A Novel Method to Measure Muscular Imbalance Using Semg and Mc Sensors and Correcting Using Ems and Basic Strength Training Principles

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Abstract – This article gives the overall view of the articles published in Journal of Network Communications and Emerging Technologies. Abstract should be written in a motivate manner such a way it should make the readers to browse through the article completely. Abstract must be written with Times New Roman font with font size 9. Authors can make use of this template in preparing their final version of the manuscripts.

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1. INTRODUCTION

While performing the analysis of surface electromyography signals, abbreviated as sEMG signals, it's necessary to learn regarding the of muscle working state's time based characteristics specially, such as onset and offset time along with the reaction duration speed. One of the most commonly evaluated parameters amongst these is the onset of muscle contraction. The sEMG recordings of the residual limb in the prosthesis control are utilized to decide each movement of the prosthesis framework in view of the assurance of beginning alongside span of sEMG. Onset and offset time of muscle compression in multi muscle helpful activity are required in the biomechanical investigation of human movement.

For the determination of onset EMG, primitively used method is visually determined decision that is usually performed with the help of EMG recording's visual estimation. The above mentioned method holds less inaccuracy (as low as about (+-5 to 10ms)); have high reliability having no sensitivity towards noise. However, it shows fewer repetitions in its results and requires analyzer with specialized trainings. It's usually used for method comparison and off line analysis since it's subjective and can't be used in identification of line.

There exists a considerable amount of PC based strategies for the location of onset. For an instance, there exists sliding window normal with threshold choice, low pass channel with threshold choice, both low pass channel and sliding window normal with edge choice and that's only the tip of the iceberg. Utilizing the innovations including computerized flag preparing has been the normal standard to accomplish the full wave amended EMG flag envelope, at that point making an examination of the follow with a given limit in specific procedures. The occasion when the envelope initially outperforms the edge is perceived as the beginning time.

EMG signals are electrical signals that represent the contractions taking place in the muscle. It is generally achieved via two ways, one being surface EMG while the other being needle electrodes. The prime focus of this paper in on surface EMG, determination of muscular imbalance and its correction using database application.

Surface EMG are gained via muscle activities in the form of electrical signals. These EMG signals are produced by using the electrodes that are placed onto particular parts on the surface of the skin and from the movement activities acquiring the values of the voltage shift. However these signals also obtain the noise during the movement while travelling through different tissues.

Amongst the previous researchers, many of them have used Fast Fourier transform for the analysis of the EMG signals in the early stages. Despite that this technique fails to provide the signal's time dependant factors information. Wavelet transform [WT] is hence propounded to overcome the above mentioned limitation.

Even though WT offers high time resolution for high frequency component and high frequency resolution for low frequency signals like transient, it holds some disadvantages such as that of computation burden since it involves plenty of equations to be computed, noise sensitivity level and its accuracy dependency on the wavelet that has been chosen. [2]

In this paper we are using spectrogram to determine the sEMG signals and linking the results with the database to provide the required exercises for the correction of any imbalances.

2. RELATED WORK

The related work to be done under this paper has been listed below to find the muscular contraction details using sEMG and MC Sensor for finding the force-tension relationship

- MC Sensors to determine the contractions
- Database holding records of exercises
- EMG Electrodes to get the EMG signals recorded
- Force gauge to apply force to provide force to sensor tip
- A digital monitor to display results

2.1 MC Sensors to determine the contractions:

During the estimation the sensor is settled on the skin surface over the muscle. The sensor tip applies weight and causes a space of the skin a middle of the road layer straightforwardly over the muscle and muscle itself. The power on the sensor tip is then estimated. The power is generally corresponding to the strain of the muscle. The estimation is non-intrusive and particular. Selectivity of MC estimation alludes to particular muscle or part of the muscle that is being estimated and is constrained by the measure of the sensor tip. The sensor is generally little and light with the goal that the estimations can be performed while the deliberate subject performs diverse exercises.

2.2 Database holding records of exercises:

Since most of the muscular imbalance can be corrected with exercises, this database will hold the record of hundreds of exercises and will be linked with the sensor in such a manner that the results will automatically determine the efficient exercise from the database and suggest it to the user.

2.3 EMG Electrodes to get the EMG signals recorded:

The outline of the electrode unit is the most basic part of the electronic device which will be utilized to get the signal. The constancy of EMG signal distinguished by the electrode impacts all resulting treatment of the signal.It is extremely troublesome (relatively unimaginable) to enhance the loyalty and the signal to noise proportion of the signal past this point. In this manner it is vital to devise an electrode unit that gives negligible mutilation and higher signal to noise proportion.

2.4 Force gauge to apply force to provide force to sensor tip:

The sensor tip in an EMG sensor puts pressure on the muscle which produces some force which has to be recorded using special devices like a force gauge.

2.5 A digital monitor to display results: -

The EMG Sensor is linked to a digital monitor that displays the results of contraction in the muscle and also the calculated parameters from where the exercise in the database is selected and provided to the user.

3. PORPOSED MODELLING

Basic Principle and Construction of the MC Sensor

The sensor we are mentioning about in this paper allows skeletal muscle tension determination through a totally noninvasive in site and selective way. The method is said to be the Muscle Contraction (MC) measuring method while the device is called an MC sensor. This propounded MC method measures the force on the person's skin that's above the skeletal muscle. The tension of this muscle changes during a skeletal muscle activity. Because of the ability of skeletal muscles of producing various levels of contractile force, different levels of tension is induced in the skeletal muscle.

In a very basic structure of an MC sensor, it consists of a supporting part, a sensor tip and a force meter. The sensor is placed on the skin surface of the person above the intermediate layer and the skeletal muscle measured.

The construction of the sensor is in such a manner that the pressure over the subject's skin results in the compression of the skin surface along with the intermediate level by the sensor tip, thus applying pressure upon the measured skeletal muscle at the end. It is necessary to accordingly shape the sensor tip in order to push down upon the person's skin at an appropriate site in a noninvasive manner. The supporting part in combination with the attaching part provides satisfactory attachment as well as fixation of the sensor on the skin surface of the subject.

A force F_X is produced by the measured muscle tension in the direction along the muscle surface. The force becomes responsible for the pressing of the intermediate layer and the skin on the sensor tip. The force F' is the vector summation of all the forces in the direction along the sensor tip. The force meter measured this force.

$$F' = 2F_X \cos A$$

Here 'A' is the angle between F' and F_X's directions. However the equations don't hold exactly in the real world. Despite that for as long as the sensor tip stays constant that is there is no change in the angle A between the two forces, the measured force and the force generated by the muscle tension remain proportional to each other. Sensor is placed on to the skin of the person through its supporting part. Between the skin and the measured muscle and the skin there also exists an intermediate level. The elasticity along with the thickness of the tissue and the skin varies from person to person because of which absolute value of the muscle force cannot be determined without certain calibration of the device separately for each person. However, observation of the muscle force's dynamical changes can be made without individual calibration being needed.

Bigger power on the sensor tip causes extending of the transitional level and therefore decreases the developing of the concavity that the sensor tip produces. The point 'A' between the muscle and sensor drive is expanded and the affectability of the sensor is decreased as a result of this lessening which brings about a specific measure of nonlinearity. The extending will vanish by and large if the power has a tendency to be sufficiently extraordinary conveying the sensor to immersion.

Having dependency on unknown factors such as thickness as well as elasticity of the intermediate layer that differ from person to person, it isn't possible to analytically determine the saturation and the nonlinearity. It's only possible to empirically determine these effects using sensor implementations and measurements.

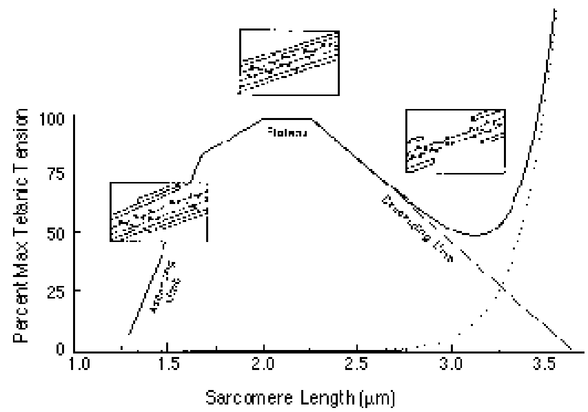
Electrical Muscle Stimulation

Electrical muscle incitement (EMS), otherwise called neuromuscular electrical incitement (NMES) or electromyostimulation, is the elicitation of muscle constriction utilizing electric driving forces. EMS has gotten an expanding measure of consideration over the most recent couple of years for some reasons: it can be used as a quality preparing apparatus for solid subjects and competitors;[8] it could be utilized as a restoration and preventive device for in part or completely immobilized patients; it could be used as a testing device for assessing the neural as well as strong capacity in vivo; it could be utilized as a post-practice recuperation device for athletes.[9] The motivations are produced by a gadget and are conveyed through terminals on the skin close to the muscles being fortified.

The Operating Principle of Electrical Muscle Stimulation Your muscles move when they receive electrical stimuli. These stimuli can in the case of conscious movements come from the brain or from the spinal cord[7].

It is majorly used for Strength Conditioning and therapeutic treatments for athletes. Also, can be used for the patients who have medical conditions related to muscular movement restrictions and response problem[9]. The device can be placed on the muscle group to be made active and in order to make it work to an optimal , the patients and athletes are advised to perform any major muscle activity on which the EMS is used to create neuromuscular bridge and bond between muscle and neuromuscular adaptation.

Movement Of Muscles And Ems Action



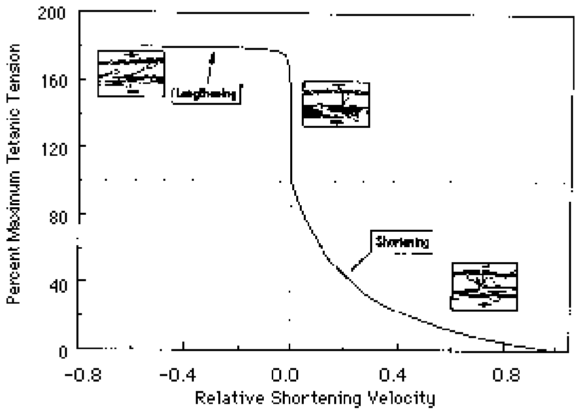
a)Length-Tension Relationship The isometric length-tension curve represents the force a muscle is capable of generating while held at a series of discrete lengths. When tension at each length is plotted against length, a relationship such as that shown is obtained.

b)Force-velocity Relationship The force generated by a muscle is a function of its velocity. Historically, the force-velocity relationship has been used to define the dynamic properties of the cross-bridges which cycle during muscle contraction.[1]

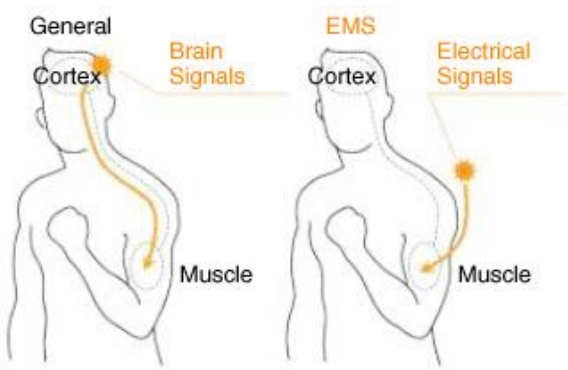
The force-velocity relationship, like the length-tension relationship, is a curve that actually represents the results of many experiments plotted on the same graph.[1] Experimentally, a muscle is allowed to shorten against a constant load. The muscle velocity during shortening is measured and then plotted against the resistive force. The general form of this relationship is shown in the graph below.[3] On the horizontal axis is plotted muscle velocity relative to maximum velocity (Vmax) while on the vertical axis is plotted muscle force relative to maximum isometric force (Po).

An EMS stimulus fires all the motor neurons in the treated area simultaneously, creating an uncoordinated contraction, which is primarily isometric in nature. Voluntary muscular contractions, on the other hand, roll through the muscle in a wave to generate a coordinated, directed force.

EMS works directly on the muscles, bypassing the body's energy conservation system, thus there's no limit to the percentage of fiber that can be activated. The EMS stimulus "spills over" from fully contracted fiber to activate remaining fiber (given sufficient current) allowing the athlete to experience a training stimulus that's unattainable by any other means.



This way the natural activation of the muscle during the movement is increased thereby increasing the amount of muscle fibers recruited during the motion of the exercise. Which results in better development of the muscle and in the same way the muscular growth on dominant and non-dominant side can be balanced.



Preliminary Test

The Preliminary Tests are performed using the EMG Sensors and MC Sensor. The EMG and MC signals were estimated at the same time. We accepted that the estimations don't meddle with each other, as the primary estimation is electrical and the second is mechanical. On one hand, EMG electrodes were too a long way from the MC sensor to make any critical change the power following up on the MC sensor[2]. Then again, the MC sensor was electrically secluded from the skin and couldn't have any noteworthy impact on the electrical EMG signals. As the muscles were contracted willfully, the trials performed can't be precisely recreated. Be that as it may, isolate estimations of EMG and MC signals did not demonstrate any subjective contrast from synchronous estimations.

a)EMG Recording: The recording electrodes were set over the paunch of the muscle, roughly halfway between the helper crease and the midpoint of the cubital fossa. The reference elestrode was put over the volar arch. The interelectrode impedance was kept underneath 5,000 Ω through skin scraped area. The EMG signal was recorded utilizing a 24 bit resolution, 25 mV/V NI 9237 module.

b)MC Sensor Recording: The sensor is placed at the cross-sectional area of the muscle group (longitudinal and traversal) at the same NI 9237 module.

Signal Processing

The EMG signal is taken at 5 kHz rate and filtered at 10–450 Hz. To calculate the amplitude of the EMG, the RMS value and regulated the signal using a 10 Hz Butterworth filter. The MC signal was taken at 5 kHz and then smoothed at 10 Hz. The amplitudes of the MC and force (F) were taken as differences between baseline and maximum peak values of signals[2].

The muscle tension and force is calculated using the above observations taken from the preliminary test and then are compared to the observations taken on both the sides of the muscle(dominant and non-dominant). If a difference of frequency is observed between the two graphs so formed, then the EMS method is used accordingly.

Correction Of Muscle

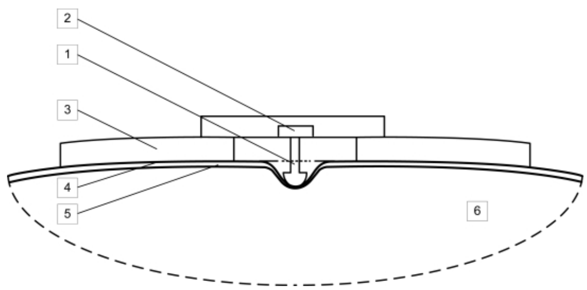
The recorded results are analyzed and the data is sent to the database of exercise to find the suitable exercises which can differ from isometric holds for muscle to an isolation bodyweight or external weight exercise to engage the muscle and further increase the muscular to reach as same to that of the dominant muscle group.

The EMS is introduced in the process. The muscle group is given EMS for a latent time period of 10-20 min followed by the exercises selected from the database for correction.

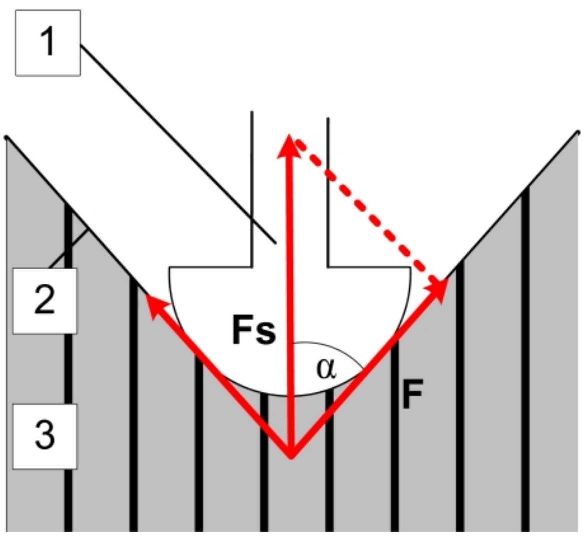
The exercise pattern is followed by taking the exercise(if external weight is used then it should be around 60-75% of your 1Rep Max) and perform for 10-15 repetitions on the non-dominant side and perform the same number of repetitions on the dominant side. This procedure should be followed for 2-3 times per week and after each session the muscle groups should be allowed the rest period of 24-48 hours i.e. the muscle should not be trained primarily for this period and can used as a secondary muscle for other movements in certain exercises[10].

4. RESULTS AND DISCUSSIONS

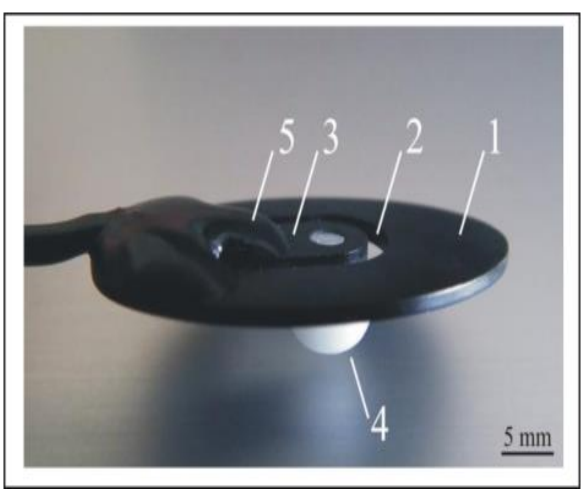
In this system there are following gadgets used for taking the recordings and observations from the subject. MC Sensor and EMG Sensors for recording the muscle tension and force during the time of movement.



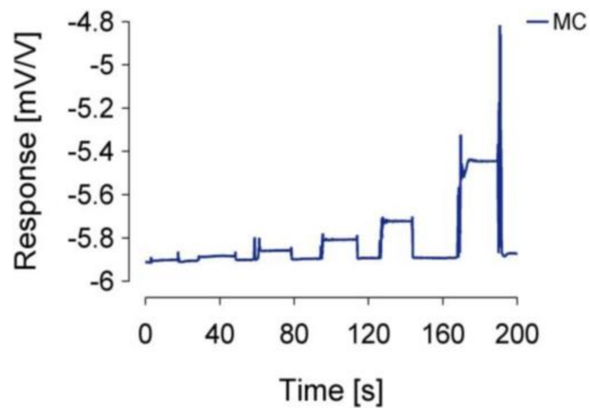
MC sensor for recording mechanical and physiological behavior of skeletal muscles (1): sensor tip; (2): force meter; (3): supporting part; (4): skin surface; (5): intermediate layer; (6): skeletal muscle.



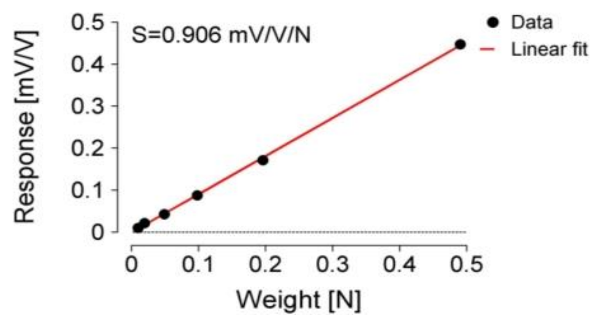
Representation of how the MC Sensor be placed and take the data (1): sensor tip; (2): skin and intermediate layer; (3): measured muscle



MC sensor (1): laminate; (2): incision; (3): tonguelet; (4): sensor tip; (5): strain gauge.

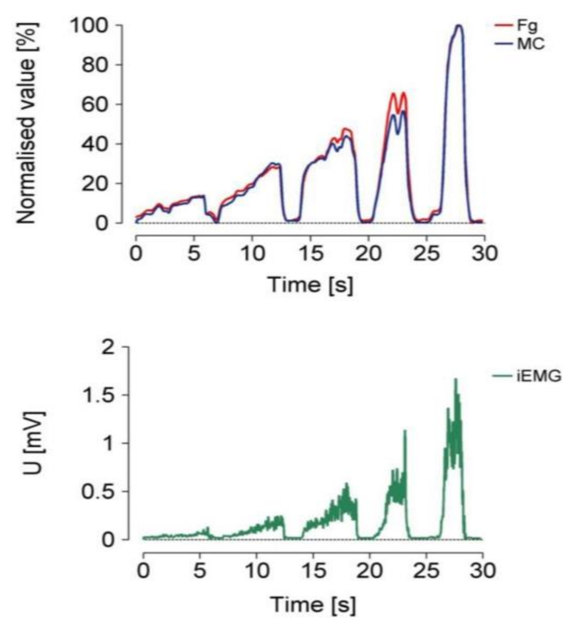


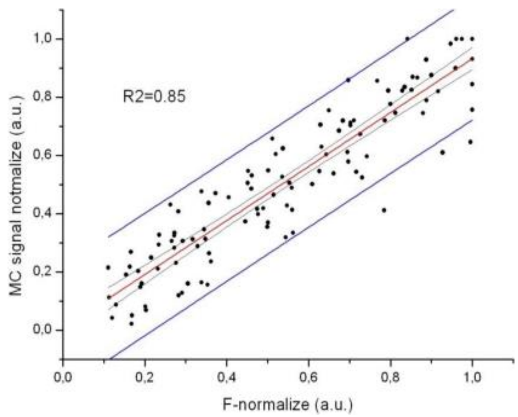
The output response of the MC Sensor with various weights hanged from it.



MC Sensor Sensitivity

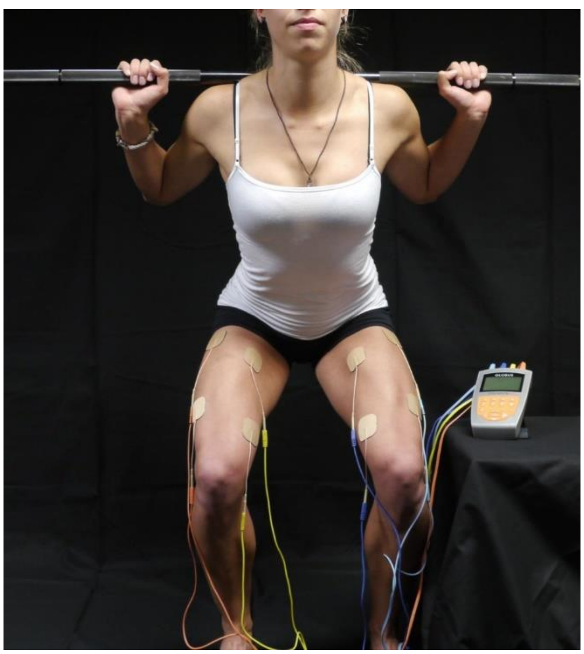
Further the simultaneous recording from the MC Sensor and EMG are recorded for Force determination and both the variables are normalized to the maximum value.





In the above given graph, a relationship between force (F) and MC (normalized values). The linear fit is shown with a red line. The grey lines indicate the 95% prediction level, and the blue lines represent the upper and lower 95% prediction limit.

After taking the recordings and deciding the exercises given in the database fit for correction, the EMS is introduced to the patients and is given to the patient's muscle group. As seen in the figure given below



In the above given figure, the patient has an imbalance recorded in the left quadricep muscle and therefore the EMS treatment is given to the patient and a neuromuscular demanding exercise is done during the procedure to increase the volume and recruitment of muscle group same as that of the dominant side.

5. CONCLUSION

The system presented above in the following paper will be used for understating the science and protocol used by a human body for muscle contraction and how the area of muscle is affected. The basic idea of correcting the muscular imbalance stands behind the amount of muscle recruitment and activation during the movement. The sensing of the movement and major of activation is taken using the MC Sensors and sEMG sensor both are which noninvasive in nature i.e. the patient won't even feel any pain during the process of measurement. Hence, depending upon the muscle group the isolation and isometric exercise are chosen to implement exercising part and based on the recordings the dominant and non-dominant side is chosen which is later given a series EMS Treatment to increase the neuromuscular recruitment and henceforth reduce the imbalance by correcting it over time with the combination of treatment and exercises.

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