

**ERGONOMIC RISK ASSESSMENT
AND WHOLE-BODY VIBRATION
MEASUREMENT IN RELATION WITH
WORK-RELATED MUSCULOSKELETAL
DISORDERS AMONG FOOD DELIVERY
RIDERS IN TERENGGANU, MALAYSIA**

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UNIVERSITI SAINS MALAYSIA

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AND WHOLE-BODY VIBRATION
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RELATED MUSCULOSKELETAL DISORDERS
AMONG FOOD DELIVERY RIDERS IN
TERENGGANU, MALAYSIA**

by

ELYAS BIN AHMAD

**Thesis submitted in fulfilment of the requirements
for the
Doctor of Public Health**

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DECLARATION

I, Elyas bin Ahmad, declare that the work presented in this thesis is originally mine.
The information that has been derived from other sources is clearly indicated in the thesis.

Elyas Bin Ahmad

Student ID: P-UD 0080/19

Signed on 25th December 2022

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Factors Associated with Whole-Body Vibration (WBV) exceeding Exposure Action Value (EAV) limit among Food Delivery Riders in Eastern Peninsular Malaysia

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LIST OF ABBREVIATIONS

WMSDs	Work-Related Musculoskeletal Disorders
WBV	Whole-Body Vibration
LBP	Low Back Pain
RTA	Road Traffic Accident
MCO	Movement Control Order
EU	European Union
EAV	Exposure Action Value
ELV	Exposure Limit Value
WHO	World Health Organization
REBA	Rapid Entire Body Assessment
RULA	Rapid Upper Limb Assessment
OWAS	Ovako Working Posture Analysis System
ISO	International Organization for Standardization
BMI	Body Mass Index
NMQ	Standardized Nordic Musculoskeletal Questionnaire
M-SNMQ	Malay-translated Standardized Nordic Musculoskeletal Questionnaire

LIST OF SYMBOLS

$>$	More than
$<$	Less than
$=$	Equal to
$\geq$	More than and equal to
$\leq$	Less than and equal to
α	Alpha
β	Beta
$\%$	Percentage
p	p-value
m/s^2	Meter per second squared

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ABSTRAK

Latar Belakang: Gangguan Muskuloskeletal Berkaitan Kerja (GMBK) pada masa ini menjadi subjek kebimbangan dalam dunia pekerjaan di mana ia merupakan punca utama ketidakupayaan dan ketidakhadiran dalam kalangan pekerja. Fenomena ini menjejaskan ekonomi global akibat pengurangan produktiviti dalam kalangan pekerja. Pandemik Covid-19 telah menyebabkan kesan negatif di dalam dunia pekerjaan di mana ramai orang kehilangan pekerjaan. Di Malaysia, penghantar makanan menggunakan motosikal merupakan pilihan pekerjaan alternatif dan popular terutamanya semasa pandemik Covid-19 kerana perkhidmatan penghantaran makanan disenaraikan sebagai perkhidmatan penting semasa Perintah Kawalan Pergerakan (PKP). Bagaimanapun, kejadian kemalangan jalan raya terus meningkat dengan kadar kematian yang tinggi dalam kalangan penghantar makanan yang menggunakan motosikal. Banyak kajian telah melaporkan GMBK adalah antara faktor yang menyumbang kepada kesalahan tingkah laku jalan raya melibatkan penunggang motosikal di mana GMBK boleh menyebabkan tekanan psikologi dalam kalangan penunggang motosikal. Hal ini membawa kepada kesalahan lalu lintas seperti memandu laju dan melanggar lampu isyarat untuk mengejar jumlah “trip”. Selain itu, terdapat banyak faktor yang dikenalpasti mempunyai kaitan dengan perkembangan GMBK seperti postur bekerja dan pendedahan kepada getaran kronik. Justeru, kajian ini bertujuan untuk menilai postur ergonomik menggunakan kaedah Rapid Entire Body Assessment (REBA) dan pengukuran Getaran Seluruh Badan (GSB) berkaitan GMBK dalam kalangan penghantar makanan menggunakan motosikal di Terengganu.

Metodologi: Kajian keratan rentas telah dijalankan dalam kalangan 191 penghantar makanan menggunakan motosikal di Terengganu, Malaysia. Kaedah persampelan

Bola Salji digunakan dengan “Captain Rider” bertindak sebagai benih. Kajian ini melibatkan soal selidik swa-tadbir, serta penilaian REBA dan pengukuran GSB. Borang soal selidik yang diuruskan sendiri mengandungi soal selidik “Standardized Nordic Musculoskeletal Questionnaire” terjemahan Bahasa Melayu yang telah direka bentuk untuk dilengkapkan dalam masa 30 minit. Kemudian, postur kerja dinilai menggunakan kaedah REBA untuk mengukur risiko GMBK. Selain itu, pengukuran GSB dilakukan menggunakan Larson Davis HVM 100 Human Vibration Meter yang telah ditentukan beserta pad tempat duduk pecutan tiga paksi mengikut piawaian ISO 2631-1. Data dianalisis menggunakan SPSS 20.4 dengan analisis deskriptif, regresi logistik mudah dan berganda telah dilakukan.

Keputusan: Kajian ini membuktikan kadar GMBK yang tinggi (74.9%) dalam kalangan penunggang yang didominasi oleh sakit bahagian pinggang (73.3%). Tambahan pula, min (Sisihan Piawai) Skor REBA Akhir juga adalah tinggi iaitu “5”(0.88) menunjukkan risiko sederhana terhadap pembentukan GMBK yang memerlukan siasatan lanjut dan keperluan perubahan yang perlu dilakukan. Tambahan pula, min (Sisihan Piawai) Pendedahan Getaran Harian, A(8) juga tinggi (0.624 (0.317) m/s²) dan melebihi Nilai Tindakan Pendedahan (NTP). Tiga faktor didapati menjadi faktor yang dikaitkan dengan GSB melebihi paras NTP iaitu purata hari bekerja (aOR=1.56;95% CI=1.11,2.19;p=0.011), kehadiran GMBK (aOR=2.93;95% CI=1.37,6.28;p=0.006) dan penyelenggaraan penyerap hentakan motosikal (aOR=0.39;95%CI=0.19,0.82;p=0.012). Kajian ini juga merumuskan tiga faktor yang mempunyai perhubungan yang signifikan dengan pembentukan GMBK dalam kalangan penghantar makanan menggunakan motosikal di Terengganu iaitu peningkatan purata hari bekerja (aOR=2.00; 95% CI=1.34,2.98 ;p=0.001), GSB

melebihi had NTP (aOR =2.71;95% CI=1.13,6.53;p=0.026), dan tidak melakukan senaman ringan sebelum bekerja (aOR=21.63; 95% CI=7.45,62.79;p<0.001).

Kesimpulan: Kelaziman GMBK yang tinggi dalam kalangan penunggang penghantaran makanan secara signifikan dikaitkan dengan postur tidak ergonomik yang dicerminkan oleh skor REBA yang tinggi dan GSB melebihi tahap NTP. Hasil daripada kajian ini harus digunakan oleh sektor kesihatan sebagai petunjuk untuk melaksanakan perubahan dan menambah baik persekitaran kerja penunggang. Pendekatan pelbagai sektor adalah penting untuk memastikan kelaziman GMBK dalam kalangan penghantar makanan menggunakan motosikal ini dapat dikurangkan yang seterusnya dapat mengurangkan kemalangan jalan raya dan kematian dalam kalangan penunggang.

Kata Kunci: Getaran Seluruh Badan, REBA, Gangguan Muskuloskeletal Berkaitan Kerja

ABSTRACT

Background: Work-Related Musculoskeletal Disorders (WMSDs) were currently a subject of concern on occupational world where they were the leading cause of major disabilities and absenteeism among the workers. These phenomena affected global economic due to reduce in productivity among the workers. Pandemic Covid-19 had caused major drawback in occupational world where many people lose their job. In Malaysia, food delivery riders became the alternative and popular choice of job especially during pandemic Covid-19 as food delivery services were listed as essential service during Movement Control Orders (MCOs). However, the incidence of Road Traffic Accident (RTA) keeps increasing with high mortality rate among the riders. Many studies had reported the WMSDs were among the factors which contributed to the inappropriate riding behaviour among motorcyclist where WMSDs tend to cause psychological distress among the riders. These eventually lead to inappropriate behaviour such as speeding and violation of traffic light to chase for the trips. Meanwhile, there were many factors was revealed to be significantly associated with development of WMSDs such as working posture and exposure to the chronic vibration. Thus, this study aimed to assess the ergonomic posture using REBA Method and WBV measurement in relation with WMSDs among food delivery riders in Terengganu.

Method: A cross-sectional study was conducted among 191 food delivery riders in Terengganu, Malaysia. A snowball sampling method was applied in this study where the “Captain Rider” act as the seed. This study involved answering self-administered questionnaire, REBA assessment and WBV measurement. The self-administered questionnaire contained validated Malay-Translated Standardized Nordic

Musculoskeletal Questionnaire (M-SNMQ) which was designed to be completed within 30 minutes. Then, working posture was assessed using REBA method to quantify the risk of WMSDs. Meanwhile, WBV measurement was done using a calibrated Larson Davis HVM 100 Human Vibration Meter with a tri-axial accelerometer seat pad following ISO 2631-1 standards. The data was then analysed using SPSS 20.4 where descriptive analysis, simple and multiple logistic regression were performed.

Result: This study revealed high prevalence of WMSDs (74.9%) among the riders which predominant by Low Back Pain (LBP) (73.3%). In addition, the mean (SD) Final REBA Score also was high which was “5”(0.88) indicating of medium risk of developing WMSDs which requires further investigation and the need of change to be done. Furthermore, the mean (SD) of Daily Vibration Exposure, $A(8)$ was also high (0.624 (0.317) m/s^2) which exceeded Exposure Action Value (EAV). Three factors were found to be the factors associated with WBV above EAV level which were average working days (aOR=1.56;95% CI=1.11,2.19;p=0.011), presence of WMSDs (aOR=2.93;95% CI=1.37,6.28;p=0.006) and suspension service (aOR=0.39;95%CI=0.19,0.82;p=0.012). This present study also proved that three factor significantly associated with WMSDs development among food delivery riders in Terengganu which were increasing average working days (aOR=2.00; 95% CI=1.34,2.98 ;p=0.001) , WBV above EAV limit (aOR=2.71;95% CI=1.13,6.53;p=0.026), and not doing stretching exercise before work (aOR=21.63; 95% CI=7.45,62.79;p<0.001).

Conclusion: The high prevalence of WMSDs among food delivery riders were significantly associated with unergonomic posture which reflected by high REBA

score and WBV exceeded EAV level. The result from this study should be used by health sectors as an indicator to implement change and improve the working environment of the riders. Multi-sectoral approach is vital to ensure the prevalence of WMSDs among this neglected group can be reduced which in turn can reduce the incidence of RTA and mortality among the riders.

Keywords: REBA, Whole-Body Vibration, Food Delivery Riders, WMSDs

CHAPTER 1

INTRODUCTION

1.1 Ergonomics and Musculoskeletal Disorders (MSDs)

The role of ergonomic factors in development of Musculoskeletal Disorders (MSDs) in occupational world has been a subject of concern worldwide. It also has been focus discussion among occupational health practitioners in recent year. Ergonomics is defined as the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance (IEA, 2015). The main aim of ergonomics was to avoid musculoskeletal disorders (MSDs) and injuries to soft tissues which caused by sudden or prolonged exposure to force, vibration, repetitive motion, and uncomfortable posture (NIOSH, 2018). MSDs which affect hundreds of millions of people around the world, are the most common cause of serious long-term pain and physical disability (Woolf *et al.*, 2012). “Musculoskeletal Disorders” is a term that covers a very diverse category of illness and symptoms where in some cases, the symptoms are very specific to certain physiological and anatomical cause which arise from a known pathological mechanism (Jaiyesinmi *et al.*, 2018). It is currently affecting not only industries, but also general population.

Otherwise, Work-related musculoskeletal disorders (WMSDs) are conditions in which the work environment and performance of work contribute significant development of MSDs; and/or the MSDs were made worse or persists longer due to work conditions (CDC, 2020). WMSDs has been proved to cause significant burden

to the global economy. In the United State and Canada, WMSDs had caused significant burden on their health system which later give huge impact on the economic growth of both country due to high budget allocation on health sector to treat WMSDs among the workers (Baldwin and Kinesiology, 2004). In addition, WMSDs among workers also indirectly caused disturbance in global economic growth due to reduction in the workers productivity. In 2005, the estimated lost due to WMSDs in comparison with workers productivity was 171.7 million USD which representing about 0.2% of Gross Domestic Product (GDP) in Colombia (Piedrahita, 2006). The factors contributing to reduction of productivity among workers affected with WMSDs were absenteeism and job change (Salik and Özcan, 2004; Stock *et al.*, 2014).

Knowledge on ergonomics had been used combatting WMSDs among workers by improving the working posture of the workers in various field. Many ergonomic assessment tools have been introduced in quantifying the postural risk of developing WMSDs. The ergonomic assessment tools vary from easiest form such as observational method until the sophisticated form such as computer analysis method. However, the most famous method used by researchers was pen and paper method because of high accuracy despite less expensive and less time consuming (Li and Buckle, 2000). In addition, the choose of ergonomic assessment method were heavily depend on the time and resources availability (David, 2005). Later, the ergonomic posture assessed were used by ergonomist to improve the working posture. However, with the introduction of machineries that requires certain unnatural working posture, the multidisciplinary approach must be taken to improve the workstation such as by using hierarchy of control like engineering control to reduce the prevalence of WMSDs among the workers. For example, the used of arm support and alternative computer

mouse had reduced the prevalence of neck and shoulders pain among office workers (Hoe *et al.*, 2018).

1.2 Work-Related Musculoskeletal Disorders (WMSDs) among motorcyclists

Occupational motorcyclists were among high-risk group to develop WMSDs. Many studies worldwide had revealed high prevalence of WMSDs among motorcyclist (Jaiyesinmi *et al.*, 2018; Ramasamy *et al.*, 2017; Ullah *et al.*, 2022). In particular, occupational motorcyclists were found to have higher prevalence of WMSDs as compared to non-occupational motorcyclists. This could be due to prolong exposure to static position, prolong riding time and prolong exposure to vibration (Diyana *et al.*, 2019). Furthermore, motorcycle riding posture provide unnatural workstation for the riders as there are minimal position adjustment can be made during riding process to meet the riders need (Karmegam *et al.*, 2013). In Malaysia , Hafzi *et al.* (2011) reported that, the prevalence of Low Back Pain (LBP) among occupational motorcyclist was higher (82.3%) compared to non-occupational motorcyclist (62.8%).

WMSDs were postulated as one of the indirect causes of Road Traffic Accident (RTA) among motorcyclist as it can directly affect the psychosocial factor of an individual. MSDs was described as an iceberg floating in the a social sea (Sauter and Moon, 1996). According to WHO (2018), there were three main factors of RTA among motorcyclists which were individualfactor, road condition and vehicle condition. The individual factors include fatigue, inappropriate driving, and psychological distress. Many studies proved significant association between these individual factors and WMSDs (Bolghanabadi and Pour, 2014; Carayon *et al.*, 1999b; Sauter and Moon, 1996). In addition, Michael *et al.* (2014) proved that, psychological distress among

motorcyclists predisposed them to inappropriate driving attitude especially speeding which predisposed them to involve in RTA.

1.3 Effect of Pandemic Covid-19

Pandemic Covid-19 caused many people lose their job. People started to search for other alternatives to gain money during the pandemic in order to pay for their daily basic needs. In Malaysia, becoming a food delivery rider was among the job of choice to substitute their old job. Moreover, food delivery service was listed as one of the essential services by Malaysian Government during Movement Control Order (MCO) implementation since 18 March 2020 as the alternative for the citizen to buy their food through online services because they were not allowed to dine in during MCO. There were many food delivery services companies operated during this period. MCO was implemented a preventive measure by the federal government of Malaysia in response to the COVID-19 pandemic in the country (KPDNHEP, 2021). This caused becoming food delivery riders a popular choice among Malaysian citizen as the demand keeps increasing from time to time. However, with increasing demand and increasing number of people becoming food delivery riders in Malaysia, the occurrence of RTA among food delivery riders also keep increasing. According to Malaysia Institute of Road Safety Research (MIROS), in 2019 alone, although there was not a specific breakdown for delivery riders, 66% of people killed from RTA in Malaysia were motorcyclist with often headlines in the news about accident involving food delivery riders (Dave, 2020).

1.4 Food Delivery Services in Malaysia

Food delivery services has been introduced since 2013 in Malaysia. However, the demand was exponentially increased especially during MCO as people tend to

order their food through online services because their movement was restricted and dining inside food premises was prohibited. Currently, there are more than 20 food delivery service companies available in Malaysia such as Food Panda, Grab Food, Bungkus-It, Running Man, Lalamove, and others. In 2021, there were more than 30000 registered Food Panda riders across the country who worked for more than three trips per hour to deliver food to the customers (Surin, 2021). In every state, there will be an appointed person to be a leader among the riders for every company known as “Captain Rider”. The riders work in shift system where most of them worked more than 8 hours a day. The average delivery time was 30-40 minutes depending on the location and traffic. The riders earn their salary based on the trips they had on that day. The more trip they did means more money in return. This caused them to chase as many trips as possible to raise more income for living which in long run can cause physical and psychological distress among the riders. This phenomenon was translated into increasing trend of RTA among food delivery riders worldwide. For instance, there were 1317 injuries involving food delivery riders in Korea which required compensation from the government in 2015 (Byun *et al.*, 2020). In Malaysia, there were 1242 cases of RTA reported involving food delivery riders from 2018 until May 2019 which constitute of 1,048 light injuries, 82 serious injuries and 112 deaths (Martin *et al.*, 2022). Unfortunately, the trend keeps increasing where in 2021, out of 2576 RTA mortality cases among motorcyclist in Malaysia, 1700 mortality were RTA cases among food delivery riders and more than 70% of food delivery riders were caught doing traffic misconduct during the MCO such as speeding and violating traffic light (MIROS, 2021).

1.5 Problem Statement

Food delivery riders were high-risk group of developing WMSDs. The development of WMSDs could be due to prolong exposure to static position, longer riding duration and prolong exposure to vibration (Diyana et al., 2019). The WMSDs among the riders had been proved to be the indirect factor which contributed to the occurrence of RTA among the riders. This was explained by Michael *et al.* (2014) where MSDs can lead to psychological distress among the riders which later affected their driving behaviour and made them tend to speed during working. With increasing trend of more people becoming food delivery riders in Malaysia, more incidence of RTA among food delivery riders in Malaysia were expected to be occurred if no immediate action is taken. With limited local studies among food delivery riders in Malaysia, initial step must be made to find the root cause.

1.6 Study Rationale

This was an exploratory research in which by conducting this research, we could establish the magnitude and depth of the issues. The information obtained from this research, hopefully would be the basis of further interventional studies of programme in the near future as there were very limited knowledge on WMSDs among food delivery riders in Malaysia. In addition, this research also might be the basis of other engineering innovation for ergonomics studies to improve the workstation (motorcycle used) among food delivery riders. Through this research, we also can create more awareness among riders and their employers regarding WMSDs and the need for training and early screening of the problem so that it can be prevented in early phase. Finally, this research can be the basis of other preventive and monitoring programme where the long-term aim of this study would be to reduce the incidence of RTA among

this high-risk group subsequently would reduce the mortality and morbidity among food delivery riders in Malaysia.

1.7 Research Questions

- 1) What is the prevalence of Work-Related Musculoskeletal Disorders (WMSDs) among food delivery riders in Terengganu?
- 2) What are ergonomic posture scores using REBA (Rapid Entire Body Assessment) methods among food delivery riders in Terengganu?
- 3) What is the level of Whole-Body Vibration (WBV) experienced by food delivery riders in Terengganu in comparison with the limit values required by European Directive 2002/44/EC?
- 4) What are the factors associated with WBV among food delivery riders in Terengganu?
- 5) What are the associated factors of WMSDs among food delivery riders in Terengganu?

1.8 Objectives

1.8.1 General

To assess the ergonomic posture using REBA Method and Whole-Body Vibration (WBV) measurement in relation with Work-Related Musculoskeletal Disorders (WMSDs) among food delivery riders in Terengganu.

1.8.2 Specific

- 1) To determine the prevalence of Work-Related Musculoskeletal Disorders (WMSDs) among food delivery riders in Terengganu.
- 2) To assess the ergonomic posture of motorcycle riding using REBA (Rapid Entire Body Assessment) methods among food delivery riders in Terengganu.
- 3) To measure the level of Whole-Body Vibration (WBV) experienced by food delivery riders in Terengganu and compare the parameters with the limit values required by European Directive 2002/44/EC.
- 4) To determine the factors associated with WBV exposure above Exposure Action Value (EAV) limit among food delivery riders in Terengganu.
- 5) To determine the associated factors of WMSDs among food delivery riders in Terengganu.

1.9 Hypothesis

- 1) There is high prevalence of Work-Related Musculoskeletal Disorders (WMSDs) among food delivery riders in Terengganu.
- 2) There is high final REBA score among food delivery riders in Terengganu.
- 3) The level of Whole-Body Vibration (WBV) experienced by food delivery riders in Terengganu exceeds the EAV limit required by European Directive 2002/44/EC.
- 4) Motorcycle factors and individual factors are the factors associated with WBV above EAV level among food delivery riders in Terengganu.
- 5) There are significant associations between sociodemographic factors, occupational factors, REBA score, and Whole-Body Vibration with WMSDs among food delivery riders in Terengganu.

CHAPTER 2

LITERATURE REVIEW

2.1 Prevalence of MSDs among motorcyclists

Most of the studies used Standardized Nordic Musculoskeletal Questionnaire (NMQ) to quantify the prevalence of MSDs among motorcyclists. NMQ was developed by Kuorinka *et al.* (1987) where the prevalence of MSDs were divided into four categories which are lifetime prevalence, 12-months prevalence, 1-month prevalence, and 7-days prevalence based on eight specific body regions. Study by Montolalu *et al.* (2018) revealed all respondents of online transportation riders in Indonesia complaint at least one region of musculoskeletal pain. Moreover, majority of them claimed to experience WMSDs symptoms after working hours. Meanwhile in a systematic review by Ospina-Mateus and Quintana Jiménez (2019) showed almost all of the studies (83%) included evidence that physical fatigue and postural discomfort affect the performance and are related to musculoskeletal conditions where 63% of the studies named lower back pain (LBP) as the most reported MSDs among motorcyclist followed by shoulder/forearms, neck and buttock pain with 51%, 43% and 34% of the studies respectively.

In Malaysia, more than half of the general population who rode motorcycle experienced body discomfort (Karmegam *et al.*, 2009). In comparison among occupational motorcyclists and non-occupational motorcyclists among Malaysian, a study by Hafzi *et al.* (2011) revealed a higher prevalence of MSDs among occupational motorcyclist compared to non-occupational motorcyclists (82.3% vs 62.8%) which the most reported MSDs was LBP. However, this study did not include food delivery

riders as their participant. Meanwhile, Diyana *et al.* (2019) also reported high prevalence of MSDs (67.9%) among male traffic policemen using high-powered motorcycles in Malaysia due to long static position on motorcycle and long riding period.

2.2 Rapid Entire Body Assessment (REBA) method

REBA is a postural ergonomic assessment method developed by Hignett and McAtamney (2000). The development of REBA aimed to make a postural analysis system sensitive to musculoskeletal risks in a variety of tasks, divide the body into segments to be coded individually, with reference to movement planes, provide a scoring system for muscle activity caused by static, dynamic, rapid changing or unstable postures and give an action level with an indication of urgency. REBA was quite easy to be performed as it requires minimal equipment. In addition, REBA was categorized under pen and paper observational method of ergonomic postural assessment. Other groups include computer-assisted analysis, self-reported assessment tools, and direct instrumental methods (Li and Buckle, 2000).

The advantages of using REBA for ergonomic postural assessment were more versatile and less expensive in term of time allocation and other resources such as money and sophisticated software as compared to other objective laboratory measures (Micheletti Cremasco *et al.*, 2019). A study on comparison between most available postural assessment methods which were REBA, Rapid Upper Limb Assessment (RULA), Agricultural Lower Limb Assessment (ALLA) and Ovako Working posture Assessment (OWAS) revealed REBA had 100% hit rate of expert assessment of working posture as compared to RULA, ALLA and OWAS (Kong *et al.*, 2018). Moreover, REBA was used in many occupational fields as an ergonomic tool to

quantify the MSDs risk among the workers so that more innovation and adjustment can be made in order to ensure the workstation can be as ergonomic as possible to the workers postural adaptation.

2.3 Ergonomic Posture Assessment on motorcyclist by REBA

To the best researcher search, most of the ergonomic posture assessment on motorcyclists done using REBA method. This was due to unique features hold by REBA which make it the method of choice for postural assessment on motorcyclist. Most of the studies revealed at least moderate risk level on REBA score. For example Dutta *et al.* (2017) reported moderate to high risk of MSDs level on RULA and REBA among motorcyclist in India. A study in Indonesia by Rahmawati and Utami (2020) also revealed high REBA score among motorcyclist indicated high risk which required corrective measures as soon as possible. In addition, Montolalu *et al.* (2018) also reported final REBA score among online transportation riders in Indonesia showed a moderate risk level of developing MSDs which required further action need to be taken. Furthermore, REBA score can be highly associated with the types of workstations where the workers had very limited postural adjustment capacity to meet their need. For motorcyclists, the types of motorcycle used plays very important roles in postural assessment score where Rashid *et al.* (2014) concluded changes in different riding posture in different types of motorcycle namely sedan, standard and cruiser, caused high discomfort among the riders.

2.4 Whole Body Vibration (WBV)

Whole-body vibration is defined as: “mechanical vibration that, when transmitted to the whole body, entails risks to the health and safety of workers, in particular lower-back morbidity and trauma of the spine”(Griffin and Medicine,

2004). Exposure to WBV at low levels was unlikely on its own to cause back injury, but it can aggravate existing back injuries which may cause pain. In centuries, chronic exposure to WBV has been shown to cause back pain especially on the lower part among workers. For example, Bovenzi (1996) found that there was significant association with total WBV dose with WMSDs among tractor and bus drivers. In addition, LBP has been shown to be the leading major cause of industrial disability in the population under the age of 45 years and has been linked to whole body vibration exposure (HSA, 2022).

In 2002, European (EU) Vibration Protection Directive 2002/44/EC had come out with regulation on vibration to ensure minimum safety requirement being implemented on the workers to reduce vibration related illness. The directive has come out with WBV limit values which are Exposure Action Value (EAV) and Exposure Limit Value (ELV). The EAV limit value was 0.5 m/s^2 while ELV limit value was 1.15 m/s^2 . In addition, when the WBV exposure exceeded EAV limit value, the directive suggested the employers to establish any programs related to reduce the exposure level. However, workers should not be exposed to any vibration exceeded ELV level. The total WBV exposure measured in Daily Vibration Exposure (8-Hour Weighted, A8) (OSHA, 2002). Meanwhile, motorcyclists were among high risk group subjected to extreme WBV due to the vibrations of its engine, improper structural design of the motorcycle and the bad road conditions (Shivakumara *et al.*, 2010).

2.5 Factors associated with WBV among motorcyclists

There were four main factors can affect the WBV among motorcyclist namely individual factors, working factors, motorcycle factors and environmental factors. However, in this study, will focus more on motorcycle factors, working factors, and

individual factors due to limited time and resources. For motorcycle factors, Moreno *et al.* (2011) reported that engine size and motorcycle age were among significant predictors of WBV among riders where Exposure Action time Value (EAV) is higher for newer motorcycles and big engine size. In addition, (Chen *et al.*, 2009) revealed types of motorcycles were among predictors of WBV among motorcyclist where WBV exposure levels of common motorcycle riders are distinctively higher than those of scooters and motorbikes, even on a regular paved road. Seat and suspension also can affect the magnitude of WBV transmitted to the motorcyclist where the vibration magnitude was significantly influenced by the location of rider seat and the stiffness of the suspension (Ndimila *et al.*, 2015).

For individual factors, Ciloglu *et al.* (2015) proved that weight of the riders will also determine the magnitude of WBV transmission where WBV was significantly reduce with lower riders weight. Moreover, individual working posture and Body Mass Index (BMI) also had been shown to have positive association with WBV (Kumar *et al.*, 2021). Furthermore, WBV dose was significantly correlated with working hours where longer working hours predispose the workers toward more cumulative vibration dose. In particular, Maeda *et al.* (1998) suggested that the workers should not work for more than 2.5 hours daily due to excessive exposure to WBV dose.

2.6 WBV in comparison to EAV and ELV limit values

There were many international standards available to compare the vibration level measured such as EU Directive 2002/44/EC, ISO-2631 and BS-6841. In this particular research, we used standard values mention in EU Directive 2002/44/EC while the measurement method was used according to ISO-2631 suggested by the directive. The

ISO-2531 standards suggested that WBV must be measured in the three translational axes with specific guidelines and requirements (ISO, 2010). Several studies worldwide had shown the WBV exceeded the EU Directive 2002/44/EC. For example in a study by Eger *et al.* (2011) revealed the daily vibration exposure after intervention was still above EAV limit value even though other parameters were below ISO-2631-1 limit values among speed train operators. Among motorcyclists, a study by Roseiro *et al.* (2016) concluded the riders had daily vibration exposure exceeding the limit values regulated by EU Directive 2002/44/EC when they rode outside the track. However, to the best researcher search, there was still limited knowledge on WBV measurement among food delivery riders in comparison with EU Directive 2002/44/EC.

2.7 Sociodemographic Factors associated with WMSDs

Sociodemographic factors had been proved to play an important role in WMSDs development among the workers. Karmegam *et al.* (2013) concluded that gender's difference can predispose motorcyclists to different risk of getting WMSDs as the mean discomfort score for female on thighs and calf leg below knee are significantly higher than the male mean score. There were also significant differences on thighs ($p < 0.001$) and calf leg below knee ($p < 0.001$) was recorded between the male and female motorcyclists in Malaysia. In addition, a systematic review by Alias *et al.* (2016) also came to the same conclusion where female motorcyclist also had a higher number (total) of significance on discomfort symptoms (56%) compared to male motorcyclists (51%). In other study, age has been found to be a significant factor for development of WMSDs where Jaiyesinmi *et al.* (2018) revealed a significant association between age groups and WMSDs among commercial motorcyclist in Ibadan North Local Government Area, Nigeria ($p < 0.001$).

Moreover, WMSDs development among the workers also has been showed to have association with Body Mass Index (BMI) where a study by Amin *et al.* (2014) among nurses in Malaysia concluded a significant association between BMI and pain or discomfort in upper limbs (OR: 1.05, 95% CI: 1.00-1.11). Furthermore, marital status was found to be significantly associated with development of MSDs reported among male traffic policemen using high-powered motorcycles in Malaysia (Diyana *et al.*, 2019). In addition, smoking habit and exercise also were among factors that had association with WMSDs where Dalimunthe and Ramdhan (2019) revealed strong association of smoking habit (OR = 5.104, $p < 0.001$) and exercise activity (OR = 10.688, $p < 0.001$) with WMSDs among Ojek Riders in Indonesia. A short period of exercise before work was very beneficial to the workers as a meta-analysis by Harvey *et al.* (2017) revealed stretching exercise which had been done between five to ten minutes before starting their activities can reduce the incidence of muscle soreness. Finally, Assuncao and Abreu (2017) showed higher education level was significantly associated with WMSDs among Brazilian population ($p < 0.001$).

2.8 Occupational Factors associated with WMSDs

In previous studies, several occupational factors were shown to be significantly associated with WMSDs namely working experience, working duration and working distance. For instant, years of service was among significant risk factor for high prevalence of MSDs among male traffic policemen using high-powered motorcycles in Malaysia (OR 1/4; 0.152, 95% CI: 0.040, 0.567) (Diyana *et al.*, 2019). In addition, it was proved Amin *et al.* (2020) that nurses with longer work service had shown to experience greater risk of WMSDs. For working duration, many studies concluded that the development of WMSDs was significantly associated with longer working

duration (Hafzi *et al.*, 2011; Sadri, 2003; Tamrin *et al.*, 2014). Finally, Porter and Gyi (2002) revealed positive, significant correlations between annual mileage and the number of occasions (Pearson's r correlation coefficient = 0.1, $P \leq 0.05$) and days ever absent from work ($r = 0.2$, $P \leq 0.001$) with low back trouble.

2.9 Association of REBA and WBV with WMSDs

Many studies had proved significant association between MSDs and REBA. For example, Samaei *et al.* (2017) found a significant correlation between MSDs and the final REBA score where for a one-unit increase in score, the risk or complaint of neck and low back pain increased by 48.5% and 37.1% respectively. In addition, Kazemi (2016) also revealed significant relationship between different parts of body region namely neck pain, hip pain, shoulder pain, elbow pain, and wrist pain and REBA score ($p < 0.05$). Regarding WBV, Xu *et al.* (1997) proved that exposure to whole body vibration (WBV) was an important factor associated with MSDs and the most frequently reported adverse effects was LBP (OR=1.28). Furthermore, WBV also had been demonstrated to directly cause lumbago, sciatica, and intervertebral disc herniation and degeneration (Teschke *et al.*, 1999).

2.10 Conceptual Framework

Based on literature review, sociodemographic factors, occupational factors, REBA, and WBV parameters were among factors found to be significantly associated with development of WMSDs among workers. In this research, we also had measured the factors associated with WBV as it affected directly on the measurement of the WBV parameters. However, due to limited resource and time, we were not able to measure the environmental factors and psychological factors as illustrated in Figure 2.1.

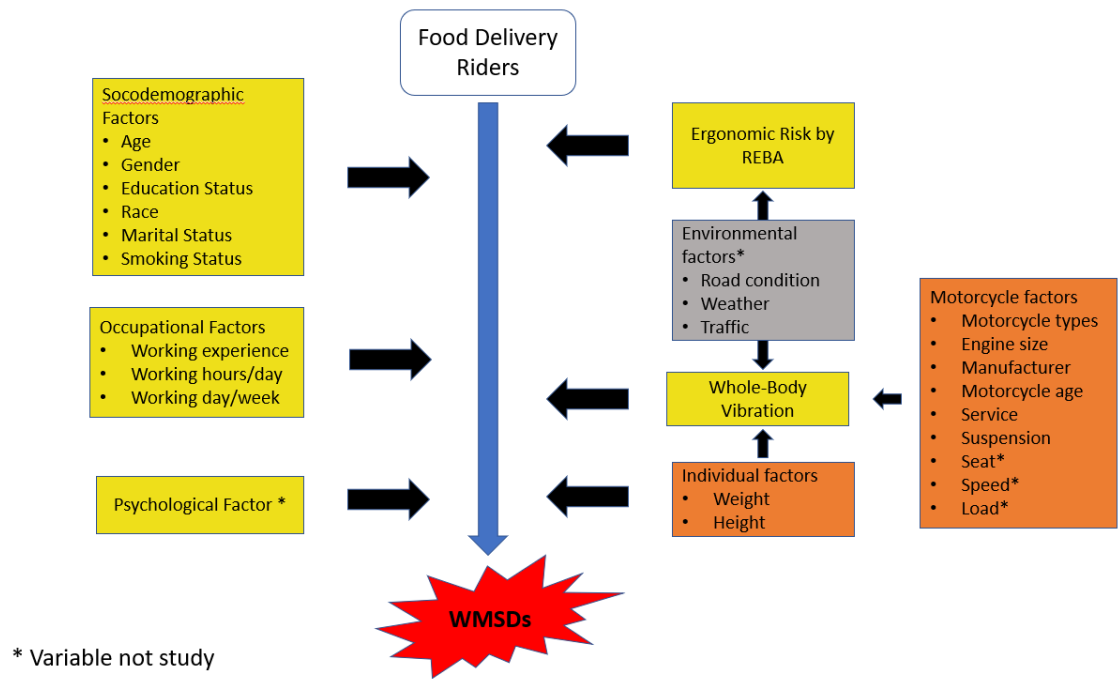


Figure 2.1: Conceptual Framework

CHAPTER 3

METHODOLOGY

3.1 Research design

This was a cross-sectional study involving 191 food delivery riders in Terengganu, Malaysia

3.2 Study area

This study was conducted in Terengganu, Malaysia. This area also known as North-Eastern of West Malaysia. It covers almost 13000 km² area. The state of Terengganu is bounded by Kelantan on the north and northwest, South China Sea on the east and Pahang on the south and southwest. It has eight districts namely Hulu Terengganu, Kuala Terengganu, Kuala Nerus, Marang, Dungun, Kemaman, Setiu, and Besut as shown in Figure 3.1. The total population in 2021 was around 1.1 million with Malay majority which were more than 95% of total population (DOSM, 2022). Terengganu was selected as the study area as the “Captain Rider” in Terengganu agreed to give cooperation in making this study successful. In addition, there were more than 500 registered food delivery riders operated in Terengganu.



Figure 3.1: Map of Terengganu

3.3 Study duration

This study was initially planned to be conducted between July 2021 and March 2022. However, due to pandemic Covid-19, the study was extended to September 2022 due to difficulty in completing data collection.

3.4 Study population

3.4.1 Reference population

All food delivery riders in Malaysia

3.4.2 Source population

All food delivery riders registered with “X” company in Terengganu. The purpose of choosing only one food delivery service company was to ensure the homogeneity in the working shift.

3.5 Study criteria

3.5.1 Inclusion criteria

The inclusion criteria include fulltime food delivery rider, riders with working experience as food delivery rider more than 6 months and able to comprehend and read Bahasa Melayu

3.5.2 Exclusion criteria

In this study, rider with congenital musculoskeletal disorders and with recent motor vehicle accident (MVA) were excluded to minimize any possible bias as person with congenital MSDs tend to deteriorate faster even with slight external factors.

3.6 Sample size estimation

3.6.1 Objective 1: To determine the prevalence of WMSDs among food delivery riders in Terengganu

Sample size calculated using single proportion formula as shown in Table 3.1.

$$n = \left(\frac{Z_{(1-\alpha/2)}}{\Delta} \right)^2 P(1 - P)$$

- n= number of participants required
- $Z_{1-\alpha/2}$ = Level of confidence
- If 95% level of Confidence, $\alpha=5\%$
- P= Population's proportion (from previous study)
- Δ =precision of estimation (one side)

Table 3.1: Proportion of WMSDs among motorcyclists

Z (95% CI)	Δ	P	n	N (n+10%)	Reference
1.96	0.10	0.82	57	64	Hafzi et al., 2011
1.96	0.10	0.92	114	127	Jaiyesinmi et al., 2018

3.6.2 Objective 4: To determine the factors associated with WBV exposure above EAV limit among food delivery riders in Terengganu

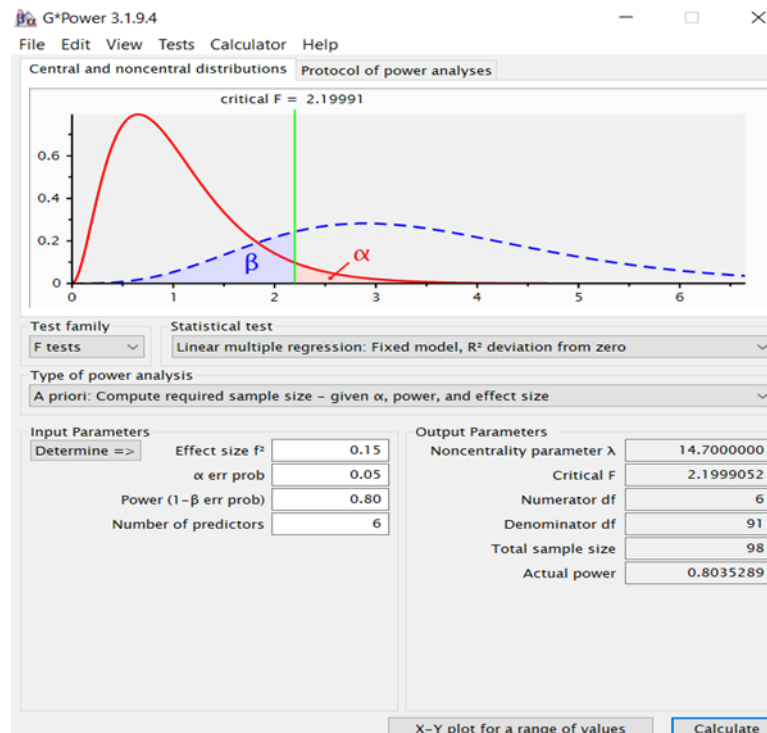


Figure 3.2. G-Power Software

- Multiple logistic regression analysis was used to identify factors associated with of Whole-body Vibration parameters (RMS, VDV,)
- The sample size calculated using G*Power software ver.3.1 as shown in Figure 3.2.
 - Effect size : 0.15 (medium)
 - α : 0.05
 - β : 0.80
- Sample size calculated:
 - 98
- Adjusted sample size with 10 % anticipated dropout
 - **109**

3.6.3 Objective 5: To determine the associated factors of WMSDs among food delivery riders in Terengganu

Sample size calculated using 2 independent proportions as shown in Table 3.2.

$$n = \left(\frac{m+1}{2m} \right) \frac{(P_1(1-P_1) + P_0(1-P_0))}{(P_1 - P_0)^2} \left(Z_{(1-\frac{\alpha}{T})} + Z_{(1-\beta)} \right)^2$$

- n= number of participants required
- m= ratio between the control to cases
- Po= Proportion among controls
- P1= Estimated proportion among cases
- α = Type I error (level of significance)
- T= number of tail (usually two tailed)
- 1- β = power of study

Table 3.2: Proportion values of factors with significant association on WMSDs

Variables	α	m	p0	p1	n	(n x 2) + 10%	References
Marital Status	0.05	1	0.33	0.60	52	114	(Amin et al., 2014)
Education Status	0.05	1	0.18	0.40	66	145	(Tamrin et al., 2014)
BMI	0.05	1	0.44	0.65	87	191	(Tamrin et al., 2014)
Gender	0.05	1	0.43	0.65	80	176	(Karmegam et al., 2013)
Working Hours	0.05	1	0.28	0.50	76	167	(Awang Lukman et al., 2019)

Po = Proportion of exposed factors associated with no WMSDs

P1 = Estimated proportion exposed factors associated with WMSDs

Power of study = 80%, α = 0.05, Dropout rate = 10%

3.6.4 Summary of sample size

Table 3.3: Summary of Sample Size

No	Objectives	Highest Required Sample Size
1	To determine the prevalence of Work-Related Musculoskeletal Disorders (WMSDs) among food delivery riders in Terengganu	127
2	To determine the factors associated with WBV exposure above EAV limit among food delivery riders in Terengganu	109
3	To determine the associated factors of WMSDs among food delivery riders in Terengganu	191

In conclusion, the sample size of this study followed the highest sample size calculated which were **191** respondents as summarized in Table 3.3.

3.7 Sampling method and subject recruitment

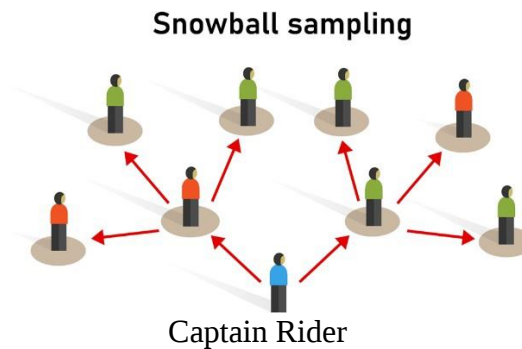


Figure 3.3: Snowball sampling method

Snowball sampling method was applied as illustrated in Figure 3.3. All participants were selected based on study criteria while the “Captain Rider” act as the “seed”. Even though this sampling method was non-probability types of sampling method, this was the best method to ensure privacy and confidentiality among the respondent. During pre-survey interviews with “Captain Rider”, he claimed most of the respondent did not want to disclose their identity because there were riders used to had higher job status before becoming food delivery rider.

3.8 Research tools

3.8.1 Proforma checklist

In this study, a proforma checklist was used to identify related independent variables which may contribute to the development of Work- Related Musculoskeletal Disorders such as sociodemographic information and occupational information. Meanwhile, in order to identify related independent variables which may affect the whole-body vibration measurement, a proforma checklist was used to identify the motorcycle information used by the riders.