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**MUSCLE CONTRACTION ANALYSIS OF THE PROLONGED
ASTRIDE-SITTING ON MOTORCYCLE USING
ELECTROMYOGRAPHY**

Hartomo Soewardi (a), Ekky Anastasia Pramita (b)*
*Corresponding author

(a) Industrial Engineering Department, Faculty of Industrial Technology, Islamic University of Indonesia,
Yogyakarta, Indonesia, hartomo@uii.ac.id

(b) Industrial Engineering Department, Faculty of Industrial Technology, Islamic University of Indonesia,
Yogyakarta, Indonesia, 13522253@students.uui.ac.id

Abstract

Commonly, the motorcycle riders are in an astride position during the trip. They placed the legs on a pedal by the same token of passengers. It will produce the inner-thigh pressure which leads to the transient paresthesia in the form of an insufficient blood supply. Oftentimes the syndrome is experienced by children of 3-4 years old. The objective of this study is to investigate the health impact on the upper legs based on muscle contraction. The empirical study is conducted to record the signal of muscle contraction by attaching some sensors on Semimembranosus muscle area. Six males and six females of children were involved in the experiment. Blood pressure was also measured to identify the blood flow. The result of this study found that the contraction of semimembranosus muscle has the difference between male and female with average RMS value are 0.57 mV and 0.17 mV respectively in on-engine condition and 0.1 mV and 0.05 mV respectively in off-engine condition. The blood pressure value of systolic and diastolic have the average value of 88.33/65 mmHg before the experiment, 76.67/63.33 mmHg after experiment for male and 95/73.33 mmHg before the experiment, 78.33/66.67 mmHg after the experiment for female. Those values showed that the prolonged sitting in on-engine condition is having higher muscle fatigue than off-engine for both, male and female.

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Keywords: Paresthesia, blood pressure, muscle contraction, electromyography, motorcycle.



1. Introduction

The motorcycle is a popular vehicle for middle to low-level society. It is considered an economic transportation mode to make a short or long trip or just to go around the city. Therefore, many people use this vehicle because of its flexibility. Traffic demand also lead motorcycle to be chosen as a private vehicle (Wandani, Siti, Yamamoto, & Yoshida, 2016). According to Indonesian statistical centre bureau (BPS), the amount of the motorcyclist in Indonesia is highest in 2016 as much 105.150.082 million and it will increase continuously (Badan Pusat Statistik, 2018). Indonesia is one of the circumstances where motorcycles are utilized as family vehicles which is usually children tend to travel as pillion riders at an early age, most commonly seated in front of the rider, either on fuel tank or in the carrying basket or alternatively behind the rider (Paiman et al., 2014).

As stated in Indonesia constitution number 22 of 2009 on Road Traffic and Transportation Article 106 paragraph (9) that "Every person who drives a motorcycle without an additional train is prohibited in carrying passenger more than 1 (one) person". It means that the motorcycle is for 2 passengers. In fact, according to the preliminary study that has been done with 15 interviewees, most of them used a motorcycle for bringing more than 1 passenger for longer 2 hours of a long trip. The passenger's sitting position during riding motorcycle is even in astride-sitting and sideways. The standard position of motorcycle passenger is astride-sitting as it is designed with two pedals on each side. For those passengers in 3-4 years old does not be able to put their foot on the footrest or hang up/down. It because of no facilities to support the passenger's feet. Moreover, for children whose age are 3-4 years old, the seat depth is not suitable to them that were too shallow increased muscle work, thus increasing fatigue and discomfort (Oguntibeju, Owonuga, & Odunaiya, 2014). Since movement skills supported by the muscle that used for daily activity needs physical fitness. Muscular strength and balance are latent by nature. Gender differences have the different motor response as its physical exertion phenomenon in the potential of physical fitness and movement skills (Ikeda & Aoyagi, 2009). The footrest is needed for motorcyclist and passenger to make a balance of the upper body and legs as well as avoiding a fatigue. But it is currently designed suitable for those who are adequately tall (Amrutkar & Rajhans, 2011). This condition will produce the inner-thigh pressure which occluded blood supply then it leads to transient paresthesia (Alhoseini et al., 2012). As stated by Shivakumara and Sridhar, (2010), the blood is having the role to give the muscle energy to get muscular system activity. The measurement of blood pressure is needed to know whether there is the decreasing or increasing the blood flow and the blood flow pressure impact on the semimembranosus muscle during riding motorcycle to avoid transient paresthesia.

Transient Paresthesia is an abnormal sensation of burning, numbness, tingling, itching or prickling caused by the insufficient blood supply to muscle so as inflicting muscle fatigue at the bottom of the thigh (Alhoseini et al., 2012). A study from Suhardi et al (2016) expressed that unavailability of the footrest can lead to the muscle fatigue, especially for children. Muscle fatigue is a decrease in the ability to produce force which it is caused by a reduce the net blood flow to the working muscle (Wan et al., 2017). So that, if the blood flow is occluded, the oxygen will be misfired and nerve cannot deliver muscle contraction (Joyner & Casey, 2015).

The Hamstring muscle is located between the hip and knee behind the thigh area. It is composed of three muscle bellies of Bicep Femoris, Semitendinosus and Semimembranosus muscle. The muscle location

which from medial hamstring and lateral hamstring is Semimembranosus, Semitendinosus, and Biceps Femoris muscle (Onishi et al., 2002). The astride-sitting position is having contact to the lower extremities of buttock pressure, and another system around the seat. For those who cannot reach the pedal, the inner thigh surface will be pressed as it balances the physical human posture (Balasubramanian & Jagannath, 2014). In this case, the semimembranosus muscle is involved as its location in the inner of the thigh while the hamstrings are contributed in hip and knee postural flexion (Higashihara et al., 2014).

To know the muscle activity, the Electromyography (EMG) is used for measuring muscle contraction through the electrical signal that could be detected by using an electrode pad. It is one of the ergonomic purposes to measure how the design can cause the physical injury to the user (Konrad, 2005). As recognized by many research works, surface electromyography (sEMG) is one of the reliable devices used to evaluate muscle fatigue that is safe for use as it is affixed skin surface to know the muscle activity (Criswell, 2011). Windblast, vibration, noise, and motion is an environmental element that could be (Rashid et al., 2017). This research involves the vibration that could give impact to blood pressure. Static vibration will cause the blood flow not smooth where the accumulation of the lactic acid increase leading multifunctional muscle pain (Bernard, 1997). The magnitude of EMG activation was determined using three methods: peak RMS (pRMS), mean RMS (mRMS) and integrated EMG (iEMG). Peak RMS was the maximum value of the RMS signal during the stance phase of gait. Conversely, mean RMS was the mean of the RMS signal during the stance phase of gait. For the integrated EMG analysis, EMG signals were integrated across the stance phase of gait (Renshaw, Bice, Cassidy, James, & Powell, 2010). Thus, the objective of this study is to investigate the muscle contraction of children's inner thigh for motorcycle passenger by using Surface Electromyography and the signal calculated by mRMS to get the amplitude.

2. Problem Statement

Ideally every person who drives a motorcycle should carry passenger only one. It means that the motorcycle is for 2 passengers. Therefore, they can sit comfortably and be able to put their foot on the footrest or pedals. In fact, most of them used a motorcycle for bringing more than 1 passenger for longer two hours of trip where the passenger sits with the foot is in hang up/down especially for children passenger. It because of no facilities to support the passenger's feet as well as the seat depth is not suitable to them. Consequences of this condition will increase muscle work and produce the inner-thigh pressure which occluded blood supply then it leads to transient paresthesia. Thus the footrest is needed for motorcyclist and passenger to make a balance of the upper body and legs as well as avoiding a fatigue and discomfort.

3. Research Questions

How is the effect of prolonged sitting on the motorcycle as the passenger at Semimembranosus muscle contraction and blood pressure using Surface Electromyography (sEMG) and Oscillometric blood pressure and what is the difference between male and female?

4. Purpose of the Study

- To Evaluate the Semimembranosus muscle contraction in thigh based on the EMG signal when riding the motorcycle as a passenger between male and female passengers.
- To Evaluate the blood pressure when riding a motorcycle as a passenger

5. Research Method

5.1. Subject

The subject of the study are 6 males and 6 females. Their age is 3-4 years old which each of them was involved for two machine conditions, off and on. No activities before experiment was done by participant to avoid early fatigue and free from any medications or lifestyle treatments that will influence blood pressure and muscle (Kaur et al., 2015).

5.2. Apparatus

In this study, a motorcycle with $0,06 \text{ m/s}^2$ vibration is required as a stimulus. Electromyography (Lab Quest 2: Vernier Tech & Soft, Texas, USA) is used to identify the contraction of a specific muscle by attaching the electrode at the muscle. The data recorded by Lab Quest 2 will be directly transferred to Logger pro software to quantify some electric signal into filtered EMG data. While The blood pressure data was recorded by using an Oscillometric blood pressure device to provide the comparison between respondent's pre and post-experiment blood pressure. The data was processed statistically using the Statistical Package for the Social Science (SPSS) software version 22 (see figure 01).

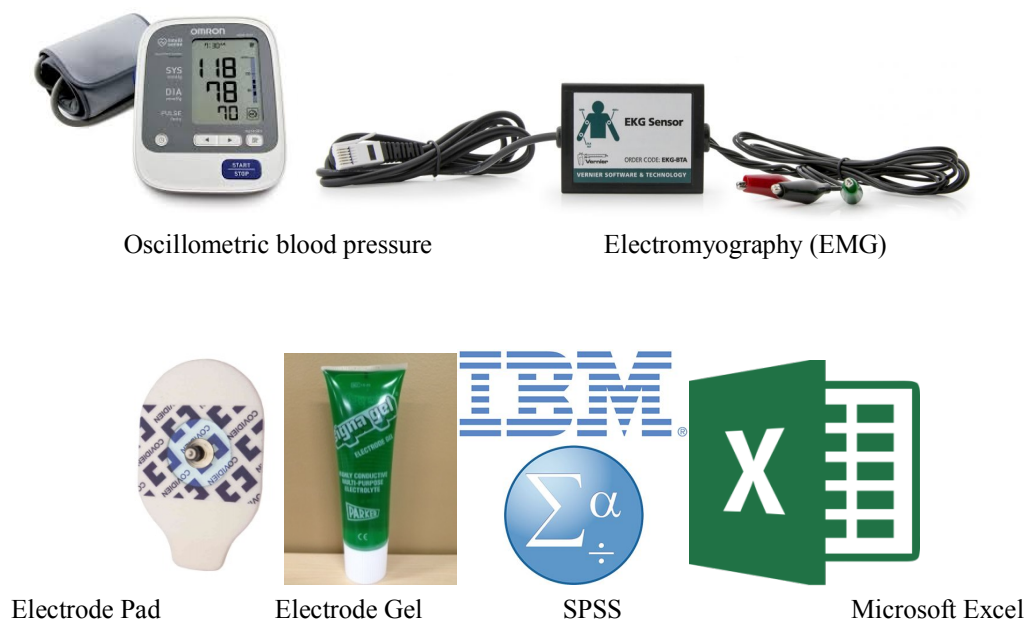


Figure 01. Apparatus for the empirical study

5.3. Experiment Design

The experiment involves two conditions of motorcycle. They are the on-engine and off-engine which leads the immediate exposure of vibration to the seat and to whole body (Halim, Omar, Saman, & Othman, 2012). This experiment is performed in the outdoor as it has the ground floor. The electrode is attached to the Semimembranosus muscle where the muscle got pressed by the force of passenger's weight. The semimembranosus muscle is shown in figure 02 below:

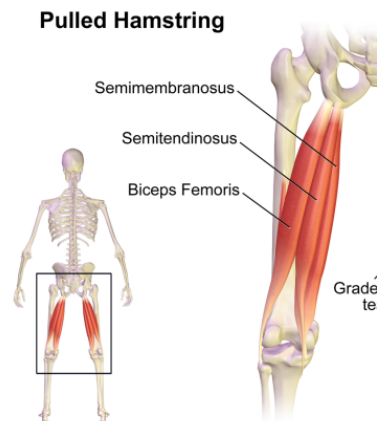


Figure 02. Semimembranosus Hamstring Muscle

Source: <https://www.dovemed.com/diseases-conditions/hamstring-muscle-injuries/>

5.4. Task

The subject is instructed to sit on the motorcycle for 1 hour in an off-engine motorcycle and 1 hour in an on-engine motorcycle in the next day or vice versa. The subject is expected to sit in the same position as they are in a motor riding, the EMG is started to record the signal at Semimembranosus muscle contraction.

5.5. Procedure of Experiment

This experiment is done in the outdoor which has the ground floor. The electrode is attached at Semimembranosus muscle to identify contraction. Each subject was participated in each experiment. Before the experiment, the subject should take the position as they are riding on the motorcycle. Then, the electromyography wire attaches to the attached electrode pad to record it by using logger pro for 1 hour in off-engine condition. On the next day, they continue to the on-engine condition for 1 hour as well. Each pre and post-experiment, the respondent's blood pressure will be check.

5.6. Statistical Analysis

EMG signal data analysis is done using signal analysis and the parametric statistical analysis method. Blood pressure data is analyse using the descriptive statistics. The mean root mean square (mRMS) is used as parameter of the muscle contraction. The paired and independent T-Test and Descriptive statistics is carried out to identify the difference between experiment condition and gender.

6. Findings

6.1. Semimembranosus Muscle Contraction Analysis

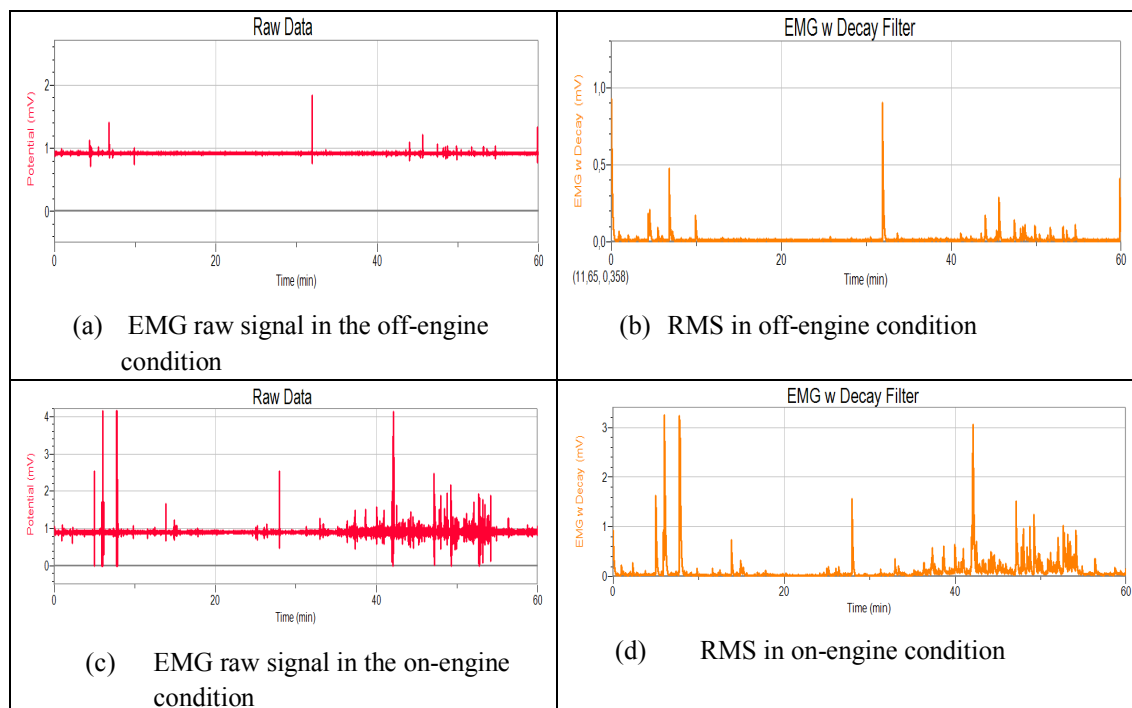


Figure 03. The EMG signal (a) the off-engine condition (b) RMS in off engine condition (c) the on-engine condition (d) RMS in on-engine condition

Figure 03 (a) and (b) presents the raw signal and the RMS signal of the muscle contraction on off-engine condition for 1 hour duration. While Figure 03 (c) and (d) shows EMG records on the on-engine condition for the raw signal and RMS signal. The on-engine condition has the vibration that transmitted from the engine as it is operated. The vibration of the motorcycle during the experiment is $0,06 \text{ m/s}^2$. It is the minimum value of the vibration as it is excluded the dynamic vibration from the engine usage during riding. During on-engine and off-engine condition, the EMG signal increase for the time. In this study, means of the root mean square (mRMS) of each subject's muscle contraction would not be changed by the time and less affected of the signal noise (Renshaw et al., 2010).

Table 01. Statistical Test of the Muscle Contraction

	Asymp. Sig. (2 tailed)
Each gender towards on condition	0,014
Each gender towards off condition	0,000018
Male respondents towards both conditions	0,028
Female respondents towards both conditions	0,000012

Table 01 shows result of the independent T-test of the on-engine condition and the off-engine condition. Male and female subject during the on-engine condition have the significant value of 0,014 where the p-value is less than 5% or 0,05. Thus the hypotheses one (H_1) is accepted. It means that there is a significant differences between male's and female's muscle contraction during the on-engine condition.

As for during the off-engine condition, male's and female's muscle contraction have a significant value of 0,000018 where the p-value is less than 5% or 0,05. It means that hypotheses one (H1) is accepted and indicate that between male and female during the off-engine condition has the different a muscle contraction.

At conditions of the on-engine and the off-engine condition have different muscle contraction which male tends to have higher amplitude during the on-engine condition and also during the off-engine condition than female. In some experimental study conducted by Ahamed et al., (2015) and Cioni, et. al., (1988), it was found that male has higher a muscle contraction than female where male's muscle signal generated higher and steadier. Male's skeletal muscles are generally faster and have higher maximum power output than female's muscles. While Glenmark (2004) express that, female's muscles are generally more fatigue resistant and recover faster during repeated contractions.

The comparison of mRMS of each subject between the on-engine and the off-engine condition is shown in Table 0.1. Result of the paired independent T-test presents that the difference of male during the on-engine and the off-engine condition has significance value of 0,028 where the p-value is less than 5% or 0,05. It means that hypoteses one (H1) is accepted. This indicates that male have different muscle contraction between during the on-engine and the off-engine condition. While female during the on-engine and the off-engine condition have a significant value of 0,000012 where the p-value is less than 5% or 0,05. It means that hypoteses one (H1) is accepted. This shows that female have a different muscle contraction between during the on-engine and the off-engine condition. Both different on muscle contraction during the on-engine and the off-engine condition shows that male and female have the higher inclination of amplitude value in the on-engine condition than in the off-engine condition.

6.2. Blood Pressure Analysis

Table 02. Descriptive statistics of blood pressure results

	N	Minimum	Maximum	Mean	Std. Deviation
Value	96	60	100	75,00	11,050
Valid N (Listwise)	96				

Table 02 shows the descriptive statistics of blood pressure, systolic and diastolic value which is there are 96 data from 12 subjects have systolic and diastolic value in each the on-engine condition and the off-engine condition. Figure 04 presents a comparison of blood pressure between the on engine and the off-engine.

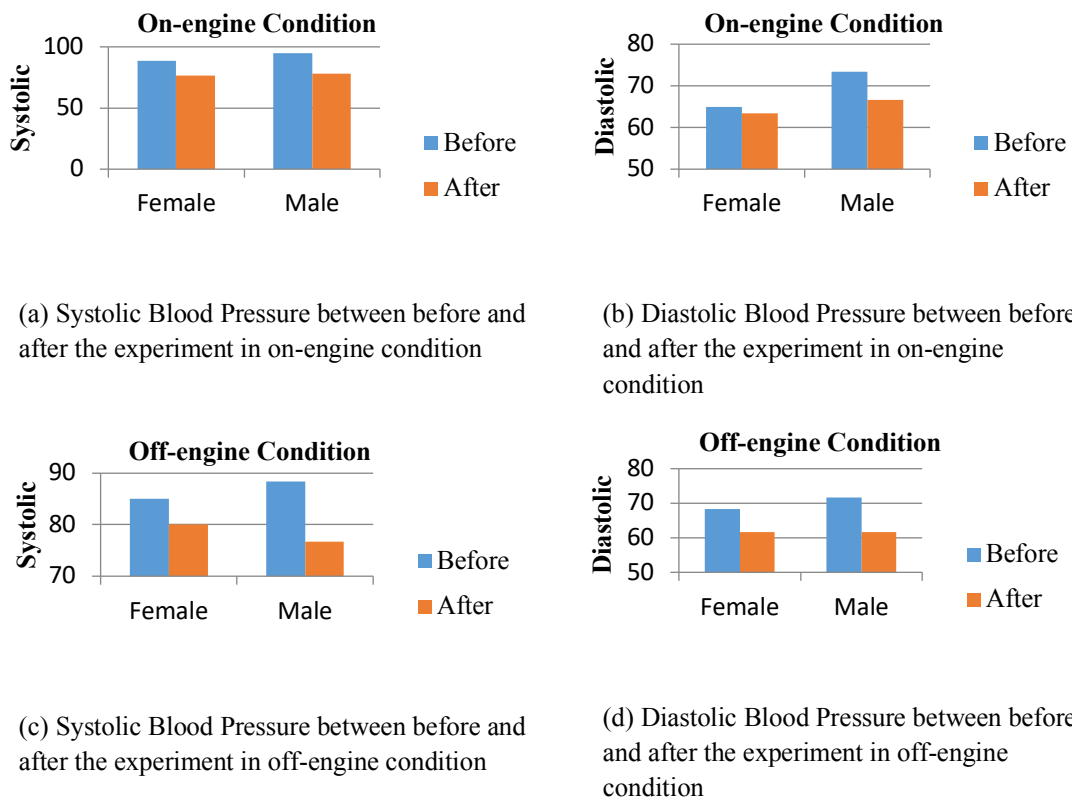


Figure 04. A comparison of blood pressure between the on engine and the off-engine

The difference in systolic blood pressure between before and after the experiment in the on-engine and the off-engine condition is shown in Figure 04 (a) and (c). In Figure 04 (a) shows that between male and female, the systolic blood pressure decreased in the on-engine condition. Systolic blood pressure value of male before the experiment is higher than female. Male's systolic blood pressure value after the experiment has a same value with female. Likewise in Figure 04 (c) shows that a similar result between male and female in the off-engine condition. Male's systolic blood pressure value before the experiment is higher than female. As for Female's systolic blood pressure value after the experiment is higher than male.

The difference in diastolic blood pressure between before and after the experiment in the on-engine and the off-engine condition is shown in the Figure 04 (b) and (d). In figure 04 (b) is shown that between male and female, the diastolic blood pressure is decreased in the on-engine condition. Male's diastolic blood pressure value before the experiment is higher than female. And male's diastolic blood pressure value after the experiment is higher than female. It is Also in Figure 04 (d), It is shown that between male and female, the diastolic blood pressure is decreased in the off-engine condition. Male's distolic blood pressure value before the experiment is higher than female respondent but Male's diastolic blood pressure value after the experiment has the same value with female.

Figure 04 (a) and (c) showed the systolic blood pressure between the on-engine and the off-engine condition before the experiment. From these Figures, it is shown that the mean systolic blood pressure is different but the difference is not related to the experiment. The systolic value is taken when the respondent in health and relax condition with no fatigue. These Figures also showed that male has higher systolic blood

pressure than female though they are not in fatigue. Figure 04 (b) and (d) showed the diastolic blood pressure between on-engine and off-engine condition before the experiment. From these Figures, it is shown that the mean diastolic blood pressure is different but the difference is not related to the experiment also. The diastolic value is taken when the respondent in health and relax condition with no fatigue. These Figures also showed that male has higher diastolic blood pressure than female though they are not in fatigue.

As for after the experiment, it is shown in same Figure above where shows that the mean systolic blood pressure after the experiment of female between the on-engine is lower than the off-engine condition. It was affected much by vibration during the on-engine condition. The figure also shows that the mean systolic blood pressure after the experiment of male between the on-engine is higher than the off-engine condition. It was affected also by vibration during the on-engine condition. Figure also shows that the diastolic blood pressure between the on-engine and the off-engine condition after the experiment where the mean diastolic blood pressure after the experiment of female between the on-engine is lower than the off-engine condition. The figure also shows that the mean diastolic blood pressure after the experiment of male between the on-engine is higher than the off-engine condition. It was affected by vibration during on-engine condition.

After the experiment, Systolic blood pressure in the on-engine and the off-engine condition shows that there were decreasing. It is caused by the occluded blood flow during the uncomfortable sitting. The edge of the seat pressed the hanging leg. The prolonged uncomfortable sitting causes muscle contraction blood pressures decreased due to prolonged lower body immobilization, which causes poor systematic circulation (Balasubramanian et al., 2014). A static position causes damage at the muscular system. It is caused by the muscle rhythm act through the contraction and relaxation to blood flow that brings oxygen and removes the waste secret product from the active muscle. The groups of muscles will make contraction of the muscle in long static position. In these conditions, contractions lead to the occlusion of blood vessels and prevent blood supply and disposal of waste products. This can cause temporary painful muscle cramps, the pain makes one stop by assuming a person's static position and renewing the blood supply to the contracting muscle (Adar, 2004) also the blood flow occluded, the blood supply to the muscular tissue will be blocked as it will also decrease their energy. Hence, it will be dangerous to face prolonged exposure to vibration will cause several diseases such as high blood pressure (Shivakumara & Sridhar, 2010). This condition will produce the inner-thigh pressure which occluded blood supply then it leads to transient paresthesia (Alhoseini et al., 2012).

7. Conclusion

1. The result of this study found that the contraction of semimembranosus muscle has the difference between male and female with average RMS value are 0,57 mV and 0,17 mV respectively in the on-engine condition and 0,1 mV and 0,05 mV respectively in the off-engine condition. Supported by statistical analysis to compare the experiments within the subject which is 0,014 and 0,000018 and comparison between gender is 0,028 and 0,000012 between male. The amplitude is higher due to the vibration transmission than no-vibration. It will increase since the vibration during real driving is dynamic of the engine operation. The male respondent would likely have higher muscle contraction than female contraction

as there are different skeletal muscles between male and female. But, both of them has an increasing amplitude which leads to muscle fatigue.

2. The position of astride sitting made hung legs that weighted to the edge of the motorcycle seat which made high possibility to be pressed over the blood flow. There are decreasing between both female and male in both conditions. The blood pressure value of systolic and diastolic have the average value of 88,33/65 mmHg before the experiment, 76,67/63,33 mmHg after experiment for male and 95/73,33 mmHg before the experiment, 78,33/66,67 mmHg after the experiment for female. The decreasing signs the occlusion of blood flow lead to the accumulation of the lactic acid increasing and block oxygen supplies that lead multifunctional muscle pain that causes insufficient blood supply that makes transient paresthesia.

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