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SELECTION OF MUSCLE GROUPS FOR SURFACE ELECTROMYOGRAPHY (sEMG) MEASUREMENT IN ANALYZING MOTORCYCLING ACTIVITY

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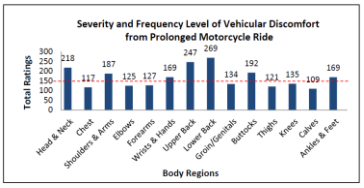
Graphical abstract



Abstract

While riding motorcycle have become a popular mode of transportation in most parts of the world, increase in motorcycle road accidents are very alarming. Many factors have been found to cause such motorcycle accidents and among others is motorcyclist fatigue. The aim of this study is to identify muscle groups that are related to motorcycling activity that may lead to motorcyclist muscle fatigue especially during prolonged riding. The groups of muscle recommended by this study were extracted from current literatures and studies, questionnaires and direct observation, and also a pilot surface electromyography (sEMG) experiment. Direct observation was made on motorcyclists' hand and foot positioning during riding including their riding posture. Upon confirming the recommended muscle groups, a sEMG experiment was conducted using an established adjustable motorcycle test rig, the Postura MotergoTM. Several torso muscle groups were identified and recommended for analyzing motorcyclist muscle fatigue. However, lower extremity body muscle groups were not listed. This is due to no considerations were made by neither researchers nor being testified by participants answering the questionnaire.

Keywords: Motorcycle, ergonomics, surface electromyography (sEMG), muscle groups

1.0 INTRODUCTION

Motorcycling activity either for daily commute or leisure have been very popular amongst motorcyclist in most parts of the world. Increment of new registered motorcycle can be seen in many other parts of the world especially in the ASEAN countries [1, 2]. Statistics of motorcycle road accidents also increased significantly. This was reported by the World Health Organization (WHO) in 2013 which states that over all traffic deaths globally, 23% were attributed from motorcycle fatalities [3]. Upon overcoming this shocking scenario, vast studies and actions were done to minimize the statistics.

However, upon those studies and actions taken, only small considerations of ergonomics were looked into of such cause of motorcycle accidents [4, 5]. Among other common factors that have been established in literatures related to motorcycle accidents are violating the motorcyclist right-of-way (ROW) and also loss of control during cornering [6]. While neglecting safety precautions of using helmets, alcohol or drug abuse and not having legal license add up the risk of higher motorcycle fatalities during an accident.

Henceforth, studies in preventing motorcycle road accidents were then broaden to take into account other contributing factors including ergonomics. This includes physical or muscle fatigue that is experienced by motorcyclist especially during prolonged riding [5, 7]. However, studies relating to muscle fatigue experienced by motorcyclist are quite lacking where most of the conclusions were based on self-reported data without having a well designed and controlled methodology [8].

2.0 Review on Muscle Groups Selected From Literature

2.1 Pre- and Post-sEMG Measurements

A study done by Velagapudi et al. in 2010 [7] performed a sEMG measurement prior and post to the motorcycling activity. The aim was to determine physical fatigue when riding in two different road conditions; i) high number of road shocks and ii) heavy traffic. Measurements were taken bilaterally after the motorcyclists exert maximum voluntary contraction (MVC) before and after each ride according to the respective routes.

The muscles selected as shown in Table 1 were identified based on the preconception that the region where the muscles are located would frequently experience physical fatigue.

2.2 sEMG Measurements During Riding

Meanwhile a study done by Balasubramanian and Jagannath [9] measured muscles activity during the motorcyclist is riding the motorcycle on the roads of low traffic density environment using a sEMG and also a seat interface pressure. The mucles activities were measured for an hour to determine physical fatigue and also discomfort. The study opt to use the Extensor Carpi Radialis muscle instead of the Flexor Carpi Ulnaris muscle and added another two muscle groups (Biceps Brachii and Sternocleldomastoid mucles) that were used in Velagapudi et al. study.

These muscle groups that were selected based on preliminary studies. Because the sEMG device used was utilizing wired electrodes, several limitations were identified and consideration of muscle groups used was also based on the intensity of the sEMG signal and the accessibility of the muscle for electrode application [9].

Table 1 Justification of muscle groups consideration [7]

Muscle Group	Justification
Flexor Carpi Ulnaris	Used in controlling the throttle, clutch and brake levers
Trapezius	Controlling head motion and absorbing any shocks from going to the head
Lattisimus Dorsi Erector Spinae	Hold the body and absorb any shocks that are transmitted via the seat

3.0 RESEARCH METHODOLOGY

3.1 Survey Study

Prior to this study, a preliminary survey using a set of questionnaire was done to determine the public's perception on vehicular discomfort for variable body regions. The survey involved 50 male undergraduate students from Universiti Teknologi MARA, Malaysia which have at least a 1 year experience of driving a car or riding a motorcycle.

The questionnaire used Likerts's scale to rate the level of discomfort ranging from 1 to 5 that represent 'strongly disagree', 'disagree', 'neutral', 'agree' and 'strongly agree' respectively. Calculations were made to identify the level of discomfort of body regions based on the number of respondents agreeing or disagreeing with a certain Likert's scale. The total numbers of respondents were multiplied with the Likert's scale respectively and summed up to represent total ratings of a specific body region discomfort level.

3.2 sEMG Pilot Experiment

A sEMG pilot experiment was done in this study to test the muscle groups used in previous studies. Eight healthy male respondents participated in the sEMG pilot experiment (mean age 25.1 years, standard deviation 3.09), (mean height 1.70 m, standard deviation 0.027), (mean weight 73.9 kg, standard deviation 18.9), (mean BMI 19.5, standard deviation 7.04). Every respondent are frequent motorcycle users with at least two years of motorcycle riding experience and have no history of severe motorcycle accidents in the past six months. The procedure used was approved by the Research Ethics Committee of the Research Management Institute (RMI), Universiti Teknologi MARA, Malaysia.

The respondent were required to perform four riding postures based on the Riding Posture Classification (RIPOC) system [10] using an established adjustable motorcycle test rig; the Postura MotergoTM. Four muscle groups were measured bilaterally for five minutes using an eight channel Biomonitor ME6000 EMG device at one time. Another muscle was added into the list that is the

Triceps muscle (upper arm). Necessary skin preparations were made before attaching the electrodes by referring to the SENIAM guidelines. Figure 1 shows one of the respondents performing the four RIPOC riding postures on the Postura MotergoTM test rig.

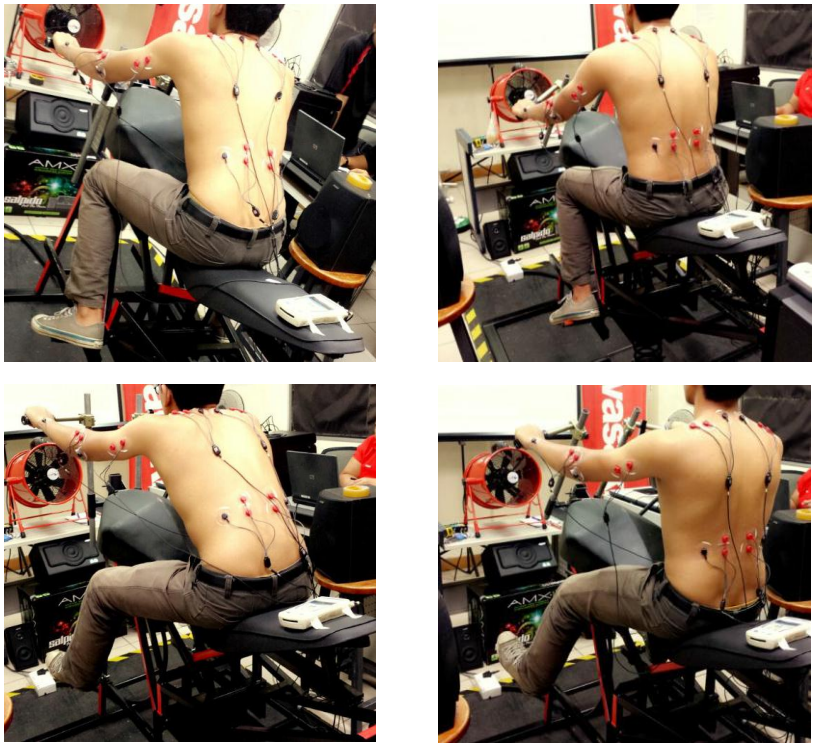


Figure 1 sEMG pilot experiment on the Postura MotergoTM test rig

4.0 RESULTS AND DISCUSSION

4.1 Results

Figure 2 shows the results from the questionnaire survey done prior to this study. From the survey questionnaire, body regions scoring more than 150 total ratings for vehicular discomfort are mostly the torso body regions; head and neck, shoulder and arms, wrists and hands, upper back and lower back. Only two lower extremity body regions were rated for having high discomfort that are the buttocks, ankles and feet. This discomfort area of body regions match the findings in the study by Balasubramanian and Jagannath that reported a high claim of discomfort especially at the buttocks, back and shoulders after an hour of motorcycle riding [9].

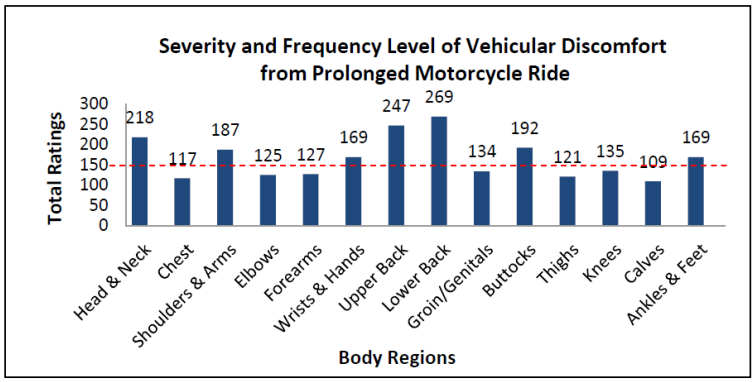


Figure 2 Survey questionnaire results of total ratings against body regions

Meanwhile from the sEMG pilot experiment, muscle groups involving the Erector Spinae, Latissimus Dorsi, Trapezius, Triceps and Extensor Carpi Radialis showed signals of muscle activities especially at the Extensor Carpi Radialis muscle.

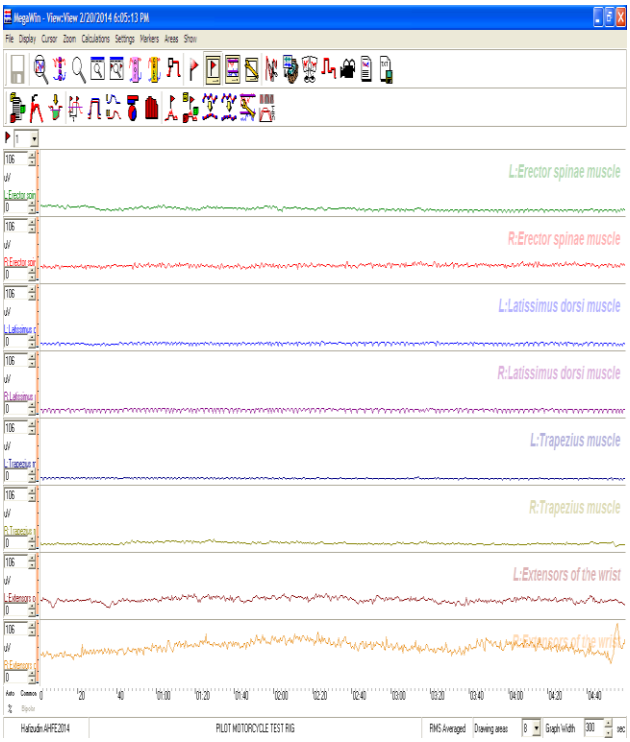


Figure 3 sEMG readings of muscle activities

Figure 3 shows the muscle activities readings on one of the respondent performing an upright sitting posture (RIPOC Type 2) [10] on the Postura MotergoTM test rig. As seen, the Extensor Carpi Radialis (left and right) muscles show a higher muscle activity compared to other muscle groups. This show how significant is the muscle in controlling and manoeuvring the motorcycle hence dominates other muscle groups' activities during riding a motorcycle.

However, no muscle activity reading was obtained from the Flexor Carpis Ulnaris muscle when the respondents twist the Postura MotergoTM test rig's throttle with their right hand and having the same hand position with their left hand.

4.2 Discussion

The aim of this study was to identify suitable muscle groups of a motorcyclist that may lead to physical or muscle fatigue during riding a motorcycle. The build up of muscle fatigue would be much severe if the motorcyclists are involved in a prolonged and monotonous riding [8, 9] involving different riding postures [10] with different riding environments [7].

Apart from the muscle groups being used in previous sEMG studies involving motorcyclist fatigue, result from the questionnaire survey of body region discomfort total ratings done prior to this study is well linked. Five body regions that rates the highest discomfort level were mainly the torso regions [7, 9] whereby it is clear that body discomfort due to riding or driving any vehicle is highly associated with muscle fatigue and pain [9]. The torso regions were much focused in previous sEMG studies compared to lower extremity of the body because control and manoeuvring of a motorcycle mainly involves the torso regions e.g. handlebar, throttle, brake and clutch lever, signal, headlight, horn and resistant from the wind [7-9].

During the pilot sEMG experiment done in this study, it was found that one of the muscle group considered by Velagapudi et al. [7] conflicts with the motorcyclist hands positioning on the handlebar during riding. For the Flexor Carpi Ulnaris muscle to be activated during riding a motorcycle, the hands positioning involving the wrist should be in a flexion state as shown in Fig. 4(a).

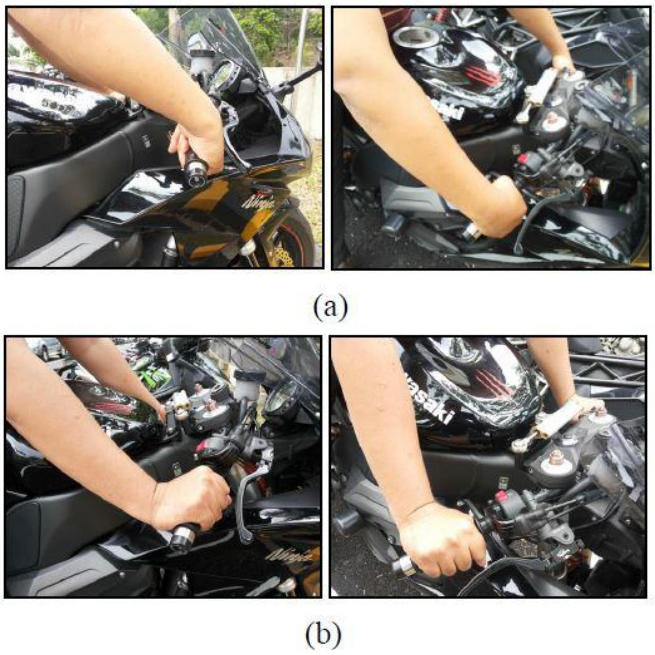


Figure 4 Hand and wrist positioning during motorcycling

Whereas in real world application through direct observation, the hands are positioned in an extension state as shown in Fig. 4(b). This muscle behaviour was confirmed by an expert physiotherapist from the Faculty of Health Sciences, Universiti Teknologi MARA, Malaysia. This condition is due to the work demand for the motorcyclist to twist the throttle using the right hand. The same hand positioning is commonly performed by the left hand although no twisting of throttle is required, so that the motorcyclist have a balance hands positioning throughout the ride.

Therefore, to reflect the correct muscle groups with respect to correct hands and wrists positioning during motorcycling, Extensor Carpi Radialis muscle was measured in the sEMG pilot experiment.

5.0 CONCLUSION

Conclusively, selection of muscle groups recommended for surface electromyography (sEMG) in analysing motorcycling activity that is associated with muscle fatigue and vehicular discomfort based on this study are; Erector Spinae, Lattisimus Dorsi, Trapezius, Triceps, Biseps Brachii, Extensor Carpi Radialis and Sternocleldomastoid muscles. Finally, although this study recommends the torso region muscle groups only, further studies to incorporate muscle groups of the lower extremity body need to be carried out to better understand how does the whole body behaves during motorcycling activity.

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