World Academy of Science, Engineering and Technology
International Journal of Bioengineering and Life Sciences
Vol:8, No:12, 2014

Electromyography Activity of the Rectus Femoris and Biceps Femoris Muscles during Prostration and Squat Exercise

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***Abstract*—**This paper investigates the activity of the rectus femoris (RF) and biceps femoris (BF) in healthy subjects during *salat* (prostration) and specific exercise (squat exercise) using electromyography (EMG). A group of undergraduates aged between 19 to 25 years voluntarily participated in this study. The myoelectric activity of the muscles were recorded and analyzed. The finding indicated that there were contractions of the muscles during the *salat* and exercise with almost same EMG's level. From the result, Wilcoxon's Rank Sum test showed significant difference between prostration and squat exercise ($p<0.05$) but the differences was very small; RF (8.63%MVC) and BF (11.43%MVC). Therefore, *salat* may be useful in strengthening exercise and also in rehabilitation programs for lower limb activities. This pilot study conducted initial research into the biomechanical responses of human muscles in various positions of *salat.*

***Keywords*—**Electromyography, exercise, muscle, *salat.*

I. Introduction

THE electrical activity in the human muscles can be measured using electromyography (EMG). This allows for the measurement of the change in the membrane potential as the action potentials are transmitted along the fiber. The study of the muscles from this perspective can be valuable in providing information concerning the control of voluntary and reflexive movement. The study of muscle activity during a particular task can yield insight into which muscles are active and when the muscles initiate and cease their activities [1].

EMG is also used to study neuromuscular function, including identification of which muscle develop tension throughout a movement and which movements elicit more or less tension from a particular muscle or muscle group. It is also used clinically to access nerve conduction velocities and muscle response in conjunction with the diagnosis and tracking of pathological condition of the neuromuscular system [2].

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The *salat* is a ritual Islamic prayer that's given by all those practicing the Muslim religion five times a day. The *salat* shows an individual's dedication to God and is considered the most important act of worship. *Salat* has precise steps that all Muslim all over the world must do it. The various motions of the *salat* include standing, bowing, prostration, and sitting. The joins that are involved in the movements are the shoulders, wrists, elbows, metacarphophalangeals (MP), proximal interphalangeals, distal interphalangeals, temporomandibular, vertebral column, hip, knee, ankle, subtalar, metatarsophalangeal, and antanto-axial [3].

The Muslim performing salat using those movements: 1) begins his prayer by standing facing the direction of the *Qibla* and raises his hands and speaks aloud a phrase called the *takbir*, 2) standing while his hands were placed between chest and stomach and reciting Al-Quran. 3) Bows, repeating the *takbir*, 4) return to standing position, 5) prostrates, placing his forehead, nose, hand, knee, and toes on the floor, 6) upright sitting position, 6) repeat the act prostrates position, 7) upright sitting position while reciting *tashahhud*, 8) conclude the *salat* by turns first towards his right and toward his left called *salam*. This position and movement involve a lot of muscle contraction and relaxation, which is good for exercise activity. Besides that, Muslim is commanded to perform *salat* regularly, five times a day.

There are a lot of benefits for someone that always doing exercise or training for their muscles. During training of the muscular system, a neutral adaptation modifies the activation levels and patterns of the neural input to the muscle. In strength training, for example, significant strength gains can be demonstrated after approximately four week of training. This strength gain is not attributable to an increase in muscle fiber size but is rather a learning effect in which neural adaptation has occurred [4], resulting in increases in factors such as firing, and motorneuron excitability [5]. Besides that, strength training also recognized as an effective form of exercise for elderly individuals. A believed to be related to reduce activity levels [6]. Strength training that is maintained into the later years may counteract atrophy of bone tissues and moderate the progression of degenerative joint alteration. Eccentric training also been shown to be effective in developing strength in the elderly [7].

The purpose of this experiment is to identify the muscle potential during *salat's* movement and position that can be one of the daily exercise and training for our muscle. This is because, it is obligatory for Muslim to perform *salat* five

prayers during day and night with difference *rakat* or unit; dawn prayer 2 *rakat*, midday prayer 4 *rakat*, afternoon prayer 4 *rakat*, dusk prayer 3 *rakat* and night prayer 4 *rakat*. Each *rakat* consist a routine start from standing-bowing-standing-prostration-sitting-prostration-standing. Besides the obligatory or prescribed five daily routine (prayers), Muslims are strongly advised to perform the non-obligatory prayers.

II. Subject And Method

A. Subject

A total of 8 subjects undergraduates (age: 19.5 ± 5.1 years) with no medical history were recruited as subjects of the study. Subjects were verbally informed about the experimental protocols, and they read and signed a consent form prior to participating in the experiments. Three repetitions were recorded for prostration and squat exercise.

B. Apparatus

Disposable bipolar Ag-AgCl disc surface electrodes with a diameter of one cm were affixed over the chosen muscle groups, parallel to their fiber orientation in the muscle belly. The electrodes were attached to the right leg over the belly of the RF, BF, Gas and TA. Those electrodes were placed over the midpoint of the muscle belly. The common-earth electrode was applied on the head of the fibula of the same side. The electrodes were connected to an EMG data collection system (Myomonitor IV Wireless Transmission, Delys) and the signals were collected using customized software (Delys EMGWorks, Boston, MA, USA). These records were then downloaded into a personal computer (Toshiba, Japan). The EMG bandwidth was 10-500Hz at a sampling rate 1500Hz. The electrodes were placed according to the SENIAM recommendation [8]. The myomonitor was capable of recording 16 muscles simultaneously.

C. EMG Normalization Procedure

In order to compare value of muscle activity across subjects it was necessary to normalize the EMG data. To normalize the EMG data, a record was made of the maximum voluntary contraction (MVC) for the all muscles involved in the experiment. To obtain stable maximum force prior to formal EMG data collection, enough practice time was allowed for warming-up and for the subjects to familiarize themselves with the testing procedures. Subjects maintained the same level of contraction for 5 s and the 3 s with the most constant root mean square (RMS) EMG signal were selected and used to represent the normalized value (100% MVC).

To access MVC of RF, subject stood on a chair with 90^0 knee flexion. Then, they extended the knee between 90° and 70° while imagining a large resistance load. For BF, subject stood on a chair by completely extending the knee and then flexed the knee with imagining a large enough load pressing to opposite. Three repetitions were recorded for every muscle.

D. Description of Task

Subject was asked to perform prostration and squat exercise. According to Alex SM et al. [9], squat exercise consists two phases; eccentric phase and concentric phases. We just access during eccentric phase. Subjects performed eccentric phase starting with the subject standing up, leg parallel with a small lateral rotation of the feet, feet approximately 30-40cm apart, flex the knee till 90^0. For the prostration, subjects started from standing upright, flex the knee till knees, forehead and palms of the hands touch the ground. These movements were done during the duration of 5 second stated from standing upright. Fig. 1 showed the movements and position in the experiment.

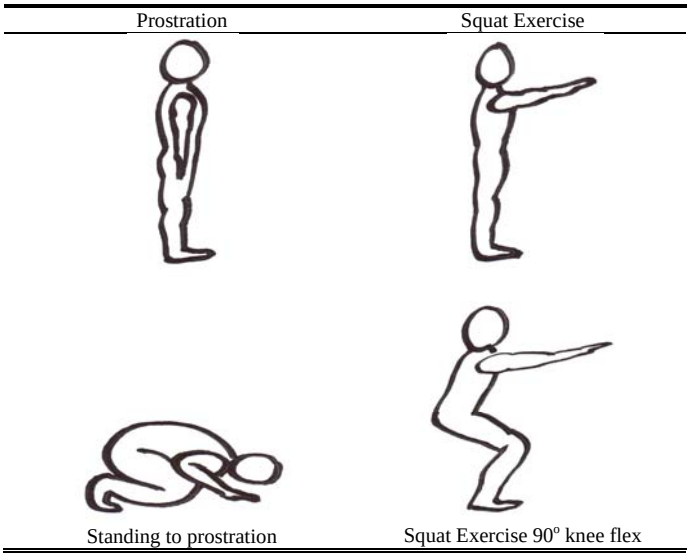

Fig. 1 Prostration and squat exercise

E. EMG Processing

Both the EMG level during prostration and squat exercise were identically processed. The EMG signals were analyzed using EMG analysis software version 3.5.1.0, (EMGWorks, Delsys, Boston, MA), then a root mean square (RMS) technique was used to smoothen the data thus producing a linear envelope of EMG activity record. The data obtained from each subject were downloaded into a personal computer (Toshiba, Japan). The values of all RMS were averaged and then normalized as % MVC. Then, each position of prostration and squat exercise were compared.

F. Statistical Analysis

A descriptive statistics was used to study the features of the entire signal. The Wilcoxon Rank Sum was used to examine the differences between the prostration and squat exercise in term EMG level. The significant level was set at $p<0.05$. The data was analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 18.0.

III. Result

The experimental results of the EMG signals for all the subjects indicate that there were muscles contractions for all of the muscles during prostration and squat exercise. RF and BF produce almost same level of EMG for prostration and squat

exercise. These EMG level averages in % MVC of every muscle was shown in Table I.

TABLE I
EMG AVERAGE IN % MVC

Muscle	EMG average in % MVC	
	Prostration	**Squat exercise**
RF	70.18	78.81
BF	75.43	86.86

EMG level in %MVC was shown in Table I. From this histogram, there are very small differences of EMG level between prostration and squat exercise with RF 8.63% and BF 11.43%. These small differences showed that the forces that all the muscles use to contract and stretch are quite same between prostration and squat exercise.

Although the result showed that RF and BF have small differences in EMG level during squat exercise compare to prostration, Wilcoxon Rank Sum Test also showed a statistically significant difference between prostration and squat exercise ($p<0.05$).

TABLE II
STATISTICAL ANALYSIS OF PROSTRATION AND SQUAT EXERCISE

Posture	Median	Z	p
Rectus Femoris			
Prostration	70.32	-2.240	0.025
Squat exercise	78.34		
Biceps Femoris			
Prostration	78.57	-2.380	0.017
Squat Exercise	90.73		

IV. DISCUSSION

From this experiment, we can see that muscle contraction appeared during prostration (*salat)* as well as squat exercise. Rectus femoris, hamstring and gastrocnemius are the most important muscle during walking. Two-joint muscle that work together in walking are the sartorius and rectus femoris at heel strike; the hamstrings and gastrocnemius at midsupport; the gastrocnemius and rectus femoris at toe-off; the rectus femoris, Sartorius and hamstrings at forward swing; and the hamstring and gastrocnemius at foot descent [10]. By doing exercise for these muscles, it will help to maintain movements at lower limb especially during gait cycle. The gait cycle is one of the most important activity during our activity daily living which is involves a lot of lower limb muscles.

Muslim performs *salat* regularly. They need to perform *salat* daily and follow all the cycles. The cycles that they follow are same. There is a growing realization that regular participation in physical activity can give us a lot of benefit for our health. For example, regular exercise reduces the blood pressure by reducing body weight and increasing elasticity of the blood vessels [11], [12]. Moreover, regular exercise prevents people from having habits causing cardiovascular risk such as smoking and alcohol consumption, malnutrition, stress, anxiety etc. and experiencing healthier lifestyle. Regular exercise is a quite effective tool in prevention and rehabilitation of cardiovascular diseases [13]. Barlet et al. [14] found that regular program of weight-bearing exercise, such as walking can increase bone health and strength even among individuals with osteoporosis. All the activities that we perform regularly will show the effect of those activities. All experts will advise to do exercise regularly to get the best results. Same with the muscle contraction and relaxation, if we perform regularly, we will get the result either good or bad results.

In this study, we just access squat exercise and *salat* (prostration) during eccentric phase which is the movement is from standing upright and flex the knee to lowering the body. But in squat exercise and *salat*, there is also concentric phase to complete the task, which will produce difference result [9]. Electromyographic activity is different between eccentric and concentric muscle actions [15], [16]. Eccentric actions typically result in less EMG amplitude than concentric contractions for the same relative level of force production.

In this experiment, the result showed that there are very small differences between muscle contraction during *salat* (prostration) and exercise (squat exercise). These small differences can be considered as differences of techniques of exercises for lower limb muscle. Although the muscle contraction during prostration is lower than squat exercise, it still can be one simple warming up exercise for the lower limb muscle.

Traditionally, the treatment of low back pain has included strengthening exercises for the back extensor muscle. Prone arch or their variations, prone trunk, and leg lifting exercises, have been known to alleviate back pain [17]. Consistent activity in the erector spine in patients with low back pain provides stability to help protect the diseased passive spinal structure from movements that may cause pain [18]. Strengthening exercises for the abdominal muscles are frequently used in the rehabilitation of low back pain. It is hypothesized that the local muscles, such as the transverse abdominal and internal oblique abdominals, are instrumental to the stabilization of the lumbosacral spine [19]. The global muscles, including the rectus abdominal and external oblique abdominals, are responsible for producing gross movements of the trunk and pelvis [20]. Rectus femoris and biceps femoris also involve in producing the movements for the treatment of low back pain.

V. CONCLUSION

In conclusion, the *salat* position such as prostration can be one of the exercises to maintain our lower limb performance. To every Muslim that performs *salat* 5 times a day automatically was doing exercise for their lower limb muscle especially rectus femoris and biceps femoris muscles. Besides, it also can be one of the flexibility exercises to maintain ROM for our joints. This pilot study can be useful for therapist in rehabilitation or exercise programs.

Muscle contraction and muscle relaxation that occur show agonist-antagonist response that is good for exercise and strengthening programs. The investigations can be extended to other muscles exercises either involving standing or sitting positions.

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