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ORIGINAL ARTICLE

# THE EFFECT OF GRASPING THE STEERING WHEEL WHILE POSITIONING THE SHOULDER CLOSER TO THE BODY

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## ABSTRACT

Discomfort and pain issue at the body part are common complaints reported by car drivers. It is due to driving task require physical demands and need to maintain and adapt several postures in a constrained space while controlling the car. Hence, this study aims to determine the pattern of shoulder activation muscle consisting of the Trapezius muscle in two different driving posture. Respondents were required to grasp the steering wheel at 8 and 4 hand position. The Surface Electromyography was used to get the reading for left muscle's Trapezius Descendent (TD) at two different positions; i) closest distant from steering wheel and ii) far distant from the steering wheel. Then, Temporal Analysis was used to evaluate the pattern of the driving action. From the experiment, it shows the different value of muscle activation occurred while driving according to turning action. The far seated position depicted greater activation on driving action compared to the closer seated to the steering wheel. In conclusion, the driving posture effects the activation of shoulder and arm's muscles as early as after 20 seconds of driving activity. Hence, choosing the correct driving posture allowed a comfortable driving environment for the driver.

***Keywords***: *Trapezius, steering wheel, SEMG, driver, temporal analysis, driving posture*

## INTRODUCTION

Limited space in the car while driving may hinder drivers to put themselves in the preferred driving style[1]. Some drivers tend to sit near to the car controller, while some drivers are more comfortable to sit far away from the car controller. In this case, car controller refer to the steering wheel, gear and car pedal.

However, most of the time, drivers tend to change the position of their hand according to their comfort level when driving. As mentioned by Liuet al.[2], vehicles are generally operated in a closed loop with the driver, and thus the dynamic characteristics of the driver's steering are needed in order to optimize the dynamic behaviour of the vehicle. There are many hand grip styles when driving, depending on driver's preference. Normally, drivers tend to put their hand at 9 and 3 or 10 and 2 positions[3-6]. Past studies demonstrated that more than fifty muscles of upper limb and shoulder are involved in controlling the steering wheel[7-9]. In this study, only one significant muscle was observed based on past research known as Trapezius Descendent (TD). In addition, participants were required to grasp the steering wheel at 8 and 4 hand position.

Up to this date, there is no study carried out to investigate the effect of this hand position on the muscle. About four past studies were investigated the effect of the muscle activity based on the shoulder muscle groups, particularly trapezius by grasping the steering wheel at 9 and 3 as well as 10 and 2 o'clock hand positions[9,10-12]. For example, Balasubramanian andAdalarasu[10] have analysed the changes in muscle activity from two groups, professional and non-professional drivers while performing 15 minutes driving tasks in a simulated condition. The findings show that changes in electrical activity was found to exist in bilateral trapezius muscle group of all the subjects. Another study conducted by Jagannathand Balasubramanian[9] found that surface electromyography (SEMG) showed significant physical fatigue in back and shoulder muscle groups in 60 minutes of driving activity. Franz[11] focused on the effect of the lightweight massage system (LWMS) on the car seat on the trapezius muscle. It shows that the LWMS helps to lower down the impact on the trapezius muscle activity. In addition, all these studies did not evaluated the effect of turning action while operating the steering wheel. Therefore, it is hoped this study can provide the reference for all researcher regarding the effect of different of hand position while turning the steering wheel.

Due to these reasons, this study aims to investigate the TD muscle contraction while engaging with the steering wheel task under different positions. SEMG technique was used in this study to record the muscle activity. Past studies show that SEMG techniques was found to be really useful in determining muscle activity and contraction while engaging with different car controls[9-10,13]. Based on this assessment, the relationship between the degree of steering wheel turning and muscle contraction at certain posture can be demonstrated from this study.

## METHODS

### Subject

Eight respondents with no history of health problem have participated in the study. All eight respondents have more than two years of driving experiences with the mean age was 22 years old. Informed consent was obtained from each subject, and ethical approval was permitted from UniversitiKebangsaan Malaysia.

### Main **apparatus**

A driving simulator as displayed in Figure 1 was used in this study. The simulator consists of an adjustable driver's seat (inclination of the backrest, lower or elevate head rest, forward or backward seat), steering wheel, clutch, accelerator and brake pedals, handbrake, and manual gear shift. The screen was located in front of the driver and has the virtual dashboard on it when using the simulator. In this study, the test subjects were required to grip on the steering wheel of the car simulator and act according to the instruction given by the researcher.

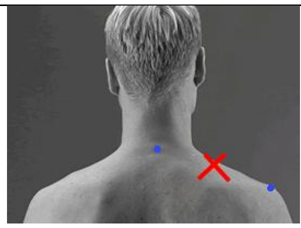
*Figure 1- Simulator design*

### Data collection protocol

All the respondents were allowed to adapt with the car simulator setup and car seat adjustment before starting the experiment. The experiment was started after five minutes the respondent has been in the driving position. This is to allow them to adapt to the seat environment and fabrics.

SEMG is a well-known tool to study the function of the muscle when controlling the steering wheel. Changes in the muscle activity of the shoulder part was observed by using the SEMG. A Trigno™ Personal Monitor with Parallel-Bar Sensors from Delsys Incorporation was used to collect these muscle activity analog data with sample rate up to 1000 Hz interfaced with 5-channel signal amplifier. The myo-electrical signal of surface had been converted to the analog data, which later converted to digital data at the signal analysis personal computer interface. SEMG measurement was performed by placing electrodes on the skin's surface and electrical activity of the TD was recorded. The procedure of collecting data on the selected muscle was in accordance to the Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) recommendations[14]. Table 1 shows the electrode placement for this study. The cross mark (x) shows the trapezius muscle location. The sensor should be placed at this area. Only one electrode was required to detect the muscle activity from the TD muscle.

***Table 1- Identification of selected muscle and electrode placement position***

| Muscle | Electrode placement | Orientation |
|---|---|---|
| TD | Electrode need to be placed at the 50% on the line from the acromion to the spine on vertebra C7. |  |

Source: SENIAM[14]

Each subject has to adopt hand position as shown in Figure 1 and Figure 2 with two different driving positions; i) closer to the steering wheel, and ii) far away from the steering wheel. Then, each respondent was required to perform four actions as depicted in Figure 3.

*Figure 1- Hand position*

*Figure 2-Driving condition from side view*

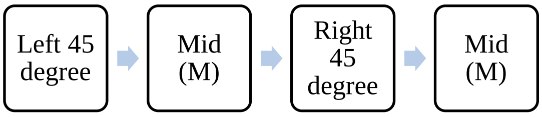



*Figure 3- Main actions in steering wheel*

**Data analysis**

Figure 4 shows the flow chart of EMG data analysis. Matlab and Microsoft Excel are the two main operators for analysing EMG data in this study. Raw data from the sEMG was changed to Microsoft Excel format. Then, the data was exported into txt data formatting. Data was saved separately according to the muscles types. The data in txt format was transferred to the Matlab software for data filtering process. Some coding code by using Matlab language system was used to filter the data. The clean data was produced, and it was segmented in the Microsoft Excel. Then, plot the suitable graph RMS (microVolt) versus Time (seconds) and the comparison performed based on the data. Careful palpation and parallel to its muscle fibers. The procedure for electrodes placement such as; location of electrodes, orientation and muscle are depicted in Table 1. After the electrodes were placed and fixed, the electrodes could then be connected to the SEMG equipment and a clinical test could be performed to test whether the electrodes have been placed properly on the muscle and connected to the equipment so that a reliable SEMG signal can be recorded.

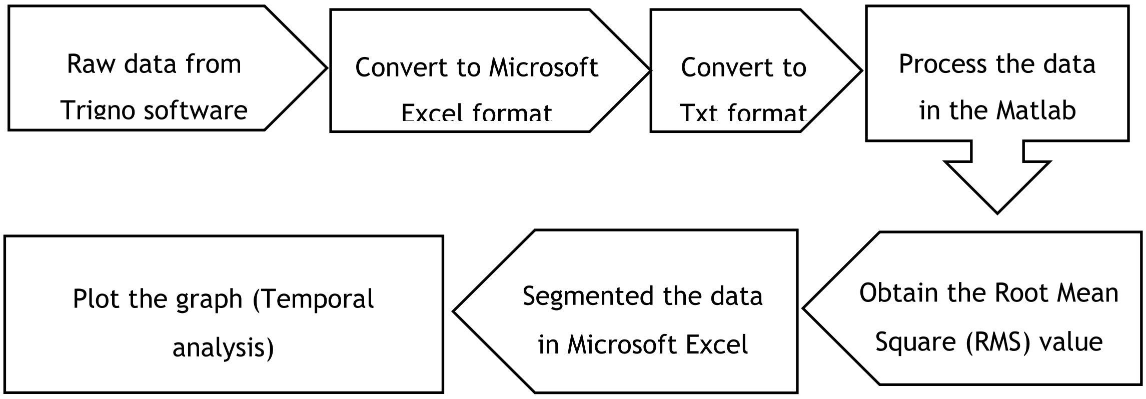



*Figure 4- Flow chart*

**RESULTS AND ANALYSIS**

This section demonstrate the findings for the TD when engaging with steering wheel under different actions. For this section, data for the first position was depicted first, then data for the second driving position was explained in the next paragraph.

**Temporal analysis for steering wheel task**

The Temporal Analysis was conducted to understand the muscle pattern when interacting with certain driving task. Figure 5 shows the Temporal Analysis for TD response in the first position as mentioned in the previous section after the filtering process. Each action was recorded for at least five seconds. Based on the data, the TD muscle was activated according to each actions. This pattern was in line with past study conducted by Khamiset al.[12]. Even though in this study the hand was place at 10-2 o'clock position, it shows that the trapezius muscle is activated when turning the steering wheel to the left, right and centre.

Based on the TD muscle activity during the first five to seven seconds, it shows the greatest value of RMS compared to the next seconds, between seven to eleven seconds. In this timeframe, the RMS value was decreased. Then, it was started to increase again within five seconds before it lay down in the last five seconds. Therefore, according to the Figure 5, it is obvious that the TD muscle operated differently when performing the turning action to 45 degrees or to the centre. In general, when turning at 45 degrees, the TD muscle shows the highest activation, compared to the centre turning.

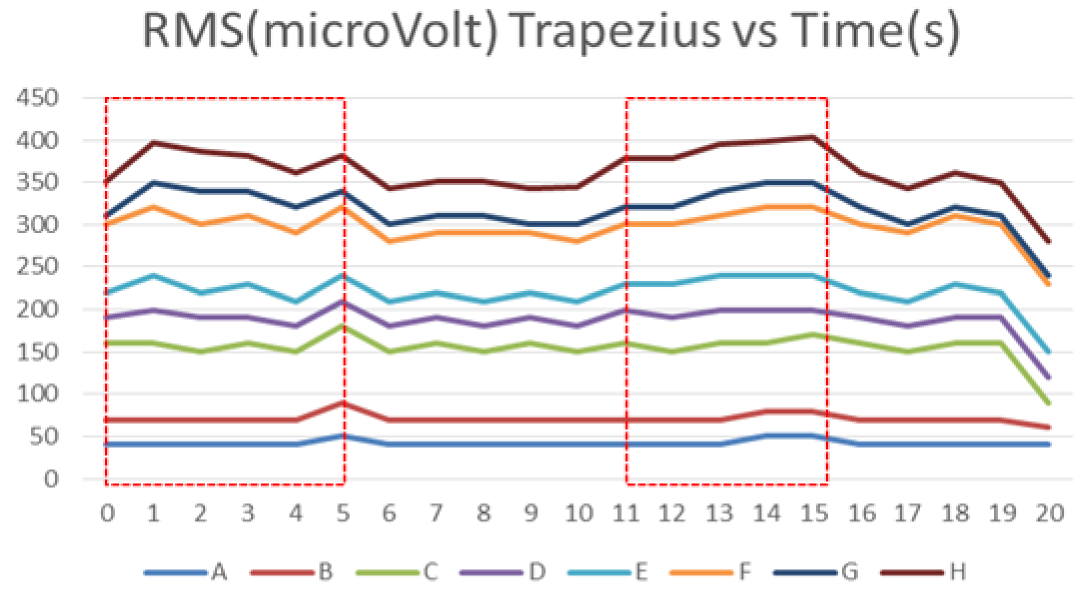



*Figure 5- Temporal analysis for the first driving position*

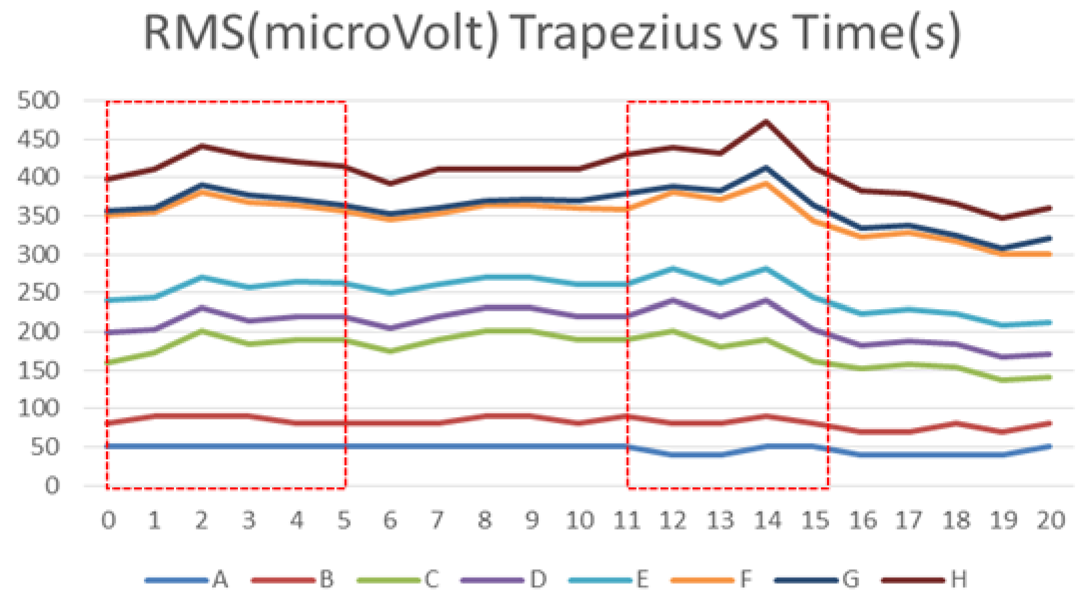



*Figure 6- Temporal analysis for the second driving position*

The similar pattern was seen on the second position as shown in Figure 6. During the first five seconds, it shows the greatest value of RMS compared to the next seconds, between five to ten seconds. In this time frame, the RMS value was decreased. Then, it was started to increase again within five seconds before it lay down in the last five seconds. Therefore, according to the Figure 6, similar findings was seen for both positions.

However, the second position demonstrated the highest activation compared to the first position. In fact, these findings were supported by the theory of the center of gravity on the shoulder. Grujicicet al.[15] explained as the shoulders are reduce, the center of gravity focused on hands and then reduce the workload for the muscles when making a movement. All in all, the pull activity and the arm's weight required scapula to stabilize muscular load experienced from the movement of shoulder joint. Qinet al.[16] indicated that the trapezius works to achieve required shoulder joint performance in the monotonous activity.

## CONCLUSION

Hand placement while coordinating the steering wheel is expected to engage with shoulder muscle activity. The finding from this study was supported by the principle of muscle loading to shoulder joint movement while driving and coordinating the steering wheel. In this study, the trapezius muscle at the far distant from the steering wheel depicted the greatest activation compared to the closer position to the steering wheel.

In term of driving action, different action produces different activation value. Based on the findings, when the driver turns the steering wheel at certain turning degree, the muscle will activated and produce certain amount of muscle activation.

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## COMPETING INTERESTS

There is no conflict of interest.

## REFERENCES

1. Kyung, G. *An integrated human factors approach to design and evaluation of the driver workspace and interface: driver perception, behaviour, and objective measures*.PhD Thesis, Virginia Polytechnic Institute and State University, 2008.

2. Liu, Y., Ji, X., Hayama, R., Mizuno, T., & Nakano, S. Method for measuring a driver's steering efficiency using electromyography. Proceedings of the Institution of Mechanical Engineers, Part D: *Journal of Automobile Engineering*2014; 228: 1170-1184.

3. Klein, J. *Performance enhancing mechanisms for human manipulation*. University of California, Irvine, 2009. http://search.proquest.com/docview/304851419?accountid=37552 [10 May 2016].

4. Mossey, M. E., Xi, Y., McConomy, S.K., Brooks, J.O., Rosopa, P.J., &Venhovens, P.J. Evaluation of four steering wheels to determine driver hand placement in a static environment. *Applied Ergonomics*2014; 45(4): 1187-1195.

5. De Waard, D., Van den Bold, T.G. & Lewis-Evans, B. Driver hand position on the steering wheel while merging into motorway traffic. *Transportation Research Part F: Traffic Psychology and Behaviour*2010; 13(2):129-140.

6. Walton, D. & Thomas, J.A. Naturalistic observations of driver hand positions. *Transportation Research Part F: Traffic Psychology and Behaviour*2005; 8(3): 229-238.

7. Mathiassen, S. E., Winkel, J., &Hägg, G. M. Normalization of surface EMG amplitude from the upper trapezius muscle in ergonomic studies—a review. *Journal of electromyography and kinesiology*1995; 5(4): 197-226.

8. Gao, Z. H., Fan, D., Wang, D., Zhao, H., Zhao, K., & Chen, C. Muscle activity and co-contraction of musculoskeletal model during steering maneuver. *Bio-medical materials and engineering*2014; 24(6): 2697-2706.

9. Jagannath, M. & Balasubramanian, V. Assessment of early onset of driver fatigue using multimodal fatigue measures in a static simulator. *Applied Ergonomics*2014; 45(4): 1140-1147.

10. Balasubramanian, V., &Adalarasu, K. EMG-based analysis of change in muscle activity during simulated driving. *Journal of Bodywork and Movement Therapies*2007; 11(2): 151-158.

11. Franz, M., Zenk, R., Vink, P., &Hallbeck, S. The effect of a lightweight massage system in a car seat on comfort and electromyogram. *Journal of Manipulative and Physiological Therapeutics*2011; 34(2): 107-113.

12. Khamis, N.K., Deros, B.M., Yusoff, A.R., Nawawi, R. and Nuawi, M.Z. Muscle activation pattern of the shoulder part while handling car steering wheel. *International Conference on Environmental & Occupational Health (ICEOH 2016)*, Putrajaya, 2016.

13. Khamis, N.K., Basrah, N., Deros, B.M. and Nuawi, M.Z., Electromyography as an objective measurement for evaluating physical fatigue: An overview. *JurnalTeknologi*2015; 77(27): 51-57.

14. SENIAM. 2017. *Surface electromyography for non-invasivemeasurement*. ww.seniam.org.[28 September 2017].

15. Grujicic, M., Pandurangan, B., Xie, X., Gramopadhye, A.K., Wagner, D., &Ozen, M. Musculoskeletal computational analysis of the influence of car-seat design/adjustments on long-distance driving fatigue. *International Journal of Industrial Ergonomics*2010; 40(3): 345-355.

16. Qin, J., Lin, J. H., Buchholz, B., & Xu, X. Shoulder muscle fatigue development in young and older female adults during a repetitive manual task. *Ergonomics*2014. 57(8): 1201-1212.