UNIVERSITI PUTRA MALAYSIA

EFFECT OF PROTOTYPE ARMREST ON COMFORT AND MUSCLE ACTIVITY AMONG SELECTED MALE UNIVERSITY MOTORCYCLISTS DURING PROLONGED RIDING PROCESS

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December 2015

Chair: Sharifah Khadijah binti Syed Ismail, PhD
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Introduction: Motorcycles had become one of the most popular modes of transportation, well accepted by Malaysians. The awareness for the need safety in motorcycles has increased, with more inventions being applied to ensure safety and comfort motorcyclist. However, motorcyclist struggles with discomfort of their arm during prolonged riding as most of motorcycles in market are not equipped with arm posture support. Riding motorcycles without armrest can cause adverse health and psychological effects among motorcyclist in a long term. Therefore, the primary aim of this study is to examine the effect of using prototype armrest in terms of discomfort rating and muscle activity on the selected male university motorcyclists during prolonged riding process.

Method: This study was experimental study among male students and staffs in Universiti Putra Malaysia (UPM). A total of 102 motorcyclists had participated in this study with 51 motorcyclists of experimental group were asked to sit on a motorcycle with armrest and another 51 motorcyclists of control group sat on a motorcycle without armrest. The experiment took place in a quiet room in a laboratory with adequate lighting. Each respondent had to attend experimental sessions on two different days (with a minimum three day interval between them). Each session had lasted for 2-hour. During the 2-hour session, a riding simulator system was displayed and respondents were asked to control the handlebar of motorcycle as in real road. The video screen of the riding simulator presented a view of road scenery with computer generated video simulating daytime riding condition. At every 15-minute interval, respondents were required to evaluate their discomfort level for all body part on the Borg's CR-10 questionnaire. The Borg's Scale Rating ($\geq$ 5) is considered as the 'break point', as point where the respondents rated their discomfort as strong. Therefore, this point considered where the respondents started to feel the discomfort in their parts of body. Besides that, Electromyography signals were used to monitor recorded muscle activity for the right and left arm of the respondents with the surface of electrodes attached.

Results: The discomfort rating of the experimental group had showed 5% to 15% reduction compared to the control group during the testing period. Results showed that the discomfort rating of arm and hands was significantly lower (2.0 ± 2.20, $p<0.05$) among experimental group compared to control group. In terms of discomfort 'break point' (Borg's Scale Rating ≥ 5), arms and hands are the most affected body parts prior to +82% comfort changes with the use of the prototype armrest. Muscle activity of respondents showed that there are 10% to 25% reductions of electromyography levels for both right and left arm's muscles. There is a positive effect of exertion changes (%) on the flexor carpum radialis (right=24.54%, left=23.98%) and flexor carpum ulnaris (right=8.18%, left=10.62%) muscles of both arms with usage of prototype armrest. The results also revealed that there were significant exertion (X^2 (63) = 757.76, $p<0.001$) of electromyography levels among experimental group compared to the control group with 2-hour riding process.

Conclusion: This study has provided new insights into the effects of prototype armrest usage on motorcyclists during prolonged riding process in a controlled laboratory session. The use of prototype armrest has provided a beneficial ergonomic feature which reduces muscle and body's discomfort and increase riding performance with less negative impact on muscle activity among motorcyclist. Motorcyclists' riding posture is also related to both comfort and discomfort during the riding process. This shows prototype armrest is capable of providing an ideal support and provide comfort to the motorcyclists during prolonged riding process. Therefore, this prototype armrest may reduce fatigue and indirectly reduce accident that contributed by human factors.

Keywords: Prototype, armrest, comfort, muscle activity, motorcyclists, riding process.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KESAN PROTOTAIP PELETAK LENGAN KE ATAS KESELESAAN DAN AKTIVITI OTOT DALAM KALANGAN PENUNGGANG MOTORSIKAL LELAKI UNIVERSITI TERPILIH KETIKA PROSES MENUNGGANG YANG LAMA

Oleh

AYUNI NABILAH BINTI ALIAS

Disember 2015

Pengerusi: Sharifah Khadijah binti Syed Ismail, PhD
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Pengenalan: Motorsikal ini telah menjadi satu medium pengangkutan yang paling popular, dan diterima baik oleh masyarakat Malaysia. Kesedaran terhadap keperluan keselamatan pada motorsikal juga telah berkembang, dan lebih banyak ciptaan yang diguna pakai ke arah lebih selamat dan selesa ketika penunggang motorsikal. Walau bagaimanapun, penunggang motorsikal berdepan dengan ketidakselesaan lengan mereka semasa menunggang dan kebanyakan motorsikal dalam pasaran tidak dilengkapi dengan alat sokongan lengan. Motorsikal tanpa sokongan lengan boleh memberi kesan kepada kesihatan dan psikologi dalam kalangan penunggang motorsikal dalam jangka panjang. Oleh itu, tujuan utama kajian ini adalah untuk mengkaji kesan prototaip peletak lengan dari segi ketidakselesaan dan aktiviti otot pada penunggang motorsikal lelaki university terpilih semasa proses menunggang yang lama.

Kaedah: Kajian ini adalah kajian eksperimental dalam kalangan pelajar dan staf lelaki di Universiti Putra Malaysia (UPM). Sejumlah 102 responden telah menyertai kajian ini dengan 51 penunggang motorsikal untuk kumpulan eksperimen dikehendaki duduk di atas motorsikal dengan sokong lengan dan 51 penungang motorsikal untuk kumpulan terkawal duduk di atas motorsikal tanpa sokongan lengan. Eksperimen ini berlangsung di dalam bilik yang senyap di makmal dengan pencahayaan yang mencukupi. Setiap responden dikehendaki menghadiri sesi ujian pada dua hari yang berbeza (dengan selang tiga hari minimum antara dua sesi). Setiap sesi berlangsung selama 2 jam. Selama sesi 2 jam, sistem simulator menunggang telah memancarkan pemandangan dan keadaan jalan raya menggunakan komputer yang dijana oleh video

simulasi pada siang hari. Setiap 15 minit, responden dikehendaki menilai tahap ketidakselesaan di setiap bahagian anggota badan di dalam borang soal selidik Borg CR-10. Tahap ketidakselesaan Borg ($\geq$ 5), dianggap 'pecahan ketidakselesaan', pecahan dimana responden menilai tahap ketidakselesaan sebagai kuat. Dengan itu, pecahan ini dianggap bahawa responden mula merasai ketidakselesaan pada anggota badan tertentu. Selain itu, isyarat elektromiografi telah digunakan untuk memantau aktiviti yang direkodkan pada otot lengan kiri dan kanan dengan permukaan elektrod yang dipasang.

Keputusan: Tahap ketidakselesaan dalam kumpulan eksperimen telah menunjukkan 5% hingga 15% penurunan berbanding kumpulan kawalan sepanjang tempoh ujian. Keputusan juga menunjukkan bahawa tahap ketidakselesaan bahagian lengan dan tangan adalah jauh lebih rendah (2.0 ± 2.20, $p<0.05$) antara kumpulan eksperimen berbanding untuk mengawal kumpulan. Dari segi ketidakselesaan 'break point' (Borg di skala > 5), lengan dan tangan adalah bahagian badan yang paling terjejas dengan 82% perubahan keselesaan setelah menggunakan prototaip peletak tangan. Aktiviti otot responden menunjukkan bahawa terdapat 10% hingga 25% pengurangan tahap elektromiografi pada otot di kedua-dua belah lengan. Terdapat kesan positif penggunaan perubahan (%) kepada kedua-dua otot lengan iaitu *flexor carpum radialis* (kanan=24.54%, kiri=23.98%) dan *flexor carpum ulnaris* (kanan=8.18%, kiri=10.62%) dengan penggunaan prototaip peletak tangan. Keputusan juga mendedahkan bahawa terdapat ketegangan ketara (X^2 (63) = 757.76, $p<0.001$) tahap elektromiografi antara kumpulan eksperimen berbanding kumpulan kawalan dalam 2 jam proses menunggang.

Kesimpulan: Kajian ini menunjukkan perspektif baru mengenai kesan penggunaan prototaip peletak lengan ke atas penunggang motorsikal semasa proses menunggang dalam sesi makmal yang terkawal. Penggunaan prototaip peletak lengan telah memberikan ciri ergonomik yang bermanfaat yang mengurangkan ketidakselesaan badan dan meningkatkan prestasi dengan pengurangan aktiviti otot antara penunggang motorsikal. Posisi penunggang motorsikal juga berkaitan dengan selesa dan rasa tidak selesa semasa proses menunggang. Ini menunjukkan bahawa prototaip peletak lengan mampu memberikan sokongan yang ideal dan memberikan keselesaan kepada penunggang motorsikal semasa proses menunggang. Oleh itu, prototaip peletak lengan ini mungkin prototaip mengurangkan keletihan dan secara tidak langsung boleh mengurangkan kemalangan disebabkan oleh faktor manusia.

Kata kunci: Prototaip, peletak lengan, keselesaan, aktiviti otot, penunggang motorsikal, proses menunggang.

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I certify that a Thesis Examination Committee has met on 3 December 2015 to conduct the final examination of Ayuni Nabilah binti Alias on her thesis entitled "Effect of Prototype Armrest on Comfort and Muscle Activity among Selected Male University Motorcyclists during Prolonged Riding Process" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science (Occupational Health and Safety).

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- the research conducted and the writing of this thesis was under our supervision;
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Signature: __________________________
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Signature: ___________________________
Name of Member of Supervisory Committee: _________________________

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LIST OF ABBREVIATIONS

IEA	International Ergonomic Association
CIEHF	Chartered Institute of Ergonomics and Human Factors
EMG	Electromyography
sEMG	Surface Electromyography
BMI	Body Mass Index
WHO	World Health Organization
USDHHS	U.S Department of Health and Human Services
CDCP	Centre for Disease Control and Prevention
MSDs	Musculoskeletal disorders
WMSD	Work-related Musculoskeletal Disorder
NIOSH	National Institute for Occupational Safety and Health
MRTD	Malaysian Road Transport Department
MIROS	Malaysian Institute of Road Safety
NSW	New South Wales
MVC	Maximum Voluntary Contraction
RMS	Root Mean Square
SAS	Simulator Adaptation Syndrome
UPM	Universiti Putra Malaysia

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Transportation is considered a fundamental factor for economic development and globalization in every developing nation. There are three basic modes of transportation, which are road, air and sea. In Malaysia, the road is much more preferred, as it is relatively easy, comfortable and cheaper compared with the other two modes (Karmegam et al., 2013). Motorcycles are well known as an important medium of transport locally and internationally. Motorcycles and cars are ranked as top choices for transportations for people’s daily activities in Malaysia (Mclnally, 2003). On the roads which have high traffic levels, conflicts are likely to be created between the vehicles when heavy commercial vehicles and fast moving cars are required to share the same roadway facilities with motorcycles which are slower and less protected vehicles (Faezi et al., 2011).

However, motorcycle are more preferred compare to cars as they are compact, less fuel consumption, pass easily through congested area, affordable and just need less maintenance (Mclnally, 2003). In Malaysia’s motorcycle market, motorcycle is regarded as one of the most popular modes of transportation for Malaysian people. The popularity of motorcycle is highlighted by Road Transport Department Malaysia Statistics (2014) for the new registered motorcycle for the year 2005-2013 with total 11.1 million of motorcycle (Figure 1.1). Meanwhile, according to types of road transportation, about half of the registered vehicles using roads are motorcycles (Shuaeib et al., 2002; Karmegam et al., 2009).

Motorcycle have become one of the main modes of transportation in Malaysia and used at work environment for various activities such as fast food delivery, deliver posts and patrols. Apart of that, motorcycle has also been shown as statistically unsafe method of personal transport (Shahar et al., 2010). Motorcycles are characteristically not stable and need to be control by the motorcyclist themselves to travel firmly. When compared to car drivers and other automotive drivers, the direct exposure to the environment, noise and vibration might be affecting the person who rides motorcycle (Walker, Stanton and Young, 2006).

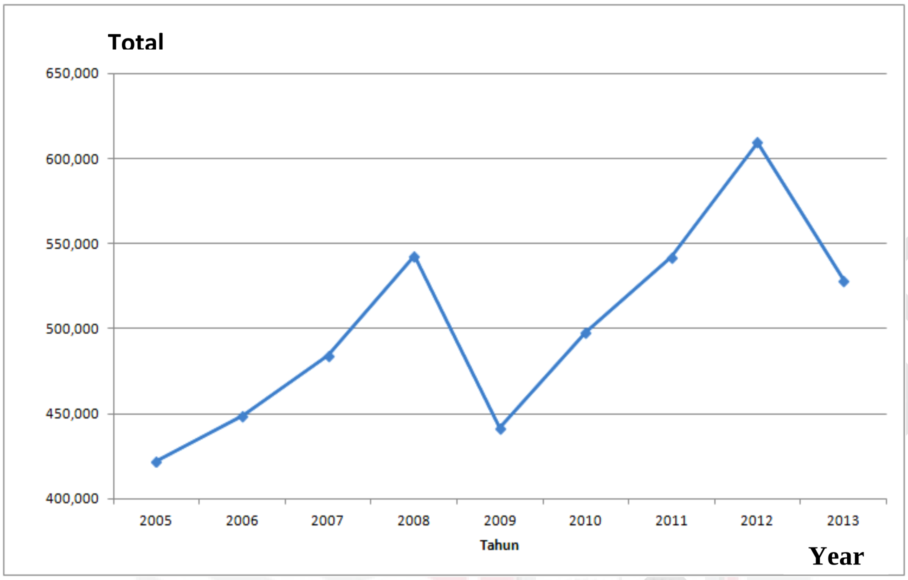

Figure 1.1: Number of Motorcycle Registration According to Year (2005-2013)
(Source: Road Transport Department Malaysia Statistics, 2014)

In Malaysia, injury is one of the six leading causes of hospital admission and deaths after ischemic heart disease, cerebrovascular disease, septicaemia, neoplastic disease and pneumonia. Most of the injuries are caused by road-related injuries specifically related to motorcycle crash (Malaysia Ministry of Health, 2012). Road traffic accident (RTA) contribute to most of the injury cases in Malaysia. According to the Malaysian Police Statistics year 2011, there were over 400, 000 reported cases of RTA. Statistically, there is an average 19 deaths due to RTA daily, a phenomenon that is very alarming.

According to the World Health Organization (WHO) ranking, Malaysia is at the 20th place in the world for death ranking due to RTA. The latest WHO report to shows that the death rate in Malaysia due to RTA is 34.5 for every 100,000 population (WHO, 2013). The majority of the RTA victims involve the most vulnerable group of road users are pedestrians, motorcyclists and their pillion riders (Malaysia Police Force, 2012). Of all RTA victims in 2012, approximately 70% involved are motorcyclists. Motorcyclists-related fatalities accounted for 57% of all road fatalities (Road Safety Department Malaysia, 2012) (Figure 1.2).

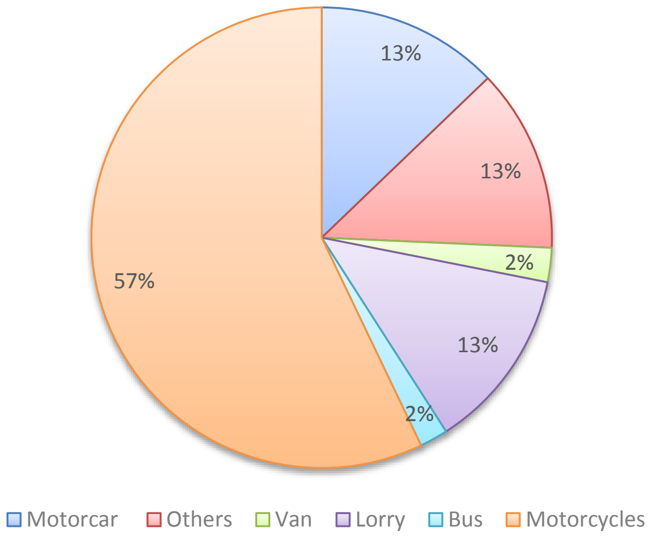

Figure 1.2: Fatal Road Accident
(Source: Road Safety Department Malaysia, 2012)

Based on statistics above, 3 factors that can contribute to accident among motorcycle are environment factors (14%), machine factors (2.6%) and human factors (91.7%) (Figure 1.3). Therefore when it comes to the interaction between machine and human factors, it is called ergonomics. As in the context of motorcyclists, ergonomics are supposed to enhance the interaction between motorcyclists and motorcycle in riding environment. Main aim in ergonomics context is to eliminate the discomfort symptoms during interaction with machine (Karmegam et al., 2008; Otte et al., 2013).

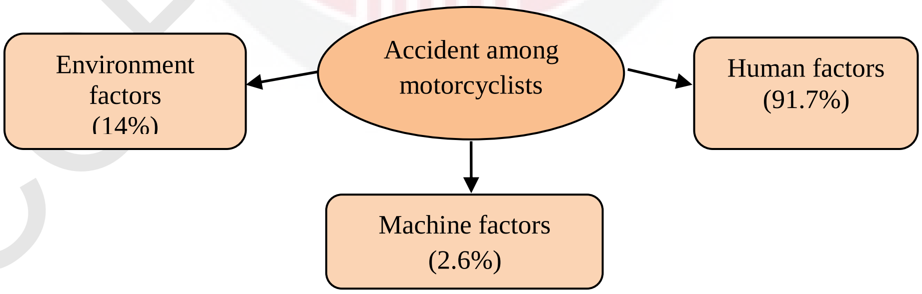

Figure 1.3: Factors Contribute to Accident

Generally, the most important aspect on designing a motorcycle is to provide motorcyclist the safety and comfort in order to reduce or eliminate fatigue and discomfort during riding process (Karmegam et al., 2012). International Ergonomics Association (IEA) defined ergonomics as a scientific discipline to design and optimize human being while interacting with industrial product. IEA also defined ergonomics as a scientific discipline concerned with understanding the interactions between humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design to optimize human well-being and overall system performance (Kroemer, 2006).

Basically, the aim of ergonomics is to eliminate the discomfort symptom which causes low job satisfaction, limited activity and long term disability (Perreault et al., 2008). The focuses of ergonomics are to ensure that human needs for safe and efficient working are met in design of work systems (Schlick and Vanwonterghem, 2009). As in the context of motorcycles, ergonomics applications are supposed to enhance the interaction between the motorcyclists and the motorcycle in a riding motorcycle in terms of safety, performance and satisfaction (Karmegam et. al., 2013).

The comfortability or satisfaction of the human body is a must and as an important factor in the current research and development of the industrial and nonindustrial field (Wahab et al., 2008). The terms comfort and discomfort are a unique estimation in the ergonomics field as they involve the human recognition (feedback) of the machine and work system environment. They are likewise hard to characterize because they involve both objective and subjective measurement (Bridger, 1995). Therefore, comfort is a generic and subjective feeling that is difficult to measure, interpret, and related to human physiological homeostasis and psychological wellbeing. The Cambridge Advanced Learner's Dictionary defines comfort as a pleasant feeling of being relaxed and free from pain whereas discomfort is defined as feeling with slight of pain and slight of unease.

Whilst, fatigue is a term that explain the internal states and performance decrements associated with a need of sleep, tasks/environments that are mentally or physically demanding, and tasks/environment that are insufficiently stimulating. Compare to comfort, fatigue may involve subjective states of sleepiness, drowsiness, weariness, exhaustion or boredom. However, performance decrements caused by fatigue are not necessarily accompanied by subjective states (Haworth and Rowden, 2006). As for the motorcyclists, the comfort and discomfort might be related to discomfort symptoms on their body parts due to the sitting posture during the riding process (Chee et al., 2008; Kolich, 2008). By and large, many MSDs (MSDs) start with humans experiencing discomfort in their body parts.

The motorcyclist's riding posture is not static and changes during the riding process. Furthermore, ideal riding posture will be similar to sitting in a chair or car with static posture or some mechanical features in that particular system that can support the body concerning the posture adjustments or changes. Nonetheless, current motorcycles do not have these features (Karmegam et al., 2008). Therefore, during the riding process, motorcyclists continue changing their posture to avoid the mechanical burden and ischemia of tissue similar to car drivers (Chee et al., 2008) which will contribute to the discomfort effects on the body parts.

Prevention of discomfort on the body parts is one of the main goals in ergonomics. Numerous techniques and methods have been proposed to identify and evaluate risk factors (Spielholz et al., 2001; Sogaard et al., 2001). Electromyography (EMG) is an important tool for the evaluation of the risks related to work activity (Clasby et al., 2003). EMG is defined as an experimental technique concerned with the development, recording and analysis of myoelectric signals. Myoelectric signals are formed by physiological variations in the state of muscle fiber membranes (Konrad, 2005).

Among others, surface electromyography (sEMG) is an important tool for the assessment of risks related to work activity. Three fundamental issues have been approached in ergonomics by means of sEMG; 1) the analysis of muscle activation, 2) the analysis of exerted forces and torques, and 3) the analysis of muscle fatigue. Numerous studies have been carried out in static conditions. In ergonomics, notwithstanding, it is more pertinent to study muscle activity and fatigue during real tasks that are, in general, dynamic. From isometric to dynamic contractions, the complexity of the interpretation of sEMG signals increases considerably. Changes in sEMG signals are identified with the consistent modifications in force output, muscle fibre length, and relative position of the surface electrodes and sources. To increase the reliability of the information extracted from sEMG, multichannel detection systems have been applied, demonstrating the possibility of overcoming some limits of the standard technique (Gazzoni, 2010).

The comfort or discomfort on the motorcyclist during the riding process can be related to a variety of factors, such as the machine (motorcycle), the riding environment, or the motorcyclist (Karmegam et al., 2013). However, there is very little (or less) information about the motorcyclist's riding discomfort especially on arm and hands of body in Malaysia. Therefore, this study was done to highlight effect of prototype armrest on comfort and muscle activity among selected male university motorcyclists during prolonged riding process.

1.2 Problem Statement

As the motorcycles had become one the most popular mode of transportation, and well accepted by Malaysians, the safety on motorcycles had also become a developing industry, with more and more inventions and gadgets being applied towards safer motorcycle riding. However, there is still a lack of ergonomics research on the aspects of arm support for the motorcyclists. The motorcyclists are relatively more exposed to sitting posture hazard compared to the car drivers. The car drivers can lean their body to the back support seat and rest their arm during driving, while the same cannot be applied for the motorcyclists. The current designs of motorcycles in the market are not equipped with arm postures support features for the motorcyclists (Figure 1.4).

Figure 1.4: Motorcycle without Arm Support
(Source: Chin, 2015)

Thus, a concern rises when hand controls, such as those motorcyclists operate a motorcycle that require excessively high force levels over long periods of times during riding, repeatedly. Exposure to such high repetition and high force tasks has been linked to discomfort on body parts and muscle activity and increased potential of getting MSDs (Conrad and Marklin, 2014). Recently, few studies have demonstrated the accumulation of muscle discomfort in the forearm muscles attributed to brake use on handlebars of motorcycle (Marina et al., 2013). Indeed, the need for a precise evaluation of motorcycle's comfort and muscle of arms is needed as they relate to safety on the roadway. During handling handlebar of motorcycle, motorcyclists tend to have force on arms and hands that can cause discomfort especially within long riding hours. Motorcyclist reported more physical tiredness especially for the body regions that might be affected during riding; the backs, arms and hands at the end of the ride day than on control day (Therese et al., 2003).

Meanwhile, motorcyclist with different posture struggles with discomfort of their arm during riding without having arm support feature at their motorcycle. Motorcycle without ergonomics design of armrest can give health and emotional effect to motorcyclist in a long term (Dutta et al., 2014). In terms of ergonomics, comfort sitting for motorcyclists is seen as one of the fundamental elements to be considered (Karmegam et. al., 2012). Besides that, bike advertisements nowadays basically focus on the showmanship. It illustrates stunts along with style and looks of the models almost ignoring the aspect of safety and physiological comfort. Hence, safety and physiological comfort that are not taken into consideration while choosing a motorcycle in order to reduce discomfort, stress and chances of motorcyclist may involve in accident (Dutta et al., 2014).

Apart from that, there is need to explore motorcyclists' discomfort. However, a review of the literature reveals that there is very little direct research evidence or information concerning motorcyclists' comfort especially on hand and arm muscle (Karmegam et. al., 2012). Thus, scientific data and research are needed concerning the effects of this type of riding on motorcyclist's comfort. Does this motorcycle without arm posture support pose significant discomfort to the motorcyclist's posture and arm muscle? Therefore, the primary aim of this study is to examine effect of the prototype armrest in terms of the discomfort rating and muscle activity on the motorcyclists during prolonged riding process (Figure 1.5).

Figure 1.5: A Prototype of Armrest

1.3 Study Justification

Motorcycle is one of the main transport in Malaysia that has been used for decades either for daily life activities or for working. Motorcyclist is the most important element when issues that are related to motorcycle. Prolonged riding process is one of the major risk that cause muscle fatigue, muscle recruitment, motorcyclist discomfort and reduce riding performance.

Motorcycle is considered as a very interesting scope of study to the researchers and ergonomics in the field of transportation. There is a need to satisfy the motorcyclists in a constrained workstation (motorcycle) where there are very limited adjustments to suit the different need of motorcyclists (Robertson and Minter, 1996).

Apart from that, lack of ergonomically design of motorcycle can increase the risk of getting musculuskeletal disorders and discomfort among motorcyclist. They have to adapt and fit into motorcycle's design during riding eventhough they feel discomfort and fatigue. Besides that, the existence of this discomfort on motorcyclist's body parts can be related to the lack of ergonomically interaction of human and machine (motorcycle) in the riding environment (Robertson and Minter, 1996; Karmegam et al., 2008).

Prolonged maintenance of awkward static posture cause postural stress and discomfort on part of the body. Thus, safety and comfort of motorcyclist must also be taken into consideration while choosing a bike in order to reduce discomfort and chances of accident. Hence, discomfort on motorcyclists's body part during prolonged riding indirectly can contribute to accident on road (Dutta et al., 2014). Thus, this prototype armrest may reduce muscle discomfort during riding process and also decrease the possibility to involve in accident among motorcyclists.

There are three types of human posture which are standing, sitting or sit-standing (Helander, 2006). Motorcyslist are normally associated with sitting posture during riding bike (Karmegam et al., 2008). This sitting posture required the motorcyclist to sit and stretch their arm. In this regard, prototype armrest that attached to handlebar is used in this study in order to indicate the level of the data distribution of discomfort rating (Borg's scale) and electromyography level in each motorcylist. Mostly, existing motorcycle design does not contain armrest support to motorcyclist.
Therefore, this study will be able to provide evidence to reduce level of discomfort and electromygraphy, reduce riding fatigue and increase performance with the intervention of prototype armrest which directly reduce riding discomfort during prolonged riding process. This prototype will provide comfort by reducing muscle activity for both arms so along with that muscle fatigue might also be reduced. The comfort and muscle acitivity of motorcyclist will be assessed by using Borg's scale discomfort rating and also electromyography equipment (EMG).

1.4 Conceptual Framework

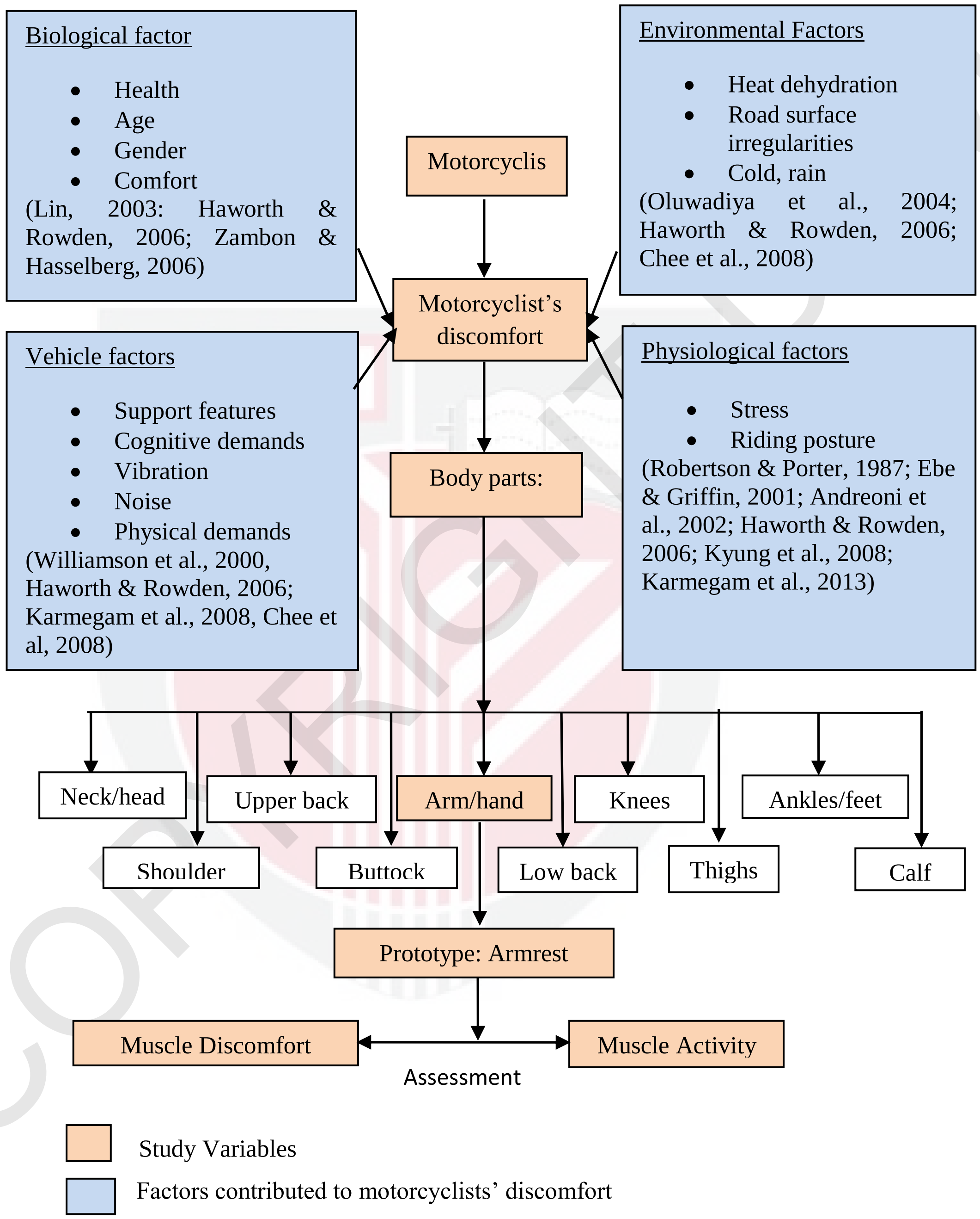

Figure 1.6: Conceptual Framework of Effect of Prototype Armrest on Comfort and Muscle Activity among Selected Male University Motorcyclists during Prolonged Riding Process

1.5 Study Objectives

1.5.1 General Objective:

To determine the effect of prototype armrest on comfort and muscle activity among selected male university motorcyclists during prolonged riding process.

1.5.2 Specific Objective:

1) To determine data distribution of discomfort rating and percentage of exertion (EMG) between experimental and control groups.
2) To determine the discomfort 'break point' (Borg's Scale Rating $\geq$ 5) between experimental and control groups.
3) To determine exertion changes (%) of flexor carpum radialis and ulnaris muscles between experimental and control groups.
4) To compare differences of discomfort rating between experimental and control groups.
5) To compare the differences of exertion percentage (EMG) of flexor carpum radialis and ulnaris muscles between experimental and control groups.

1.5.3 Study Hypothesis:

1) There are reductions of discomfort rating and percentage of exertion (EMG) between experimental and control groups.
2) There is positive effect of arm and hand on comfort with the usage of the prototype armrest in experimental group compares to control group.
3) There is positive effect on percentage of exertion changes (EMG) with the usage of the prototype armrest in experimental group compare to control group.
4) There are significant differences of discomfort rating between experimental and control groups.
5) There are significant differences of exertion percentage (EMG) of flexor carpum radialis and ulnaris muscles between experimental and control groups.

1.6 Definition

1.6.1 Body Mass Index

Conceptual Definition

Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults (WHO, 2012).

Operational Definition

Classifying of body weight and the height of a person through this formula: Body mass index = weight (kg) / Height^2 (m^2)

Table 1: The Classification of BMI

Classification	BMI (kg/m^2)
Underweight	<18.50
Normal	18.50-24.99
Overweight	25.00-29.99
Obese	≥30.00

(Source: WHO, 2012)

1.6.2 Discomfort

Conceptual Definition

The existence of this discomfort on motorcyclist's body parts can be related to the lack of ergonomically interaction of human and machine (motorcycle) in the riding environment (Robertson and Minter, 1996; Karmegam et al., 2008).

Operational definition

A body chart of discomfort using the Borg's (CR-10) scale (with numbers supported by written expression) is used to assess the degree of subjective discomfort on the body part (Karmegam et al., 2012).

1.6.3 Muscle Activity

Conceptual Definition

Muscle activity is defined for any type of muscle recruitment and is a good measure to use in ergonomics design cases in order to determine a tool or a posture that minimizes the effort of a given work task (U.S Department of Health and Human Services (USDHHS), 1992).

Operational Definition

Muscle activity can be measured as the number of motor units which are excited varies according to the force requirement. Greater numbers of action potentials are produced in a muscle per unit time. The EMG amplitude therefore increases with an increase in the force (USDHHS, 1992).

1.6.4 Prototype Armrest

Conceptual Definition

Prototype armrest is a feature that was developed in ergonomics way for the motorcyclist to rest their arms while riding the motorcycle.

Operational Definition

There are two different sessions which are session with armrest and session without armrest that attach to both sides of motorcycle handlebars.

1.6.5 Electromyography

Conceptual Definition

EMG is a nerve conducting test, performed by measuring the bioelectric signals from the muscle of a human body. The provided signal produced measures the different movements of the muscles of arm (Kawnine, 2008).

Operational Definition

A measuring, recording and evaluation process of flexor carpum radialis and ulnaris muscles activity that had been measured using electromyographic measurement (Kawnine, 2008).

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LIST OF PUBLICATIONS

Ayuni Nabilah Alias, Karmegam Karuppiah, Shamsul Bahri Mohd Tamrin, Emilia Zainal Abidin and Umi Kalsom Mohd Shafie (2015). A systematic review of intervention to reduce musculoskeletal disorders: Hand and arm disorders. *Jurnal Teknologi (Sciences and Engineering)*, 77 (27), pp. 97-103.

Ayuni Nabilah Alias, Karmegam Karuppiah, Shamsul Bahri Mohd Tamrin, Emilia Zainal Abidin and Umi Kalsom Mohd Shafie (2015). Risk factors of muscular discomfort among motorcyclist – Review article. *Iranian Journal of Public Health*, 45(1), pp. 35-43.

Umi Kalsom Mohd Shafie, Karmegam Karuppiah, Shamsul Bahri Mohd Tamrin, Emilia Zainal Abidin and **Ayuni Nabilah Alias** (2015). The effectiveness of new model of motorcycle seat with built-in lumbar support. *Jurnal Teknologi (Sciences and Engineering)*, 77 (27), pp. 97-103.

Umi K.M.S., Karmegam K., Shamsul B.M.T., Irniza R. and **Ayuni N.A.** (2014). Interventions to reduce musculoskeletal disorders among motor vehicle workers. A review. *Advances in Environmental Biology*, 8(5), pp. 219-224.

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Introduction: Motorcycles had become one of the most popular modes of transportation, well accepted by Malaysians. However, motorcyclist struggles with discomfort of their arm during prolonged riding as most of motorcycles in market are not equipped with arm posture support. Therefore, the primary aim of this study is to examine the effect of using prototype armrest in terms of discomfort rating and muscle activity on the selected male university motorcyclists during prolonged riding process. **Method:** This study was experimental study among male students and staffs in Universiti Putra Malaysia (UPM). A total of 102 motorcyclists had participated in this study. Each session had lasted for 2-hour. During the 2-hour session, a riding simulator system was displayed and respondents were asked to control the handlebar of motorcycle as in real road. At every 15-minute interval, respondents were required to evaluate their discomfort level for all body part on the Borg's CR-10 questionnaire. Besides that, Electromyography signals were used to monitor recorded muscle activity for the right and left arm of the respondents with the surface of electrodes attached. **Results:** The discomfort rating of the experimental group had showed 5% to 15% reduction compared to the control group during the testing period. Results showed that the discomfort rating of arm and hands was significantly lower (2.0 ± 2.20, $p<0.05$) among experimental group compared to control group. In terms of discomfort 'break point' (Borg's Scale Rating ≥ 5), arms and hands are the most affected body parts prior to +82% comfort changes with the use of the prototype armrest. Muscle activity of respondents showed that there are 10% to 25% reductions of electromyography levels for both right and left arm's muscles. There is a positive effect of exertion changes (%) on the flexor carpum radialis (right=24.54%, left=23.98%) and flexor carpum ulnaris (right=8.18%, left=10.62%) muscles of both arms with usage of prototype armrest. **Conclusion:** This study has provided new insights into the effects of prototype armrest usage on motorcyclists during prolonged riding process in a controlled laboratory session. The use of prototype armrest has provided a beneficial ergonomic feature which reduces muscle and body's discomfort and increase riding performance with less negative impact on muscle activity among motorcyclist.