THE INVESTIGATION OF EMG SIGNAL FOR LOWER LIMB MOVEMENT DURING SOLAH (MUSLIM PRAYER)

by

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LIST OF ABBREVIATIONS

AR	Auto Regressive
BDNF	Brain-Derived Neurotrophic Factor
ECG	Electrocardiography
EEG	Electroencephalography
EMG	Electromyography
FFT	Fast Fourier Transform
GAS	Gastrocnemius
GL	Left Gastrocnemius
GR	Right Gastrocnemius
HF	High Frequency
HP	Hands Precede
HRV	Heart Rate Variability
KP	Knees Precede
LF	Low Frequency
MVC	Maximum Voluntary Contraction
nuHF	normalized units of High Frequency
PBUH	Peace Be Upon Him
PTS	Pertaining to Sujud
S.A.W	SallallahAlaihiWasalam
SCF	Sujud with Close Feet
SENIAM	Surface Electromyography for the Non-Invasive Assessment of Muscles
SF	Forbidden Sitting

SI	Sitting of Iftirasy
SOF	Sujud with Open Feet
SP	Permissible Sitting
SPSS	Statistical Package for the Social Science
ST	Sitting of Tawarruk
SUF	Sujud with Ungrounded Feet
SVF	Sujud with Vertical Feet
TA	Tibialis Anterior
TL	Left Tibialis Anterior
TR	Right Tibialis Anterior
UPFE	Unilateral Plantar Flexion Exercise

Kajian Mengenai Isyarat EMG pada Pergerakkan Anggota Bawah Badan Semasa Solat

ABSTRAK

Isyarat elektromyografi (EMG) pada otot bawah badan semasa postur static termasuklah ketika hendak turun sujud, semasa sujud dan semasa duduk di dalam solat telah dikaji berdasarkan hadis Nabi Muhammad (S.A.W) sebagai sumber rujukan yang utama. Gastrocnemius dan Tibialis Anterior adalah otot yang terpilih di dalam kajian ini kerana kedua-duanya adalah di antara otot yang utama pada anggota bawah badan dan juga ia memenuhi kriteria untuk memperoleh data yang dikehendaki. Sekumpulan subjek seramai 20 orang yang terdiri daripada 10 lelaki dan 10 perempuan telah terlibat dalam kajian ini. Hasil data yang diperolehi telah dianalisa menggunakan MATLAB versi r2009a dan seterusnya dianalisa secara statistik menggunakan 'Paired Sample T-Test' dari SPSS versi 16.0. Hasil daripada analisa statistik menunjukkan kepelbagaian dalam dapatan yang baru lagi menarik berhubung dengan postur-postur dalam solat seperti yang terlibat. Semasa postur hendak turun sujud, kajian ini menunjukkan tiada perbezaan yang signifikan di antara mendahului tangan ataupun mendahului lutut walaupun terdapat perbezaan tafsiran dan pendapat tentang cara yang betul untuk turun sujud berdasarkan kepelbagaian hadis. Semasa postur sujud dan duduk, hasil kajian menunjukkan terdapat hubungkait di antara hadis dan postur dalam solat dalam bentuk aktiviti EMG di dalam otot. Isyarat EMG dalam bentuk %MVC yang juga merupakan pembolehubah dalam Kajian ini menunjukkan hasil kajian yang menyokong kepada hadis dan sunnah Nabi Muhammad (S.A.W). Oleh yang demikian, hasil daripada isyarat EMG yang diperolehi, ia jelas menyokong hadis dan sunnah Nabi Muhammad (S.A.W) tentang cara yang betul untuk menunaikan solat.

The Investigationof EMG Signal for Lower Limb Movement During Solah

ABSTRACT

Electromyography (EMG) signals at the lower limb muscles during static postures include pertaining to sujud, sujud and sitting in solah had been studied based on the sayings (hadith) of Prophet Muhammad (Peace Be Upon Him) as the main references. Gastrocnemius and Tibialis Anterior were the chosen muscles in this study as both are the major muscles of the lower leg and have fulfilled the criteria in order to get the required data. A group of 20 subjects had participated in this study which is 10 male and 10 female subjects. The EMG data signal results were analyzed using MATLAB Software version r2009a and then were statistically analyzed using the 'Paired Samples T-Test' from SPSS version 16.0. The statistical results showed the variety of interesting new finding regarding the particular posture of solah. Male has been found to use their Gastrocnemius muscles more while female is using their Tibialis Anterior more during solah. The results also show that there is a correlation between the authentic hadiths and the postures in term of EMG activity. During pertaining to sujud posture, this study has shown that there is no significant different between preceding by hands or preceding by knees although Muslim scholars have different interpretation and opinion of the exact way to pertain to sujud according to various narrated hadiths. During sujud and sitting postures, the EMG level in term of the %MVC as a variable in this study has shown supportive results towards postures that were commanded in the hadiths and the sunnah of the Prophet Muhammad (PBUH). Thus, the EMG results from this study have apparently supported the authentic hadiths and the sunnah of Prophet Muhammad (PBUH) about the correct way to perform solah.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The introduction chapter contains the backbone of this study which includes the background study and the problems statements in order to achieve the objectives. This chapter also contains the scopes of the study and the organization of all the chapters in this study.

1.2 Background

Solah is derived from the Arabic word *as-solah* which means *ad-dua'* or pray (Mustofa, Sillaturohman, & Khalid, 2011). Solah is an obligatory act to all Muslims from Almighty Allah through the Prophet Muhammad (Peace Be Upon Him) since 1400 years ago. An authentic hadith recorded by al-Bukhari, Prophet Muhammad (PBUH) said "Pray as you seen have me seen me praying." (Rahman, 2009). Based on that hadith, Muslims until today pray in the manner of the Prophet Muhammad had prayed since then. In this study, the posture of the lower limb during certain solah position would be study in detail. In term of muscular system, posture is the maintenance of the human body in optimal position by acting oppositely against the gravitational force (Thibodeau & Patton, 2007).

Solah involves four main postures which are qiyam (standing), rukuk (bowing), sujud (prostration) and qa'dah (sitting) (Muhiyud-Din, 2001). Among these four postures, standing and rukuk position mostly consume the upper limb muscles while prostration and sitting position involve more of the lower limb muscles. Thus, in this study, the act or postures of solah after standing rukuk such as; Pertaining to Sujud (PTS), Sujud and Sitting

during solah would be studied. The postures during these acts would be compared between the disputed acts and also between the one recommended or prohibited by the Prophet Muhammad (PBUH).

All these postures involve lower limb muscles and there are 35 lower limb muscles in total (Arnold, Hamner, Seth, Millard, & Delp, 2013). Here, Gastrocnemius (GAS) and Tibialis Anterior (TA) muscles were chosen as the muscle of interest since most of the studies related to the lower limb in solah involved these two muscles (Khanam, Islam, Rahman, & Ahmad, 2015; Safee, Abas, Ibrahim, Osman, & Salahuddin, 2012; Safee, Abas, Osman, & Ibrahim, 2013). Besides, GAS and TA muscles are the largest muscles in lower limb, their position as the outermost layer make them the most suitable muscles to be tested under surface electrodes to gain the acquired results in this study.

Therefore, electromyography (EMG) is chosen as the analysis tool for the interpretation of the muscles activities and its effect on particular work (Marras, 1990) especially related to solah since it is capable in acquiring reliable muscles activity during physiological contraction (Gant, 2012). Thus, it is interesting to observe the activity of the lower limb muscles which can be measured using EMG in relation to the postures described in Islamic jurisprudence.

1.3 Problems Statement

This study is to investigate EMG signals for lower limb muscles postures during performing solah based on the sunnah and the authentic hadiths of Prophet Muhammad (PBUH). Currently, there is no study that had been conducted using scientific measuring tools to relate the postures recommended or prohibited by the Prophet to the human wellbeing. Previous studies are confined to the aspect of comparing solah to standard

exercises. Thus, this create a necessity to explore the effect of certain postures in solah based on the recommendation of the Prophet Muhammad (PBUH) as these postures are regarded as the most authentic postures according to the Islamic jurisprudence.

Therefore, the relation between authentic hadiths and different postures of solah in term of EMG signal could be established quantitatively using statistics to assist the reasoning behind the postures as described by the Prophets Muhammad (PBUH). As a beginning, the postures using lower limbs such as pertaining to sujud, sujud and sitting would be investigated here to establish the relation of solah and their effect to the EMG signals. Hence, this may open up more studies in this area to support the established jurisprudence knowledge of Islam and also to understand the benefit of performing solah according to the authentic hadiths and sunnah of the Prophet.

1.4 Objectives

The objectives of this project are as follows:

- To analyze the differences of EMG signal result of lower limb muscles from the postures in solah which were recommended and forbidden by the Prophet Muhammad (PBUH), and also the postures which were performed due to the differences of the interpretation of the authentic hadiths of the Prophet Muhammad (PBUH) during this acts of solah:
    - Pertaining to Sujud
    - Sujud
    - Sitting

1.5 Scopes of Study

The scopes of the study include:

- To statistically verify the EMG signal data from the different positions and postures of lower limb muscles during performing solah. The results would quantitatively clarify the differences of different postures and anatomical positions of the lower limb muscles during performing solah.
- This study involved 20 healthy subjects with the range of age from 18 to 40 years old (Appendix D) which involve the most functional muscles of the lower limbs during the respective chosen postures which are Gastrocnemius and Tibialis Anterior muscles.
- The postures include pertaining to sujud, sujud and sitting in solah.
- The data of the recorded EMG signal data would be analyzed and discussed using Paired Sample T-Test from SPSS version 16.0.

1.6 Thesis organization

This thesis reports the EMG signal activity during specific postures in solah from specific lower limb muscles. This thesis consists of five chapters which are introduction, literature review, methodology, result and discussion and lastly, conclusion.

Chapter 1 reviews the overall introduction of this research such as the background of the study, problem statements, scope, and objectives.

Chapter 2 covers on the literature review of the journals and articles regarding to the study of solah using modern science and specifically the study of solah from the perspective of the EMG itself.

Chapter 3 covers the methodology for the project. The implementation of the study is written in detail regarding to the application of EMG to obtain the results and the statistical tools used to analyze the EMG signals.

Chapter 4 covers the result and discussion. The results were discussed on the EMG level in term of %MVC from both gender and from all the chosen postures which are Hands Precede (HP), Knees Precede (KP), Sujud with Close Feet (SCF), Sujud with Open Feet (SOF), Sujud with Ungrounded Feet (SUF), Sujud with Vertical Feet (SVF), Sitting of Iftirasy (SI), Sitting of Tawarruk (ST), Permissible Sitting (SP) and Forbidden Sitting (SF).

Chapter 5 is the overall summary and conclusion of this study and suggestions for possible future works.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Previous studies which are related to this study had been critically reviewed for better understanding and to improve the methodology of the study in order to achieve the objectives. Here, the authentic hadiths related to the postures of solah were referred as a guide to choose the acquired postures. Other previous studies related to the study in solah were included such as the selection of lower limb muscles of interest, the application of solah in rehabilitation and psychotherapy and the importance of biosignal in this study.

2.2 Posture in Solah

The solah consists of four different postures which are standing, bowing, prostrating and sitting (Muhiyud-Din, 2001). However, in this study the main focused are about certain postures such as pertaining to sujud (PTS), sujud and sitting between two sujud. Here, the correct positions of the respective postures are identified based on the narrated hadiths of Prophet Muhammad (PBUH).

Pertaining to sujud is the position between bowing and prostration or between rukuk and sujud. There are two opinions from the narrated hadiths about the ideal way of pertaining to sujud either preceeding by hands or preceeding by knees (Al-Albani, 2011; Al-Jauziyyah, 2013; Al-Saqqaf, 2010; Muhiyud-Din, 2001; Rahman, 2009). One narrated hadith is recorded by Abu Hurayrah regarding to pertaining to sujud preceded by hands while the another hadith recorded by Wa'il Ibn Hujr mentioned about pertaining to sujud

preceded by the knees and both of the hadiths are shown in Hadith (2.1) and Hadith (2.2) respectively (Al-Jauziyyah, 2013; Al-Saqqaf, 2010; Rahman, 2009). Based on the four main schools of Sunni jurisprudence, the Hanafites, Shafi'ites, and Hambalites followed the hadith by Wa'il which was reported by Imam at-Tirmidzi (Al-Saqqaf, 2010) and the Malikites followed the hadith narrated by Abu Hurayrah(Rahman, 2009).

إِذَا سَجَدَ أَحَدُكُم فَلاَ يَبْرُكْ كَمَا يَبْرُكُ الْبَعِيرُ وَلْيَضَعْ يَدَيْهِ قَبْلَ رُكْبَتَيْهِ

Translation: (2.1)

When one of you performs Sujud, he should not kneel down like the camel, but should place his hands before his knees (Recorded by Abu Daud, no. 840, 1/222; Ahmad, 2/381 and Al-Nasa'i, 2/207).

رَأَيْتُ رَسُولُ اللهِ صَلَّى اللهُ عَلَيْهِ وَسَلَّمَ إِذَا سَجَدَ ، وَضَعَ رُكْبَتَيْهِ قَبْلَ يَدَيْهِ ، وَإِذَا نَهَضَ رَفَعَ يَدَيْهِ قَبْلَ رُكْبَتَيْهِ

Translation: (2.2)

I saw Prophet Muhammad (PBUH) when he went down for sujud, he placed his knees on the ground before his hands and when he PBUH stood up, he PBUH raised his hands before his knees (Recorded by Abu Daud, At-Tirmirdzi, Al-Nasa'i, 2/207; Sahih Ibn Hibban).

During sujud, Muslim scholars have different interpretation of the hadiths about the correct position of feet during sujud either sujud with close or open feet. Al-Albani, al-Thahawi and ibn Khuzaimah were more inclined towards the hadith narrated by Aisyah (May Allah Has Mercy on Her) that a Muslim should sujud with close feet as shown in the Hadith (2.3) (Abasoomar, 2015; Al-Saqqaf, 2010). Meanwhile, there is an authentic hadith recorded by Abu Daud which mentioned about making sujud with open feet as shown in the Hadith (2.4) (Mohamad, 2016).

فَقَدْتُ رَسُوْلَ اللهِ صَلَّى اللهُ عَلَيْهِ وَسَلَّمَ فَوَجَدْتُهُ سَاجِدًا رَاصًا عَقِبَيْهِ ،
مُسْتَقْبِلاً بِأَطْرَافِ أَصَابِعِهِ الْقِبْلَةَ

Translation: (2.3)

Prophet Muhammad (PBUH) was wake up while I am still sleeping in bed. Later I found him in the position of sujud with closed feet and his toes are facing toward kiblat (Recorded by Ibn Khuzaimah, 1/328 and Al-Baihaqi, 2/116).

وَإِذَا سَجَدَ فَرَّجَ بَيْنَ فَخِذَيْهِ غَيْرَ حَامِلٍ بَطْنَهُ عَلَى شَىْءٍ مِنْ فَخِذَيْهِ

Translation: (2.4)

When Prophet Muhammad (PBUH) Sujud, he separates his feet and give a space between his stomach and feet (Recorded by Abu Daud, 2/734).

Even though there are two different hadiths about the different positions of the feet during sujud, there are certain common mistakes regarding to the position of the foot which are performed by some Muslims perhaps due to lack of knowledge of performing the solah correctly (Rahman, 2009). This mistake made during sujud performed by Muslim is referred to act of not bending the toes facing towards Kiblat because this is contradictory to the action of the Prophet according to a narrated hadith recorded by al-Bukhari as shown in the Hadith (2.6) (Muhiyud-Din, 2001).

عَن اَبِیْ حُمَیْدِنِ السَّاعِدِی قَالَ فِی نَفَرٍ مِنْ اَصْحَاب رَسُوْلِ اللهِ صَلَّی عَلَیْهِ وَسَلَّم اَنَا اَحْفَظُکُمْ لِصَلٰوةِ رَسُوْلِ اللهِ صَلَّی اللهُ عَلَیْهِ وَسَلَّم رَاَیْتُهُ اذَا سَجَدَ وَضَعَ یَدَیْهِ غَیْرَ مُفْتَرِشٍ وَلاَ قَابِضِهِمَا وَاسْتَقْبَلَ بِاَطْرَافِ اَصَابِعِ رِجْلَیْهِ الْقِبْلَةَ.

Translation: (2.5)

From Abu Humayd As-Saidi: He said among a party of the companions of the Messenger of Allah (May Allah confer blessing in him and grant him peace). I am more preserving in my memory of the prayer of the Messenger of Allah (May Allah confer blessing on him and grant him peace). I saw him when he prostrated himself he placed his two hands (on the ground) neither spreading nor contacting, and turned towards the Ka'bah with the ends of the toes of his two feet (Recorded by Ahmad, 5/424; Al-Bukhari, 1/201).

Another common mistake includes the uplifting of the devotees feet without touching the ground. It does not fulfill the requirement of the seven limbs which should touch the ground during solah as mentioned in the hadiths recorded by Ibn Abbas as shown in the Hadith (2.5) (Al-Albani, 2011).

إِذَ سَجَدَ الْعَبْدُ ؛ سَجَدَ مَعَهُ سَبْعَةُ آرَابٍ :وَجْهُهُ ، وَكَفَّاهُ ، وَرَكْبَتَاهُ ، وَقَدَمَاهُ

Translation: (2.6)

When one sujud, sujud with seven limbs: face, the hands, the knees and the toes. (Recorded by Ibn Abbas, 2/272)

For the sitting posture, there are no argument based on the hadiths narrated about the correct way in performing sitting during solah because it consists of two moments of sitting which is Sitting of Iftirasy (SI) during the second cycle of solah (rakaah) and Sitting of Tawarruk (ST) performed during the final rakaah (Yaman, 2011). The hadiths regarding to SI and ST are shown in Hadith (2.7) and Hadith (2.8) respectively (Rahman, 2009).

فَإِذَا جَلَسَ فِي الرَّكْعَتَيْنِ ، جَلَسَ عَلَىَ رِجْلِهِ الْيُسْرَى ، وَنصَبَ الْأُخْرَى

Translation: (2.7)

When Prophet Muhammad (PBUH) sat in the second raka'ah, he sat on his left foot and raised his right foot (Recorded by Al-Bukhari, no/ 254, 2/252).