International Journal of Applied Engineering and Technology ISSN: 2277-212X (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jet.htm
2015 Vol. 5 (1) January-March, pp.17-25/Chakrabarti et al.
Research Article

OVER VIEWED STUDY ON SEVERAL HUMAN MUSCLES TOWARDS EMG SIGNAL RECORDING ASPECT

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ABSTRACT
This paper is based on the study of various muscles of human body by detection, processing and classification of EMG signal. Strong and precise information's about the active and inactive condition of various muscles are represented in this paper. Electromyography (EMG) signals are generated due to the amount of force applied to the muscles. So, EMG measures muscle response or electrical activity in response to a nerve's stimulation of the muscle. The test is used to detect neuromuscular abnormalities.EMG signal is created due to active motor unit & background noise, detected during contraction of muscles, is the superposition of motor unit potential trains.EMG signals acquired from muscles require advanced methods for detection, decomposition, processing, and classification.

Keywords: *Electromyography (EMG), Smooth Muscle, Cardiac Muscle, Skeletal Muscle, Voluntary Muscles, Extremity Muscles, Distal Arm, Proximal Arm, Shoulder, TTP, MNP, PKF, MNF*

INTRODUCTION

Electromyography (EMG), also referred to as myoelectric activity, measures the electrical impulses of muscles at rest and during contraction. As with other electrophysiological signals, an EMG signal is small and needs to be amplified with an amplifier that is specifically designed to measure physiological signals. This signal can be recorded or measured with an electrode, and is then displayed on an oscilloscope, which would then provide information about the ability of the muscle to respond to nerve stimuli based upon the presence, size and shape of the wave the resulting action potential.
Biomedical signals are collection of electric signals in analog form obtained from organs (Boostani *et al.*, 2007). This signal is a function of time and describable in terms of amplitude, phase and frequency. Movement of muscles and positions are controlled by electric signals when they are electrically or neurologically activated. EMG recording is a technique to evaluate and collect the electrical signals. Study of this electrical signal in muscles (EMG) can thus be a valuable aid (Huang *et al.*, 2005) in discovering and diagnosing abnormalities not only in muscles but also in the motor system as a whole. It is measured by the movement of Na+ and K+ ions in the cell.
Four popular methods practiced for EMG recording are Surface EMG (SEMG), Fine Wire EMG (FWEMG), Neuromuscular Electrical Stimulation (NMES) and EMG Triggered Stimulation (EMGTS). As the amplitude of the recorded EMG signal is very low, multi-stage amplification is required to distinguish it from external noises (De Luca *et al.*, 2011). In recent days, various mathematical models, advancement of signal processing and Artificial Intelligence (AI) helps to develop advanced EMG detection and analysis technique.
Various mathematical models include wavelet transform, time-frequency approaches, Fourier Transform, statistical measures and higher order statistics. AI includes Artificial Neural Network (ANN), Dynamic Recurrent Neural Network (DRNN), and fuzzy logic. This paper is fully focused on recording and analysis of EMG signals of various muscles of human body using SEMG method. The human muscular system is made up of more than 600 muscles. Muscles move the different parts of our body, inside and outside. Muscles are attached to the bone by strong connective tissues called tendons. Muscles are made

of fiber. Each fiber is made of long thin cells, which are packed in bundles. The fibers have two kinds of proteins, myosin and actin. Each bundle is wrapped in a thin skin called perimysium.
Each muscle has lots of these bundles - the bigger the muscle the more bundles of fibers it has.

Inside the muscles there are nerves which carry messages to and from the brain.

There are also blood vessels, which carry the energy that our muscles need and also carry away waste that your muscles have finished with.

There are three kinds of muscles found in the human body.

Smooth muscle or "involuntary muscle" consists of spindle shaped muscle cells found within the walls of organs and structures such as the esophagus, stomach, intestines, bronchi, uterus, ureters, bladder, and blood vessels. Smooth muscle cells contain only one nucleus and no striations.

Cardiac muscle is also an "involuntary muscle" but it is striated in structure and appearance. Like smooth muscle, cardiac muscle cells contain only one nucleus.

Cardiac muscle is found only within the heart. **Skeletal muscle** or "voluntary muscle" is anchored by tendons to the bone and is used to effect skeletal movement such as locomotion (Merlo *et al.,* 2010).

Skeletal muscle cells are multinucleated with the nuclei peripherally located. Skeletal muscle is called 'striated' because of the longitudinally striped appearance under light microscopy.

Muscles that we can control with conscious thought are called **voluntary muscles** (Lawrence *et al.,* 1997).

The other group of muscles is automatic. Muscles that move food through our digestive system or keep our hearts beating are **involuntary muscles**.

Classification Based Study on Human Muscle Inconsideration of Emg Signal

There are three kinds of muscles found in the human body. Voluntary muscles attached to bones and capable of permitting body movement are called skeletal muscles.

In voluntary muscles found inside organs such as the stomach, intestines, and blood vessels are called smooth muscles.

The third type of muscle is the hardest working muscle and is an involuntary muscle called cardiac muscle (Al-MullaMohamed *et al.,* 2011).

Voluntary muscles receive the signal to contract or relax from the brain.

People make the decision to make a movement and the signal is sent from the brain down through the spinal column and to the appropriate muscles.

When the muscle receives the message to contact, or relaxes, it does so completely. This means that there is no such thing as a partial contraction.

The strength or weakness of muscle contractions is determined by the number of muscle fibers involved.

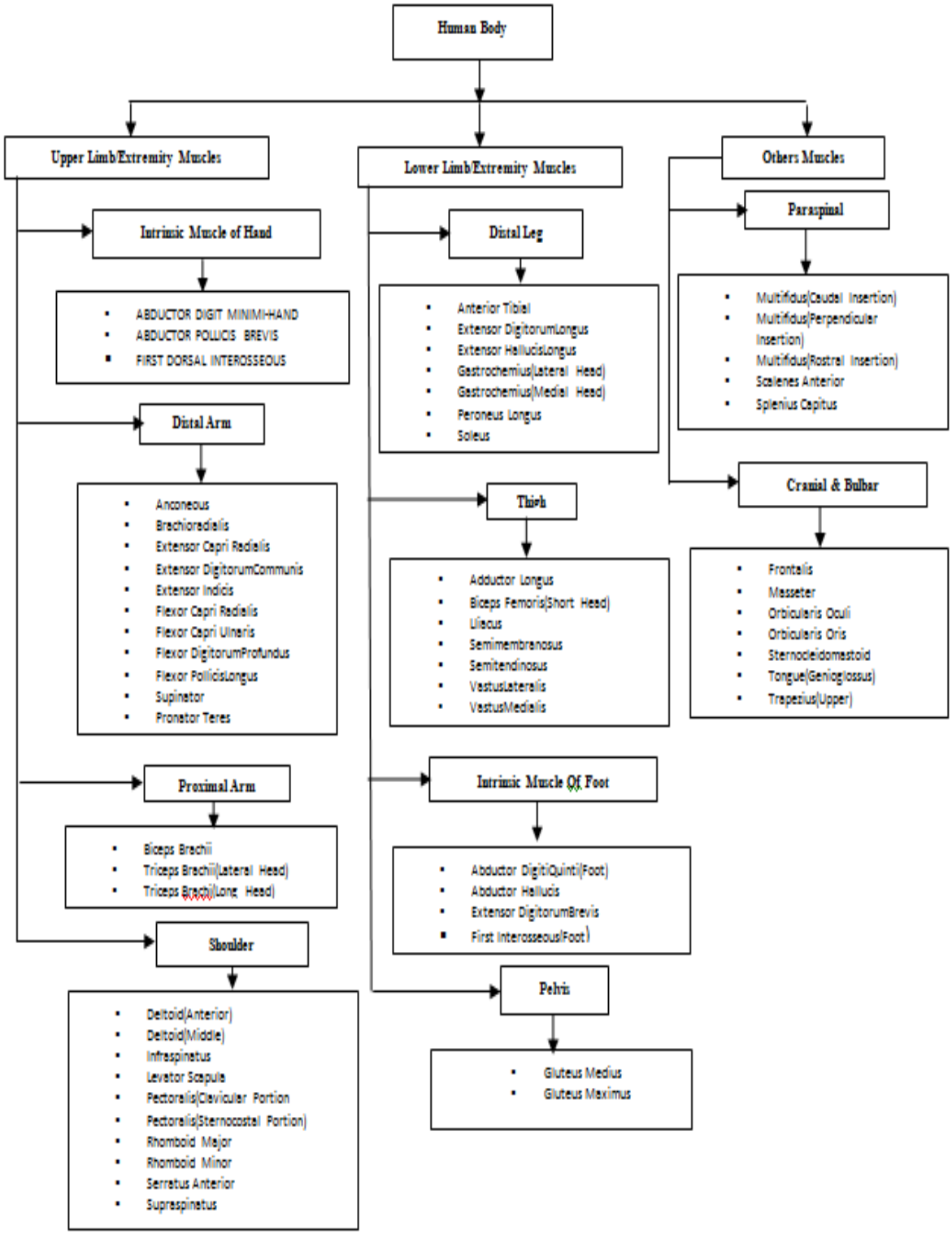

Figure 1: Different muscles of human body

Overview of Several Human Muscles & Emg Captured Position's Technique

The muscular system is the biological system of humans that produces movement. The muscular system, in vertebrates, is controlled through the nervous system, although some muscles, like cardiac muscle, can

be completely autonomous. Muscle is contractile tissue and is derived from the mesodermal layer of embryonic germ cells. Its function is to produce force and cause motion, either locomotion or movement within internal organs. Much of muscle contraction occurs without conscious thought and is necessary for survival, like the contraction of the heart or peristalsis, which pushes food through the digestive system. Voluntary muscle contraction issued to move the body and can be finely controlled, such as movements of the finger or gross movements that of the biceps and triceps. Electromyography (EMG), Okada *et al.*, (1998) also referred to as myoelectric activity, measures the electrical impulses of muscles at rest and during contraction.EMG signals are routinely used to record muscle activity in small or deep muscles using needle or fine-wire electrodes. In this paper an overview of various upper limb human muscles and EMG Captured position techniques have been described.

Upper Limb/Extremity Muscles

The upper limb is the zone in an animal stretching out from the deltoid region to the hand, involving the arm, axilla & shoulder. Upper limb muscles can be classified by origin, topography, function or innervations (Rissanen *et al.*, 2008). While a sorting by innervations reveals embryological & phylogenetic origins, the functional-topographical grouping demonstrates the similarity in action between muscles (Rissanen *et al.*, 2009).

Intrinsic muscles of hand: Muscles functioning on the hand can be isolated into two groups: extrinsic & intrinsic. Intrinsic muscles of hand are positioned on the hand itself. They are in charge of fine motor function of hand.

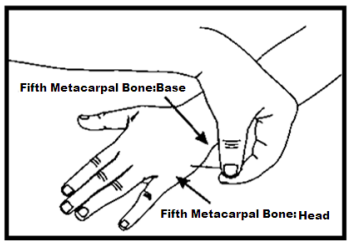

Figure 2.1: Abductor Digiti Minimi (Hand)

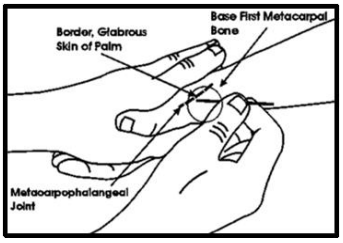

Figure 2.2: Abductor Pollicis Brevis

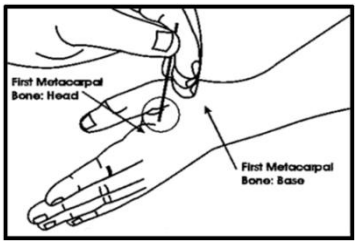

Figure 2.3: First Dorsal Interosseous

During the analysis on intrinsic muscle of hand, the hand is retained in the supine position. The needle is interjected to the depth of 0.5 to 1cm at a point midway of the fifth metacarpal bone. Too much deep enclosure may cause needle to enter opponens digiti minimi as well as may record from opponens pollicis or to lie in abductor pollicis. To energize the abductor digiti minimi muscle, patient will be asked to abduct the little finger & for abductor pollicis brevis muscles are triggered by palmar abduction of thumb& first dorsal interosseous muscle is activated by abducting the index finger. In first dorsal interosseous muscle experimentation, hand is kept on medial aspect. Now needle is inserted radial to the second metacarpal in line perpendicular to the long axis of first metacarpophalangeal joint of hand.

Distal arm: Distal refers to limbs when the structure is away from the median plane or root of limb than other structure from the limb. During the experiment in distal arm muscle, forearm is kept in different position. In anconeus observation, arm is pronated and elbow is maintained at 90^0 flexion. Needle is interpolated 4to 5 cm distal to the olecranon process radial to ulna. Too much lateral insertion may cause needle to lie in the extensor carpi ulnaris and too much deep insertion may cause it in supinator muscles. Anconeus muscle is activated by extending the elbow. In brachio radialis evaluation, arm is semi pronated. Line is divided in to three segments, between mid lateral half of the elbow crease and styloid process of radius. The needle is enclosed in to the mid proximal third segment & muscle is activated by flexing the elbow in semi pronation. In extensor carpi radialis experimentation, arm is fully pronated & needle is entered approximately $1/3^{rd}$ distance from lateral epicondyle in a line between radial styloid process & lateral epicondyle & muscle is innervated by extending the wrist. In extensor digitorum communis testing, line is divided between styloid process of ulna & lateral epicondyle into three

segments & needle is inserted into 1to 1.5cm at the function of upper & middle 1/3rd of forearm.& muscle is activated by extending metacarpophalangeal joints. In extensor indicisanalysis, needle is inserted approximately 2-3cm proximal to styloid process of ulna & muscle is activated by extending second finger. Too much lateral insertion of needle may cause to penetrate extensor carpi ulnaris & abductor pollicis longus respectively. In flexor carpi radialis, arm is fully supinated & needle is inserted into 6-7cm from the mid of elbow crease & too deep insertion may cause needle to enter flexor digitorum blimis & deeper to flexor pollicis longus.

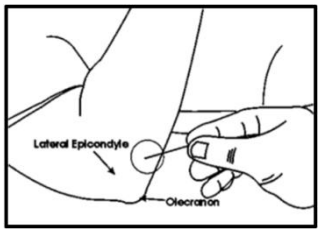

Figure 3.1: Anconeus

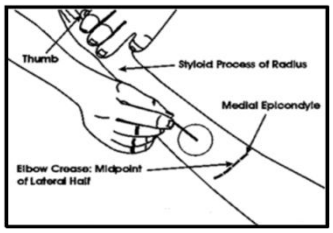

Figure 3.2: Brachio Radialis

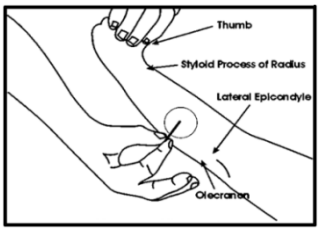

Figure 3.3: Extensor Carpi Radialis

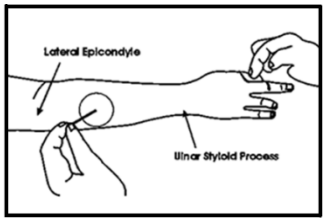

Figure 3.4: Extensor Digitor Communis

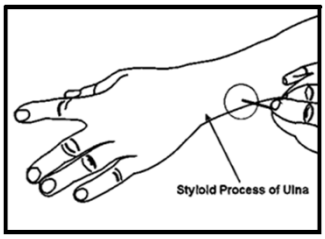

Figure 3.5: ExtensorIndicis

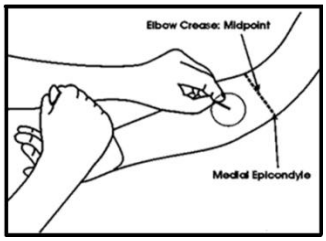

Figure 3.6: Flexor Carpi Radials

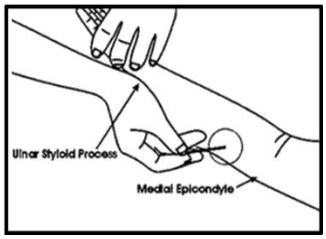

Figure 3.7: Flexor Carpi Ulnaris

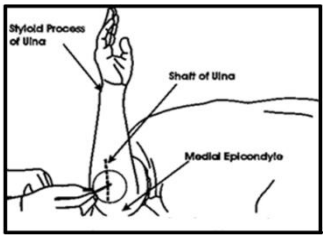

Figure 3.8: Flexor Digitorum Profundus

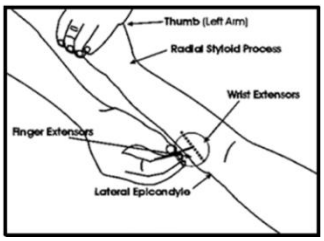

Figure 3.9: Flexor Pollicis Longus

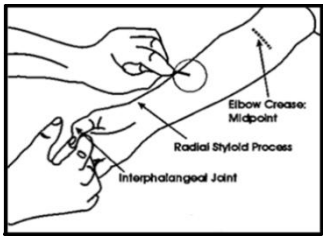

Figure 3.10: Supinator

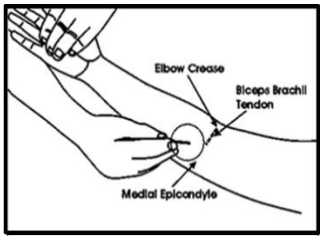

Figure 3.11: Pronator Teres

Muscle is activated by flexor of wrist with radial deviation. In flexor carpi ulnaris, line is divided from ulnar styloid to medial epicondyle into three segments & needle is inserted to mid proximal third segment &if the needle is deeply inserted, it may cause to lie inflexor digitorum profundus. This muscle is activated by abducting fifth finger. Elbow is fully supinated & flexed in analysis of flexor digitorum

profundus. Needle is inserted into proximal third segment & muscle is activatedby flexing distal phalanx. If needle is inserted deeply, it may cause to lay in flexor carpi ulnaris.
Forearm is fully supinated in experimentation of flexor pollicis longus & needle is inserted on midpoint of elbow & muscle is activated by distal phalanx of thumb flexing. In supinator analysis, needle is inserted laterally between muscle group at $1/4^{th}$ distance to epicondyle & too much lateral insertion may cause needle to enter brachio radialis & may even injure radial artery.

Here muscle is activated by supination of forearm. Needle is inserted into 3-4cm at the midpoint of line joining medial epicondyle & biceps tendon, in testing of pronator teres.

Muscle is activated by pronating forearm.

Proximal arm: The segment of digestive system that is closest to mouth is termed as proximal. Actually the structure that is close to the point of attachment to the body is proximal arm. For example, shoulder is the proximal end of the hand. So, the term proximal describes where the appendage joints the body. Total body is kept in different position during the experiment of proximal arm. At first, in biceps brachii muscle experiment, patient body is lie in supine position with arm extended & needle is interpolated to bulk of muscle in mid-arm. Now this muscle is activated by supination of forearm. In triceps brachii (lateral head) experiment, hand is kept on the chest with elbow flexion & muscle is activated by elbow flexion.

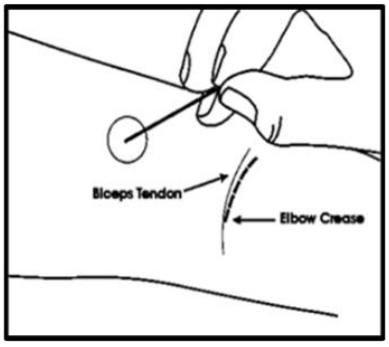

Figure 4.1: Biceps brachii

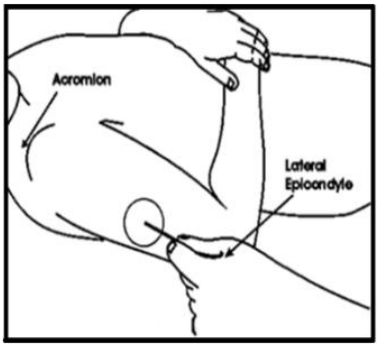

Figure 4.2: Triceps brachii (Lateral head)

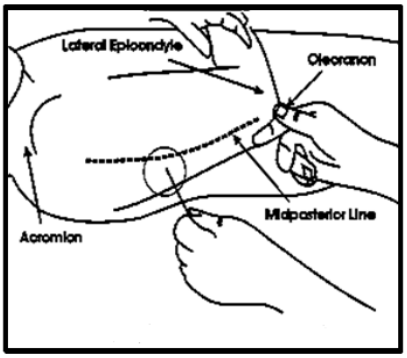

Figure 4.3: Triceps brachii (Long head)

Needle is interpolated mid poster lateral part of upper arm that should be aline from acromion to lateral epicondyle. In triceps brachii (long head) shoulder is placed in abduction & muscle is activated by elbow extension. Needle is incorporated at mid posterior line of upper arm.
Shoulder: Three bones consist shoulder; these are clavicle, scapula & humerus as well as muscles, ligaments & tendons. Shoulder joints made up due to the articulations between the bones of shoulder & this joint typically refers the glenohumeral joints & this is the major joint of shoulder. Several muscles are culpable for movement of shoulder attach to the scapula, humerus and clavicle.

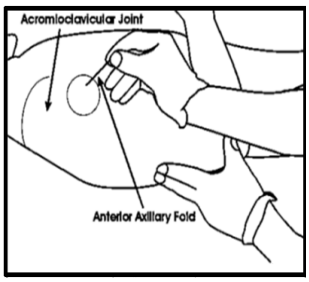

Figure 5.1: Deltoid (Anterior)

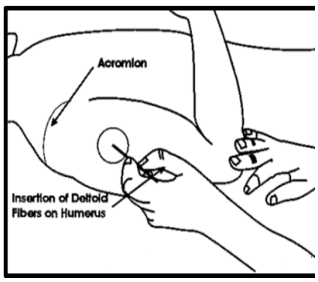

Figure 5.2: Deltoid (Middle)

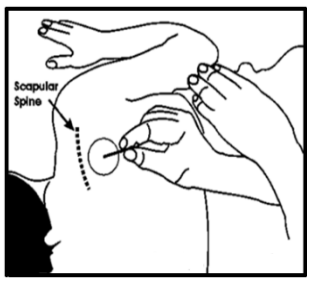

Figure 5.3: Infraspinatus

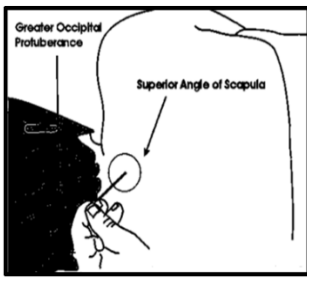

Figure 5.4: Levator Scapula

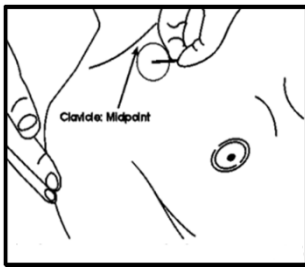

Figure 5.5: Pectoralis (ClavicularPortion)

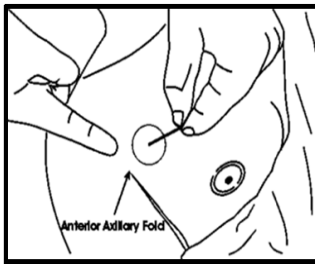

Figure 5.6: Pectorali (Sternocostal Portion)

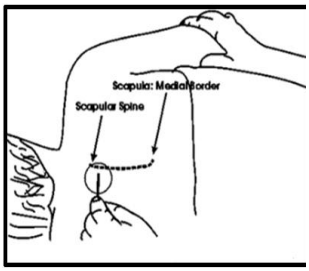

Figure 5.7: Rhomboid Major

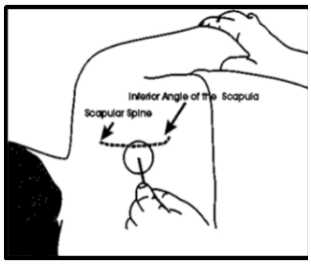

Figure 5.8: Rhomboid Minor

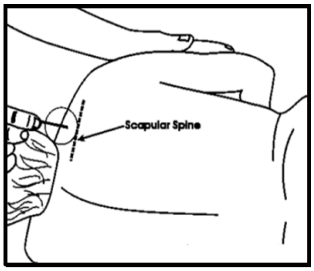

Figure 5.9: Serratus Anterior

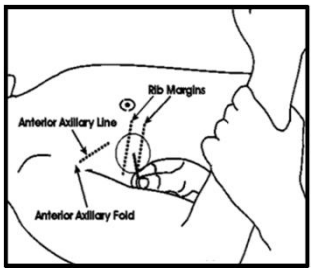

Figure 5.10: Supraspinatus

On the experiment of muscles that around the shoulder patient's body should be kept in different position. In deltoid (anterior) muscle testing, body is lie in supine position with flexed elbow & vertical forearm & needle is inserted at $1/4^{th}$ lateral distance towards lateral border of shoulder between acromiocavicular & anterior axillary fold & muscle is activated by abduction & forward flexion of shoulder. In deltoid (middle arm) testing, needle is inserted midpoint of acromion & deltoid fibers on humerus & muscle is activated by abducting of shoulder. In infraspinatus experiment, arm is kept on side of the body. Needle is inserted 3-4cm below medial portion of spine of scapula & muscle is activated by external rotation of shoulder. In levator scapula testing, arm is kept at rest along with body side with elbow flexed & needle is inserted at ½ distances from medial border of scapula & muscle is activated by elevating scapula. In pectoralis (clavical portion) needle is interpolated at midpoint of clavicle & muscle is activated by horizontal abduction of arm. But in pectoralis (sternocostal position), needle is inserted 2cm medial & superior to anterior axillary fold & muscle is activated by horizontal abduction of arm. In rhomboid major muscle testing arm is kept at rest with elbow flexed & needle is inserted midway between scapular spine & inferior angle of scapula border. Muscle is activated by elevating & abducting the scapula. But in rhomboid minor muscle, needle is inserted at the end of scapular spine. Body is kept in supine position with elbow flexed in serratus anterior muscle experimentation & muscle is activated by elevating elbow. Needle is inserted between fingers & slowly inserted in anterio inferior slanting direction of rib. Supraspinatus muscle testing, needle is inserted at middle of spine of scapula & muscle is activated by abduction of shoulder.

Characteristics and Parametric Study of Emg Signal

EMG signal is the measurement of electrical current which are generated by the muscle fibers during their contractions period which represents the neuromuscular activities. This signal is complicated and non-stationary which is controlled by nervous system because the nervous system is always responsible for muscle activity. The amplitude of EMG signal is very small (50μv to 1mv) with frequencies varying from 10Hz to 3000Hz.There are various parameters that affect the EMG signal. EMG Signal can be analyzed with different slandered parameters (Allison *et al.*, 2002).

Amplitude related parameters: EMG peak: It is the maximum value of amplitude which can be measured from rectified EMG signal that can muscle generate. Mean: This parameter tells about the strength of muscle for which we are analyzing EMG and its endurance too.

Area/IEMG: IEMG means Integrated EMG. It is the mathematical integral of the EMG amplitude, which corresponds to the area under the curve, for a given period of time. It tells about the amount of energy produced during that period of time.RMS: It means Root Mean Square and it represents the mean power of the signal. RMS is used to rectify the raw EMG signal and convert it into amplitude envelops. It can be used to measure the activation timing of a muscle. It can also to verify the signal quality and detect the presence of artifacts. RMS can be used for biofeedback and to measure the resting level of a muscle.

Frequency related parameters: Mean Frequency: It is the mathematical mean of the spectrum curve. It is an average frequency which can be calculated by taken the sum of product of the EMG power spectrum and the frequency divided by the total sum of the power spectrum (Rissanen *et al.*, 2008). As per definition it may be defined as:

$MNF=\sum_{j=1}^{M} f_j P_j / \sum_{j=1}^{M} P_j$

Where fj is the frequency value of EMG power spectrum at the frequency bin j, Pj is the EMG power spectrum at the frequency bin j, and M is the length of frequency bin. Median Frequency: This is the important parameter which (Rissanen *et al.*, 2011) divides the total power spectrum into two equal parts. MDF is also defined as a half of the total power and it may be defined as:

$\sum_{j=1}^{MDF} P_i = \sum_{j=MDF}^{M} P_i = \frac{1}{2} \sum_{j=1}^{M} P_i$

Total power spectrum: It may be define as the integral part of the spectrum curve. Its equation can be expressed as:

$TTP=\sum_{j=1}^{M} P_j$=SMO

Time related parameters: Onset Time: This is also known as activation time which is the time taken by muscle to contract. Offset Time: This is also known as deactivation time which is the time taken by muscle to go back to rest. Some other parameters that have been applied in the analysis of EMG signal are total power (TTP), mean power (MNP), peak frequency (PKF), the spectral moments (SM), frequency ratio (FR), power spectrum ratio (PSR), and variance of central frequency (VCF). The definitions of all parameters are presented in the following. TTP is an aggregate of EMG power spectrum. This feature is also defined as the energy and the zero spectral moment (SM0). Its equation can be expressed as

$TTP=\sum_{j=1}^{M} P_j$=SM0

MNP is an average power of EMG power spectrum it can be defined as

$MNP=\sum_{j=1}^{M} P_j / M$

PKF is a frequency at which the maximum EMG power occurs. It can be expressed as

PKF = max (Pj), j=1, ..., M

SM is an alternative statistical analysis way to extract feature from the power spectrum of EMG signal. Normally, the first three moments (SM1-SM3) are employed as the EMG features. Their equations can be defined as

$SM1=\sum_{j=1}^{M} P_j f_j$; $SM2=\sum_{j=1}^{M} P_j f_j^2$

FR is used to discriminate between relaxation and contraction of the muscle using a ratio between low- and high-frequency components of EMG signal. PSR is a ratio between the energy P0 which is nearby the maximum value of EMG power spectrum and the energy P which is the whole energy of EMG power spectrum. It can be seen as an extended version of PKF and FR. VCF is defined by using a number of the spectral moments (SM0-SM2) and MNF.

CONCLUSION

In this paper, we described introduction, types of EMG, characteristics of EMG signal, muscles involved in movements of all parts of upper limb which are used to analyze EMG signal, over view of several human muscles & EMG captured position techniques, variety of applications where EMG signals can be used. It started with an explanation (Samaria *et al.*, 2003) of EMG then followed on to a representation of their types. This paper will provide the researchers a good understanding of EMG signal and its analysis. This knowledge will help them to develop more powerful and efficient applications. Finally, the paper discussed the application of EMG signals.

ACKNOWLEDGEMENT
Authors would like to acknowledge All India Council of Technical Educations (AICTE) (Govt. of India) for funded the project entitled "Produce the Knowledge Based Database of Electromyography (EMG) Signal to Enrich the Interpretation Technique for Different Human arm Movement". Furthermore, authors would like to express gratitude & appreciation Technical Education Quality Improvement Programme (TEQUIP).

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