Analysis of Work Done on Limbs using EMG

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Abstract— The electromyography is a method or a technique to detect the electrical activity that is been produces by the muscle activity. It is observed that EMG voltage maintain almost nonlinear parabolic relationship with work done. We have also shown the accuracy of our proposed mathematical model considering all facts of errors numerically. A significant findings is that incrementing weight over 1.5kg undergoes in saturated EMG potential, which means muscle fatigue creates in limb muscles in that situation. Also the amount of calorie burnt by considering different weights can be found in this.

Key words: Lower Limb Muscles, Surface EMG, Work Done, Left Arm, Right Arm

I. INTRODUCTION

The electromyography is a method or a technique to detect the electrical activity that is been produces by the muscle activity. Whatever the various activities that are been performed by an instrument is the electromyography and the obtained data is the electromyogram. In this particular paper we aim to acquire the EMG signal in the laboratory, we calculate the amount of calories that are burnt by lifting various weights of 0.5kg, 1kg and 1.5 kg respectively. We also make a small compare between the work done between the gender male and female, getting smallest deviation between them. This helps the researchers in the designing of major muscular activity products. Also various robotic designed systems are been developed to help the physically weak persons' daily life motions [3]. The Surface (sEMG) is non-invasive method in which surface electrodes are placed over the skin over a muscle and are used to detect the superficial muscle activity [7]. The work done estimation from EMG signals are important information robotic data is to understand how the user will have to move. Therefore, it is very important to detect the relation between the human limb muscles activity and EMG signals the aim of this is to understand the specific mathematical relation of worked one activities and the EMG signal acquired along with the calorie burnt.

In this paper, we have proposed such an efficient numerical relation that is properly able to estimate the work done or burnt calories to complete the work from the EMG signals along MG and BF muscles to investigate lower limb activities.

II. METHODOLOGY OF STUDY

A. The Work Done Mechanically by Subject

To understand if the work on the specific object, there has to be a force that is exerted on the objects and it must move in the specific direction of force. Basically, there are three types of factors responsible to complete work. They are force, displacement, and direction.

If the work done is due to force F, the displacement is d and the angular movement of the object with the direction of force is θ , then the amount of work done, W by this given force can be expressed mathematically as,

$$W = F \times d \times \cos\theta \qquad (1)$$

According to this formulation, we have performed the work along Biceps Femoris (BF) and Medial Gastronomies (MG) muscles by lifting a weight of *m* kg against gravity from 0 to *h* meter, then the equation become as,

$$W = m \times g \times h \qquad (2)$$

Where, g is the gravitational constant of value $9.81 ms^{-2}$ on earth.

B. Data Acquisition Method

As we know, the muscle movement of our body creates action potential. Therefore, different work done produces different action potential according to the amount of work done. There is no direct procedure to estimate such potential to work done relationship. An indirect procedure can be established for estimating this relationship. For example, by performing a known amount of work done we can collect the cumulative action potential or EMG data. To do this, we will demonstrate the procedure through some practical step in our laboratory and the steps are as follows,

- Step 1: First of all, we select a height where lifting a weight maintain 90 degree angle between the Biceps Brachii (BB) and Flexor Carpi Radialis (FCR), while the Biceps Brachii will beat the parallel of the body.
- Step 2: We choose some weights to lift which were available in our laboratory. The weights were, 0.5, 1,and 1.5 kg which we can easily lift in the height level from floor to 0.31meter.
- Step 3: The EMG data have been collected from the subjects performing to lift different weights from floor= 0 m to 0.31 meter. In this case, we selected Biceps Brachii muscle of right hand to lift the weights.
- Step 4: After collecting the EMG data which resembles the action potential of the BB, we have plotted different curves weight (kg) versus action potential (mV) for male and female subjects respectively.
- Step 5: These curves show approximate non-linear parabolic relationship between weight load and EMG data i.e. action potentials. On the basis of the non-linearity, we executed interpolation and extrapolation.

C. Subjects Selection and Laboratory Specifications

The experimental data for this study were collected from6 subjects among them three are male and three are female Subjects (age: 23 ± 5 years, weight: 55±5 kg) with no medical problems. The total experiment is performed in Biomedical Signal Processing Laboratory

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

In our work, we have taken three types of mass such as, 0.50 kg, I kg, 1.5 kg respectively. The height is selected as 0.50 meter and it is well known to all that the standard of gravity, g =9.81 ms^{-2}. Therefore, for lifting m kg mass, the amount

of work will be W= (mx9.8JxO.50) joule or W/4.2 calorie (cal) [4.2 joule = 1 calorie]. The EMG signals of some weight lifting from our experiment are during lifting weights, incrementing weight over 1.5 kg undergoes in saturated EMG potential. It resembles the fatigue point of that muscle as the experiment is based on BB muscle

Fig. 1: Electrode placement and lead setting arrangement along Biceps Brachii of subjects.

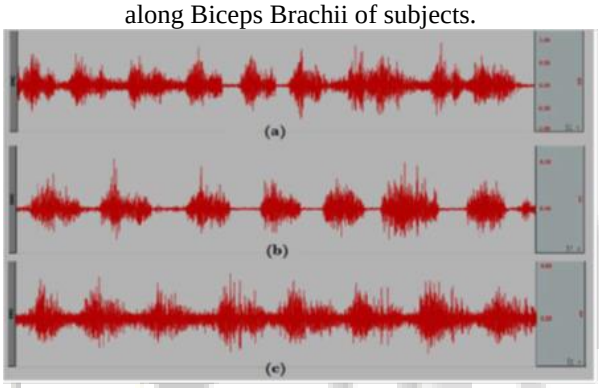

Fig. 2: Sample EMG signal in Acknowledge 4.1 software- for (a) 0.5 kg, (b) 1kg, and (c) 1.5kg weight lifting.

S. NO	EMG Amplitude (µV)	Work Done (J)	Weight of Sample (Kg)	Calorie burnt
1	19	1.51	0.5	0.3608
2	36	3.038	1	0.293
3	37	4.557	1.5	1.0874

Table 1: Work Done and Calorie Burn for Different Weights

S.no	Weight (Kg)	S1 (µV)	S2(µV)	S3 (Mv)	Mean	Standard Deviation
1	0.5	0.3767	0.3696	0.3715	0.3728	0.00371
2	1	0.5691	0.5848	0.5759	0.5738	0.00805
3	1.5	0.6911	0.6813	0.6842	0.06801	0.00602

Table 2: Measured Action Potential Value for Different weights (Male)

S.no	Weight (Kg)	S1 (µV)	S2(µV)	S3 (Mv)	Mean	Standard Deviation
1	0.5	0.3712	0.369	0.3623	0.3676	0.0046
2	1	0.5843	0.5775	0.5689	0.5769	0.0076
3	1.5	0.699	0.7025	0.6829	0.6948	0.01047

Table 3: Measured Action Potential Value for Different weights (Female)

IV. CONCLUSIONS

We have introduced and develop a new mathematical relation between performed work and the EMG results. In this work, we have explored the cumulative action potential value extracted from EMG signals. All SEMG signals were collected from different male and female healthy subjects through acquisition unit maintaining appropriate experimental protocol for EMG signal.

The main contribution of this research work is to establish a mathematical relationship between work done by limb muscle, Biceps Femoris and Medial Gastrocnemius, and these muscle extracted EMG potential. Also the work done and calories burnt for different weights of 0.5kg, 1kg, 1.5kg is obtained.

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