls and when there is a break for the muscle group for at least 10 seconds for a few minutes consecutively within the cycle. It involves a long break or pauses after a period of technical activity of a complicated movements of one or more body parts that are required to complete an operation where the muscle and mechanical recovery can occur (Colombini et al., 2001).

The ratio of one recovery with 5 work tasks or an hour of recovery period should be practiced reducing the risk of repetitive task (Hedge et al., 2004).

The risk factor related to repetitive task is when there is a lack of recovery time of the affected musculoskeletal system. Inadequate of recovery time along with the combination of several other occupational factors from repetitive task can add to the risk of musculoskeletal issues (Health and Safety Authority of Ireland, 2019). Based on Bergamasco et al. (1998), recovery time can be

adjusted to an adequate phase by increasing the recovery periods and distributing recovery times more efficiently.

2.3 Review of Repetitive Task in Manufacturing Industries in Malaysia

According to annual report of Ministry of International Trade Industry (MITI, 2018), the manufacturing industries in Malaysia is set to improve moderately and maintain in 2019 with the continued implementation of the industrial revolution 4.0 regarding technologies where the pathway for more efficient manufacturing processes, growing of manufacturing productivity, innovation and wealth creation opportunities will be provided. There are several crucial sectors in Malaysian manufacturing industries such as Petroleum Products (including Petrochemicals), Basic Metal Products, Electronics and Electrical (E&E) Products, Paper, Printing and Publishing, Chemical and Chemical Products, Rubber Products and Non-Metallic Mineral Products that contribute to the economy growth which offers several types of job opportunities to either local or foreign workers (Malaysian Investment Development Authority [MIDA], 2019). The top main sectors that contribute to overall export and import product sales are E&E goods, petroleum products, and chemicals and chemical goods (MITI, 2019).

Increasing of sales in Malaysian manufacturing industries in have shown that consumers' demands are also increasing where the manufacturing workers are required to increase the pace of their work to complete all the commands. The increasing workload caused by the consumers' demands are one of the major contributions towards the rising of occupational diseases in Malaysia for instance work-related musculoskeletal disorders (WMSDs). The workers placed in assembly line are the most affected with the risk of WMSDs as they

need to perform industrial repetitive task involving the frequent use of upper limbs parts.

Repetitive task is one of the contributing factors towards the increasing of occupational musculoskeletal diseases in manufacturing industry (Pavlovic-Veselinovic, 2013). Repetitive task is commonly involving several risk factors such as fixed body position and force. It can also act as a catalyst factor to increase the risk related to WMSDs when combined with awkward posture and forceful exertions (Middlesworth, 2020).

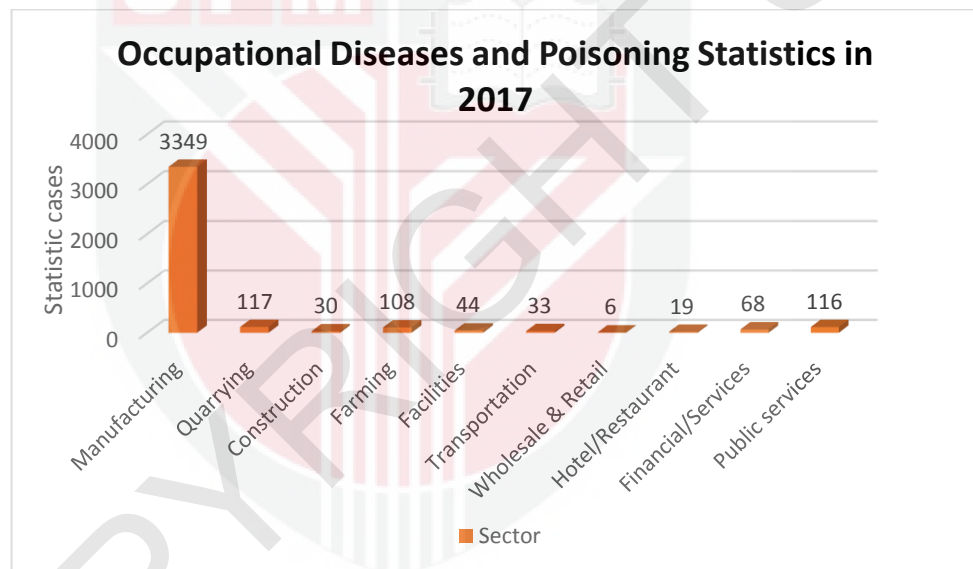


Figure 2.3: Occupational Diseases and Poisoning Statistics by DOSH, 2017

Based on Figure 2.3, DOSH (2017) reported that the manufacturing sector had the highest number of occupational illnesses and poisoning cases in 2017, accounting for 86.1% of all cases. The mining and public service industries came in second and third, with 117 cases (3.01%) and 116 cases, respectively (2.98%). From the figure, it shows that more than 3000 cases of occupational diseases and poisoning were coming from manufacturing sector with WMSDs

problems contributed as the second highest cases towards the statistic with 150 cases in 2017 and it kept years by years with 257 cases in 2018 and 408 cases in 2019 (DOSH, 2019).

Because of the growing number of manufacturing workers in the industry as a result of increased customer demands, there is a serious threat of workers being exposed to ergonomics risk factors, which may have a negative influence on their health (Nordin et al., 2018) and eventually affect their work productivity (Rahman et al., 2017). According to The Economic and Social Institute of Ireland (2013), musculoskeletal disorders cases have covered almost half of all work-related illness in Ireland within 2001 to 2013. In a past study by Mukhtar et al. (2017) stated that ergonomics risk level of the workers can affect their work performance that can be measured through total unpaid leaves taken and overtime working hours and it shows that ergonomics risk factors among construction workers tend to have a high association with total unpaid leaves applied by the workers for the past six months and the tendency for the workers to work overtime posed with medium risk level (62.7%) and high risk level (46.66%). Therefore, workers with a high-risk task such as manufacturing workers are likely to impose occupational disease with repetitive task and overload work in order to meet demands of the customers.

Ergonomics risk factors can be divided into occupational and individual risk factors where all these factors have a possibility to contribute to the formation of WMSDs (Cheng et al., 2016). Repetitive movement or repetitive task is one of the biomechanical factors comprised under occupational risk factor which are very common in industrial sector done by the production line workers as they are more prone to manual material handling task. In a developing country

like Malaysia, there are a lot of jobs in a manufacturing company that needs worker to perform manual repetitive task as it could reduce the cause of using a high end machine but consequently contribute and expose to the risk of injury due to WMSDs (Punnett, 1998; van Tulder et al., 2007). Mehta et al. (2020) stated that workers with repetitive job tasks are likely to have MSDs. It also depends on how much longer the workers are expose towards the WMSDs hazards and how long the recovery period time taken from their job task. Lack of recovery break and long working hours could contribute to additional ergonomics risk factors as well lead to the formation of WMSDs in manufacturing company (Padula et al., 2016).

Ergonomics work practices are very crucial in order to overcome ergonomics problems in workplaces. Employers play an important role to include all relevant staff and management into this ergonomics prevention and control to overall be communicated to help reduce ergonomic repetitive task in effort to reduce WMSDs and increase their work performance. Middlesworth (2020) mentioned that by implementing ergonomics interventions in workplace, it reduced 59% of musculoskeletal disorders, increase 25% productivity, improved employees' engagement by 48% reduction in employee turnover an almost 60% reduction in employee absenteeism as well as increase quality of the product to meet demand of customers by reducing scrap or errors by almost 70%. Hence, good ergonomics implementation and interventions increase workers' productivity, performance as well as reduce absenteeism which eventually meet the product quality and high demand of the customers.

2.4 Association between Work-related Musculoskeletal Disorders (WMSDs) and Repetitive Tasks

The work-related musculoskeletal disorders (WMSDs) are one of the major contributors towards occupational health problem globally (Colantoni et al., 2012). WMSDs due to repetitive task are very common among manufacturing sector especially E&E industry. Nur et al. (2014) assessed the overall prevalence of WMSDs among manufacturing employees related to industrial repetitive task was at a high rate with almost 80%. It was found that upper limb region posed the highest risk of musculoskeletal conditions including neck with almost 50% prevalence, hand or wrist with 48%, followed by shoulder with 46.7%, upper back with 33.6%, lower back with 21.7%, knee with almost 16%, thigh/gap with almost 15%, elbow and ankle below 10%. In a past study, there was a high association between industrial repetitive tasks with WMSDs with 92.5% prevalence of MSD cases were found by performing the functional test during physical examination among automotive industry workers (Spallek et al., 2010).

Previous study by McCormack et al. (1990) also stated that there was a positive correlation between repetitive task in a manufacturing workforce with the prevalence of WMSDs especially in hand/wrist tendinitis with manufacturing workers (OR= 5.4) and assembly line packers (OR= 3.9) with a variety of risk variables, such as repetition, force, and postures, are involved.

Apart from that, the performance of workers' productivity could have significant impact by performing industrial repetitive task. It happened when the workers are performing industrial task that required the use of muscle and fatigue occurs when there is an extension period of muscle usage along with

lack of recovery period of muscle rest and eventually contribute to WMSDs. Hence, muscle fatigue has a high relationship with repetitive task. The accumulation of muscle exhaustion will cause dysfunctional ability of a person to do work task and consequently resulted to musculoskeletal discomfort (Nur et al., 2014).

2.5 Cornell Musculoskeletal Discomfort Questionnaire (CMDQ)

The Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) was developed by Dr. Alan Hedge and ergonomics graduate students at Cornell University. CMDQ aim to determine the extent of musculoskeletal discomfort among office workers as a result of their work environment (Hedge et al., 1999). This questionnaire was developed for screening purpose and not for clinical diagnosis. The questionnaire was designed to assess frequency and severity of discomfort as well as interference of musculoskeletal discomfort with the ability of work by workers. It is available in three type of forms which are specifically for sedentary workers, standing workers and hand symptoms according to gender. A human body guides the completion (viewed from the back), divided into twelve regions from neck, shoulder (right and left), upper back, upper arm (right and left), lower back, forearm (right and left), wrist (right and left), hip/buttocks, thigh (right and left), knee (right and left), lower leg (right and left) and foot. The Cornell Musculoskeletal Discomfort Questionnaire has been widely used to assess WMSDs in a variety of industries for a wide range of occupational groups.

Many past studies had incorporated CMDQ to assess the musculoskeletal symptoms and discomfort level among the respondents (Aziz et al., 2017; Abdullah & Dawal, 2020; Mean et al., 2013) especially in manufacturing

industries. It was found that there was a high overall prevalence of WMSDs among manufacturing workers. Besides, prior studies that determine the WMSDs prevalence on office workers have also included CMDQ in order to assess the workers' musculoskeletal symptoms in any 20 body parts and to identify their discomfort level (Albeeli et al., 2020; Shariat et al., 2016) and a high WMSDs prevalence (83.7% & 69.7% respectively) was obtained.

2.6 Repetitive Task Assessment Tools

Repetitive task assessment tools are designed to help assessing tasks that require repetitive moving of the upper limbs. It also helps to assess some of the common risk factors in repetitive task that contribute to the development of upper limb disorders (ULDs). There are several repetitive task assessment tools which are frequently used by the researchers in their study in order to assess the risk level of repetitive task done by the workers such as Occupational Repetitive Action (OCRA) method, Assessment of Repetitive Tasks (ART), Job Strain Index (JSI) and American Conference Governmental Industrial Hygienists (ACGIH) Hand Activity Level (HAL).

2.6.1 Occupational Repetitive Action (OCRA)

Occupational Repetitive Actions (OCRA) method was developed by Occhipinti and Colombini in 1996. It is aimed to assess the workers' exposure towards repetitive task which are highly related to various upper-limbs injury risk factors (Hedge et al., 2004). The OCRA methods can be divided into two which are OCRA Checklist and OCRA index. These two methods are commonly based on a consensus document of the International Ergonomics Association (IEA) technical committee on musculoskeletal disorders (Colombini et al., 2001). Body postures and force are basically the main factors being assessed to

identify the risk level of repetitive task. The body parts included to be assessed in OCRA methods are hands, wrists, forearms, elbows and shoulders.

Many past studies had comprised OCRA method into their research in order to determine and assess the risk level of repetitive task among the workers especially those who exposed to physical exposure affecting the shoulders (Anwar & Roscecrane, 2017). Due to scarcity of references to its implementation, the OCRA technique appears to be a less popular tool among US ergonomists (Dempsey et al., 2005; Garg & Kapellusch, 2011). However, Europe practitioners especially in Italy are required to apply the OCRA method to evaluate upper limb MSD risk exposure during repetitive work, according to the International Organization for Standardization standard 11228-3 and the European Standard 1005-5 (Occhipinti & Colombini, 2012).

2.6.1.1 OCRA Checklist

This evaluation tool is a quantitative method specifically designed to assess repetitive task which are focusing on the risk of the upper limbs stating from upper arm, forearm and wrist done by the workers (Occhipinti, 1998). The OCRA checklist is a procedure that have been simplified from the OCRA index for assessing exposure to biomechanical work task of the upper limbs and it is also used for initial screening and risk mapping on the involvement of repetitive job task which several factors have been taken into account (Hedge et al., 2004). It also requires to be completed by using pen and paper observations at the field site where only ten to fifteen minutes are needed to observe one task with 30 seconds of work cycle time (Zuhaidi & Rahman, 2017).

The OCRA checklist consisted of five parts and each of different risk factors are devoted into these five parts. Movement frequency, force, lack of recovery time and awkward work posture with repetitive movements are the main four risk factors and additional risk factors will also be included such as vibration on the hand, surrounding temperature, use of inadequate Personal Protective Equipment (PPE) on hands and many more (Occhipinti & Colombini, 1996). Other than that, the net duration of the exposure towards repetitive movements also be taken into consideration. The OCRA checklist also enables for the OCRA score to be calculated by adding up the frequency, force, posture and additional factors scores, and included by the scores of inadequate recovery time and duration of work. The OCRA checklist scores will be evaluated according to classification criteria ranging from acceptable, very low, low, medium and high (Rahman & Razak, 2016).

2.6.1.2 OCRA Index

This evaluation tool is a quantitative method specifically designed to assess repetitive task which are focusing on the risk of the upper limbs starting from upper arm, forearm and wrist done by the workers (Occhipinti, 1998) same as the OCRA checklist but in a more complex assessment. Occupational Repetitive Action (OCRA) index is the complex version of OCRA checklist which is the most analytical and reliable method to be use. It is aimed to help organizations or researchers to further assess the risk level of repetitiveness of tasks at workstation as well as redesign jobs for the workers which are closely related to the work organization, job rotations, relocation of affected workers with disease or even for a strategic plan to enhance workers' productivity and satisfaction on their job task (Colombini et al., 2001). OCRA index also focus

on the upper limb parts such as hands, wrists, forearms, elbows and shoulders. OCRA index is commonly classified as the ratio between the number of mechanical actions of the one that have been carried out during work shift and the one that is recommended which has considered all the factors contributing to repetitive risk such as frequency, duration, awkward posture, recovery period, force and additional factors (Occhipinti, 1998). This assessment needs video observations to record all the actions of an individual performing repetitive task to measure the risk level. This OCRA index can produce a detailed assessment of the main mechanical and organizational factors that can lead to the formation of WMSDs. However, it can be time consuming especially for the complex and multiple repetitive tasks done by the workers (Hedge et al., 2004).

2.6.2 Assessment of Repetitive Task (ART)

The Assessment of Repetitive Tasks (ART) tool was developed by Health and Safety Executive of United Kingdom. This ART tool uses the logical flowchart process included the system of traffic light for grading the risks of repetitive task and it was developed based on Manual Handling Assessment Charts (MAC) to assess repetitive task of the upper limbs (U.K. HSE, 2009). Several past researches had incorporated RT tool to assess repetitive task involving upper limbs (Zuhaidi & Rahman, 2017; Shokri et al., 2015).

There are four factors that considered in this assessment which are frequency, repetitiveness, force, awkward postures and additional factors commonly labelled as Stage A to D respectively (Rahman & Razak, 2016). All these four stages will be added to obtain the task score then multiplied by duration multiplier and eventually the exposure of repetitive risk will be determined.

Based on Table 2.1, range of exposure level are according to exposure score obtained from the task score multiply by duration multiplier. When the exposure score is within 0 to 11, the exposure level is low, and it is consider as individual circumstances. Medium exposure level is between the exposure score of 12 until 21 where further investigation is required and high exposure level is when the exposure score is more than 22 and further investigation is needed as urgently (Zuhaidi & Rahman, 2017).

Table 2.1: Exposure score of ART tool

Exposure Level	Exposure Score	Remarks
Low	0-11	Consider individual circumstances
Medium	12-21	Requires further investigations
High	≥ 22	Requires further investigations as soon as possible

2.6.3 Job Strain Index (JSI)

Job strain index (JSI) was developed by J. Steven Moore and Arun Garg in 1995. It was developed to assess same motions or only one repetitive motion on a single job task where the same level of effort is needed for the task (Zuhaidi & Rahman, 2017). Many past studies have chosen Job Strain Index method in their research to assess repetitive force exposures of multiple job tasks on the workers (Rosecrance, 2017; Bao et al., 2008; Mohammadpour et al., 2018) especially in the United States (US).

The JSI is a method of calculating the risk of harm to the wrists and hands. It necessitates the monitoring of exertion intensity, duration of exertion each

cycle, efforts per minute, hand/wrist posture, work speed, and task duration per day (Drinkaus et al., 2005). The JSI scores can be obtained by multiplying all the six measurements known as variables multipliers. JSI exposure will then be determined by using the JSI scores. The task with the score of lower than 3 will be considered as safe, the score within 3 until 7 are considered the job as having an increase chance towards the risk of upper limbs disorders (ULDs) while the score of more than 7 defined the job as hazardous to the exposed workers (Moore & Garg, 1995).

2.6.4 American Conference Governmental Industrial Hygienists (ACGIH) Hand Activity Level (HAL)

American Conference Governmental Industrial Hygienists (ACGIH) Hand Activity Level (HAL) was developed by ACGIH to estimate the threshold limit value (TLV) of normalized peak hand force (NPF) (ACGIH Worldwide, 2001). It is an exposure assessment tool to measure the risk of developing upper limb disorders on hand, wrist or forearm caused by repetitive job task (Radwin et al., 2014). Several previous studies had included ACGIH HAL method to assess repetitive force task mainly on hand region (Wurzelbacher et al., 2010; Drinkaus et al., 2005).

The factors acquired into this assessment are exertion frequency, the speed of motion and recovery time. The scale in HAL was based on Visual-Analogue Scale (VAS) introduced by Latko et al. (1997) range from 0 to 10. The ACGIH HAL is a simple and easy to use checklist based on assessment of video recordings. However, this assessment tool checklist is very subjective as it does not consider other additional factors such as contact stress, awkward posture, environmental and mechanical factors (Rahman & Razak, 2016)

CHAPTER 3

METHODOLOGY

3.1 Study Design

In this research study, cross-sectional study design was used to determine the prevalence of Work-related Musculoskeletal Disorders (WMSDs) and its association with repetitive tasks among air-conditioning production line workers in Bangi, Selangor.

3.2 Study Location

This research was carried out at a manufacturing plant in Bangi, Selangor. Name of the company is not disclosed due to private and confidentially agreements. This manufacturing company is an Electrical & Electronic (E&E) based manufacturing industry aims to produce air-conditioning products which are closely related to the context of this research. This company's production line is divided into two which are Room Air Conditioning (RAC) line and Compressor line. 118 production line workers were involved in this study.

3.3 Study Duration

In this research, the study duration was conducted from February 2021 until June 2021.

3.4 Study Process Flow

Details of RAC flow chart working process as follows:

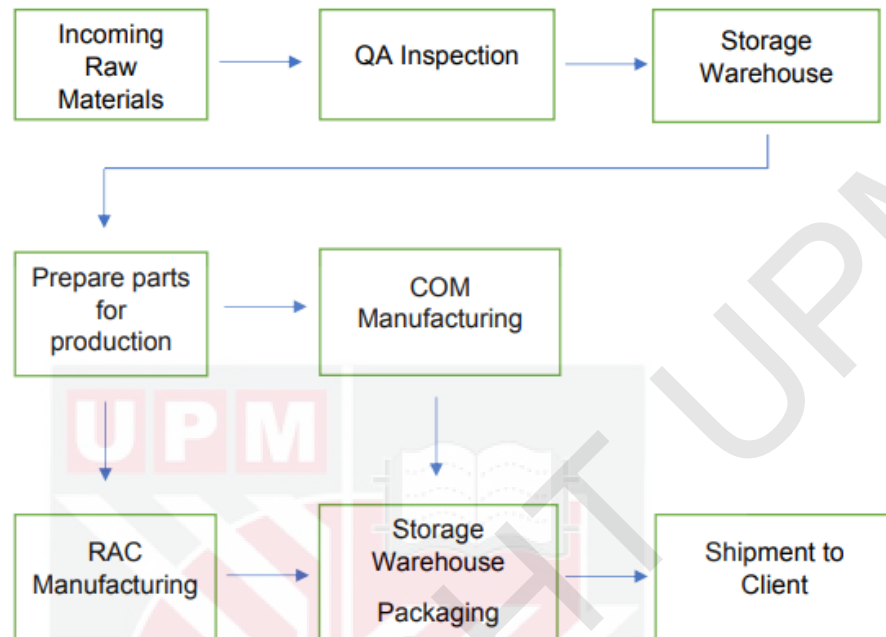


Figure 3.1 Overall General Working Process at selected E&E manufacturing company

As mentioned above, this selected company is divided into RAC and compressor manufacturing line. For this study, RAC manufacturing line was selected. Only assembly line from RAC manufacturing line which are consisted of 4 work units was selected to be focused on as it is the most exposed to the repetitive work task based on previous company's records. The 4 work units are (1) Assembly Cycle; (2) Internal Assembly; (3) Computer Test Room (CTR) and Task (4) Final Packing. The tasks process flow for each work units are as shown in Figure 3.2 to 3.5.

1



Vacuum and pinning

2



B sheet and K sheet attachment

Figure 3.2: Work unit 1 (Assembly Cycle)

1



Evaporator installation

2



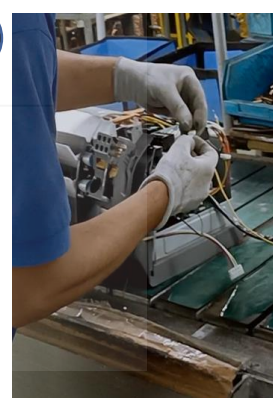
Plate installation

3



Electrical box installation

4



Wire insertion

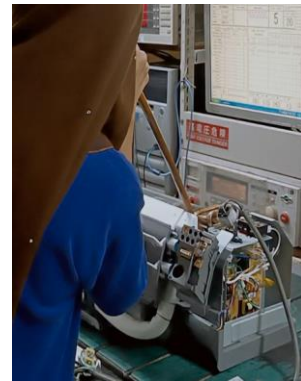
Figure 3.3 Work unit 2 (Internal Assembly)

1



Performance test

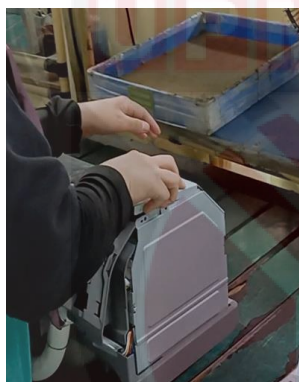
2



Sound test

Figure 3.4: Work unit 3 (Computer Test Room)

1



Terminal cover installation

2



Front cover installation

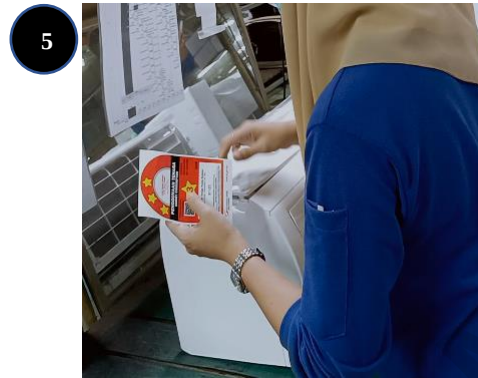
3



Cap & tape installation



Accessory installation



Label installation



Left and Right cushion attachment



Stapler sleeve DB



Loading unit to pallet

Figure 3.5: Work unit 4 (Final Packing)

The list of tasks according to work units are as follows:

Table 3.1: Task labelled according to job tasks

Work Unit	Job task	Task label
Assembly cycle	Vacuum and pinning	Task A
	B-sheet and k-sheet attachment to evaporator	Task B
Internal assembly	Evaporator installation to cabinet	Task C
	Plate installation	Task D
	Electrical box installation	Task E
	Wire insertion	Task F
Computer Test Room (CTR)	Performance test	Task G
	Sound test	Task H
Final packing	Terminal cover installation	Task I
	Front cover installation	Task J
	Cap and tape installation	Task K
	Accessory installation	Task L
	Label installation	Task M
	Left and Right cushion attachment	Task N
	Stapler sleeve DB	Task O
	Loading unit to pallet	Task P

3.5 Sampling

3.5.1 Sampling Procedure

This study was conducted after receiving approval from The University Ethics Committee Involving Human Subjects of Universiti Putra Malaysia, JKEUPM. Then, the data were collected by using two types of instruments which are integrated questionnaire consisted of pre-survey questionnaire, socio demography and working condition's information, work tasks done by the workers and Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) and Occupational Repetitive Action (OCRA) checklist form. Based on Figure 3.6, after receiving approval from JKEUPM and a permission from a selected manufacturing company to conduct the research, a walkthrough and discussion were done to further finalize the implementation of the research. Next, reliability testing was conducted on 15 Compressor line workers prior the real data collection. The selection of workstations was done by a purposive sampling method. This step was being completed by reviewing a past Initial Ergonomics Risk Assessment (ERA) report that have been done by the manufacturing company before. This procedure is very crucial in order to choose the workers which are relevant to this study.

Next, the content of the consent form was explained and the integrated questionnaire were passed to the supervisors of the line to be distributed among the workers in the selected work stations. They were given three days to fill in the questionnaire and handed in back to their supervisor before the collection of the questionnaire was done by the researcher. From the questionnaire, the researcher was further filtered the respondents according to inclusive criteria of the study which are workers; (i) with more than 1 year of working experience

in particular manufacturing company, (ii) between the ages of 18-55 and (iii) working for 8 hours per day, (iv) no history of any musculoskeletal injury for the past 12 months caused by non-occupational factors, (v) no history of any injuries for the past 12 months such as accidents and (vi) no chronic disease reported such as hypertension, diabetes, cancer. Then, video recordings were taken on 16 selected job tasks to observe the workers' daily working activity to assess their risk level of repetitive task by using OCRA checklist form.

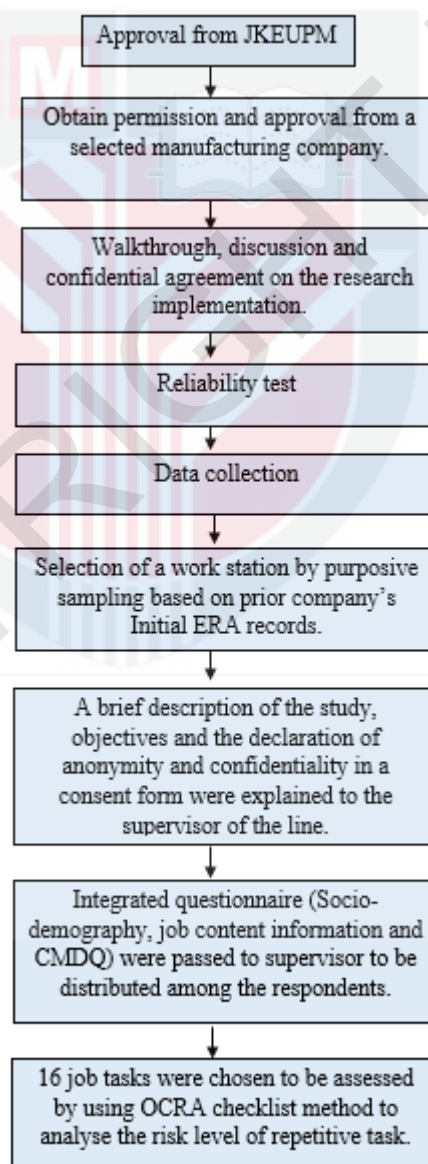


Figure 3.6: Flowchart of Sampling Procedure

3.5.2 Sampling Population

The targeted population for this study was Room Air Conditioning (RAC) production line workers from a selected manufacturing factory.

3.5.3 Study Sample

The study sample of this research was consisted of the workers from assembly line workers in RAC production line.

3.5.4 Sampling Frame

In this study, the detail information regarding the RAC line workstations and workers were obtained from HR Department of the company.

3.5.5 Sampling Unit

The sampling unit was the RAC assembly line workers that meets the inclusion criteria as stated below:

The inclusive criteria in this study:

- a) Workers who involve in repetitive job task.
- b) More than 1 year of working experience in particular manufacturing company.
- c) All respondents between the ages of 18-55.
- d) Working 8 hours per day.

The exclusive criteria in this study:

- a) Workers who had any history of musculoskeletal injury for the past 12 months which caused by non-occupational factors.
- b) Workers with any history of any injuries for the past 12 months such as accident.
- c) Workers with a chronic disease such as hypertension, diabetes and cancer.

The inclusive and exclusive criteria of this study as stated above is very crucial to be determined prior an active participation of respondents as the respondents' characteristics especially exclusive criteria will affect the result of this study on the determination of WMSDs and its association of repetitive task caused by occupational factors. According to Amin et al. (2020), the workers with chronic diseases such as hypertension, diabetes and cancer can lead to the formation of WMSDs. The history of workers with musculoskeletal injury caused by non-occupational factors and any injuries such as accident will also affect the result of this study.

3.5.6 Sampling Method

In this study, a purposive sampling method was used to select respondents who matched the research's characteristics. The selection of workstations was done by a purposive sampling method by reviewing Initial ERA that have been done by the company previously with outsider ergonomists in order to determine workstations with repetitive motion tasks. Then, the workers from the selected workstations at RAC production line that performs repetitive task were proceed with this study to answer integrated questionnaires. Workers from 16 selected job tasks were further being assessed their risk level of repetitive task by the assessor to fill in the OCRA checklist form.

3.5.7 Sample Size

The study was designed to determine the association between Work-related Musculoskeletal Disorders (WMSDs) and industrial repetitive tasks of the upper limbs among production line workers within 5% of the true prevalence with 95% confidence.

3.5.7.1 Sample Size Calculations

According to Abaraogu et al. (2015), the prevalence of work-related musculoskeletal disorders (WMSDs) on workers performing industrial repetitive task is $P = 0.914$.

The sample size for this study was calculated by using formula adopted from Lwanga & Lemeshow (1991) as from below:

$$n = \frac{Z^2_{1-\alpha/2} P(1-P)}{d^2}$$

Where,

n = sample size

$z = 1.96$

P = Prevalence of work-related musculoskeletal disorders (WMSDs) on workers performing industrial repetitive task, ($P = 0.914$). According to study conducted by Abaraogu et al. (2015).

d = precision (in proportion of one; if 5%, $d = 0.05$)

Calculation:

$$n = \frac{(1.96)^2 (0.914)(1 - 0.914)}{(0.05)^2}$$

$$n = 120.79$$

$$n = 121$$

The sample size calculated, N= 121. By considering of 20% for non-response, missing data, unavailability of subjects or refusal to participate, the sample size of this study is calculated as below:

$$n = 121 + [121 \times \left(\frac{20}{100}\right)]$$

$$n = 145$$

So, the total sample size for this study are 145 respondents.

3.6 Study Instrumentations

Instruments that were used for this study were as follows:

- i. Questionnaires
- ii. Cornell Musculoskeletal Discomfort Questionnaire (CMDQ)
- iii. Rating Perceived Exertion Borg Scale (CR-10)
- iv. Occupational Repetitive Action (OCRA) checklist
- v. Video recording

3.6.1 Questionnaires

The integrated questionnaire was divided into 4 sections which are Pre-survey questionnaire, Section A: Socio-demographic and working condition (Albeeli et al., 2020), Section B: Work Tasks done by the workers and Section C: Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) in English and Malay version which were both adopted by Hedge et al. (1999) and Shariat et al. (2016) respectively. The questionnaire was distributed to the respondents during morning briefing. Each of the workers was briefed regarding the content of the questionnaire and was asked to fill in consent form prior their participation in this study.

3.6.1.1 Pre-Survey Questionnaire

The assembly line workers in RAC production line that have been selected through a purposive sampling process were given a pre-survey questionnaire that was included in the integrated questionnaire. The pre survey questionnaire was consisted of a few personal information such as age, working experience, working schedule, employment type and other history of health information to meet the inclusive and exclusive criteria of the study. (Appendix 2.1, Questionnaire). The researcher was further filtered the respondents according to inclusive criteria of the study after the collection of the questionnaire was done.

3.6.1.2 Questionnaire on Socio Demography and Working Conditions

In this section A, the items include socio-demographic and background information such as age, gender, race, body mass index (BMI), marital status, educational level, smoking behaviour, hobbies include physical exercises, time spending on physical activity, break time and working experience. (Appendix 2.1, Questionnaire).

3.6.1.3 Questionnaire on job content

These questions were stated in section B which aims to assess exposures on the ergonomics risk factors during the work tasks done by the workers in their daily working activity. The items include questions whether the workers feel being exposed to several ergonomics risk factors such as repetitive task, awkward posture, vibrations, forceful and sustained exertions, static and sustained posture, contact stress, environmental factors and psychological factors. (Appendix 2.1, Questionnaire). The perception of repetitive task exposure by the workers recorded from this section were used as a repetitive task

measurement that to study the association between WSMDs prevalence and repetitive task among production line workers.

3.6.1.4 Questionnaire on Work-related Musculoskeletal Disorders (WMSDs)

To obtain the information on musculoskeletal disorders, Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) was used to assess the workers' musculoskeletal discomfort that interferes them with the ability to do work as well to assess the frequency and severity of it (Shariat et al., 2016). English and Malay CMDQ were both adopted by Hedge et al. (1999) and Shariat et al. (2016) respectively. The CMDQ was made available in male and female version as well as in three types of forms which are sedentary workers, standing workers and hand symptoms. Standing workers form of CMDQ was used as it contains several musculoskeletal systems of the upper limbs such as shoulder, forearm, upper arm and wrist.

In section C, there are three types of measurement that were being assessed in CMDQ such as the frequency, severity and interference score of the workers are feeling discomfort while handling their work task. There are also 20 differences of body musculoskeletal system that will be assessed starting from neck, shoulder (left and right), upper back, upper arm (left and right), lower back, forearm (left and right), wrist (left and right), hip/buttocks, thigh (left and right), knee (left and right), lower leg (left and right) and foot (left and right). (Appendix 2.2, Cornell Musculoskeletal Discomfort Questionnaire).

i- Detailed calculation

Scoring guideline of CMDQ can be used in 4 steps as follows:

1. Counting all the total number of symptoms imposed by the worker.
2. Adding up all the rating values of each respondent.

3. The total frequency score is obtained as stated in Table 3.2. 'Never' value will be multiplied with 0, '1-2 times per week' multiply with 1.5, '3-4 times per week' multiply with 3.5, 'Every day' multiply with 5 and 'Several times every day' multiply with 10.

Table 3.2: Frequency score according to rating score

Rating scores	Frequency score
Never	0
1-2 times per week	1.5
3-4 times per week	3.5
Every day	5
Several times every day	10

4. The total of discomfort score is obtained by multiply the 'slightly comfortable' frequency with 1, 'moderately uncomfortable' will be multiplied with 2 and 'very comfortable' part is multiplied with 3.

5. The interference score can be gained by multiply 'Not at all' with 1, 'Slightly interfered' with 2 and 'Substantially interfered' with 3.

6. The total frequency score is multiply with total of discomfort score and total of interference score as shown below:

Total discomfort score: Frequency of discomfort score x Severity of discomfort score x Interference of discomfort score

3.6.1.5 Rating Perceived Exertion Borg Scale (CR-10)

This rating perceived exertion Borg scale (CR-10) is used to determine the force factor in one of OCRA checklist method. Force score is obtained by interviewing the workers in order to collect data on the description regarding muscular effort made while performing repetitive task (Occhipinti & Colombini, 2006). The details of this instrument were further explained in OCRA checklist part. (Appendix 2.3: Rating Perceived Exertion Borg Scale).

3.6.2 Occupational Repetitive Action (OCRA) Checklist

Occupational Repetitive Actions (OCRA) method was developed by Occhipinti and Colombini in 1996. It is aimed to assess the workers' exposure towards repetitive task which are highly related to various upper-limbs injury risk factors (Hedge et al., 2004). In this study, OCRA checklist were used to evaluate repetitive job task of workers involving upper limbs.

Many studies had included OCRA to assess repetitive task which are focusing on the risk of the upper limbs stating from upper arm, forearm and wrist done by the workers. A study done in a corn seed production workers found that most of the job tasks are at medium risk level (Anwar, 2017). Moreover, another research by Lasota (2015) had done on packing line operators in a manufacturing shows that the job task evaluated a medium to a high-risk rating and the major risk factors were because of inadequate number of breaks, preventing employees from obtaining enough relaxation, and a short cycle - less than 15 seconds - due to the conveyor belt's-imposed pace.

The OCRA checklist is a procedure that have been simplified from the OCRA index. It is also used for preliminary screening and risk mapping by using classification of the task such as green considered acceptable risk, yellow with

low risk, red colour indicate medium risk and purple is consider a high-risk repetitive task. This OCRA checklist consisted of six parts and each of different risk factors are devoted into these parts. Organizational data, recovery multiplier, frequency score, awkward posture score and additional factors will also be included such as vibration on the hand, surrounding temperature and use of inadequate Personal Protective Equipment (PPE) usage. The OCRA checklist also enables for the OCRA score to be calculated by adding up all the frequency, score, posture and additional factors score and multiply the added score with recovery multiplier to get the final scores. (Appendix 3, Occupational repetitive action [OCRA] checklist). The method and detailed calculation of OCRA Checklist explained in 3.5.2 i) and ii) were based on the revised OCRA Checklist method by Colombini, Occhipinti and Casado (2013).

i- Methods of OCRA Checklist

The task of loading unit to pallet is one of the 16 job tasks in assembly cycle observed in this study as shown in Figure 3.7 below:



Figure 3.7: Task P (Loading unit to pallet job task)

In OCRA checklist, all the factors related to risk of repetitive task such as frequency, force, posture, additional factor, recovery and duration multiplier need to be assessed in order to get the final OCRA score. The final OCRA score will be categorized into exposure level of risk according to coded color stated before.

Firstly, before initiating the OCRA checklist assessment, the job tasks done by the workers need to be described in organizational data part. The duration of the shift, official break, lunch break and non-repetitive work will be taken and subtracted respectively to get the net duration of repetitive work. Table 3.3 and Table 3.4 below show the example of task description and organizational data information included to precisely calculate the net duration of repetitive work following the OCRA checklist.

Table 3.3 : Brief description of Task P

Name of workstation/ department	Assembly line/ RAC
Brief description of task	The box of the unit needs to be pulled from previous step (stapler sleeve to DB) to tie it by using a machine. Then it will be lifted from the conveyor belt to a pallet situated at the back of the workers at about 1 meter distance.

Table 3.4: Net duration of repetitive work calculation in OCRA Checklist

ORGANIZATIONAL DATA: DESCRIPTION		MINUTES
Duration of Shift	588 min	540
	540 min	
Official Break	3 times	50
Other Breaks (other than the official one)	50 min	
Lunch Break	30 min	30
Non-repetitive work	40 min	40
Net Duration of Repetitive Work (minutes)	420	

Based on the Table 3.4, the duration of shift started from 8am and ended at 5pm (540 minutes). The lunch break is 30 minutes, two short coffee breaks (one in the morning and one in the afternoon) about 15 minutes each and another prayer break in the afternoon for 20 minutes. From a short interview with the supervisor of the line, there is a non-repetitive work about 40 minutes as the workers are setting up the supplies while waiting for components stocks. So, the net duration of repetitive work is 420 minutes.

Then, the net total cycle time or rate can be calculated and stated according to Table 3.5 provided in the OCRA checklist by multiplying the net duration of repetitive work with 60 and the total will be divided by number of pieces or cycles (the number or real units completed by the manufacturing workers in their shift) as stated below:

$$\text{Net total cycle time} = (\text{Net duration} \times 60) / (\text{Number of unit})$$

Table 3.5: Net total time of repetitive task cycle in OCRA Checklist

ORGANIZATIONAL DATA: DESCRIPTION	MINUTES
Net Duration of Repetitive Work	420
No. of pieces (or cycles)	300
Net Total cycle time or rate (sec.)	84.0
Total time of Observed cycle or observation period	53.4
% Difference between Observed Cycle Time and Official Cycle Time	36%

Table 3.5 shows that the net duration of repetitive work obtained is multiplied by 60 minutes and divided by number of pieces (300 units). Next, the observed cycle time in the identified cycles is 53.4 seconds and there are 36% difference between observed cycle time and official cycle time. From the value of net duration of repetitive work in minutes, it needs to be conveyed into duration multiplier as shown in Figure 3.8:

MULTIPLIER OF THE NET DURATION OF THE REPETITIVE WORK PERFORMED DURING THE SHIFT	
Net duration of repetitive work (minutes)	Duration multiplier
60-120	0.5
121-180	0.65
181-240	0.75
241-300	0.85
301-360	0.925
361-420	0.95
421-480	1
Over 480	1.5

Figure 3.8: The duration multiplier based on net duration of repetitive work (minutes)

Based on Figure 3.8, the duration multiplier for loading unit to pallet Job Task is 0.95 as the net duration of repetitive work obtained was 420 minutes.

As for the recovery time factor, in order to obtain the value for further calculation, it is crucial to identify the number of working hours with inadequate break or recovery as stated in Figure 3.9:

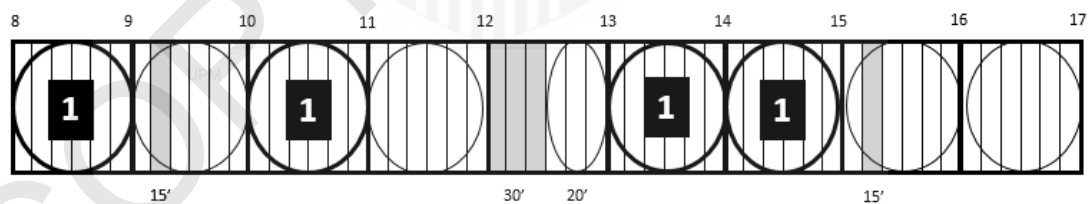


Figure 3.9: Assessment of work periods without adequate recovery time in the full workday

Based on figure 3.9, it shows that there are 4 hours of work period with inadequate recovery time when all the breaks including lunch and official breaks had been excluded. Furthermore, Figure 3.10 indicates the recovery multiplier obtained is

1.33 as the number of working hours with inadequate break time analysed from the previous step is 4 hours.

No. of hours without adequate recovery time	Recovery multiplier	Difference for 4 hours without recovery (%)
0	1	-24.8%
0.5	1.025	-22.9%
1	1.05	-21.1%
1.5	1.086	-18.3%
2	1.12	-15.8%
2.5	1.16	-12.8%
3	1.2	-9.8%
3.5	1.205	-4.9%
4	1.33	0.0%
4.5	1.4	5.3%
5	1.48	11.3%
5.5	1.58	18.8%
6	1.7	27.8%
6.5	1.83	37.6%
7	2	50.4%
7.5	2.25	69.2%
8 or more	2.5	88.0%

Figure 3.10: Value of recovery factor based on number of working hours with inadequate recovery time

Next, in order to obtain work frequency value, the frequency of technical actions needs to be observed in 60 seconds time. As for this job tasks, the observed technical actions for right and left upper limbs is 13 actions per minute where short interruptions are possible and the frequency obtained is less than 22.5 as shown in Figure 3.11. Since there is no static actions more than five consecutive seconds involved, the frequency value for this task for both sides are 0.

FREQUENCY	A	B
	Frequency factor score when brief interruptions ARE possible	Frequency factor score when brief interruptions ARE NOT possible
<22.5	0.0	0.0
22.5 to 27.4	0.5	0.5
27.5 to 32.4	1	1
32.5 to 37.4	2	2
37.5 to 42.4	3	4
42.5 to 47.4	4	5
47.5 to 52.4	5	6
52.5 to 57.4	6	7
57.5 to 62.4	7	8
62.5 to 67.4	8	9
67.5 to 72.4	9	10
> 72.4	9	10

Figure 3.11: Work frequency score according to existence of brief interruptions

Next, the force factor scores can be obtained by using the Borg CR-10 for OCRA checklist by method of interviewing the workers in order to collect data on the description regarding muscular effort made while performing repetitive task (Occhipinti & Colombini, 2006). The force factor scores can be calculated by following the time percentage the force is applied by the workers in their work task. Force value felt by the worker handled this job tasks was 6 and he was exposed to the force factors for about 1/3 of the cycle time. Thus, the force score obtained is 8 as shown in Figure 3.12:

FORCE OF 3-4		FORCE OF 5-6-7		FORCE OF 8-9-10	
Time as %	Score	Time as %	Score	Time as %	Score
5	0.50	0.33	4.00	0.33	6.00
10	0.50	1.00	8.00	1.00	12.00
18	1.00	1.50	9.00	1.33	13.00
26	1.50	2.00	11.00	1.67	14.00
33	2.00	2.50	11.00	2.00	15.00
37	2.50	3.00	12.00	2.33	16.00
42	3.00	3.50	13.00	2.67	17.00
46	3.50	4.00	14.00	3.00	18.00
50	4.00	4.50	15.00	3.33	19.00
54	4.50	5.00	16.00	3.67	20.00
58	5.00	5.63	17.00	4.00	21.00
63	5.50	6.25	18.00	4.33	22.00
67	6.00	6.88	19.00	4.67	23.00
75	6.50	7.50	20.00	5.00	24.00
83	7.00	8.13	21.00	5.63	25.00
92	7.50	8.75	22.00	6.25	26.00
100	8.00	9.38	23.00	6.88	27.00
		10.0	24.00	7.50	28.00
				8.13	29.00
				8.75	30.00
				9.38	31.00
				10.00	32.00

Figure 3.12: Force percentage of time and value exposure towards force factors

Next, as for the presence of awkward postures, it is very crucial to prior identify the awkward postures of body parts involved in this assessment such as hand (pinch, grasp, hook grips), shoulder (over postures, arm at or above shoulder level with inadequate support), wrist (awkward position such as flexion, extension, deviation) and elbow (awkward position, sudden actions) for bilateral sides. From the observation, the worker was exposed to awkward posture in shoulder form 1/3 of the time (score=6), elbow for less than 1/3 time (score=1), wrist for 1/3 of the time (score=2) and hand for 1/3 of the time (score= 2) as shown in Figure

3.13. The cycle of the task was more than 15 seconds and it repeats the same action for almost all the time (score=3). The overall posture score obtained is 9 after the highest score of awkward posture which is at the shoulder part is added with stereotype score.

Time in awkward posture	Score
Shoulder The arms are kept at about shoulder height, without support, (or in other extreme postures) for	
10% - 24% of the time	2
25% - 50% of the time	6
51% - 80% of the time	12
more than 80% of the time	24
Elbow The elbow executes sudden movements (wide flexion-extension or pronosupination, jerking movements, striking movements) for	
25% - 50% of the time	2
51% - 80% of the time	4
more than 80% of the time	8
Wrist The wrist must bent in an extreme position, or must keep awkward postures (such as wide flexion/extension, or wide lateral deviation) for	
25% - 50% of the time	2
51% - 80% of the time	4
more than 80% of the time	8
Hand The hand take objects or tools in pinch, hook grip, pinch or other different kinds of grasp for	
25% - 50% of the time	2
51% - 80% of the time	4
more than 80% of the time	8

Figure 3.13: Awkward posture score on shoulder, elbow, hand and wrist according to percentage of the full cycle time of work

However, if the awkward work posture involves greater precision, the assessment for this factor is according to Figure 3.14, the stereotype value will be included with high level score of 3 if the cycle time is less than eight seconds or intermediate score of 1.5 if the cycle time is in between 8-15 seconds. From the assessment, this task possessed a score 3 for stereotype as the identical technical actions were performed almost the entire time.

HAND		SHOULDER		WRIST		ELBOW	
Time (s)	Score	Time (s)	Score	Time (s)	Score	Time (s)	Score
0.05	0.00	0.03	0.50	0.05	0.00	0.05	0.00
0.10	0.50	0.05	1.00	0.10	0.50	0.10	0.50
0.15	1.00	0.08	1.50	0.15	1.00	0.15	1.00
0.20	1.50	0.10	2.00	0.20	1.50	0.20	1.50
0.25	2.00	0.12	2.50	0.25	2.00	0.25	2.00
0.31	2.50	0.14	3.00	0.31	2.50	0.31	2.50
0.37	3.00	0.16	3.50	0.37	3.00	0.37	3.00
0.44	3.50	0.18	4.00	0.44	3.50	0.44	3.50
0.50	4.00	0.20	4.50	0.50	4.00	0.50	4.00
0.54	4.50	0.22	5.00	0.54	4.50	0.54	4.50
0.57	5.00	0.24	5.50	0.57	5.00	0.57	5.00
0.61	5.50	0.25	6.00	0.61	5.50	0.61	5.50
0.65	6.00	0.28	6.50	0.65	6.00	0.65	6.00
0.69	6.50	0.31	7.00	0.69	6.50	0.69	6.50
0.72	7.00	0.34	7.50	0.72	7.00	0.72	7.00
0.76	7.50	0.37	8.00	0.76	7.50	0.76	7.50
0.80	8.00	0.40	9.00	0.80	8.00	0.80	8.00
1.00	8.00	0.43	10.00	1.00	8.00	1.00	8.00
		0.46	11.00				
		0.50	12.00				
		0.54	13.00				
		0.58	14.00				
		0.62	15.00				
		0.66	16.00				
		0.70	17.00				
		0.74	18.00				
		0.78	19.00				
		0.82	20.00				
		0.86	21.00				
		0.90	22.00				
		0.94	23.00				
		1.00	24.00				

Figure 3.14: Awkward posture score for each joint segment with higher precision

Lastly, in order to determine additional risk factors score, physical, mechanical and socio-organisational factors are taken into account and the additional score from both factors are calculated according to Figure 3.15 as shown below. From the observation, the additional factors score is 2 as the worker did not wear suitable gloves while handling the units.

ADDITIONAL FACTOR	
<i>Choose one answer per block. The final score is the sum of the two partial scores.</i>	
Block A: Physico-mechanical factors	
2	Inadequate gloves (uncomfortable, too thick, wrong size) are used more than half the time for the task.
2	Presence of 2 or more sudden, jerky movements per minute.
2	Presence of at least 10 repeated impacts (use of hands as tools to hit) per hour.
2	Contact with cold surfaces (less than 0°C) or performance of tasks in cold chambers for more than half the time.
2	Use of vibrating tools at least one third of the time. Assign a score of 4 if these tools involve a high degree of vibration (e.g., pneumatic hammers, etc.).
2	Tools are used that cause compression of muscle and tendon structures (check for the presence of redness, calluses, wounds, etc., on the skin).
2	More than half the time is spent performing precision tasks (tasks on areas of less than 2 or 3 mm), requiring the worker to be physically close to see.
2	More than one additional factor (e.g., ...) is present at the same time for more than half the time.
3	One or more additional factors (e.g., ...) are present almost the entire cycle.
Block B: Socio-organisational factors.	
1	The work rate is determined by the machine, but 'recovery spaces' exist allowing the rate to be sped up or slowed down.
2	The work rate is entirely determined by the machine.

Figure 3.15: Assessment of additional factors in OCRA checklist

ii- Detailed calculation

Once all of each part have been assessed completely, OCRA checklist score can be calculated by adding up all the frequency, force, posture and additional risk factors score then multiply with recovery and duration multiplier as equation below. Below were the OCRA score obtained from the assessment of the 'loading unit to pallet' job task:

OCRA score: (Frequency + Force + Posture + Additional risk) score

x Recovery multiplier x Duration multiplier

OCRA score: (0 + 8 + 9 + 2) x 1.33 x 0.95

OCRA score: 24.01

Then, the final score obtained will be converted into the risk level to determine the exposure level along with colour coding for risk mapping purpose. Based on Table 3.6 below shows OCRA score of 24.01 indicates a high-risk level with purple coding. The final score of 7.5 is indicated as an acceptable risk or no risk (green), score within 7.6 to 11.0 is considered very low risk in yellow indicator, score within 11.1-14.0 is considered medium-low risk (light red), score within 14.1-22.5 is considered medium risk (dark red) and score of more than 22.6 is labelled as a high risk of repetitive task (purple).

Table 3.6: OCRA checklist score exposure level

OCRA CHECKLIST	LEVEL	RISK
< 7.5	Green	Acceptable risk
7.6 – 11.0	Yellow	Very low risk
11.1 – 14.0	Light red	Medium-low risk
14.1 – 22.5	Dark red	Medium risk
≥ 22.6	Purple	High risk

3.6.2.1 Video Observations

Camera was used in this study as the workers are videotaped their entire upper body and arms parts from several angles to record their whole process of performing repetitive work task. The video was recorded as enough time to ensure it represents the entire cycle time. This step will make it easier for the assessor to observe the workers and classify their criteria of repetitive task according to OCRA checklist to assess their risk level of repetitive task.

3.7 Data Collection

Data collection of this study was done on workers at a selected manufacturing company in Bangi, Selangor. This study was conducted when the permission and approval from the company was obtained. In order to obtain the respondents that will actively participate in this study, selection of workstation was done by a purposive sampling method where Initial ERA that have been done by the company will be reviewed in order to choose the workstations with repetitive task exposure. Next, a brief description of the study, objectives and the declaration of anonymity and confidentiality in a consent form were explained to the each of supervisors of the line. The integrated questionnaire which contains socio-demography, job content information and Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) were passed to the supervisor to be distributed among the respondents. Then, 16 chosen job tasks were videotaped and assessed their risk level of repetitive tasks by using OCRA checklist method. Figure 3.16 below shows the flowchart of data collection of this study.

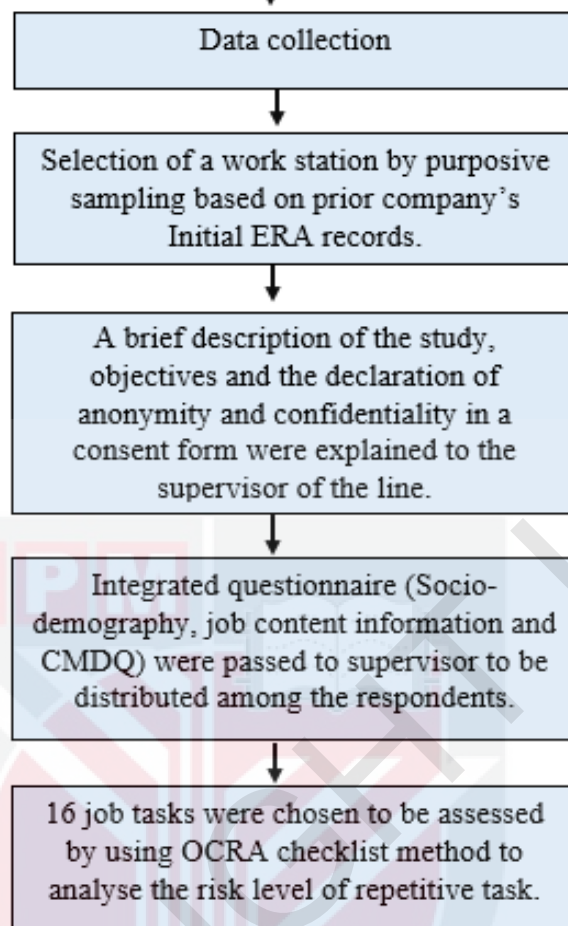


Figure 3.16: Flowchart of data collection

3.8 Statistical Analysis

The data that had been collected were analysed by using the statistical computer software IBM Statistical Package Service and Solution (SPSS), version 25.0 in accordance to objectives of this study. Table 3.7 below shows the objectives of this study and its appropriate statistical analysis.

Table 3.7: Types of statistical tests used for each objective

Objectives	Statistical Analysis
i. To determine socio-demographic characteristics of production line workers.	Descriptive analysis
ii. To determine the prevalence of WMSDs among production line workers.	Descriptive analysis
iii. To determine the risk level of repetitive task among production line workers.	Descriptive analysis
iv. To study the association between prevalence of WMSDs and repetitive task among production line workers.	Chi-square
v. To determine the association between prevalence of WMSDs and repetitive task according to work units.	Chi-square

3.9 Quality Control

Quality control was done to ensure the result of the data that was obtained throughout the study. The questionnaire had to undergo reliability testing by using cronbach's alpha. Pre-test was conducted about 10% from the sample size. Fifteen subjects who were parallel with the respondent's criteria were selected to undergo pre-testing. Pre-test aims to assess whether the respondents understand or not the questions that were being asked in the questionnaire. The result of the α -Chronbach test for questionnaire was as shown in following Table 3.8:

Table 3.8: Questionnaire reliability testing

Questionnaire	Chronbach's Alpha
Questionnaire on Job Content	0.715
Cornell Musculoskeletal Discomfort Questionnaire (CMDQ)	0.921

As for OCRA checklist, the instrumentation factor was maintained by having the same instructor and assessor for the whole research. Intra-rater reliability by using Cohen's Kappa coefficient (κ) was used to obtain the agreement score between two tests. For this OCRA checklist reliability testing, one test was conducted by using a ERGOepm software (OCRA checklist excel spreadsheet) which have been provided by EPM International Ergonomics School and there days after, another evaluation was made by using the same software. The respondent's risk level of repetitive task was assessed by the researcher and good inter reliability was obtained as shown in following Table 3.9:

Table 3.9: OCRA reliability testing

OCRA checklist	Cohen's Kappa Coefficient value (κ)
Judge 1	0.712
Judge 2	

3.10 Study Ethics

In this research study, an ethical approval was obtained from The University Ethics Committee Involving Human Subjects of Universiti Putra Malaysia, JKEUPM as shown in Appendix 4 with reference number of UPM/TNCPI/RMC/JKEUPM/1.4.18.2. A detail explanation about the study was given to the respondents prior answering the pre-survey and other questionnaires. There was also enough time allocated for them to make a decision on participating. The respondents who agreed to participate were given a written informed consent form to obtain their signature as an agreement. All the confidential of the data will be strictly controlled and maintained as only the researchers could retrieve it. (Appendix 1, Consent form, Appendix 4, Ethical approval).

CHAPTER 4

RESULTS

4.1 Socio-demographic and occupational information of the production line workers

The first objective of the study is to determine socio-demographic information of production line workers. Table 4.1 shows the information of the workers. Majority of the workers are between the age of 18 to 29 years old (57.6%), male (88.1%) and mostly are having a normal Body Mass Index (BMI) (75.4%). Almost half of the workers are single status (51.7%) and have a smoking habit (45.8%). Most of the workers are qualified in secondary educational level (75.4%) with working experience between one to ten years (70.3%) and have hobbies involve physical exercises (62.7%). However, only 52.5% of the workers would spend their time in doing physical activities while the rest (47.5%) of the workers will not having any physical activities in a week. Furthermore, more than half of the workers (93.2%) claimed that they are having a break time in between their daily job task.

Table 4.1: Socio-demographic information of production line workers

Characteristics	Frequency n	Percentage %
Age		
18 – 29 years old	68	57.6
30 – 39 years old	24	20.3
40 – 49 years old	20	16.9
> 50 years	6	5.1
Gender		
Male	105	89.0
Female	13	11.0
Race		
Malay	63	53.4
Chinese	1	0.8
Indian	4	3.4
Others	50	42.4
Body Mass Index (BMI)		
< 18.5 (Underweight)	2	1.7
18.5 – 24.9 (Normal weight)	89	75.4
25.0 – 29.9 (Overweight)	24	20.3
> 30 (Obesity)	3	2.5
Marital status		
Single	61	51.7
Married	55	46.6
Divorced	2	1.7
Educational level		
Primary education	20	16.9
Secondary education	89	75.4
Tertiary education	9	7.6
Smoking		
Yes	54	45.8
No	64	54.2
Hobbies involve physical exercises		
Yes	74	62.7
No	44	37.3
Physical activity time/ week (in minutes)		
None	56	47.5
< 150 min	54	45.8
150 – 300 min	6	5.1
> 300 min	2	1.7

Characteristics	Frequency n	Percentage %
Break time		
Yes	110	93.2
No	8	6.8
Working experience		
1 -10 years	83	70.3
11 – 20 years	14	11.9
21 – 30 years	19	16.1
≥ 30 years	2	1.7
n= 118 respondents		



4.2 Prevalence of WMSDs among production line workers

The second objective for this study is to determine the prevalence of WMSDs among production line workers (Table 4.2). The study shows that the lower back (60.17%) has the highest prevalence of WMSDs complaint followed by neck complaint (55.93%) and both shoulders (50.85%, 52.545) on the right and left side respectively as shown in Table 4.3. The overall discomfort score shows neck (14.79%) with the highest percentage followed by lower back (12.28%) and both shoulders (8.35%, 8.43%) right and left side respectively as shown in Table 4.4. The overall WMSDs from this study shows a very high prevalence of 70.3% as shown in Table 4.3.

More specifically, the result (Table 4.2) indicates that 66 (55.9%) workers sensed discomfort in the neck 1-2 times or more per week and 55 of them assessed that this discomfort had a slightly or substantially effect on their ability to work. 71 (60.2%) of the workers assessed low back discomfort for 1-2 times or more per week and because of this discomfort, 54 (45.7%) of them estimated that this had either slight or substantial effect on their ability to work. Moreover, for both shoulders, 60 (50.8%) and 62 (52.5%) workers had evaluated discomfort 1-2 times or more per week on right and left side respectively and 43(36.4%) of them had felt that this discomfort was causing them difficulty to do work.

Table 4.2: Prevalence of WMSDs among production line workers

Body Parts	During the last work week how often did you experience ache, pain, discomfort in: n (%)					If you experience ache, pain, discomfort, how uncomfortable was this? n (%)			If you experience ache, pain, discomfort, did this interfere with your ability to work n (%)		
	Never	1-2 times last week	3-4 times last week	Once every day	Several times per day	Slightly uncomfortable	Moderately uncomfortable	Very uncomfortable	Not at all	Slightly interfered	Substantially interfered
Neck	52(44.1)	24(20.3)	18(15.3)	20(16.9)	4(3.4)	26(22.0)	30(25.4)	10(8.5)	11(9.3)	44(37.3)	11(9.3)
Shoulder_R	58(49.2)	29(24.6)	14(11.9)	13(11.0)	4(3.4)	36(30.5)	20(16.9)	5(4.2)	19(16.1)	33(28.0)	10(8.5)
Shoulder_L	56(47.5)	32(27.1)	14(11.9)	12(10.2)	4(3.4)	37(31.4)	23(19.5)	3(2.5)	19(16.1)	33(28.0)	10(8.5)
Upper Back	59(50.0)	30(25.4)	14(11.9)	12(10.2)	3(2.5)	35(29.7)	22(18.6)	3(2.5)	18(15.3)	34(28.8)	8(6.8)
Upper Arm_R	64(54.2)	28(23.7)	17(14.4)	6(5.1)	3(2.5)	34(28.8)	18(15.3)	3(2.5)	16(13.6)	31(26.3)	8(6.8)
Upper Arm_L	64(54.2)	27(22.9)	18(15.3)	6(5.1)	3(2.5)	35(29.7)	17(14.4)	3(2.5)	18(15.3)	29(24.6)	8(6.8)
Lower Back	47(39.8)	39(33.1)	18(15.3)	11(9.3)	3(2.5)	40(33.9)	33(28.0)	1(0.8)	20(16.9)	47(39.8)	7(5.9)
Forearm_R	71(60.2)	27(22.9)	9(7.6)	9(7.6)	2(1.7)	27(22.9)	18(15.3)	2(1.7)	14(11.9)	25(21.2)	8(6.8)
Forearm_L	71(60.2)	28(23.7)	9(7.6)	8(6.8)	2(1.7)	28(23.7)	17(14.4)	2(1.7)	15(12.7)	24(20.3)	8(6.8)
Wrist_R	60(50.8)	27(22.9)	15(12.7)	13(11.0)	3(2.5)	25(21.2)	28(23.7)	5(4.2)	10(8.5)	38(32.2)	10(8.5)
Wrist_L	59(50.0)	28(23.7)	16(13.6)	12(10.2)	3(2.5)	27(22.9)	26(22.0)	5(4.2)	12(10.2)	37(31.4)	9(7.6)
Hip/Buttocks	86(72.9)	20(16.9)	8(6.8)	1(0.8)	3(2.5)	18(15.3)	10(8.5)	4(3.4)	9(7.6)	17(14.4)	6(5.1)
Thigh_R	86(72.9)	22(18.6)	7(5.9)	2(1.7)	1(0.8)	23(19.5)	8(6.8)	1(0.8)	10(8.5)	18(15.3)	4(3.4)
Thigh_L	86(72.9)	22(18.6)	7(5.9)	2(1.7)	1(0.8)	23(19.5)	8(6.8)	1(0.8)	10(8.5)	18(15.3)	4(3.4)
Knee_R	79(66.9)	26(22.0)	10(8.5)	1(0.8)	2(1.7)	25(21.2)	11(9.3)	3(2.5)	12(10.2)	19(16.1)	8(6.8)
Knee_L	80(67.8)	25(21.2)	10(8.5)	1(0.8)	2(1.7)	25(21.2)	11(9.3)	2(1.7)	12(10.2)	20(16.9)	6(5.1)
Lower Leg_R	81(68.6)	28(23.7)	5(4.2)	3(2.5)	1(0.8)	25(21.2)	10(8.5)	1(0.8)	12(10.2)	19(16.1)	5(4.2)
Lower Leg_L	82(69.5)	26(22.0)	6(5.1)	3(2.5)	1(0.8)	25(21.2)	10(8.5)	1(0.8)	15(12.7)	26(22.0)	6(5.1)
Foot_R	72(61.0)	27(22.9)	10(8.5)	6(5.1)	3(2.5)	28(23.7)	14(11.9)	5(4.2)	15(12.7)	27(22.9)	6(5.1)
Foot_L	72(61.0)	27(22.9)	10(8.5)	6(5.1)	3(2.5)	28(23.7)	15(12.7)	4(3.4)	13(11.0)	34(28.8)	6(5.1)

Table 4.3 Overall WMSDs prevalence in any complaints (timeline)

Part of the body	WMSDs prevalence	
	Frequency (n)	Percentage (%)
Neck	66	55.93
Shoulder_R	60	50.85
Shoulder_L	62	52.54
Upper Back	59	50.00
Upper Arm_R	54	45.76
Upper Arm_L	54	45.76
Lower Back	71	60.17
Forearm_R	47	39.83
Forearm_L	47	39.83
Wrist_R	58	49.15
Wrist_L	59	50.00
Hip/Buttocks	32	27.12
Thigh_R	32	27.12
Thigh_L	32	27.12
Knee_R	39	33.05
Knee_L	38	32.20
Lower Leg_R	37	31.36
Lower Leg_L	36	30.51
Foot_R	46	38.98
Foot_L	46	38.98
WMSDs in any part of the body	83	70.3

n = 118

Table 4.4: Discomfort score of any body parts

Body parts referred to in the questionnaire	Frequency n	Discomfort n	Interference n	Overall discomfort score %
Neck	239.0	116	132	14.79
Shoulder_R	197.5	91	115	8.35
Shoulder_L	197.0	92	115	8.43
Upper Back	184.0	88	110	7.20
Upper Arm_R	161.5	79	102	5.26
Upper Arm_L	163.5	78	100	5.16
Lower Back	206.5	109	135	12.28
Forearm_R	137.0	69	88	3.36
Forearm_L	133.5	68	87	3.19
Wrist_R	188.0	96	116	8.46
Wrist_L	188.0	94	113	8.07
Hip/Buttocks	93.0	50	61	1.15
Thigh_R	77.5	42	58	0.76
Thigh_L	77.5	42	58	0.76
Knee_R	99.0	56	74	1.66
Knee_L	97.5	53	70	1.46
Lower Leg_R	84.5	48	65	1.07
Lower Leg_L	85.0	48	85	1.40
Foot_R	135.5	71	87	3.38
Foot_L	135.5	70	99	3.80

4.3 Risk level of repetitive task according to job task

The third objective of the study is to determine the risk level of repetitive tasks according to job tasks on the right and left upper limbs. For the right and left upper limbs, Table 4.5 and Table 4.6 show the recovery multiplier (recovery multiplier=1.33) and recovery score (recovery score=4) are the same for all the job tasks. Task A (vacuum and pinning), Task F (insert wire) and Task H (sound test) have the highest frequency score (Frequency=2.5), while Task P (loading unit to pallet) has the highest force score (Force=8). As for the overall posture score in the right upper limbs, Task J (front cover installation) and Task P (loading unit to pallet) recorded the biggest value for overall posture (Overall posture=9), while Task N (cushion installation), Task O (stapler sleeve DB) and Task P (loading unit to pallet) for the left side. Furthermore, most of the job tasks have the highest additional score of 3.

Based on Table 4.7, Task P (loading unit to pallet) has the highest score (Risk level=24.01) for the right and left side, while the lowest score (Risk Level=5.99) is Task K (cap & tape installation) for the left upper limbs.

Figure 4.1 and Figure 4.2 shows the distribution of OCRA checklist map result for right and left upper limbs. The risk mapping for the risk level of repetitive task shows most of the job tasks among production line workers in assembly line are at medium-low to medium risk which referred to a red level.

Table 4.5: Checklist OCRA score according to job tasks (Right side)

Job Task	Recovery multiplier	Recovery score	Frequency	Force	Side	Shoulder	Elbow	Wrist	Hand	Stereotype	Overall posture score	Additional	Checklist OCRA score
A	1.33	4	2.5	4	Right	2	1	2	4	3	7	2	20.62
B	1.33	4	0	4	Right	2	1	3.5	2	3	6.5	1	15.30
C	1.33	4	0	4	Right	2	1	2	4	3	7	3	17.69
D	1.33	4	0	1	Right	2	1	2	3.5	3	6.5	1	11.31
E	1.33	4	0	1	Right	2	2	4	4	3	7	3	14.63
F	1.33	4	2.5	1	Right	2	2	4	4	3	7	1	15.30
G	1.33	4	0	0	Right	2	0	2	4	3	7	3	13.30
H	1.33	4	2.5	0	Right	2	2	2	2	3	5	3	13.97
I	1.33	4	0	0	Right	2	1	2	2	3	5	3	10.64
J	1.33	4	0	1	Right	6	2	4	4	3	9	3	17.29
K	1.33	4	0	0	Right	6	1	2	2	1.5	7.5	1	11.31
L	1.33	4	0	0	Right	2	1	2	2	3	5	3	10.64
M	1.33	4	0	0	Right	2	1	1	2	3	5	3	10.64
N	1.33	4	0	0	Right	2	1	2	3.5	3	6.5	3	12.64
O	1.33	4	0	4	Right	2	4	4	4	3	7	3	18.62
P	1.33	4	0	8	Right	6	1	2	2	3	9	2	24.01

Job Task	Recovery multiplier	Recovery score	Frequency	Force	Side	Shoulder	Elbow	Wrist	Hand	Stereotype	Overall posture score	Additional	Checklist OCRA score
A	1.33	4	0	4	Left	2	1	2	4	3	7	2	17.29
B	1.33	4	0	4	Left	2	1	2	2	3	5	1	13.30
C	1.33	4	0	4	Left	2	2	2	3.5	3	6.5	3	17.06
D	1.33	4	0	1	Left	2	1	1	2	3	5	1	9.31
E	1.33	4	0	1	Left	2	2	3.5	2	3	6.5	3	13.97
F	1.33	4	0	1	Left	2	1	3.5	3.5	3	6.5	1	11.31
G	1.33	4	2.5	0	Left	2	0	2	2	3	5	3	13.97
H	1.33	4	0	0	Left	2	1	2	2	3	5	3	10.64
I	1.33	4	0	0	Left	2	1	1	1	3	5	3	10.64
J	1.33	4	0	1	Left	2	1	2	2	3	5	3	11.97
K	1.33	4	0	0	Left	2	1	2	2	1.5	3.5	1	5.99
L	1.33	4	0	0	Left	2	0	1	1	3	5	3	10.64
M	1.33	4	0	0	Left	2	1	1	1	3	5	3	10.64
N	1.33	4	0	0	Left	6	2	2	2	3	9	3	15.96
O	1.33	4	0	4	Left	6	3.5	2	4	3	9	3	21.28
P	1.33	4	0	8	Left	6	1	2	2	3	9	2	24.01

Table 4.6: Checklist OCRA score according to job tasks (Left side)

Table 4.7: Summary risk level of repetitive tasks according to job task

(Both sides)

Work unit	Job task	OCRA value (classification)	OCRA value (classification)
		Right side	Left side
Assembly cycle	A	20.62 (Medium risk)	17.29 (Medium risk)
	B	15.30 (Medium risk)	13.30 (Medium-low risk)
Internal assembly	C	17.69 (Medium risk)	17.06 (Medium risk)
	D	11.31 (Medium-low risk)	9.31 (Very low risk)
	E	14.63 (Medium risk)	13.97 (Medium-low risk)
	F	15.30 (Medium risk)	11.31 (Medium-low risk)
Computer test room (CTR)	G	13.30 (Medium low risk)	13.97 (Medium-low risk)
	H	13.97 (Medium-low risk)	10.64 (Very low risk)
Final packing	I	10.64 (Very low risk)	10.64 (Very low risk)
	J	17.29 (Medium risk)	11.97 (Medium-low risk)
	K	11.31 (Medium-low risk)	5.99 (Acceptable risk)
	L	10.64 (Very low risk)	10.64 (Very low risk)
	M	10.64 (Very low risk)	10.64 (Very low risk)
	N	12.64 (Medium-low risk)	15.96 (Medium risk)
	O	18.62 (Medium risk)	21.28 (Medium risk)
	P	24.01 (High risk)	24.01 (High risk)

Acceptable risk (< 7.5)

Very low risk (7.6-11.0)

Medium-low risk (11.1-14.0)

Medium risk (14.1-22.5)

High risk (≥ 22.6)

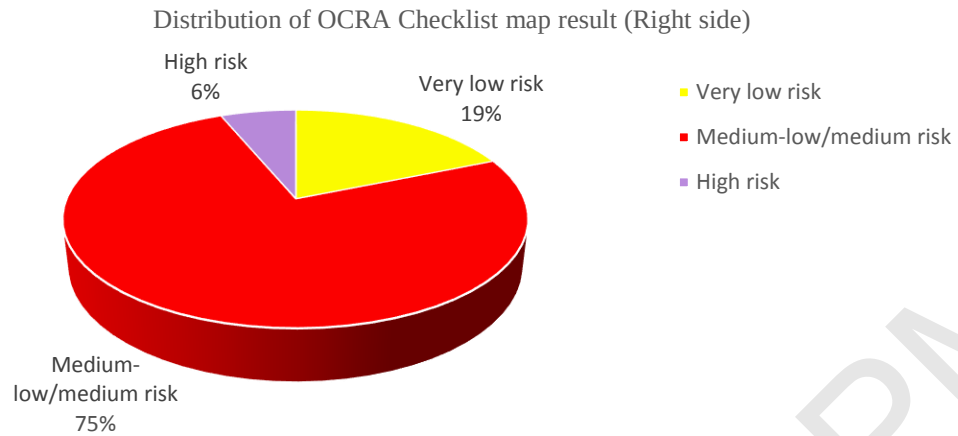


Figure 4.1: Risk mapping for the risk level of repetitive task in assembly line cycle (Right side)

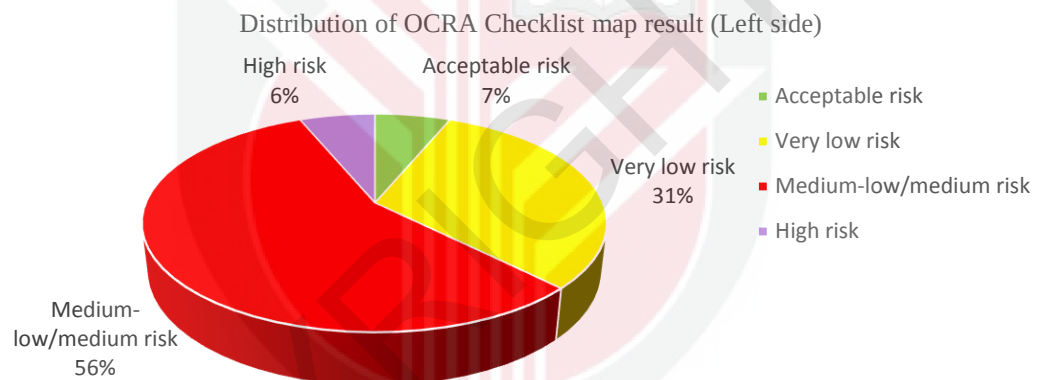


Figure 4.2: Risk mapping for the risk level of repetitive task in assembly line cycle (Left side)

4.4 The association between repetitive task with WMSDs among production line workers

Objective of the study is to determine the association between repetitive tasks with WMSDs prevalence among production line workers. The study shows that the overall prevalence of WMSDs have a significant association with repetitive task ($p < 0.05$, $\chi^2 = 4.348$).

Table 4.8: Association between prevalence of WMSDs and repetitive task among production line workers.

Variables	Repetitive task		χ^2	p-value
	Yes (78%)	No (22%)		
Prevalence of WMSDs				
Yes (70%)	69	14	4.348	0.037
No (30%)	23	12		

n=118

Another chi-square test was done to determine the association between repetitive tasks with WMSDs prevalence among production line in the selected work units such as assembly cycle, internal cycle, computer test room and final packing. The chi-square results revealed that only repetitive task done by the production line workers from assembly cycle ($\chi^2 = 3.091$, $p = 0.044$) and final packing ($\chi^2 = 2.959$, $p = 0.047$) are significantly associated with WMSDs symptoms reported.

**Table 4.9: Association between repetitive tasks with WMSDs prevalence
among production line in every work unit**

Prevalence WMSDs Work unit	Repetitive task			
	Yes (78%)	No (22%)	χ^2	p-value
Assembly cycle				
Yes (70%)	12	1	3.091	0.044
No (30%)	2	3		
Internal Assembly				
Yes (70%)	21	6	0.049	0.660 ^b
No (30%)	6	3		
Computer Test Room (CTR)				
Yes (70%)	5	4	0.313	0.580 ^b
No (30%)	5	1		
Final Packing				
Yes (70%)	31	3	2.959	0.047
No (30%)	10	5		
n=118 ^b : Fisher Exact Test				

CHAPTER 5

DISCUSSION

5.1 Background information

A research was conducted to determine the prevalence of WMSDs and the association with repetitive task among production line workers. A total of 118 production line workers had participated in this study started from March 2021 until May 2021.

5.2 Prevalence of WMSDs among production line workers

One of the objectives of this study is to determine the prevalence of WMSDs among production line workers. The study shows a high prevalence (70.3%) of WMSDs among production line workers in one of the selected Electrical & Electronic (E&E) manufacturing industry which has the highest complaints that occur at twenty areas of the body. The result is the same with the finding of Nur et al. (2014) which stated a high rate of overall WMSDs prevalence among manufacturing workers. The overall finding of WMSDs prevalence between Nur et al. (2014) with the present study was almost at the same rate (76.97%). Another study by Foong et al. (2014) also showed a high prevalence of WMSDs (79.6%) among production line workers in manufacturing company in Malaysia.

This study found that from 20 body parts, lower back is the highest complaint among Malaysian production line workers followed by neck, shoulder, upper back, wrist, upper arm, forearm, foot, knee, lower leg, thigh and hip/buttocks. The finding of this study is relevant with Hossain et al. (2018) that reported lower back pain (24.7%) is the highest complaint reported by the workers in

Bangladesh. Moreover, in another study completed by Chee (2004), semiconductor workers who performed repetitive tasks and awkward posture while working showed a high occurrence of WMSDs in the neck or shoulder (61.5%) followed by wrist (30.8%). Other than that, the workers who situated at assembly line work unit also have a high prevalence of WMSDs in the shoulders/ neck (54.8%).

Another similar study by Nur et al. (2014) found that neck (49.3%) and shoulder (46.7%) pain are one of the contributors towards the high prevalence of WMSDs in electrical and electronic manufacturing company. The most common musculoskeletal symptoms in a research study reported by Shamsudin et al. (2016) among industrial packaging workers were at shoulders (89%), lower back (74%) and neck (42%). The high prevalence of WMSDs among Malaysian manufacturing workers might be due to manual handling activities such as pushing, pulling and lifting tasks. The data obtained from the sample is demonstrated to be usable for this study and comparable to other studies since the body parts reported having pain in this study are similar to prior studies finding. Foong et al. (2014) also mentioned that a high prevalence of WMSDs in a developing country like Malaysia might be the leading cause of occupational injury, work-related disability and lost-time illness.

5.3 Risk level of repetitive task

The next objective of this study is to analyse the risk level of repetitive task according to job tasks in assembly line by using Occupational Repetitive Action (OCRA) checklist method. The risk assessment results revealed that 75% of the job tasks done by the production line workers are at a moderate-low to moderate risk level. This is relevant with a similar study by Anwar (2017) where most of the task done by the corn seed production workers were also at medium risk level along with the significant discomfort on upper limbs region. The packaging unit task have possessed the highest OCRA score for right side while threshing of corn cobs indicated the lowest OCRA score for left side upper limbs and instant improvements on the method or system of work are crucial to reduce the driver factors such as force, posture and recovery factors. However, if compared with the present study, OCRA index was used by Anwar (2017) to analyse the risk level of repetitive task.

In another study reported by Rosecrance et al. (2017), the finding of OCRA checklist score was much lower which was almost half (49.1%) out of the 32 tasks observed in cheese manufacturing company done were classified as hazardous. Other similar study by Dhadhari et al. (2019) also reported that the OCRA index shown among the pesticide factory workers in packaging line were exposed to the medium to high risk level of job tasks. According to Takala et al. (2010) and Chiasson et al. (2012), this OCRA approach may also offered information with the most comprehensive exposure model among any other Upper Extremity Musculoskeletal Disorders tools, making it an important tool in an ergonomics assessment toolkit.

5.4 The association between prevalence of WMSDs and repetitive task among production line workers

The final objective of this study is to determine the association between prevalence of WMSDs and repetitive task among production line workers. All the musculoskeletal discomfort and repetitive task information contributing to WMSDs were collected from the respondents by using questionnaire. This study revealed that there was a significant relationship ($p < 0.05$) between WMSDs and repetitive task among the workers especially among assembly cycle and final packing workers.

In a wide range of occupational activities involving repetitive motions and heavy upper-limb exertions, the findings of the study were also supported by Ohlsson et al. (1995) stated that there is a significant association between repetitive industrial work on the neck or shoulder (prevalence odds ratio, POR=4.6). If compared Ohlsson et al. (2015) findings with the present study, neck and shoulder were among the top affected body parts felt by the industrial workers that possibly lead to formation of WMSDs.

In another study by McCormack et al. (1990), there was a positive correlation between repetitive task in a manufacturing workforce with the prevalence of WMSDs especially in hand/wrist tendinitis with manufacturing workers (OR= 5.4) and assembly line packers (OR= 3.9) with a variety of risk variables, such as repetition, force, and postures, are involved. The study also found a link between tendinitis and job seniority, the quantity of things handled, the frequency with which movements are repeated, and the force utilised. Lastly, the findings of this study are similarly in line with Liu et al. (2015), who found

a significant relationship ($p < 0.05$) between WMSDs and repetitive labour every minute and consistently repetitive job (every day).



CHAPTER 6

CONCLUSION AD RECOMMENDATION

6.1 Conclusion

This research was carried out with the purpose to determine the association between Work-related Musculoskeletal Disorders (WMSDs) and repetitive tasks among production line workers. The main conclusions based on the statistically significant findings are as below:

1. There was a high prevalence of WMSDs found among production line workers in manufacturing industry.
2. There were a major moderate-low to moderate risk level of repetitive job tasks in assembly line.
3. There were significant differences of prevalence of WMSDs and repetitive tasks among production line workers.
4. There were significant differences of WMSDs prevalence and repetitive tasks among assembly cycle and final packing workers.

In general, this research has revealed insights on the risk level of repetitive task by using OCRA checklist method on production line workers. This have been done at assembly cycle line with the most exposure towards repetitive motions in their daily job tasks. OCRA checklist method is beneficial for initial screening and risk mapping such as classification of task such as green (no risk), yellow (significant or borderline risk), red (medium risk) or purple (high risk) on the involvement of repetitive job task which several factors have been considered. It is used to assess repetitive task which are focusing on the risk of the upper limbs stating from upper arm, forearm and wrist done by the workers.

Furthermore, OCRA checklist have provided general suggested actions according to the risk classification obtained. This can be done as initiatives to reduce the repetitive factors in daily workers' tasks as it is one of the risk factors that could contribute to the occurrence of WMSDs especially among manufacturing workers who constantly dealt with repetitive manual handling job tasks. This concludes that OCRA checklist score obtained can indirectly reduce WMSDs prevalence among production line workers in assembly line when suggested actions are implemented in order to reduce repetitive job tasks.

6.2 Study Limitation

There are some limitations in this study that cannot be avoided by the researcher such as the information obtained from the respondents' confession regarding their musculoskeletal symptoms in the questionnaire. This is because there is not any clinical examinations and diagnosis that have been done on the workers to ensure their claims on the body parts' complaints. The workers also need to recall back their muscle pain symptoms on any body parts within past seven days and this process might be bias since no records were collected. These were only based on what were claimed by the respondents. However, all the information claims by the respondents were considered accurate and acceptable as it is beyond the researcher's control to verify each of the information.

Moreover, the questionnaires were left to the supervisors to be distributed among all the workers as the factory management did not permit the researcher to interrupt the production flow by the absence of workers. Other than that, due to spike of COVID-19 cases, the factory management also remind the researcher to always practice social distancing with the respondents to prevent

any contamination of the virus. Prior to that, the researcher has explained all the required details regarding this research to the supervisors. Other than that, the integrated questionnaire that was self-administered by the respondents was only available in Malay and English language. This might impose some language barrier issues on the foreign workers especially Bangladeshi as they are the most of the foreigners that serve at the particular selected manufacturing company.

As for the risk level of repetitive task, only 16 respondents according to the chosen job tasks were recorded and analysed by using OCRA checklist method because of time constraints of this research. The understanding of the researcher regarding OCRA Checklist method was based on OCRA checklist reading materials requested from the author itself, Daniela Colombini and other internet sources.

6.3 Recommendation

The recommendations that suggested for this study are as following:

1. The OCRA checklist method should be done on all the respondents as there will be differences in the workers of doing the same job tasks.
2. Future studies should focus on to determine the prevalence of WMSDs with risk level of repetitive task obtained from OCRA checklist.
3. The sample size of the study should be widened in future studies which include several factories from the same background in order that the results are more reliable to represent the same background factories across Malaysia.
4. An interview session with the workers on assessing the musculoskeletal symptoms by using CMDQ should be used instead of self-reported assessment.
5. Further studies can take advanced step to focus on improvements of work method or system to ensure the reduction of repetitive task among the workers.
6. The management of the company can take actions to improve on the force and posture factors reported from the OCRA checklist method as these two revealed a significant contribution to a high score of OCRA checklist.
7. The workers should be advised to constantly wear Personal Protective Equipment (PPE) provided such as suitable glove to eliminate additional factors in their daily work task.

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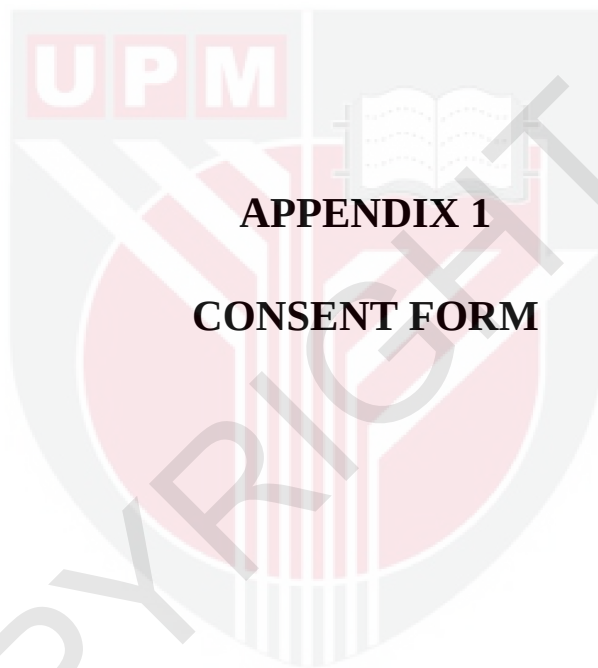
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APPENDIX 1
CONSENT FORM



RESPONDENT'S INFORMATION SHEET AND INFORMED CONSENT FORM

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

1. STUDY TITLE :

The Association between Work Related Musculoskeletal Disorders and Repetitive Task of Upper Limbs among production line workers.

2. INTRODUCTION:

You are invited to participate in this research because you are at risk in experiencing musculoskeletal discomfort that could lead to the formation of Work-related Musculoskeletal Disorders (WMSDs) due to industrial repetitive task of upper limbs. Repetitive task is one of the most important risk factor that could contribute to upper limbs region injury and resulted in work-related musculoskeletal disorders (WMSDs). WMSDs could affect the performance and the productivity of your work as you may suffer from musculoskeletal pain and discomfort.

Your participation in this research is voluntary. You do not have to join this research if you do not want to. You also have the right not to answer any questions you do not want answered. You can also withdraw from this research at any time. If you withdraw, everything information that has been obtained before you withdraw will still be used in this research. If you do not want to participate or withdraw from research this, your actions will not affect all medical rights and privileges the health you deserve.

3. WHAT WILL YOU HAVE TO DO?

You will be given a set of questionnaire form and you will need to complete them in a given period of time and give it back to the researcher. From this questionnaire, it contains 2 sections: Section A (Socio demographic and characteristics jobs); Section B (Cornell Musculoskeletal Discomfort Questionnaire). After you have finished answering the questionnaire, you will be needed to perform your job task as usual because the researcher will start to videotape your task cycle for 3 to 5 minutes for the purpose to fill in Occupational Repetitive Action (OCRA) checklist that will be done by the researcher.

4. WHO SHOULD NOT PARTICIPATE IN THE STUDY?

If you had any history of any musculoskeletal injury or any injuries for the past 12 months or/and history of chronic disease or/and a part-timer worker, you are excluded to participate in this research as it will affect the results of the study.

5. WHAT WILL BE THE BENEFITS OF THE STUDY:

(a) TO YOU AS THE SUBJECT?

This research may be beneficial or not at all beneficial to you. All information obtained from this research will help in order to make improvement on the treatment or prevention methods towards the other respondents who might have the same risk exposure, illness or health problem regarding musculoskeletal discomforts that could lead to the formation of work-related musculoskeletal disorders as you. The result of the study may help the management of your company to provide the best ergonomic practices for you as the worker in order to prevent any musculoskeletal injuries.

TO THE INVESTIGATOR?

This research will be beneficial to the researcher. All the information obtained from this research will be used to evaluate the prevalence of work-related musculoskeletal disorders among manufacturing workers and its association with repetitive task of the upper limbs done by the workers. This information could also be used as a reference towards other future research related to association between work-related musculoskeletal disorders and industrial repetitive task of upper limbs in a manufacturing industry.

6. WHAT ARE THE POSSIBLE RISKS?

Only minimal risk and side effects will be impacted from this study because it is not invasive.

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

All your information obtained in this research will be stored and conducted in a confidential manner, in accordance with regulations and / or laws concerned. If the results of this research are published or presented to the public, your identity will not be revealed without your prior permission first. As for the images/photos/video recordings that has been taken, it can only be published according to your permission stated in the consent form. Only research team are allowed to access your information. By signing this consent form, you are agreed to the record review, information storage and data process as per described.

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

If you have any questions about this study or your rights, please contact:

1. Miss Nur Syazadini Binti Nor Azmi (Researcher)
H/p: 013-3709636
Email: syazaazmii@gmail.com
2. Prof. Dr Shamsul Bahri Md Tamrin
H/p: 017- 3134792
Email: shamsul_bahri@upm.edu.my

Please initial here if you have read and understood the contents of this page_____

RESPONDENT'S INFORMED CONSENT FORM

I Identity Card No.
address.....
.....hereby voluntarily agree to take part in the
research stated above *(video recording/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
(Respondent)

Signature
(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**

PENERANGAN DAN PERSETUJUAN RESPONDEN

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

1.TAJUK KAJIAN:

Hubungan Antara Gangguan Muskuloskeletal Yang Berkaitan Dengan Pekerjaan Dan Tugas Berulang Dalam Kalangan Pekerja Barisan Pengeluaran.

2. PENGENALAN:

Anda dijemput untuk mengambil bahagian dalam penyelidikan ini kerana anda berisiko mengalami ketidakselesaan muskuloskeletal yang boleh menyumbang kepada penyakit Gangguan Muskuloskeletal yang berkaitan dengan pekerjaan disebabkan oleh pergerakan berulang melibatkan anggota badan bahagian atas. Pergerakan melibatkan tugas berulang adalah salah satu faktor risiko yang paling penting yang boleh menyumbang kepada kecederaan kawasan anggota badan atas dan mengakibatkan gangguan muskuloskeletal yang berkaitan dengan pekerjaan. Gangguan muskuloskeletal yang disebabkan oleh pekerjaan boleh mempengaruhi prestasi dan produktiviti kerja anda kerana anda mungkin mengalami kesakitan dan ketidakselesaan muskuloskeletal di bahagian badan anda.

Penyertaan anda dalam penyelidikan ini adalah sukarela. Anda tidak perlu menyertai penyelidikan ini jika anda tidak mahu. Anda juga berhak untuk tidak menjawab soalan yang tidak mahu dijawab. Anda juga boleh menarik diri dari penyelidikan ini pada bila-bila masa. Sekiranya anda menarik diri, semua maklumat yang telah diperoleh sebelum menarik diri masih akan digunakan dalam penyelidikan ini. Sekiranya anda tidak mahu mengambil bahagian atau menarik diri dari penyelidikan ini, tindakan anda tidak akan mempengaruhi semua hak perubatan dan hak istimewa kesihatan yang anda layak.

3. APAKAH YANG PERLU ANDA LAKUKAN?

Anda akan diberikan satu set borang soal selidik dan anda perlu melengkapkannya dalam jangka masa tertentu dan mengembalikannya kepada penyelidik. Dari borang soal selidik ini, ia mengandungi 2 bahagian: Bahagian A (Sosial demografi dan ciri-ciri pekerjaan); Bahagian B (Soal Selidik Ketidakselesaan Musculoskeletal Cornell). Setelah anda selesai menjawab borang soal selidik ini, anda perlu melakukan tugas pekerjaan anda seperti biasa kerana penyelidik akan mula merakam video anda sedang melakukan tugas-tugas anda selama 3-5 minit bertujuan untuk mengisi senarai semak Occupational Repetitive Action (OCRA) yang akan diisi oleh pengkaji.

4. SIAPA YANG TIDAK BOLEH MENYERTAI KAJIAN INI?

Sekiranya anda mempunyai sejarah kecederaan muskuloskeletal atau kecederaan dalam jangkamasa 12 bulan yang lalu atau / dan sejarah penyakit kronik atau / dan seorang pekerja sambilan, anda dikecualikan untuk mengambil bahagian dalam penyelidikan ini kerana ia akan mempengaruhi hasil kajian .

5. APAKAH FAEDAH MENYERTAI KAJIAN INI?

a) KEPADA ANDA SEBAGAI PESERTA?

Penyelidikan ini mungkin bermanfaat atau sama sekali tidak bermanfaat bagi anda. Semua maklumat yang diperoleh daripada penyelidikan ini akan membantu untuk memperbaiki kaedah rawatan atau pencegahan terhadap responden lain yang mungkin mempunyai risiko pendedahan, penyakit atau masalah kesihatan yang sama mengenai ketidakselesaan muskuloskeletal yang boleh menyebabkan pembentukan gangguan muskuloskeletal yang berkaitan dengan pekerjaan seperti anda. Hasil kajian ini juga mungkin dapat membantu pihak pengurusan syarikat anda untuk menyediakan amalan ergonomik terbaik untuk anda sebagai pekerja untuk mengelakkan sebarang kecederaan pada otot ketika melakukan sebarang pekerjaan.

b) KEPADA PENYELIDIK?

Penyelidikan ini akan sangat bermanfaat bagi penyelidik. Semua maklumat yang diperoleh dari penyelidikan ini akan digunakan untuk menilai tahap gangguan muskuloskeletal yang berkaitan dengan pekerja di kalangan pekerja perkilangan dan kaitannya dengan pergerakan melibatkan tugas berulang bahagian anggota atas. Maklumat ini juga dapat digunakan sebagai rujukan terhadap penyelidikan masa hadapan yang mempunyai kaitan kajian yang sama.

6. ADAKAH IA BERISIKO?

Hanya risiko dan kesan sampingan yang minimum yang akan dipengaruhi oleh kajian ini kerana tidak invasif.

7. ADAKAH MAKLUMAT DAN IDENTITI SAYA KEKAL RAHSIA?

Semua maklumat anda yang diperoleh dalam penyelidikan ini akan disimpan dan dilakukan secara rahsia, sesuai dengan peraturan dan / atau undang-undang yang berkaitan. Sekiranya hasil penyelidikan ini diterbitkan atau disampaikan kepada umum, identiti anda tidak akan didedahkan tanpa kebenaran anda terlebih dahulu. Mengenai gambar atau rakaman video yang telah diambil, jika ianya perlu untuk disampaikan ketika pembentangan kajian, ia hanya akan disiarkan mengikut persetujuan anda yang dinyatakan dalam borang persetujuan. Hanya pasukan penyelidik yang dibenarkan mengakses maklumat anda. Dengan menandatangani borang persetujuan ini, ia menandakan anda bersetuju dengan tinjauan rekod, penyimpanan maklumat dan proses data seperti yang dijelaskan di atas.

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

Sekiranya anda mempunyai sebarang pertanyaan mengenai kajian ini atau hak anda dalam kajian ini, sila hubungi:

1. Miss Nur Syazadini Binti Nor Azmi (Researcher)
H/p: 013-3709636
Email: syazaazmii@gmail.com
2. Prof. Dr Shamsul Bahri Md Tamrin
H/p: 017- 3134792
Email: shamsul_bahri@upm.edu.my

PERSETUJUAN RESPONDEN

Saya..... No Kad Pengenalan.
beralamat.....
.....dengan ini bersetuju untuk mengambil bahagian secara sukarela
dalam penyelidikan yang tersebut di atas *(rakaman video/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.

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

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

*potong yang tidak berkenaan

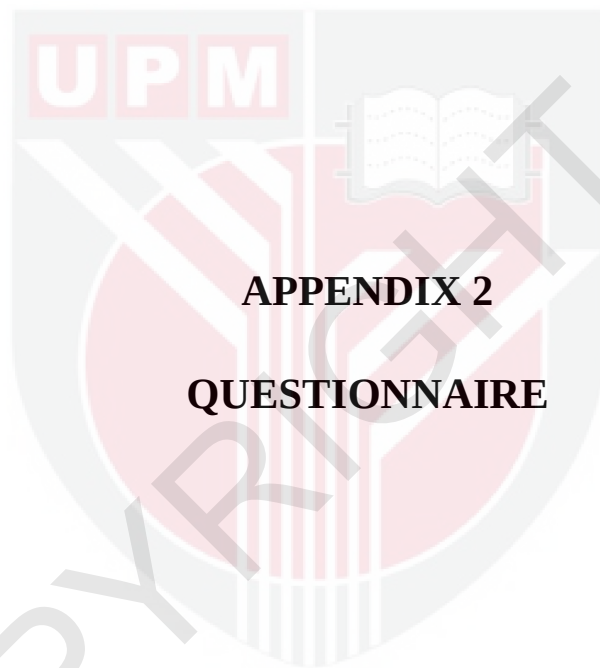
Tandatangan Tandatangan
(Responden) (Saksi)

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)



APPENDIX 2
QUESTIONNAIRE

Appendix 2.1: Questionnaire

Date/ Tarikh:

ID No.:



PRE-SURVEY QUESTIONNAIRE/BORANG KAJI SELIDIK TINJAUAN AWAL

NO.	RESEARCH TITLE/ TAJUK KAJIAN	RESEARCHER NAME/ NAMA PENKAJI
1	The association between work-related musculoskeletal disorders and repetitive task among production line workers.	Nur Syazadini binti Nor Azmi

Instructions/Arahan:

This pre-survey questionnaire contains questions to screen your individual characteristics to be matched with inclusive and exclusive criteria of this study.

Borang kaji selidik tinjauan awal ini mengandungi beberapa soalan untuk menyaring ciri-ciri individu anda agar bersesuaian dengan kriteria kajian ini.

INSTRUCTIONS: Please tick your answer and fill in the blanks for the questions below.

ARAHAN: Sila tandakan jawapan anda dan isi jawapan di ruangan yang disediakan untuk soalan dibawah.

1. Age/ Umur :
- a. ☐ < 18 years old / < 18 tahun
 - b. ☐ 18 – 55 years old / 18- 55 tahun
 - c. ☐ > 55 years old / > 55 tahun

2. Working experience/ Pengalaman bekerja:

- a. ☐ Less than 1 year/ Kurang dari 1 tahun
- b. ☐ More than 1 year / Lebih dari 1 tahun

3. Working schedule/ Jadual bekerja:

- a. ☐ Normal shift/ Jadual seperti biasa
(8.00a.m. – 5.30p.m) p.m.)iasa
- b. ☐ Shift/ Syif

4. Employment type/ Jenis pekerjaan:

- a. ☐ Full time worker/ Pekerja sepenuh masa
- b. ☐ Part time worker/ Pekerja sambilan

5. Have you been clinically diagnosed with musculoskeletal disorders or any injuries in the past 12 months caused by non-occupational factors?

Adakah anda telah disahkan secara klinikal mengalami masalah kecederaan muskuloskeletal atau kecederaan lain dalam tempoh 12 bulan yang lalu yg bukan disebabkan oleh pekerjaan?

a. ☐ Yes/ Ya

b. ☐ No/ Tidak

6. Have you been clinically diagnosed with any non-communicable diseases such as with hypertension, heart attack and stroke, diabetes, cancer?

Adakah anda telah disahkan secara klinikal mengalami sebarang masalah penyakit tidak berjangkit seperti tekanan darah tinggi, sakit jantung dan strok, kencing manis dan kanser?

a. ☐ Yes/ Ya

b. ☐ No/ Tidak

- **Please state your type of job tasks/Sila nyatakan jenis pekerjaan anda (Contoh: Memasang front cover)**

Date/ Tarikh:

ID No.:



QUESTIONNAIRE/BORANG KAJI SELIDIK

NO.	RESEARCH TITLE/ TAJUK KAJIAN	RESEARCHER NAME/ NAMA PENGKAJI
1	The association between work-related musculoskeletal disorders and repetitive task among production line workers.	Nur Syazadini binti Nor Azmi

Instructions/Arahan

This questionnaire contains 3 sections:

Borang kaji selidik ini mengandungi 3 bahagian:

1. Section A: Socio-demographic and work characteristics
Bahagian A: Sosio-demografik dan ciri pekerjaan
2. Section B: Work Tasks done by the workers
Bahagian B: Aktiviti yang dilakukan oleh pekerja
3. Part C: Cornell Musculoskeletal Discomfort Questionnaire (CMDQ)
Bahagian C: Borang kaji selidik ketidakselesaan muskuloskeletal Cornell

**SECTION A: SOCIO-DEMOGRAPHIC AND WORK
CHARACTERISTICS**

BAHAGIAN A: LATARBELAKANG SOSIO-

INSTRUCTIONS: Please tick your answer and fill in the blanks for the questions below.

ARAHAN: Sila tandakan jawapan anda dan isi jawapan di ruangan yang disediakan untuk soalan dibawah.

1. Age/ Umur :
- a. ☐ 18 - 29 years old / 18 – 29 tahun
 - b. ☐ 30 – 39 years old / 30 - 39 tahun
 - c. ☐ 40 – 49 years old / 40 - 49 tahun
 - d. ☐ > 50 years old / > 50 tahun
2. Gender/ Jantina:
- 1. ☐ Male/ Lelaki
 - 2. ☐ Female/ Perempuan
3. Race/ Bangsa:
- a. ☐ Malay/ Melayu
 - b. ☐ Chinese/ Cina
 - c. ☐ Indian/ India
 - d. ☐ Others, Please specify/ Sila nyatakan:

4. Body Mass Index (BMI)/ *Indeks Jisim Badan*

- a. ☐ < 18.5 (Underweight) / (*Kurang berat badan*)
- b. ☐ 18.5 – 24.9 (Normal weight) / (*Berat badan normal*)
- c. ☐ 25.0 – 29.9 (Overweight) / (*Berat badan berlebihan*)
- d. ☐ > 30 (Obesity) / (*Obesiti*)

5. Marital status/ *Status perkahwinan*

- a. ☐ Single/ *Bujang*
- b. ☐ Married/ *Berkahwin*
- c. ☐ Divorced/ *Bercerai*

6. Educational level/ *Tahap pendidikan*

- a. ☐ Primary education/ *Sekolah rendah*
- b. ☐ Secondary education/ *Pendidikan menengah*
- c. ☐ Tertiary education/ *Pengajian tinggi*

7. Smoking/ *Merokok* :

- a. ☐ Yes/ *Ya*
- b. ☐ No/ *Tidak*

8. Do you have any hobbies which involve any physical exercises?
Adakah anda mempunyai sebarang hobi yang melibatkan aktiviti fizikal?

- a. ☐ Yes/ Ya
- b. ☐ No/ Tidak

9. How many minutes are you spending your time by doing physical activity such as jogging, playing gym or etc. per week?

Berapa minit anda meluangkan masa anda untuk melakukan aktiviti fizikal seperti berlari, bermain gymnasium dan sebagainya dalam seminggu?

- a. ☐ None/ Tiada
- b. ☐ < 150 mins / < 150 minit
- c. ☐ 150 – 300 mins / 150 – 300 minit
- d. ☐ > 300 mins / > 300 minit

10. Do you have a break/ rest intervals during your working day?

Adakah anda mempunyai masa rehat sepanjang anda bekerja?

- a. ☐ Yes / Ya
- b. ☐ No / Tidak

11. Working experience/ Pengalaman bekerja:

- a. ☐ 1 – 10 years / 1 – 10 tahun
- b. ☐ 11 – 20 years / 11 – 20 tahun
- c. ☐ 21 - 30 years/ 21 - 30 tahun
- d. ☐ ≥ 30 years / ≥ 30 tahun

SECTION B: WORK TASK DONE BY THE WORKERS

BAHAGIAN B: AKTIVITI KERJA YANG TELAH

INSTRUCTIONS: Please tick your answer for the questions below.

ARAHAN: Sila tandakan jawapan anda di ruangan yang disediakan

No.	Questions/ Soalan Illustrations/ Ilustrasi	Yes/ Ya	No/ Tidak
1.	Do you think you are exposed to repetitive work task while doing your job? 1.  Example of repetitive task in electrical factory <i>Antara contoh pergerakan berulang di kilang elektrik</i> Source/Sumber: (DOSH, 2017)		
2.	Do you think you are exposed to awkward posture while carry out the work task? <i>Adakah anda rasa terdedah dengan postur yang janggal ketika melakukan aktiviti kerja?</i>  Awkward postures on shoulder <i>Postur janggal pada bahagian bahu</i>		



Awkward postures on head
Postur janggal pada bahagian kepala



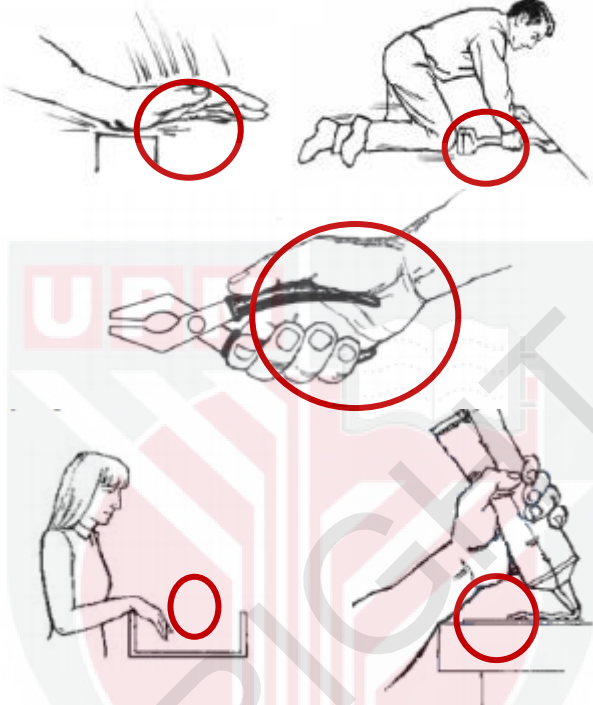
Awkward postures on back
Postur janggal pada bahagian belakang



Awkward postures on hand/ elbow/ wrist
Postur janggal pada bahagian tangan/ siku/ pergelangan tangan

	 Awkward postures on leg/ knees Postur janggal pada bahagian kaki/ lutut Source/ Sumber: (DOSH, 2017)		
3.	Do you think you are exposed to vibrations while carry out the work task by using several tools and forklift seats as follows? Adakah anda rasa terdedah dengan getaran ketika melakukan aktiviti kerja dengan menggunakan beberapa peralatan atau tempat duduk kerusi fokolif?  Whole body vibration on forklift seats Getaran seluruh badan di tempat duduk kerusi fokolif  Hand Arm Vibrations by using tools Getaran di lengan tangan menggunakan peralatan Source/ Sumber: City of Glassgow College		
4.	Do you think you are exposed to forceful and sustained exertions while carry out the work task such as carrying out a heavy stuff?		

	Adakah anda rasa terdedah dengan menggunakan tenaga yang kuat dan berkekalan ketika melakukan aktiviti kerja seperti mengangkat barang yang berat?  Examples of forceful exertions handling heavy things Antara contoh kerja yang menggunakan tenaga mengangkat barang berat Source/ Sumber: (DOSH, 2018)		
5.	Do you think you are exposed to static and sustained posture while carrying out your work task such as a minimal, restricted or no movement of the body to a particular position over a prolonged period for more than 30 minutes or 2 hours? Adakah anda rasa terdedah dengan postur statik dan berkekalan semasa melakukan kerja anda seperti kurang atau tiada pergerakan badan pada jangka masa yang lama lebih daripada 30 minit atau lebih daripada 2 jam?  Examples of static and sustained posture Antara contoh postur statik dan berkekalan Source/ Sumber: (DOSH, 2017)		
6.	Do you think you are exposed to contact stress on the floor or table especially around your hands, arms,		

	fingers or any of your body parts while carry out the work tasks? <i>Adakah anda rasa terdedah dengan tekanan permukaan lantai atau meja terutamanya pada bahagian tangan, lengan jari atau anggota badan yang lain ketika melakukan aktiviti kerja?</i>  Examples of exposure to contact stress such as floor of tables <i>Antara contoh pendedahan kepada permukaan seperti lantai atau meja</i> <i>Source/Sumber: The Canadian Centre for Occupational Health and Safety [CCOHS]</i>		
7.	Do you think you are exposed to environmental factors such as annoying noise or hot/ uncomfortable surrounding while carry out the work task? <i>Adakah anda rasa terdedah dengan faktor-faktor persekitaran seperti bunyi yang terlampau bising atau persekitaran yang panas atau tidak selesa ketika melakukan aktiviti kerja?</i> 		

	Example of exposure to hot surrounding <i>Antara contoh pendedahan kepada persekitaran yang panas</i> <i>Source/ Sumber: (DOSH, 2017)</i>		
8.	Do you think you are stress with your work task assigned by the company? <i>Adakah anda rasa tertekan dengan aktiviti kerja yang telah ditetapkan oleh majikan di tempat kerja?</i>		

Appendix 2.2: Cornell Musculoskeletal Discomfort Questionnaire (CMDQ)

SECTION C: CORNELL MUSCULOSKELETAL DISCOMFORT QUESTIONNAIRE <i>BAHAGIAN C: BORANG SOAL SELIDIK MUSKULOSKELETAL KETIKADSELESAAN</i>
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INSTRUCTIONS: Please tick your answer and fill in the blanks for the questions below.

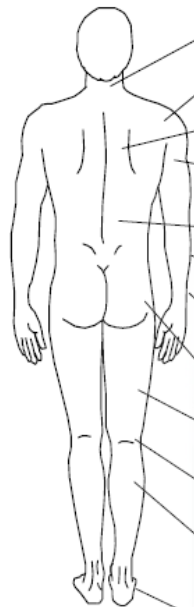
ARAHAN: Sila tandakan jawapan anda dan isi jawapan di ruangan yang disediakan untuk soalan dibawah.

This questionnaire contains 2 forms in English and Malay, please tick your answer on either one of the forms only.

Borang kaji selidik ini mengandungi 2 borang di dalam bahasa Inggeris dan Bahasa Melayu, sila tandakan jawapan anda di salah satu borang sahaja.

1. English version CMDQ

The diagram below shows the approximate position of the body parts referred to in the questionnaire. Please answer by marking the appropriate box.



© Cornell University, 2003

		During the last work <u>week</u> how often did you experience ache, pain, discomfort in:					If you experienced ache, pain, discomfort, how uncomfortable was this?			If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
		Never	1-2 times last week	3-4 times last week	Once every day	Several times every day	Slightly uncomfortable	Moderately uncomfortable	Very uncomfortable	Not at all	Slightly interfered	Substantially interfered
	Neck	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Shoulder (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Upper Back	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Upper Arm (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Lower Back	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Forearm (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Wrist (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Hip/Buttocks	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Thigh (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Knee (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Lower Leg (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	Foot (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

2. Malay version CMDQ

Gambarajah di bawah menunjukkan kedudukan bahagian badan seperti dirujuk dalam soalan. Sila jawab dengan menandakan kotak yang bersesuaian.

Sepanjang minggu bekerja yang lepas, berapa kerapkah anda mengalami kesakitan atau ketidak selesaan di:

Jika anda mengalami kesakitan atau ketidak selesaan, bagaimanakah tahapnya?

Jika anda mengalami kesakitan atau ketidak selesaan, adakah ia mengganggu kebolehan anda untuk bekerja?

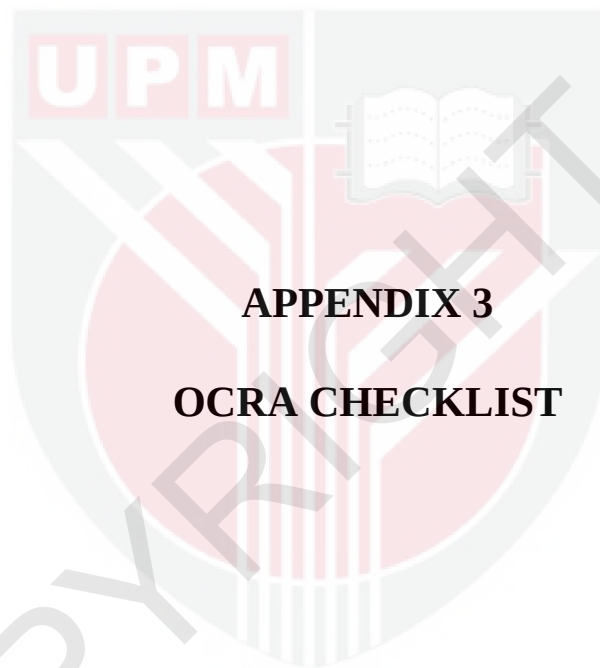


	Tidak pernah	1-2 kali lepas	3-4 kali lepas	Sekali setiap hari	Beberapa kali setiap hari	Sedikit kurang memuaskan	Agak tidak memuaskan	Sangat tidak memuaskan	Tidak sama sekali memuaskan	Sedikit memuaskan	Sangat memuaskan
Leher	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bahu (kanan)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bahu (kiri)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Belakang atas	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lengan (kanan)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lengan (kiri)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Belakang bawah	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lengan bawah (kanan)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lengan bawah (kiri)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pergelangan tangan (kanan)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pergelangan tangan (kiri)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Pinggul/Punggung	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Peha (kanan)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Peha (kiri)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lutut (kanan)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lutut (kiri)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Betis (kanan)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Betis (kiri)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kaki (kanan)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Kaki (kiri)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

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Appendix 2.3: Rating Perceived Exertion Borg Scale (CR-10)

Tahap <i>Level</i>	Tenaga yang diperlukan <i>Energy needed</i>
0	Tidak memerlukan tenaga langsung. <i>Nothing at all.</i>
0.5	Tersangatlah sedikit. <i>Extremely weak.</i>
1	Sangat sedikit. <i>Very weak.</i>
2	Sedikit. <i>Weak.</i>
3	Biasa. <i>Moderate.</i>
4	Lebih sedikit daripada tahap biasa. <i>A little more than moderate.</i>
5	Lebih daripada biasa. <i>Strong.</i>
6	Kuat daripada biasa. <i>A little more than strong.</i>
7	Sangat kuat. <i>Very strong.</i>
8	Lebih sedikit daripada tahap sangat kuat. <i>A little more than very strong.</i>
9	Lebih banyak daripada tahap sangat kuat. <i>A little less than extremely strong.</i>
10	Melampau kuat. <i>Extremely strong.</i>



APPENDIX 3
OCRA CHECKLIST

The OCRA Checklist

ANNEX 4.1: OCRA CHECKLIST MODEL

Shortened procedure for the identification of upper limb overload in repetitive tasks
by the EPM International School of Ergonomics

Page 1

Company	Area
Compiled by	date
Name of workstation/department	
Brief description of task	
-number of identical or very similar workstations	
-number of shifts per day	
-number of workers in identical/very similar workstations/ departments per day	

Organizational data	Description	Actual duration (min.)
Shift duration (for duration consider ACTUAL duration)	Official	
	Actual	
Official pauses	Contractual (hour and number)	
Actual breaks (for duration and numbers consider ACTUAL duration and ACTUAL numbers)	ACTUAL (hour and number)	
Lunch break (for duration consider ACTUAL duration). Consider NET DURATION OF REPETITIVE TASKS only if included in shift duration	Official (hour)	
	Actual	
Nonrepetitive tasks (e.g., cleaning and fetching supplies.) (for duration consider ACTUAL duration)	Official	
	Actual	
No. of units (or cycles) (consider ACTUAL numbers)	Planned	
	Actual	
Net cycle time (s)		
Observed cycle time		

Note

	Duration Multiplier
--	------------------------

Type of work interruption (with pauses or other visual inspection tasks)

(max. score allowed = 10).

Choose one answer. It is possible to choose intermediate values.

0	One interruption in the repetitive work lasting at least 8/10 min every hour (also count the meal break) or the recovery period is included in the cycle.
2	Two interruptions in the morning and two in the afternoon (plus meal break), lasting at least 8–10 min per 7–8 h shift, or at least four interruptions per shift (plus meal break), or four 8/10 min interruptions per 6-h shift.
3	Two pauses, lasting at least 8–10 min each, per 6-h shift (without meal break); or three pauses, plus meal break, per 7–8 h shift.
4	Two pauses, plus lunch break, lasting at least 8–10 min each, per 7–8 h shift (or three pauses without lunch break), or one pause lasting at least 8–10 min per 6-h shift.
6	One pause, lasting at least 10 min, per 7-h shift without meal break; or, in an 8-h shift, only a meal break (meal break not counted in the working hours).
10	– No actual pauses except for a few minutes (less than 5) per 7–8 h shift.

First hour									Last hour
Shift duration in minutes (mark breaks in the shift)									
	Recovery Multiplier								

ARM ACTIVITY AND FREQUENCY WITH WHICH WORK CYCLES ARE PERFORMED

(max. score possible = 10)

Choose one answer for each upper limb. Do NOT use intermediate scores.

If both static and dynamic actions are present, consider both static and dynamic actions.

For the most representative task, choose the one with the highest risk value.

DYNAMIC TECHNICAL ACTIONS

0	Arm movements are slow; frequent short interruptions are possible (20 actions per minute)
1	Arm movements are not too fast; short interruptions are possible (30 actions per minute)
3	Arm movements are quite fast (about 40), but short interruptions are possible
4	Arm movements are quite fast; only occasional and irregular short pauses are possible (about 40 actions per minute)
6	Arm movements are fast; only occasional and irregular short pauses are possible (about 50 actions per minute)
8	Arm movements are very fast; the lack of interruptions makes it difficult to keep up the pace (about 60 actions per minute)
10	Very high frequency; 70 or more actions per minute; absolutely no interruptions are possible

STATIC TECHNICAL ACTIONS

2.5	An object is held for more than 4 consecutive seconds, with one or more static actions maintained for 2/3 of the cycle (or observation) time
4.5	An object is held for more than 4 consecutive seconds, with one or more static actions maintained for 3/3 of the cycle (or observation) time

	R	L
Number of actions in the cycle		
Frequency of actions per minute		
Possibility of short interruptions		

R	L
FREQUENCY SCORE	

PRESENCE OF ACTIVITIES INVOLVING THE REPEATED USE OF FORCE BY THE HANDS-ARMS (AT LEAST ONCE EVERY FEW CYCLES DURING THE ENTIRE TASK ANALYZED): ☐ YES ☐ NO

More than one score can be marked and sum to obtain the final score. IF YES:

THE ACTIVITY REQUIRES THE USE OF ALMOST MAXIMUM FORCE: (8 points or more on the Borg scale)			
☐	Pulling or pushing levers		
☐	Pushing buttons	6	2 s every 10 min
☐	Closing or opening	12	1% of the time
☐	Pressing or handling components	24	5% of the time
☐	Using tools	32	Over 10% of the time (*)
☐	Lifting or handling objects		
THE ACTIVITY REQUIRES THE USE OF INTENSE FORCE: (5-6-7 points on the Borg scale)			
☐	Pulling or pushing levers		
☐	Pushing buttons	4	2 s every 10 min
☐	Closing or opening	8	1% of the time
☐	Pressing or handling components	16	5% of the time
☐	Using tools	24	Over 10% of the time (*)
☐	Lifting or handling objects		
THE ACTIVITY REQUIRES THE USE OF MODERATE FORCE: (3-4 points on the Borg scale)			
☐	Pulling or pushing levers		
☐	Pushing buttons	2	1/3 of the time
☐	Closing or opening	4	About half the time
☐	Pressing or handling components	6	Over half the time
☐	Using tools	8	Nearly all the time
☐	Lifting or handling objects		

(*) THIS CONDITION IS ABSOLUTELY UNACCEPTABLE

R	L
FORCE SCORE	

PRESENCE OF ACTIVITIES INVOLVING AWKWARD POSTURES AND MOVEMENTS OF THE UPPER LIMBS DURING THE ENTIRE TASK ANALYZED: ☐ YES ☐ NO
 More than one score: add the highest of the four posture scores to the stereotype score to obtain the final score.

TYPE OF AWKWARD POSTURE AND MOVEMENT	Duration of awkward posture or movement	Score	RIGHT	LEFT
A: Shoulder —the arms are kept at about shoulder height, without support, (or in other extreme postures)				
	Inf. 1/3 = 10%–24% of the time	2		
	1/3 = 25%–50% of the time	6		
	2/3 = 51%–80% of the time	12		
	3/3 = more than 80% of the time	24		
B: Elbow —the elbow executes sudden movements (wide flexion–extension or pronosupination, jerking movements, striking movements)				
	1/3 = 25%–50% of the time	2		
	2/3 = 51%–80% of the time	4		
	3/3 = more than 80% of the time	8		
C: Wrist —the wrist is bent in an extreme position, or adopts an awkward posture (such as wide flexion/extension, or wide lateral deviation)				
	1/3 = 25%–50% of the time	2		
	2/3 = 51%–80% of the time	4		
	3/3 = more than 80% of the time	8		
D: Hand —the hand grasps objects or tools in pinch, hook grip, or other kinds of grasp				
	1/3 = 25%–50% of the time	2		
	2/3 = 51%–80% of the time	4		
	3/3 = more than 80% of the time	8		
E - STEREOTYP can be assessed at two levels			R	L
High level: a score of 3 is assigned when the cycle time is less than 8s (and, obviously, involves use of the upper limb) or when identical technical actions are performed almost the entire time.				
Intermediate level: a score of 1.5 is assigned when the cycle time is between 8 and 15s or when identical technical actions are performed for 2/3 of the time.				

The overall score for the posture factor is the sum of the highest value calculated for a joint segment plus the stereotype value, where applicable.

R	L
AWKWARD POSTURE SCORE	

PRESENCE OF ADDITIONAL FACTORS Choose one answer per section. The final score is the sum of the two partial scores.	
Section A: physical-mechanical factors	
2	Inadequate gloves (uncomfortable, too thick, wrong size) are used more than half the time for the task.
2	Presence of two or more sudden, jerky movements per minute.
2	Presence of at least 10 repeated impacts (use of hands as tools for striking) per hour.
2	Contact with cold surfaces (below 0°C) or tasks performed in cold chambers for more than half the time.
2	Use of vibrating tools at least one-third of the time. Assign a score of 4 if these tools involve a high degree of vibration (e.g., pneumatic drill).
2	Tools are used that cause compression of muscle and tendon structures (check for the presence of redness, calluses, wounds, etc., on the skin).
2	More than half the time is spent performing precision tasks (tasks on areas of less than 2 or 3 mm), requiring the worker to be physically close to see.
2	More than one additional factor (e.g., ...) is present at the same time for more than half the time.

3	One or more additional factors (e.g., ...) are present almost the entire cycle.
Section B: organizational factors	
1	The work rate is determined by the machine, but 'recovery spaces' exist allowing the rate to be sped up or slowed down.
1.5	The pace is determined by the machine but where the line is moving at a very slow velocity)
2	The work rate is entirely determined by the machine.

R	L
ADDITIONAL FACTORS	

PAGE 4

Multipliers for total duration of repetitive task(s) in shift

60–120 min = 0.5	241–300 min = 0.85	421–480 min = 1
121–180 min = 0.65	301–360 min = 0.925	Sup 480 min = 1.5
181–240 min = 0.75	361–420 min = 0.95	

Recovery multiplier

No. of hours without recovery	0	1	2	3	4	5	6	7	8
RECOVERY MULTIPLIER	1	1.050	1.120	1.200	1.330	1.480	1.700	2.000	2.500

EVALUATION OF FINAL CHECKLIST SCORE FOR TASK/ACTIVITY

(frequency + force+posture + additional) × Net duration of repetitive task multiplier × recovery multiplier	R	L
OCRA checklist final score		

Link between OCRA index and OCRA checklist final score

Color code	OCRA value	Check-list score	Risk classification	Suggested actions
Green	UP TO 1.5	UP TO 5	Optimal	None
Green	1.6–2.2	5.1–7.5	Acceptable	None
Yellow	2.3–3.5	7.6–11	Borderline or Very slight	Recheck or improve
Red-low	3.6–4.5	11.1–14	Slight	Improve + health Surv. +training (2*)
Red-medium	4.6–9.0	14.1–22.5	Medium	Improve + health Surv. +training (3*)
Red high	More than 9.0	More than 22.5	High	Improve + health Surv. + training (4*)



APPENDIX 4
ETHICAL APPROVAL