Motorcyclists' Prolonged Riding Simulation: The Setup and Procedures

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ABSTRACT

This study focuses on pilot testing and simulation setup of motorcyclists' prolonged riding activity using an indoor motorcycle simulator facility (Postura Motergo^{TM}) that was developed by a group of researchers from the Motorcycle Engineering Technology Laboratory (METAL) at the Faculty of Mechanical Engineering, Universiti Teknologi MARA, Malaysia. The facility is amongst the many motorcycle simulators available all around the world but with several special additional features that makes this facility to be the first of its kind. Five (5) healthy male respondents age of 23 were involved in this pilot testing that required them to ride the motorcycle simulator for a maximum of two hours non-stop. The riding environment replicated near-to-real motorcycle riding experience that includes the motorcycle, control system, visual display, sounds, vibrations, motion and windblast. The environments' simulation setups were monitored using digital electronic and

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scientific devices to make sure that the setup is within the allowable safety range being permitted. Meanwhile, the respondents' muscle activities were also monitored using a wireless surface electromyography (sEMG) device to observe for any signs of muscle fatigue during the non-stop prolonged riding simulation. Findings from this study highlighted new issues on the significant muscle groups being observed that may contribute to motorcyclists' muscle fatigue during prolonged riding and also several setup requirements. The outputs of this study are hoped to be a reference platform for further indoor motorcycle simulation activities in the near future.

Keywords: *Motorcyclist, Motorcycle simulator, Postura Motergo^{TM}, Prolonged riding, Surface electromyography (sEMG), Muscle fatigue.*

Introduction

Motorcycle has become a very popular mode of transportation all around the globe especially in congested areas with high numbers of road vehicles. Not just because of its small and compact size that allows it to manoeuvre between other vehicles during traffic jams, but also because of its economical attributes that require less fuel per kilometre compared to other road vehicles [1, 2]. This leads to the increase number of motorcycles on the roads and tend to make them as the most vulnerable road users compared to others. In fact, statistics of road accidents puts motorcyclists as the highest contributor of road fatalities and injuries worldwide. In 2013, the World Health Organization (WHO) reported that over all fatal road accidents worldwide, 23% were motorcycle fatalities [3]. The same scenario was depicted in Malaysia with a 62% in 2015 involving the same category of road users [4]. This scenario has become a very alarming concern to many organizations including the government, state authorities and fellow researchers that try to collaborate to find solutions to minimize the number of motorcycle fatalities that keep on increasing every year. This is possible with proper ergonomic assessment and identification of ergonomic risk that may contribute to such events [5].

At the Motorcycle Engineering Technology Laboratory (METAL), Universiti Teknologi MARA, Shah Alam, Malaysia, a group of researchers are currently focusing their research on motorcycle ergonomics that considers the human factors aspect specifically on both motorcyclist and pillion. The motivation was also towards researching solutions on how to help motorcyclists to have a safer ride. As an alternative, researchers tend to develop and use indoor motorcycle simulators to simulate near-to-real motorcycling experience in a controlled laboratory. Since the last decade, several motorcycle simulators have been developed for research purpose by several institutions and agencies mainly for studying the interactions between the motorcyclist and the displayed surrounding environment according to different setups [6–7]. This effort was also adapted by the research team at the METAL laboratory by developing their patent pending motorcycle simulator called the Postura Motergo™.

However, references on setting up and executing a motorcycle simulation experiment especially involving prolonged riding and concurrently recording respondent's muscle activities during the ride are quite lacking or not yet to be found in the literature archives. Therefore, via the Postura Motergo™, experimental pilot tests of prolonged riding were conducted to evaluate the functionality of the whole simulator's system to provide a systematic procedure and simulation setup in conducting such experiment.

Methodology

The experimental pilot tests in this study were conducted at the Motorcycle Engineering Technology Laboratory (METAL), Faculty of Mechanical Engineering, Universiti Teknologi MARA, Shah Alam, Malaysia. Prior to this study, ethics approval was applied due to the nature of the experimental pilot tests that involved human participants. The ethics approval was approved by the Research Ethics Committee of the Research Management Institute (RMI), Universiti Teknologi MARA, Malaysia (600-RMI (5/1/6)). Throughout the pilot tests, the Postura Motergo™ motorcycle simulator was extensively used to simulate near-to-real motorcycle riding experience to the motorcyclist participants in a non-stop two hours of prolonged riding. Concurrently, the participants' muscle groups activities were recorded using a sEMG device throughout the prolonged riding simulation pilot tests. The followings are the requirements, simulation setup and procedures that are required for researchers to perform an indoor motorcyclists' prolonged riding simulation to collect data on motorcyclists' muscle activities during the simulation.

The Postura Motergo™ Motorcycle Simulator

The Postura Motergo™ Motorcycle Simulator as shown in Figure 1 is a full-scale ergonomic and adjustable motorcycle simulator facility developed by researchers at the Motorcycle Engineering Technology Laboratory (METAL), Faculty of Mechanical Engineering, Universiti Teknologi MARA, Malaysia. Unique from other simulators, the facility is equipped with semi-automated equipment and electronic devices to increase the realness of motorcycling experience in an indoor controlled laboratory.

It includes Human-Machine-Environment Interaction (HMEI) [8, 9] elements into the setup and capable to cater various type of riding postures including standard upright, forward-lean and slightly recline postures within a single motorcycle chassis of the simulator as shown in Figure 2. This is possible by adjusting the length and height positions of the handlebar, seat and foot-pegs according to actual motorcycle dimensions. The Postura Motergo™ is not only an ergonomic workstation, but also offers a new motorcycle simulation facility in a controlled and safer environment for both rider and pillion motorcyclist.

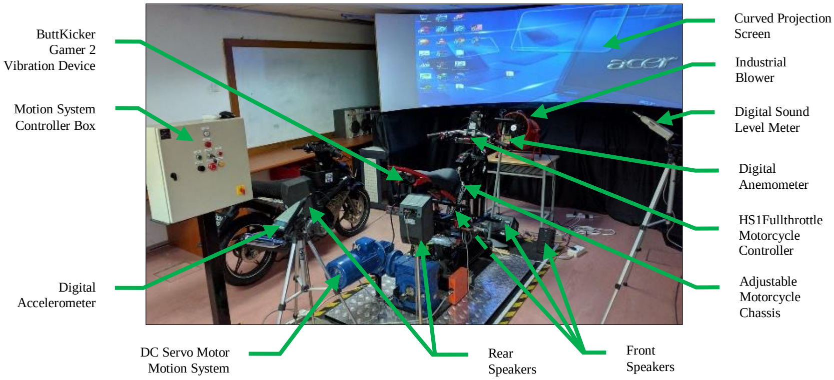

Figure 1: The Postura Motergo™ Motorcycle Simulator

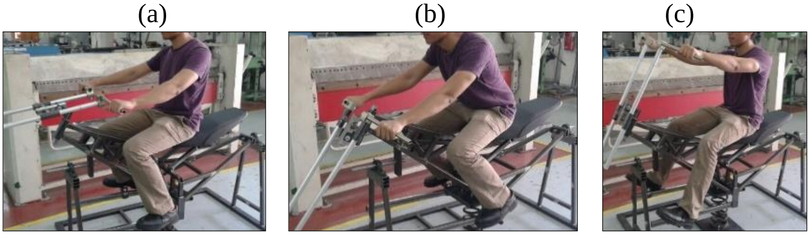

Figure 2: Common motorcycle riding postures; (a) Standard upright, (b) Forward-lean, and (c) Slightly reclined

Prolonged Riding Simulation Setup

In setting up the prolonged riding simulation on the Postura Motergo™, several main setups were focused to provide a near-to-real and better fidelity of motorcycling activity using an indoor motorcycle simulator as shown in Table 1.

Table 1: Main setups and attributes of a motorcycle simulator

Main Setup	Attribute	Function
Software	Motorcycle game (e.g. Ride)	• As a simulation interaction medium between motorcyclist and the simulator

		system
Motorcycle controller	Counter-steering handlebar system (e.g. HS1 Fullthrottle)	• Enable motorcyclist to control the simulator and other functions
Audio visual system	Surround speakers, projectors, curved projection screen	• Provide surround environment sounds and 120° view for motorcyclist
Windblast system	Wind blower (e.g. Industrial blower)	• Generate frontal wind during riding
Vibration and noise system	Vibrator and speakers (e.g. ButtKicker Gamer 2)	• Generate vibration effects and surround sounds
Motion system	Electric motor (e.g. DC motor)	• Provide left-right lean in roll axis during cornering
Monitoring devices	Digital electronic monitoring devices (e.g. Accelerometer, sound level meter, anemometer,)	• Monitor level of vibration, noise and windblast speed

Surface Electromyography (sEMG) Procedures

During the two hours non-stop prolonged riding simulation, the participants’ muscle activities were measured and recorded using a wireless surface electromyography (sEMG) device, the Myon 320. Five healthy male participants aged of 23 were recruited. The inclusion criterion for the participants included at least a one year experience of riding a motorcycle, poses a motorcycle riding license, no recent motorcycle accidents in the past six months and have a normal body mass index (BMI).

The sEMG procedure of preparing the participants’ skin before applying the electrodes was mainly referred to the *Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles (SENIAM)*, a European standard procedure for sEMG [10]. Seven bilateral muscle groups of the upper extremity body regions were used in this study. Table 2 shows the relation of the identified muscle groups based on literatures [10–12] compared with fatiguing body regions from a questionnaire survey of 330 respondents conducted prior to this study. Data from the survey were further analysed using SPSS with 95% confidence level and a standard deviation of $\alpha \leq 0.05$, in which the results of $p \leq 0.05$ were considered significant. Only percentage more than 30% of ‘very fatigue’ and ‘fatigue’ were considered from the questionnaire survey.

Table 2: Identified muscle groups for the motorcycle simulation

Literatures' Muscle Groups	Questionnaire Survey		
	Body Region	*Level of Fatigue*	*Percentage (%)*
Latissimus Dorsi	Middle back	Very fatigue	31.92
Erector spinae	Lower back	Very fatigue	31.00
Biceps	Upper arm	Fatigue	36.17
Extensor carpi radialis	Forearm	Fatigue	33.74
	Wrist	Fatigue	33.44
Trapezius			
Posterior deltoid	Shoulder	Fatigue	34.04
Sternocleidomastoid			

* Coefficient of Cronbach's Alpha value, α=0.946.

Participants were attached with seven pairs of medical grade hypoallergenic electrodes before being attached with sEMG transmitters as depicted in Figure 3. For the simulation, the participants wore complete attire as a normal daily motorcyclist that includes a helmet, riding jacket, jeans and covered shoes. The electromyogram signals were monitored from time to time in case for any irregularities or losses of signal. The sEMG signals were recorded with a 5 minutes interval recording time until the two hours prolonged riding simulation has completed. Post simulation semi-structured interview were conducted to gather information on their body fatigue level after every session ended.

Figure 3: Transmitters connected to the electrodes and attached to the respondent's body

Results and Discussions

Figure 4 shows a sample of the sEMG data acquired on one of the participants for three muscle groups out of the seven considered for this study. These three muscle groups reflected the most fatigued body regions being claimed by the participant after the two-hour simulation. While Table 3 and Table 4 depict the values of average Root-Mean-Square (RMS) and Mean-Power-Frequency (MPF) for three bilateral muscle groups of the participants. The fatigued muscles are identified by a concomitant rise in the average RMS amplitude and drop in the MPF marked by * [11, 12].

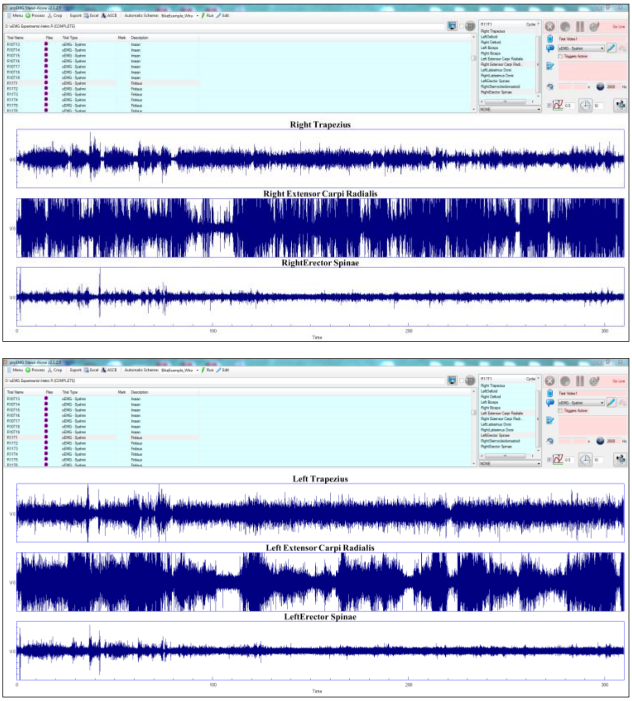

Figure 4: Sample sEMG signals of one participant for three bilateral muscle groups

Table 3: Average RMS amplitudes of the participants

Muscle Group	Average RMS Amplitude (V)									
	Participant 1		Participant 2		Participant 3		Participant 4		Participant 5	
	Start	End	Start	Start	Start	End	Start	End	Start	End
Erector spinae (L)	0.020*	0.022*	0.012*	0.028*	0.012*	0.034*	0.018*	0.025*	0.013	0.011
Erector spinae (R)	0.019	0.016	0.232	0.016	0.036*	0.054*	0.020*	0.038*	0.018	0.019
Trapezius (L)	0.112*	0.239*	0.079	0.069	0.073*	0.140*	0.242	0.122	0.146*	0.189*
Trapezius (R)	0.037*	0.043*	0.085*	0.088*	0.046*	0.104*	0.069	0.054	0.099*	0.137*
Extensor carpi radialis (L)	0.146	0.059	0.048	0.039	0.098*	0.282*	0.118*	0.124*	0.098*	0.730*

Extensor carpi radialis (R)	0.034*	0.037*	0.073*	0.074*	0.184*	0.246*	0.122	0.113	0.126	0.065

* (L) left and (R) right side of the body

Table 4: MPF values of the participants

Muscle Group	MPF Values (Hz)									
	Participant 1		Participant 2		Participant 3		Participant 4		Participant 5	
	Start	End	Start	Start	Start	End	Start	End	Start	End
Erector spinae (L)	1.98	1.99	2.79	4.61	3.39	4.88	3.18*	3.14*	4.91	5.07
Erector spinae (R)	3.13*	2.60*	8.32*	5.04*	5.36*	3.93*	4.43*	3.49*	3.46	4.00
Trapezius (L)	3.94	5.94	2.91	3.85	3.18	4.06	4.72*	4.13*	3.55*	2.87*
Trapezius (R)	3.33*	3.32*	3.58*	3.20*	2.80	3.06	4.11*	3.41*	4.56*	3.60*
Extensor carpi radialis (L)	3.60*	2.12*	4.10*	2.27*	2.86	3.03	2.21	2.69	10.20	13.70
Extensor carpi radialis (R)	2.49	3.36	3.63	3.99	3.81*	2.96*	3.43*	3.37*	3.10*	3.01*

* (L) left and (R) right side of the body

The sEMG results show that the participants experienced muscle fatigue due to the prolonged riding especially on the three muscle groups being described in Table 3 and Table 4 respectively. Out of the seven muscle groups being measured in this study, only these three were claimed to be very dominant by the participants via the post simulation semi-structured interview. These three muscle groups reflect the upper extremity body regions that are most being used when riding a motorcycle [10, 13, 14]. The forearm and wrist are used to twist the motorcycle's throttle and to grip firmly the handlebar. The shoulder is used to maintain this hand position throughout the ride while, the lower back muscle is used to maintain the body posture in a standard upright manner with very minimal movements. Upon time, these three muscle groups tend to fatigue first compared to other muscle groups being recorded.

These sEMG results that show obvious signs of muscle fatigue are only possible to be extracted from their raw data if the participants are riding a motorcycle in a true riding environment. This is because when a motorcyclist is riding a motorcycle, it demands several riding tasks for the motorcyclist to properly operate the motorcycle [15, 16]. These tasks involve the movement of certain body parts triggered from specific muscle contractions, thus enables the muscle activities to be recorded using a sEMG device. Failure to properly operate the motorcycle may cause the motorcyclist to lose control and involve in a road accident. However, collecting sEMG data of motorcyclist riding on real roads have been proven to be very dangerous and affects the reliability of data being recorded [17]. Therefore, replicating a near-to-real riding environment that provides HMEI elements in a controlled laboratory setting using a simulator is much safer and applicable. Nevertheless, the simulator used must be well equipped considering all HMEI elements involved. Table 5 and Table 6 summarizes the HMEI elements to replicate a near-to-real motorcycle riding experience in an indoor motorcycle simulator as provided by the Postura Motergo™ motorcycle simulator.

Table 5: Interactions between motorcycle controller and its functions

Feature	Function
Throttle Input (handlebar)	• Accelerates and decelerates the motorcycle • Controls the windblast's speed where the faster the motorcycle, the stronger the windblast and vice versa • Controls the noises sound level where the faster the motorcycle, the louder the surrounding noises generated from engine and air movement and vice versa • Controls the vibration intensity where the faster the motorcycle, the stronger it vibrates and vice versa (using the sound inputs)
Steering Input (handlebar)	• Steers the motorcycle for cornering left or right
Front Brake Input (right hand lever)	• Stops the motorcycle using front brake
Rear Brake Input (right foot brake)	• Stops the motorcycle using rear brake
Gear Input (left foot gear shifter)	• Step up or down the gear of the motorcycle
Clutch Input (left hand lever)	• Enables the gear to be stepped up or down

Table 6: Environment element settings of a motorcycle riding simulation

Environment Element	Setting
Windblast	• Maximum windblast speed for maximum motorcycle speed limit of 110km/hr is 60km/hr
Vibration	• Maximum vibration for maximum motorcycle speed limit of 110km/hr is between $9 m/s^2$
Noise	• Maximum noise for maximum motorcycle speed limit of 110km/hr is 90dB
Motion	• Maximum lean for mopeds during cornering is 15° to the left or right

Conclusions

As motorcycle accidents keep on increasing every year globally, certain safety measures need to be taken to overcome this issue. Amongst other method to study the contributing factors on either the motorcycle or the motorcyclist, is via using a motorcycle simulator. However, simulating a motorcycle riding activity in an indoor controlled laboratory facility needs to be well equipped and prepared. Human-machine-environment interactions (HMEI) need to be integrated into the whole setup to provide a near-to-real and better fidelity of motorcycling in a controlled environment. This study has managed to provide a reference platform based on the Postura Motergo™ motorcycle simulator for setting up a facility that could be used to study issues related to motorcycle ergonomics, and procedures to record muscle activities of motorcyclists using a sEMG device. From the sEMG raw data, average RMS and MPF could be extracted and further studied especially on motorcyclists' muscle fatigue. Furthermore, usage of such motorcycle simulator with a proper setup managed to give better results compared to only use a motorcycle simulator with less or no HMEI attributes at all. This study is hoped to assist and catalyse future research in the niche area of motorcycle ergonomics and help to reduce motorcycle accidents on the roads.

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