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Electromyographic Activity of the Medial Gastrocnemius and Lateral Gastrocnemius Muscle during *Salat's* and Specific Exercise

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***Abstract*—**This paper investigates the activity of the gastrocnemius (Gas) muscle in healthy subjects during *salat* (*ruku'* position) and specific exercise [Unilateral Plantar Flexion Exercise (UPFE)] using electromyography (EMG). Both lateral and medial Gas muscles were assessed. 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 no significant difference between *ruku'* and UPFE for both medial (p=0.082) and lateral (p=0.226) of GAS muscles. Therefore, *salat* may be useful in strengthening exercise and also in rehabilitation programs for lower limb activities.

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

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].

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, 7) repeat the act prostrates position, 8) upright sitting position while reciting *tashahhud*, 9) 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 biomechanical response of human muscle during *salat's* positions. From that, we can do further investigations on the impacts of *salat* for our physical and mental health. This also will be an initial step to do more experiments on *salat* as one of the physical activities during prays.

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II. Subjects and Methods

A. Subject

A total of 10 subjects undergraduates (age: 19 ± 8 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 every *salat* and exercise protocol.

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 medial and lateral Gas muscles. 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].

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).

The MVC task of the Gas involved a gradual increase in the plantar flexion force exerted by the triceps surae muscle from baseline to maximum in 5 s and then sustained at maximum for 3 s. Each subject performed at least three MVC trials.

D. Description of Task

Subjects were assessed during bowing's position and UPFE. During assessing the bowing's position, subjects band his hip as far as he could to reach 90^0 bending position with both hand gripped the knee. Subjects hold the position in 10 s and 3s with most constant RMS EMG signal were selected. When performing UPFE, subjects sat on the floor with their legs extended in front of them, bend their body forward and hold the toes with fingers. The toes of the feet were pulled towards their body. Subjects hold the position in 10 s and 3s with most constant RMS EMG signal were selected.

E. EMG Processing

Both the EMG level during salat and 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 *salat* and 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 salat and 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 17.0.

III. Result

The experimental results of the EMG signals for all the subjects indicate that there were muscles contractions during *salat* (ruku's position) and exercise (UPFE). Both medial and lateral Gas produce almost same level of EMG for *salat* and exercise. These EMG level averages in % MVC of every muscle was shown in Table I.

TABLE I
EMG Level

Muscle	EMG average in % MVC	
	Salat (Bowing)	Exercise (GTTE)
Medial Gas	61.58	68.76
Lateral GAs	57.50	86.24

Although the result shows that UPFE produced the EMG's level a little bit higher compare to *salat*, but Wilcoxon's Rank Sum test showed a statistically no significant difference between *salat* and exercise with medial Gas ($p=0.082$) and lateral Gas (0.226).

TABLE II
Result of Salat and Exercise

Posture	SD	z	p
Medial Gas			
Salat	14	-1.739	0.082
Exercise	11.6		
Lateral Gas			
Salat	25.5	-1.209	0.226
Exercise	32.8		

IV. Discussion

From this experiment, we can see that muscle contraction appeared during *salat* as well as exercise. Gastrocnemius is one of the important muscles 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 [9]. By doing exercise for these muscles, it will help to maintain movements at lower limb especially during gait cycle.

Muslim performs *salat* regularly. 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 [10, 11]. 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 [12]. Barlet et al found that regular program of weight-bearing exercise, such as walking can increase bone health and strength even among individuals with osteoporosis [13].

From the subjects involved, some of them are not Muslim and do not carry out *salat* regularly. This will in turn cause some inaccurate result in this experiment. The subjects maybe not undergone proper *salat* movement. Besides, the EMG may also have some undetected or wrong signal transmission. Several reading was inaccurate since the electrodes channel used for some subjects was faulty and the experiment cannot be repeated since the subject was not able to repeat. An overall calibration and detailed analysis for the equipment used is necessary before starting an experiment [14].

V. Conclusion

In conclusion, *salat* can be one of the daily exercises or warm-up maneuver to enable the gastrocnemius muscle perform optimally. *Salat* therefore, may have orthopedic benefits and some way it has the same benefit as exercise.

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