The Study of Lower Limb EMG Signals Between Male and Female Muslim during Pertaining to Sujud Postures in Solat

H. Harun, N.F. Mohd Nasir, A.F. Salleh

***Abstract*—Electromyography signal level in term of %MVC at lower limb muscles on static posture of feet during sujud (prostration) in solat had been studied based on the sayings of Prophet Muhammad (hadiths). Gastrocnemius and Tibialis Anterior were the chosen muscles as both are the major lower leg muscles on the lower limb part. A total of 10 male and 10 female subjects had participated in this study. The EMG data signal results were analyzed statistically using the Paired-Samples T Test as all the data are normally distributed. The statistical result showed that there is no significant difference of the muscles' signal on the respective posture between male and female. The result of EMG level in term of %MVC between male and female showed that during pertaining to sujud posture, Gastrocnemius muscles are more active in male while Tibialis Anterior muscles are more active in female.**

***Index Terms*—Electromyography, Solat, Gastrocnemius, Tibialis Anterior.**

I. Introduction

Electromyography (EMG) is the generated bioelectrical signals in human muscles. The EMG signal is generated by the electrical activities of the muscle fibers activated during a contraction. The skeletal muscle fiber membrane is the seat of the bioelectric phenomena that resulted in the EMG signal [1]. Gastrocnemius (Gas) and Tibialis Anterior (TA) are the skeletal muscles in the lower limb muscles groups. Gas muscles are in group of extrinsic foot muscles which are located in the leg but exerted their actions by extending the foot and flex the lower leg. However, TA acts contrarily. As an intrinsic foot muscles, TA are responsible to flex the foot [2].

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Solat is an act of worship to Allah which is an obligatory for all the Muslims [3]. Sujud (Prostration) is one of the four reverential postures including qiyam (standing), rukuk (bowing) and qa'dah (sitting) [4]. Pertaining to sujud (PTS) posture comes after bowing and just before prostration posture. Based on the hadith narrated from Wa'il Ibn Hujr about the posture of PTS, he said "I saw the Messenger of Allah (Peace Be Upon Him (PBUH)) when he prostrated himself, he placed his knees on the ground before placing his hands and when he got up, he raised his hands before his knees" (Recorded by Abu Daud, al-Nasai, 2/207; Sahih Ibn Hibban) [5] as shown in Figure 1. This hadith is used as the main reference for both Muslim male and female for this act.

Figure 1. Pertaining to sujud posture in male.

The study of solat using EMG is one of the indicators and variables to magnify the muscles activity in a quantitative way. In 2012, Safee et al. studied the similarities of EMG activity during solat and specific exercise. They proved that solat has similar EMG characteristic with some particular exercise movements, thus solat could be used as an alternative to certain type of exercises which able to maintain lower limb performance [6]. In 2013, the same group had also investigated the EMG activities on medial and lateral of Gas muscles and they showed that there were no significant difference on these muscles activities during solat and the exercise compared [7]. Recently in 2015, Khanam et al. estimated the muscles activity during solat through surface EMG analysis. Their study explored the muscle's potentials and forces during the Solat's movements and positions. They suggested that solat can be a part of the

daily exercises for our muscles. As a conclusion,they proposed that solat is a physical acts where, nearly all the muscles of the human body become more active than any kind of physical exercise without causing muscle fatigue [8].

Therefore, the purpose of this study is to investigate the differences of EMG signals and muscles activites for male and female during PTS posture in solat based on the narrated hadiths of Prophet Muhammad (PBUH) as stated before. Here, all other variables were fixed such as the same muscles and the same posture were used. Thus, this study is expected to contribute quantitative evidence in term of EMG level based between male and female during pertaining to sujud act in solat.

II. METHODOLOGY

A. Subject

A total of 10 male and 10 female subjects with the age from 18-40 years old with normal body mass index had volunteered as the subjects for the study. The subjects chosen have a healthy lower limb muscles with no medical history. Subjects were verbally informed and were showed a demonstration about the task given. Three repetitions were recorded for every trial. All the experiments were performed under the consent of the subjects.

B. Apparatus

Disposable bipolar silver/silver chloride (Ag/AgCl) disc surface electrodes were affixed pair in a central position over the muscle belly of the Gas and TA muscles [9]. Muscles were identified by palpation and the electrodes were applied to the muscle belly [10]. The electrodes were attached on one-third of the line between the head of fibula and the heel for Gas muscles and one-third of the line between the tip of fibula and the tip of Medial Malleolus for TA muscles for both right and left sides of leg [11]. The common electrodes were attached on the Medial Malleolus for both sides. The electrodes were connected to the EMG data collector system ADInstrument Powerlab devices and the signal were recorded using software LabChart version 7.0.

C. Experimental procedure

1) Maximum Voluntary Contraction (MVC)

Amplitude (microvolt scaled) of the EMG signals can strongly vary between subject and to overcome it is the normalization to reference value by using MVC value of a reference contraction [9]. For Gas muscles, subjects were sitting with right angle of hip on the fixated chair and performed an unilateral plantar flexion at 90° ankle position [9]. For TA muscles, subjects were against the fixated bottom of table as manual resistance and work the ankle unilaterally [9].

2) Tasks

The all 20 subjectsperformed static postureof PTS for ten seconds with three repetitions. The best three seconds stabilize signals were extracted and analyzed [6].

D. Signal processing

EMG signals data were processed using MATLAB. The raw EMG signals data were filtered by band-pass 10-500 Hz to remove the noise [12]. This were later rectified and smoothed by 20Hz low-pass filter to produce linear envelope. [1]. The smoothed data were calculated to get the Root Mean Square (RMS). The values of all the RMS were averaged and then normalized as the percentage of Maximal Voluntary Contraction (MVC) [6].

E. Data analysis

A descriptive statistics was used to study the features of the entire signal. [7]. Data were analyzed using software Statistical Package for the Social Science (SPSS) version 16.0. Normality test were used to test the distribution of the data. As all the data was normally distributed, Paired-Samples T Test was used to examine the differences between male and female during PTS in terms of the EMG level of lower limb muscles. The significant level was set at $p<0.05$. The average of EMG level in term of % MVC between both genders for each muscle were compared and further discussed.

III. RESULT

All the raw data were analyzed using MATLAB software version r2009a. Then, it is further tested statistically using SPSS software version 16 to determine the normality of the distribution for all data. The results of Normality Tests are then was tested using Paired-sample T Test to compare the mean between two respective genders. EMG level in term of %MVC were compared between the gender for each muscles in order to analyze EMG level and muscle activity during PTS in solat for the respective lower limb muscles.

TABLE I
TEST OF NORMALITY. VALUES SHOWN ARE SIGNIFICANT VALUE SET P<0.05

Postures	Gas Left	Gas Right	TA Left	TA Right
Male	0.087	0.137	0.640	0.087
Female	0.961	0.337	0.813	0.200

From the test of normality for 10 male and 10 female subjects during PTS as shown in Table 1, all the data in both genders during PTS are normally distributed. As the entire data all normally distributed, the data were continued being analyzed by Paired-Sample T Test using SPSS as shown in Table2.

TABLE II
PAIRED-SAMPLE T TEST. VALUES SHOWN ARE SIGNIFICANT VALUE SET P<0.05

Paired Postures	Gas Left	Gas Right	TA Left	TA Right
Male-Female	0.449	0.726	0.309	0.140

As shown in Table 2, Gas and TA muscles in both right and left side between male and female has no significant different during PTS. Statistical results show that there is no significant difference between different postures of PTS as it shows very small percentage difference of the EMG level between male and female as shown in Table 3 which shows the value of EMG level in term of %MVC for male and female in all tested muscles during PTS.

TABLE III
EMG LEVEL IN TERM OF %MVC

Postures	Gas Left	Gas Right	TA Left	TA Right
Male	52.05	50.96	49.50	45.76
Female	44.20	57.12	60.95	63.75

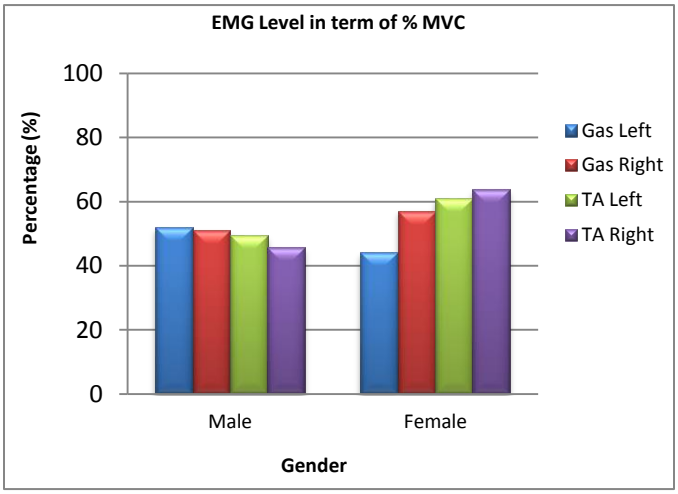

Figure 2. EMG level in term of percentage of maximum voluntary contraction during pertaining to sujud between male and female.

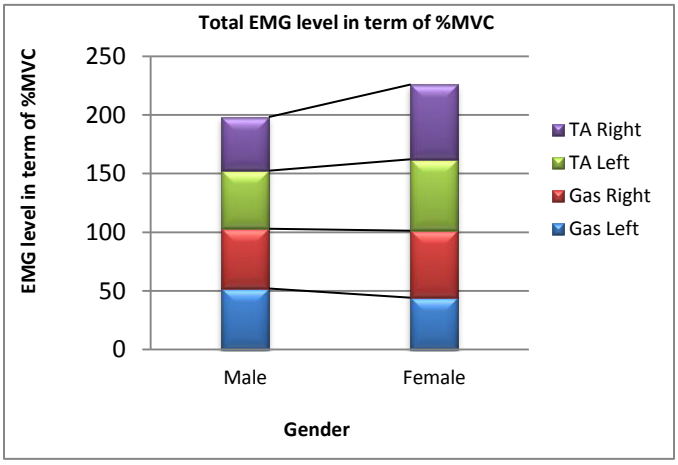

Figure 3. Total EMG level in term of percentage of maximum voluntary contraction during pertaining to sujud between male and female.

TABLE IV
TOTAL EMG LEVEL IN TERM OF %MVC FOR EVERY MUSCLES AND SIDES BETWEEN MALE AND FEMALE

Comparison by muscles [Total percentage (%)]	
Gas	Male *(103.01)*> Female*(101.32)*
TA	Female *(124.7)* >Male *(95.26)*
Comparison by sides [Total percentage (%)]	
L	Female *(105.15)* >Male *(101.55)*
R	Female *(120.87)*>Male *(96.72)*

As shown in Figure 2 and Figure 3, female has higher EMG level in term of %MVC compared to male. From the left Gas muscles, the right Gas muscles, the left TA muscles and to the right TA muscles, the male subjects show a decreasing pattern in the graph while the female subjects show the increasing pattern but with a higher scale than male.

During PTS, male has higher EMG level in Gas muscles than female by 1.69% while female has higher EMG level in TA muscles than male by 29.44%. For the both left and right side of all tested muscles, female has the higher EMG level than male. For the left side, female is 3.6% higher than male while for the right side, female is 25.15% higher than male as shown in the table 4.

IV. DISCUSSION

This study investigated the differences in EMG level and muscles activity between male and female during PTS. EMG level and muscles activity are influenced by the body postures [13]. It is known that male and female have different anatomical and physiological posture [2]. However, during the experiments, both male and female did the same posture of PTS. Thus, the results show no significant difference during the statistical tests. During PTS, Gas and TA muscles act on the same behavior but with different angles. Gas is flexing and TA is extending. The joint angles for Gas action muscles during PTS is in the range of 50° and TA is in the range of 20° [3]. Here, the difference of angles resulted in no significant differences of EMG level of the lower limb muscles.

The contrast pattern of graphs as shown in Figure 2 shows that during PTS, the male subjects were using more Gas muscles than TA muscles while the female subjects were using more TA muscles than Gas muscles. Thus, to stay in a posture, the body position should be maintained securely [2]. In order to maintain the body position at the best, these finding shows that the male is contracting more Gas muscles, meanwhile the female is contracting TA muscles more during PTS. In addition, the differences of figure between male and female such as their skeletal structure may influences the muscles function.

The total EMG level in term of %MVC as shown in Figure 3 shows that female has more muscles activity than male during PTS. The comparative result as shown in Table 4 also shows that female uses TA muscles much more than male uses Gas muscles during PTS. While, female has higher %MVC of EMG level on the right in comparison to the left side. It can be said that during PTS, female leans their body weight on the right sides which cause the muscles

on the right side contracted more thus resulting the higher EMG level on the right side of the female. Meanwhile, the male has the higher of the total muscles used at the left side contrary to the female. This can be concluded that the male was more inclined to their left side during PTS.

The overall experimental results show that there are no significant difference between male and female during PTS in solat. However, the male has more active Gas muscles compared to the female which has more active TA muscles during PTS. The male also have more active muscles on the left side but the female have more active muscles on the right side. However the total EMG level in term of %MVC shows that the female has more active muscles during PTS compare to the male.

V. Conclusion

In conclusion, even though through statistical analysis, it shows that there are no significant different between male and female during PTS but the EMG level in term of %MVC shows that the muscles work contrary. Many factors may lead to the reasons behind the differences of the muscles activity such as from the anatomical, the physiological or the human system perspective. Furthermore, these finding also concluded that the male and the female shows contrary body reaction while performing certain activities and the interesting outcomes are shown from this study.

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