ORIGINAL ARTICLE

BICEPS BRACHII MUSCLE CONTRACTION DURING DIFFERENT DRIVING POSTURES

Darliana M[1], Baba MD[2], Dian DID[3] and Ahmad RI[I]

[1]Department of Industrial Design, Faculty of Creative Technology & Heritage, Universiti Malaysia Kelantan
[2]Department of Mechanical and Materials Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia
[3]Department of Mechanical Engineering, Faculty of Engineering, Universiti Pertahanan Nasional Malaysia

ABSTRACT

This study was conducted to analyses the Biceps Brachii (BB) muscle contraction during different driving postures. Drivers' posture is one of the factors that contribute to driving fatigue that eventually may lead to road accident and injuries. The experiment conducted for this study is using the surface electromyography (SEMG) method for objective evaluation of muscle involved in driving activities. A total of 14 participants are involved in the experiment. The experiment was done on three different posture based on comfortable angles published by previous research. From the results analysis, the RMS value for activity left turn is lower than activity for right turn for all three postures and results also shows that posture B with elbow angle of 134° is perceived as most comfortable based on the lowest value of muscle contraction with a value of 15.67μV. The outcomes from this study are hoped to benefit both manufactures and also car users in ensuring better and optimum driving postures that can avoid fatigue and injuries.

***Keywords**: comfort; seat design; surface electromyography; driving posture; muscle contraction*

INTRODUCTION

Driving postures' is one of the factors that need to be considered in ensuring driver's comfort. Awkward driving posture during long duration driving may lead to fatigue[1-5]. Fatigue consequently can cause road accident and injuries. Study from MacLean et al.[6] show that 20% of road accident is due to driver's fatigue. Fatigue usually also is associated with posture discomfort. As mentioned by de Looze et al.[7], feelings of discomfort are mainly associated with pain, tiredness, soreness and numbness. Discomfort factor is often used as factor in driving posture objective measurement[8].

On the other hand, it is found that physical fatigue is mainly caused of driving posture[9]. An experiment conducted by Costanzo et al.[1] detected the different levels of muscular fatigue between correct and incorrect postures, which is defined from the distance of drivers from the steering wheel. A field measuring devices which was introduced by Hermanns et al.[10] also showed that awkward postures and high vibration exposure while in driving position might resulted in high risk condition for musculoskeletal disorders. There have been many past research and experiments conducted in driver's car posture such as by Na et al.[11], Hirao et al.[9], Hermanns et al.[10], El Falou et al.[2], Park et al.[5], Andreoni et al.[12], Kyung & Nussbaum[13], Reed et al.[14]and Sun et al.[15]but the obtainableof comfortable driving angles for Malaysian population are limited. However, Mohamad et al.[16]had published a set of comfortable driving angles recommended for Malaysian drivers. But the published comfortable angles are measured only from subjective evaluation. It is advisable to include both subjective and objective evaluation in driving posture's discomfort studies to ensure more balance and competent outcome[17].Surface Electromyography (SEMG) is one of the widely used methods to investigate the muscle contraction changes in driving postures. SEMG able to detect the muscle contraction during different driving posture and also able to identify fatigue level of every posture measured[18-20]. Electromyography evaluation for upper limb movement can provide further insight into the movement nature and can be useful for further studies in the future[21]. Past research using SEMG had resulted a low correlation between the shoulder muscle activation and the movement of the steering wheel which shown that the active muscle known during is limited. Due to this, usually measurements for SEMG are done on large superficial muscle such as deltoid, trapezious, biceps and triceps[22]. Biceps Brachii is one of the popular muscle used in assessing the action of maneuvering the steering wheel[1,23].

The purpose of this study is mainly to investigate the Biceps Brachii muscle contraction while manuevering the steering wheel during three different postures. The outcome are able to guide researchers to get more clear information on the relationship between the muscle and the driving action measured.

METHODS

Participants

This study involved 14 participants comprise of 6 males and 8 females. All participants are

required to have at least one-year driving experience. The participant's age ranges are between 32 to 24 years old. All participants are required to signed an informed consent before the experiments and are given a token as an appreciation for their contribution at the end of the sessions.

Procedure

The experimental protocol was approved by the University's board of research ethics due to the usage of SEMG. Each participant was briefed first in details on the objectives and procedures of the experiment. Participants then will be required to sit on the driver's seat of a simulator with hand placement on the steering wheel at 10-2 o-clock position. Participants then need to manoeuvre the steering wheels for 30 second[5]as instructed with the range of steering wheel turn between 45°-90°. The activities instructed during the 30 second are as shown in Figure 1.

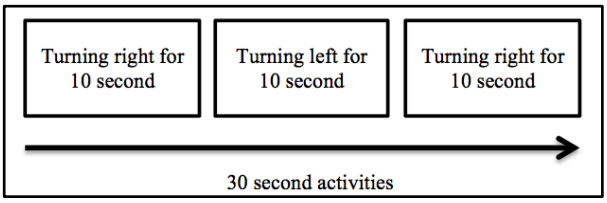


Figure 1 - TheActivities for Objectives Measurement

These activities then were repeated for three different postures with controlled angles as shown in Figure 2.

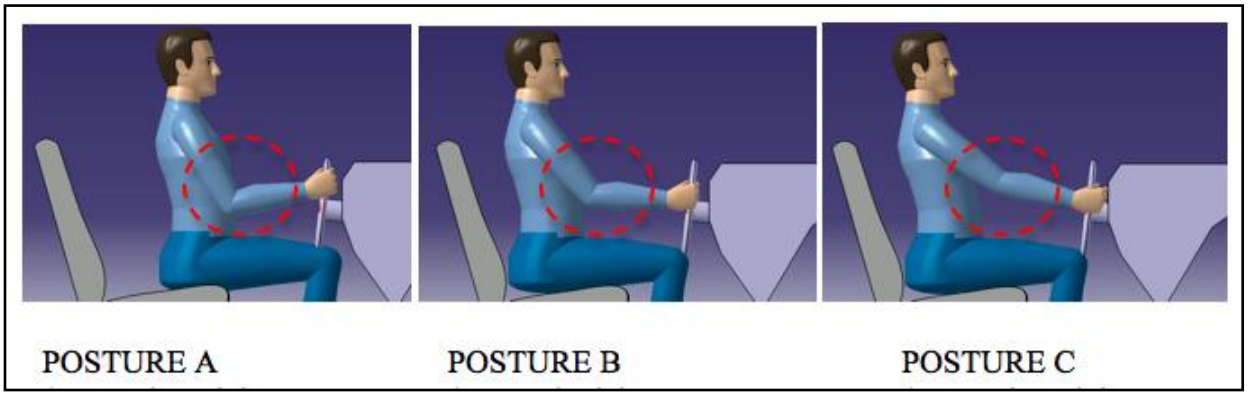


Figure 2 – Postures Involved in SEMG Experiment

The postures in Figure 2 were differentiate by the elbow angle as depicted in Table 1. These three driving posture position are compiled from study done by Mohamad et al.[16] that publish comfortable angles for Malaysian's drivers.

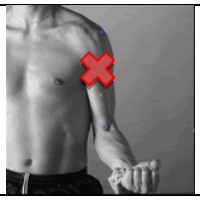
Table 1 - Elbow Angles for Driving Postures

Posture	Elbow angle
Posture A	Less than 134°
Posture B	Around 134°
Posture C	More than 134°

Surface Electromyography Experimental Design

Surface electromyography (SEMG) experiment was conducted on the participant using TrignoTM Personal Monitor with Parallel-Bar Sensors from Delsys Incorporation. Measurement was taken from the right Biceps Brachii (BB) muscle. The procedure in conducting SEMG experiment was accordance to the Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) recommendations. The identification of BB muscle and electrode placement position on skin is depicted in Table 2.

Table 2 - Identification of BB Muscle and Electrode Placement Position

Muscle	Biceps Brachii Long Head
Starting Posture	Sitting on a chair with the elbow flexed at a right angle and the dorsal side of the forearm in a horizontal downwards position.
Electrode Placement	Electrodes need to be placed on the line between the medial acromion and the fossa cubit at 1/3 from the fossa cubit.
Orientation	

Prior to the electrode placement, detailed skin preparations were done for the participant. This process was necessary to avoid skin impedance and ensuring stable electrode contact. Standard preparation processes were done that are shaving to remove excess hair on skin and then cleaning the skin by rubbing alcohol.

Maximum Voluntary Isometric Contraction Research Design

Maximum voluntary isometric contraction (MVIC) was conducted to normalize electromyography signals and compare data among participants[24]. The procedure to collect MVIC for muscle BB is shown in Table 3 below. The SEMG value divided by MVIC reference value will give the normalized MVIC percentage value.

Table 3 - MVIC Action for Biceps Brachii

Muscle	Bicep Brachii
Action	A valid biceps brachii MVC needs a very stable elbow and trunk fixation. This can best be arranged in a seated or kneeling position (in front of a bench). Consider using the latissimus d. MVC-test as a control exercise.
Diagram	

SEMG Data Analysis

The collected raw electromyography data were filtered through the band pass and notch filter process using MATLAB software. The band pass filter consisted of two types that are the high pass and the low pass filter and for this experiment the value were set at 20 Hz and 500 Hz respectively. While for notch filter cut off frequency is set at 50 Hz. The cut off frequency used for both filter were according to SENIAM. After the process of data filtering, the filtered EMG signals then were epoch according to segments. Epoch is a time window in a stipulated time used for analysis. In this study, epoch is taken for 10 second in every segment. Epoch was taken based on 30% of MVIC for right turning action and 8% MVIC for left turning action.

The signals were transferred to full-wave rectified SEMG signal for amplitude analysis. Amplitude analysis calculation was then conducted using Microsoft Excel software to determine muscle activity in Root Mean Square (RMS) value. Amplitude analysis was performed at time domain and the amplitude unit is in microvolt (μV). The RMS equation in discrete time is defined in Equation 1.

$$R.M.S = \sqrt{\frac{1}{N}\sum_{n=1}^{N} EMG[n]^2} \quad (1)$$

Where N is the number of data and n is the EMG data in μV.

RESULT & DISCUSSSION

Amplitude Analysis

Amplitude analysis was done to determine the muscle contraction value for each posture position. The RMS value of muscle BB for three different postures are calculated. The RMS value taken for each activity in steering wheel turn is taken according to MVIC percentage. For right turn the %MVIC taken is 30% and for left turn the %MVIC is 8%. Table 4 shows the RMS value of Biceps Brachii.

Table 4- Statistical Analysis of Biceps Brachii

Postures	Right Turn	Left Turn
A	22.93μV	3.90μV
B	15.67μV	3.40μV
C	24.28μV	3.29μV

For an elaborate and clearer description of RMS data calculated, the line chart in Figure 3is constructed to shows the BB muscle RMS value of two activities for Posture A (Elbow Angle<134˚), Posture B (Elbow Angle=134˚) and Posture C (Elbow Angle>134˚).

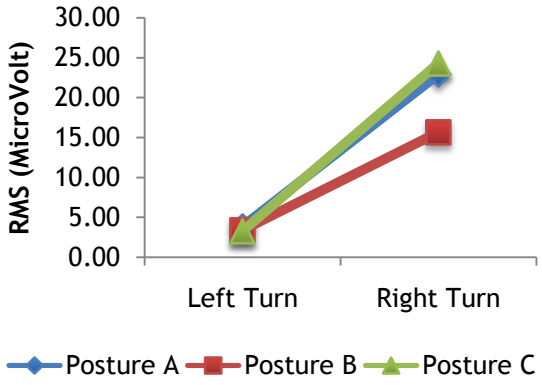


Figure 3 - RMS Value for Biceps Brachii

From the line chart depicted in Figure 3, the RMS value for activity left turn is lower than activity for right turn for all three postures. This shows that the right BB muscle activation is high when doing the right turn while driving. Past research also had shown a positive correlation of right BB muscle while manoeuvring the steering wheel for right turning[25-27]. Jung et al.[27] had found that the biceps brachii is considered to be the main action muscle while turning the vehicle to the right.

Figure 3 also shows the differences of muscle activity value between three postures measured in this study. From the figure, the lowest muscle activity value for right turn is for Posture B (Elbow Angle=134˚) with RMS value of 15.67μV

and the highest muscle activity value for right turn is for Posture C (Elbow Angle>134°) with RMS value of 24.28μV. This is in-line with previous studies that found the value for EMG activity significantly increased with higher elbow angle flexion[23]. Von-Werder&Disselhorst-Klug[28] also had found that the value of normalized sEMG in biceps brachii increased with increasing angles of elbow flexion. The low muscle activity shows that driving in Posture B is ensuring less exhaustion and more comfort for the drivers. It is supported by previous research that displays an increase trend in comfort level with low muscle contraction[7]. Studies by Costanzo et al.[1]and Pandis et al.[22]also shown comfortable driving posture is found with low level of EMG muscle contraction.

CONCLUSION

The objective of this study that is to investigate the Biceps Brachii muscle contraction during different driving postures is achieved. From the RMS value of SEMG, it is found that the best posture to be perceived as comfortable is Posture B with elbow angle around 134°. Besides that, this study also shows that the right BB muscle is in high contraction while manoeuvring the steering wheel right. The outcome from this study is able to benefit the manufacturers and designers especially in automotive field by designing a detailed and adequate size of car seat and its interior cabin.Besides that, the value of comfortable posture angles given in this study able to assist user in ensuring better and optimum driving posture that consequently can avoid fatigue and injuries.

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COMPETING INTERESTS

There is no conflict of interest.

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