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An Electromyographic and Video Analysis Study of the Shoulder Girdle Musculature Activity during Exercise with the Multi Sport Cord

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An Electromyographic and Video Analysis Study of the Shoulder Girdle Musculature Activity During Exercise with the Multi Sport Cord

by

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An Independent Study

Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine

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for the degree of

Master of Physical Therapy

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May
1997

This independent Study, submitted by Melanie B. Michaels in partial fulfillment of the requirements for the degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)

PERMISSION

Title An Electromyographic and Video Analysis Study of Shoulder Girdle Musculature Activity During Exercise with the Multi Sport Cord

Department Physical Therapy

Degree Master of Physical Therapy

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Signature Melanie Michaels

Date December 19, 1996

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This research project is dedicated to

all the future P.T. students who are

courageous enough to take on

an EMG and Motion Analysis project.

Good Luck!!

ABSTRACT

Purpose: The Multi Sport Cord is a resistive device used to strengthen the shoulder girdle musculature. The purpose of this study is to determine which shoulder girdle muscles are active, as well as when they are active throughout the range of motion of selected therapeutic exercises with the Multi Sport Cord. **Methods:** Five healthy male subjects (ages 23-28) without shoulder pathology were recruited for this study. The subjects performed five exercises two times each: once with the Multi Sport Cord and once with a free weight. The selected exercises were the following: sidelying external rotation, prone external rotation, standing external rotation, scaption, and flexion. EMG data was collected from the following muscles: anterior deltoid, posterior deltoid, infraspinatus, teres major, upper trapezius, and latissimus dorsi via surface electrodes. Motion analysis equipment was used simultaneously. This allowed the researchers to compare the EMG data to joint movement. **Results:** Qualitative analysis showed that the EMG activity from the Multi Sport Cord and the free weight were comparable in an anti-gravity position in terms of which muscles were active and how much EMG activity was elicited. The Multi Sport Cord tended to elicit the peak activity later in the cycle when compared to the free weight. In a gravity-eliminated position, however, the Multi Sport Cord elicited 2-4 times the amount of EMG activity as did the free weight. **Conclusions:** The Multi Sport Cord is advantageous to individuals with shoulder pathologies, because of the irrelevance of the patient position when performing exercises with this device. It is

also easily adjusted and simple to use; thus, increased patient compliance with home exercise program can be expected with the Multi Sport Cord.

INTRODUCTION

Chapter 1

Shoulder maladies, both post-injury and post-surgical, represent a significant amount of a physical therapist's caseload in an outpatient or sports medicine setting.[1-2] This is primarily due to the fact that the shoulder is the most mobile joint in the human body. [1,3-6] Athletes whose sport requires the upper extremity to be in an overhead position during a significant portion of the sport (overhead athletes) are very susceptible to shoulder injuries.[2,4,5,7,8] In fact, it is reported that 50% of professional pitchers sustain injury to the rotator cuff entity.[7] Other sporting activities classified as overhead sports include swimming, golf, javelin throwing, and football.[4]

Therapists utilize several different types of resistive equipment to rehabilitate the injured shoulder back to an optimal functional status.[1,5,6] One resistive device that was recently designed to aid in the strengthening of the shoulder girdle musculature is called the Multi Sport Cord (MSC). The Multi Sport Cord consists of a neoprene waist belt with theratube laced around it through buckles attached to the neoprene. The theratube fastens to either a cuff that wraps around the wrist or one that wraps around the distal arm, just proximal to the elbow (Fig.1). The Multi-Sport Cord is designed to minimize substitution patterns and provide tactile

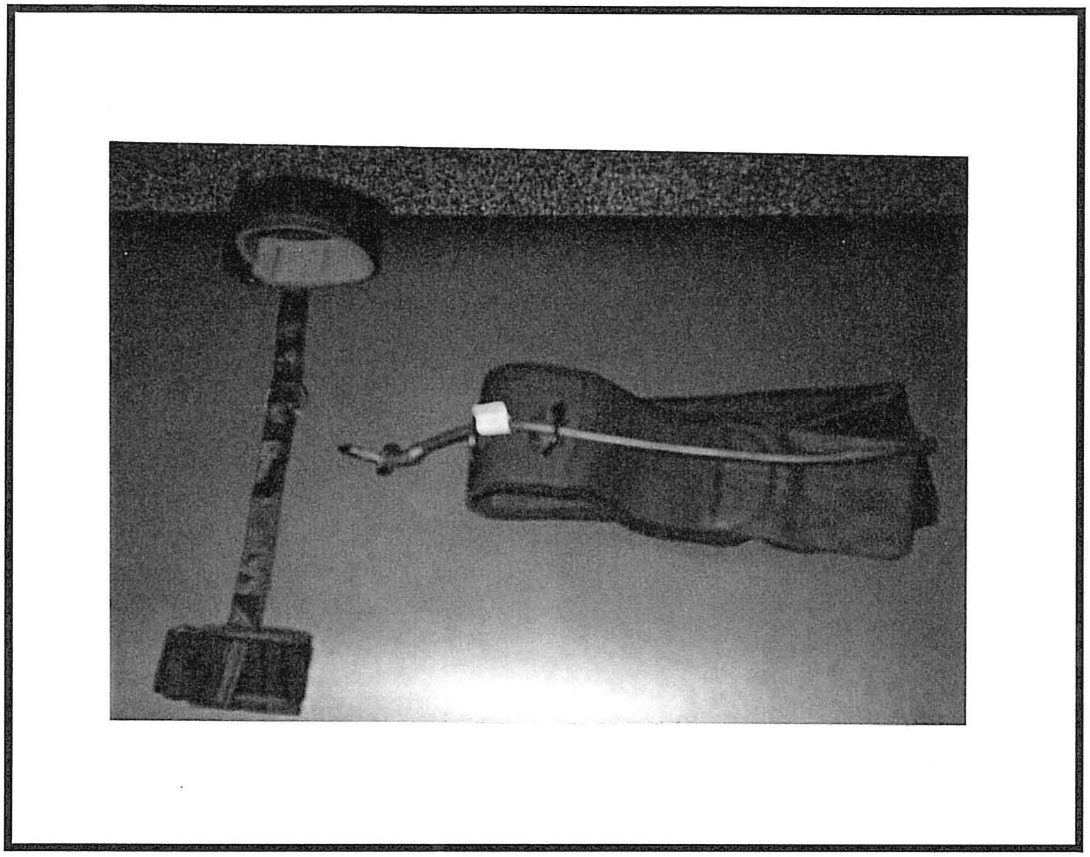


Figure 1. Multi Sport Cord

offered by the Multi Sport Cord. The resistance varies according to the size of the theratube utilized. This device was specifically designed with the overhead athlete in mind. Pink, et al[4] has suggested that shoulder pathologies in individuals under 35 years of age are most commonly seen in the overhead athlete due to the excessive ranges of motion and repetitive action which the overhead athlete's shoulder endures.[4]

Six muscles were chosen for analysis in this study. They include the following: anterior deltoid, posterior deltoid, upper trapezius, infraspinatus, teres major, and latissimus dorsi. Table 1 outlines the origin and insertion of each muscle, as well as the action produced by each muscle.

Table 1. Origins, Insertions, and Actions of Selected Muscles[1-3]

MUSCLE	ORIGIN	INSERTION	ACTION
Anterior Deltoid	Lateral third of clavicle and acromion	Deltoid tuberosity of humerus	Flexion and internal rotation of arm
Posterior Deltoid	Acromion and spine of scapula	Deltoid tuberosity of humerus	Extension and external rotation of arm
Upper Trapezius	Medial third of superior nuchal line; external occipital protuberance, ligamentum nuchae	Lateral third of posterior border of clavicle	Elevation and upward rotation of scapula
Infraspinatus	Infraspinous fossa of scapula	Middle facet on greater tubercle of humerus	External rotation of arm; stabilization of humeral head in glenoid cavity
Teres major	Dorsal surface of inferior angle of scapula	Medial lip of intertubular groove of humerus	Adduction and internal rotation of arm
Latissimus dorsi	Spinous processes of the inferior six thoracic vertebrae, inferior 3 or 4 ribs, thoracolumbar fascia, posterior third of iliac crest, inferior scapular angle	Floor of intertubercular groove of humerus	Extension, adduction, and internal rotation of humerus

The following exercises have been shown via EMG to elicit high activity from the anterior deltoid muscle: scaption with internal and external rotation, flexion, military press, abduction, horizontal abduction with external rotation, FLABER (flexion portion of PNF D_1 pattern), FLADER (flexion portion of PNF D_2 pattern), and press-ups.[4,9,12]

The posterior deltoid is active during extension and external rotation of the humerus.[3,4] Depending on the joint angle, the posterior deltoid can also be active during adduction of the humerus.[4] It has been shown to be highly active during the extension phase of the D_1 PNF pattern (EXABIR).[9] As with the anterior deltoid, the posterior deltoid is active during scaption, horizontal abduction with external rotation, rowing, extension, external rotation and press-up exercises as well.[4] Jobe,et al[12] found that horizontal abduction in internal rotation elicited the most EMG activity from the posterior deltoid, followed by horizontal abduction in external rotation and rowing exercises. It also functions in deceleration of the upper extremity during overhead throwing activities.[12]

The upper trapezius participates in shoulder elevation and upward rotation of the scapula.[3,2,13] Upward rotation of the scapula is achieved via a force couple generated between the actions of the upper and lower trapezius and serratus anterior and is essential for proper biomechanics of the shoulder.[2,7] The upper trapezius also acts in conjunction with the serratus anterior to maintain the optimal length/tension ratio for the deltoid.[2] The upper trapezius is an essential muscle in maintenance of proper posture alignment; this is evidenced by a high percentage (67%) of Type 1 fibers forming the trapezius.[2] Suggested exercises for strengthening of the upper trapezius include the following: shoulder shrugs, rowing activities, scaption, flexion, horizontal shoulder abduction, military press, press-ups, and push-ups with a plus.[2,4,14] Moseley, et al[14] found that the upper trapezius functions as a scapular retractor during rowing and horizontal abduction exercises; whereas, it functions as an upward rotator during the military press and scaption exercises. It is important to note that an increased ratio of upper trapezius strength to lower trapezius strength has been implicated as a source of shoulder pathology in overhead athletes.[7]

The main action of the infraspinatus is external rotation of the humerus.[2,3,13] It is also one of the four muscles that make up the rotator cuff; the infraspinatus, along with the subscapularis and teres minor, prevents superior movement of the humeral head within the glenoid cavity.[2,4] Exercises that have been found to elicit notable EMG activity from the infraspinatus include sidelying external rotation, prone external and internal rotation in a horizontally abducted position, scaption in external rotation, PNF FLADER (flexion portion of PNF D_1 pattern) and FLABER (flexion portion of PNF D_2 pattern).[9,11,12] The infraspinatus acts as a decelerator, as well, during overhead throwing activities.[12]

The teres major is active during internal rotation, adduction, extension, and abduction of the humerus.[3,13] However, EMG studies by Basmajian et al[15] have shown that the teres major is recruited mainly during resisted motions of internal rotation, adduction, and extension. It was active during hyperextension and adduction without resistance when the arm was behind the coronal plane.[15]

The latissimus dorsi is involved with extension, adduction, and internal rotation of the humerus.[3,13] Because of its attachment to the inferior angle of the scapula, it can also influence downward rotation or depression of the scapula.[2,13] Exercises which elicit activity from the latissimus dorsi include press-ups, lat pull-downs, sitting push-ups, and PNF D_1 (EXABIR) pattern.[9,12] Jobe et al[8], have identified the latissimus dorsi along with the pectoralis major as the power and driving force during throwing activities.

Several articles have been published regarding the use of electromyographic (EMG) data to determine effective exercises for the shoulder musculature.[5,6,9-11] Some researchers incorporated video analysis or cinematography into their studies to compare EMG data to a specific point in the range of motion.[6,10] However, since the Multi-Sport Cord is a new product, there has been no research completed to determine the efficacy of this device to effectively work the muscles that need to be rehabilitated in an injured shoulder. Therefore, the purpose of this study is to determine which shoulder girdle muscles are active, as well as when they are active throughout the range of motion of selected therapeutic exercises with the Multi Sport Cord. This will be accomplished through use of motion analysis and electromyography.

METHODS

Chapter 2

SUBJECTS

Five normal, healthy male subjects were used in the study (Table 2). None of the subjects had a previous history of shoulder pathology. They all signed a letter of informed consent (Appendix A) prior to the testing procedure. The study was approved by the Institutional Review Board at the University of North Dakota (Appendix B).

Table 2. Characteristics of Subjects (n=5 males)

	Mean	**Range**	**Standard Deviation**
Age (years)	24.6	23-28	2.1
Height (inches)	69.6	65-74	3.5
Weight (pounds)	163	145-185	16.4

INSTRUMENTATION

Electromyography

The electromyographic data was collected using a Noraxon Telemyo8 telemetry unit (Noraxon USA, 13430 North Scottsdale Rd., Scottsdale, AZ, 85254). The telemetried information from the EMG electrodes was collected by a Noraxon

Telemyo 8 receiver and then digitized by an analog to digital interface board installed in the Peak Analog Sampling Module (Peak Performance Technologies, 7388 S. Revere Parkway, Suite 601, Englewood, CO, 80112-9765). The digitized EMG signals were analyzed using the Peak Motus software package. The electromyographic data was synchronized with the video data using the Peak Event Synchronization Unit. To start the EMG data collection, the synchronization unit was triggered by a manual switch and EMG data was collected for a period of 10 seconds with a sampling frequency of 1080 Hz.

Video

Each subject was asked to wear dark clothing. Three reflective markers were placed on each subject. The position of the reflective markers varied between exercises. The precise placement of the reflective markers is described below. The cameras used to film the motion were Peak High Speed Video 60/120 Hz cameras (Peak Performance Technologies, 7388 S. Revere Parkway, Suite 601, Englewood, CO, 80112-9765). The camera was set at a scanning frequency of 60 Hz. The shutter speed was set at 1/250 of a second. The video information was subsequently recorded on tape using a JVC Model BR-S378U video cassette recorder (JVC of America, 41 Slater Drive, Elmwood Park, NJ, 07407). The video tape was encoded using a SMPTE time code generator.

After recording of the subject's movements, the video taped data was analyzed using the Peak Motus Software. A Sanyo Model GVR-S955 (Sanyo, 1200 W. Artesia Blvd., Compton, CA 90220) video cassette recorder was used to play back the video tapes for digitization.

Procedure

The electromyographic (EMG) activity was collected from the following muscles: anterior deltoid, posterior deltoid, upper trapezius, infraspinatus, teres major, and latissimus dorsi. These muscles can be monitored via surface electrodes and are representative of each motion at the shoulder joint.

To record the EMG activity, surface electrodes were placed over the motor points of each of the muscles studied. The motor point of each monitored muscle was found using a hand held electrical stimulator. The skin over the motor point was prepared by cleansing the skin with alcohol before attachment of the EMG electrodes. The electrodes (Multi Bio-Sensors, El Paso, TX, 79913), coated with pre-gelled adhesive, were then attached to the skin.

The EMG signals were transmitted to the receiver unit and then into a computer for display and recording of the data. The EMG information for each subject was recorded and stored on the computer hard drive for future analysis.

Prior to the trials, each subject's age, height and weight was recorded. The right upper extremity was used for the study. Before beginning the experiment, each of the subjects was given a short training session on the proper use of the Multi Sport Cord (Frappier Acceleration Products, 2301 25th Street South, Suite E, Fargo, ND 58103). In addition, each subject was taught to perform the exercise in time with an audible metronome that was used to pace the subject during the exercise. This was done to assure consistency of movement, since EMG activity is velocity dependent.

The shoulder exercises included in this study were taken from an exercise protocol developed specifically for the overhead athlete by Pink, et al[1]. The exercises were based on a concept referred to by the developers of the protocol as the "4 P's", which stands for protectors (the rotator cuff muscles), pivotors (scapular rotator muscles), positioners (three heads of the deltoid), and power drivers (pectoralis major and latissimus dorsi).

Not all of the exercises listed in the protocol were included in this study. A description and illustration of each of the selected exercises follows, as well as a description of the location of the reflective markers for each exercise. Each exercise and placement of the reflective markers is depicted in Figures 3-7.

Sidelying external rotation is the first exercise targeted towards strengthening of the glenohumeral protectors. The subject lies on the contralateral side and externally rotates the humerus while the elbow is in 90^0 of flexion (Fig. 3). It is suggested that a small pillow be placed in between the exercising arm and the thorax to prevent circulation disturbances. The reflective markers were placed on each subject's acromion process, radial head, and mid-anterior thigh.

Progression of rotator cuff musculature strengthening includes prone external rotation with the humerus in a horizontally abducted position (Fig 4). For this exercise, the reflective markers were placed on the olecronon process, the ulnar head, and the lateral iliac crest of each subject.

External rotation with the arm at the side or slightly abducted, between 0^0 and 30^0 of abduction, while in a standing or sitting position is the next exercise in the progression of glenohumeral protector strengthening (Fig. 5). This exercise may be progressed from performance of the exercise at low speeds to performance at high speeds. The reflective markers during this exercise were placed on the acromion process, the proximal phalanx of the middle finger, and the anterior superior iliac crest of each subject.

Scaption is elevation of the upper extremity performed in the scapular plane, which is halfway between flexion and abduction or 30-45^0 anterior to the coronal plane[16]. It can be performed in either extreme internal rotation or extreme external rotation (Fig.6). However, for this study the "empty can" position (extreme internal rotation) was utilized. For the scaption exercise, the reflective markers were placed on the acromion process, the proximal phalanx of the middle finger, and the anterior superior iliac crest.

The fifth exercise in this study is forward flexion of the shoulder with a straight arm and neutral shoulder rotation (Fig. 7). The reflective markers were placed on each subject on the acromion process, the proximal phalanx of the middle finger, and the anterior superior iliac crest.

Each exercise was performed two times by each subject twice: once against the resistance of Multi Sport Cord and once against the resistance of a six pound free weight. The length-tension curve of the Multi Sport Cord is displayed in Figure 7. The most resistance given by the Multi Sport Cord at its end range was 6.1 pounds of force.

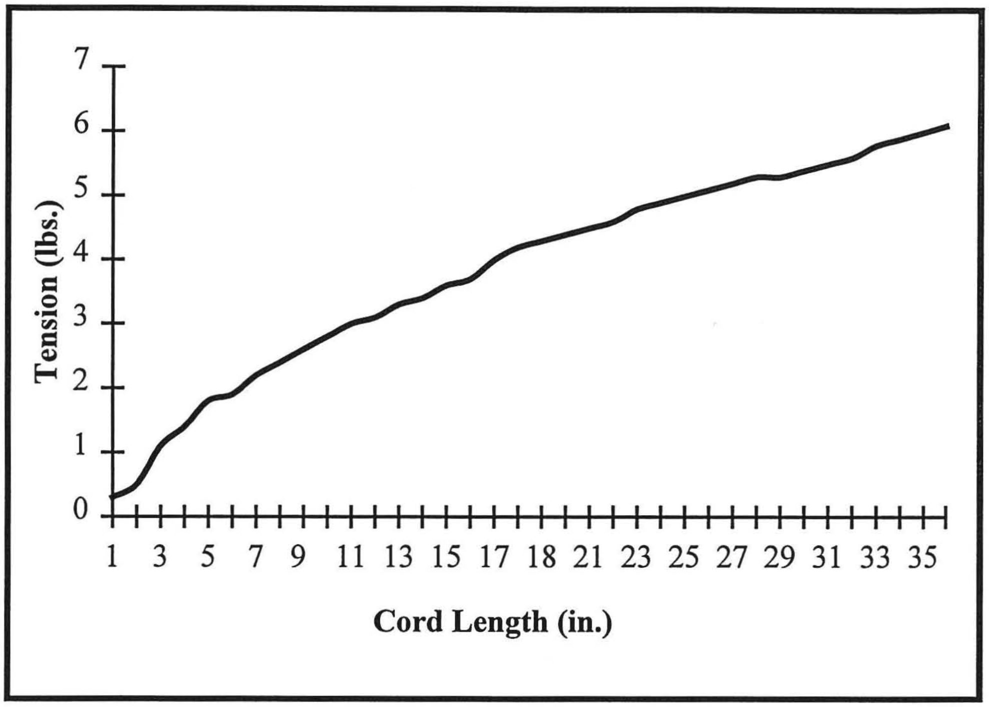


Figure 2. Length-Tension Curve of the Multi Sport Cord

DATA ANALYSIS

Prior to videotaping, the camera was calibrated by videotaping a meter stick. Then the video footage for each exercise trial was calibrated to meters, cropped to the first three repetitions of each exercise, and digitized using the Peak system. The software calculated the angles and segmental motion. The raw analog data was scaled and matched to the video. Reports were then generated to show stickman-figure representation of the motion, relative range of motion curve, and integrated EMG data of the three repetitions of each trial.

Qualitative analysis was employed to compare the EMG data between the performance of each exercise with the Multi Sport Cord and the free weight, as well as the EMG data between subjects.

Synchronization of the EMG and video data was achieved by utilizing an event switch, which was triggered by each subject at the start of each subject at the same point of motion of each exercise.

Statistical testing for significant differences between and within subjects was not performed due to the small number of subjects.

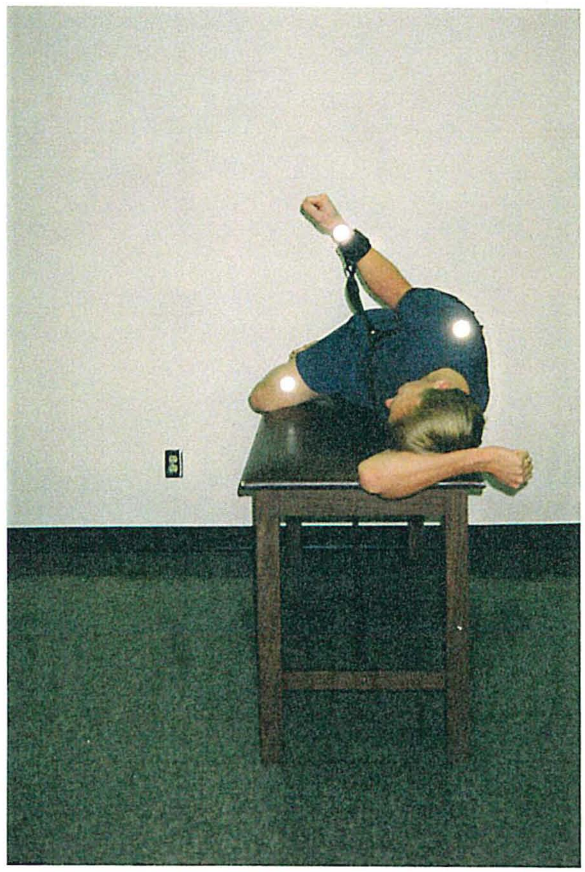


Figure 3. Sidelying External Rotation and Placement of Reflective Markers

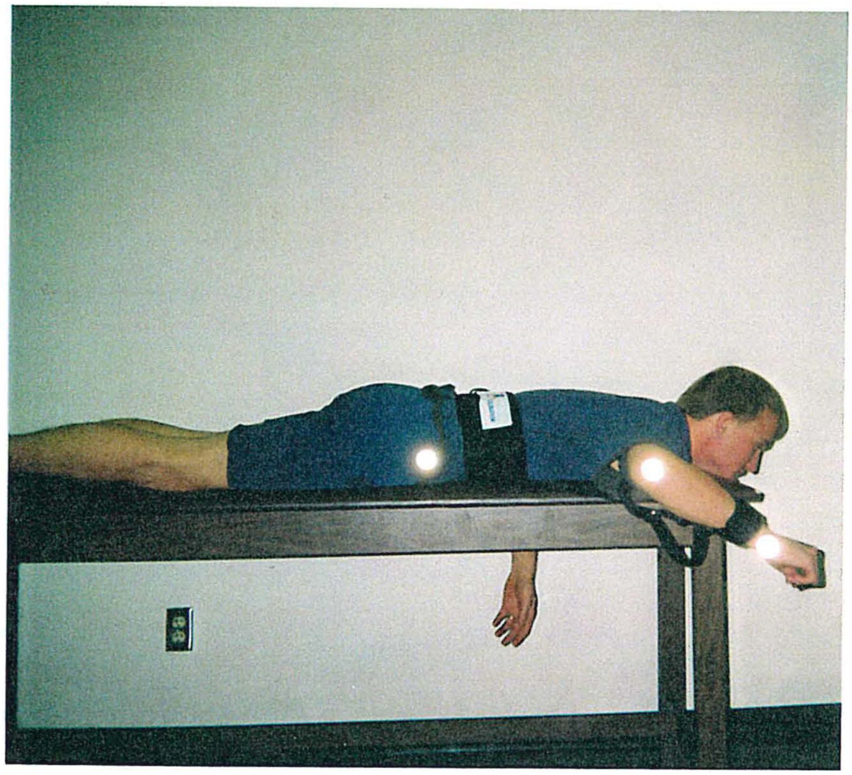


Figure 4. Prone External Rotation and Placement of Reflective Markers

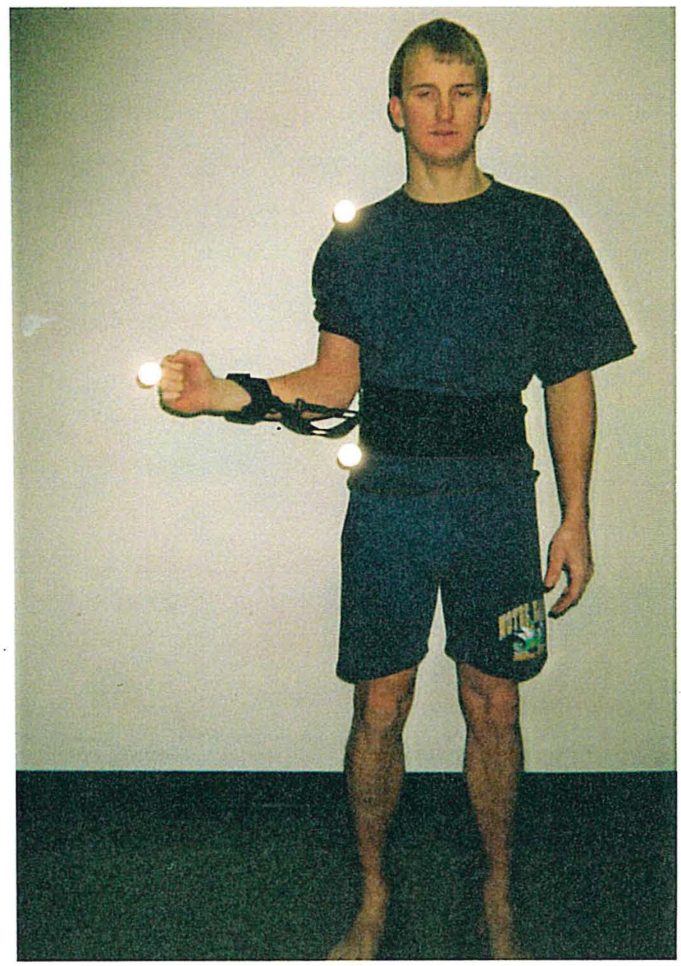


Figure 5. Standing External Rotation and Placement of Reflective Markers

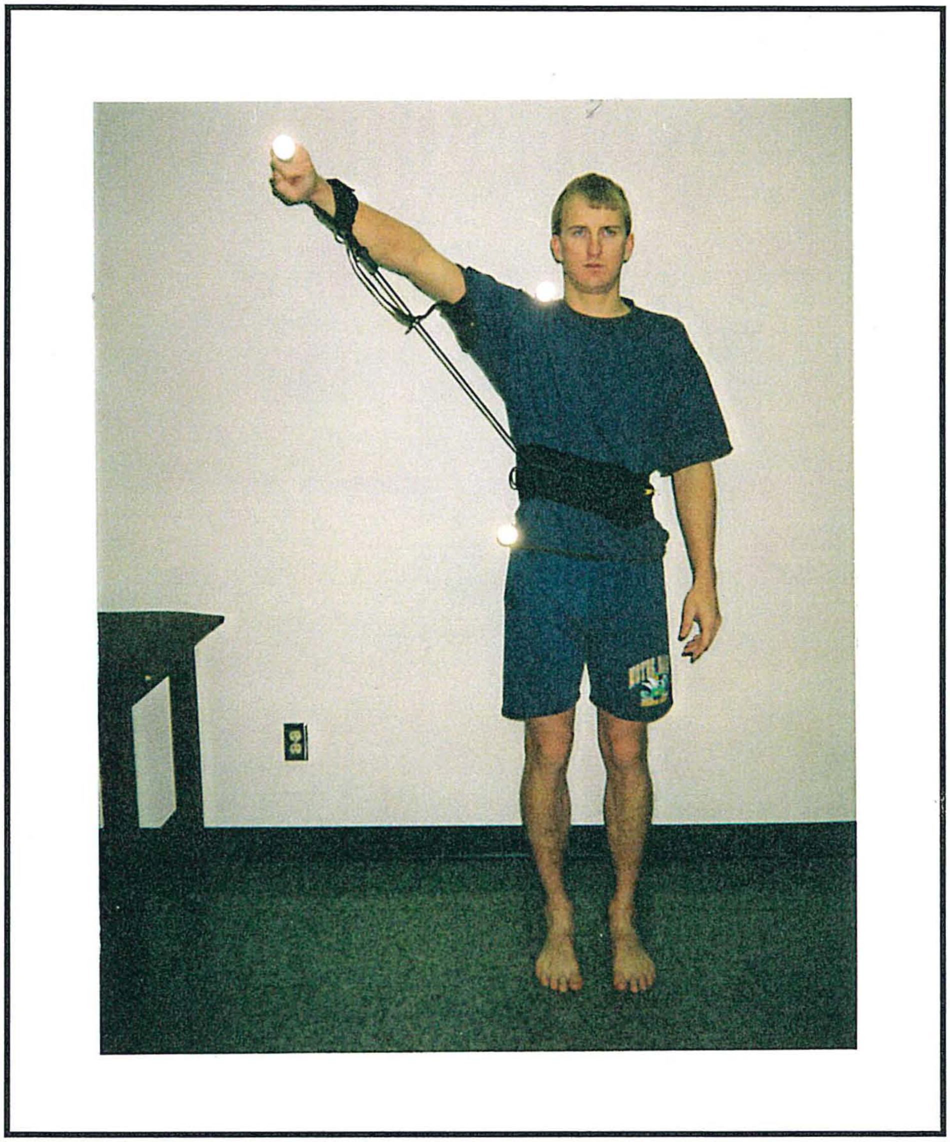


Figure 6. Scaption and Placement of Reflective Markers

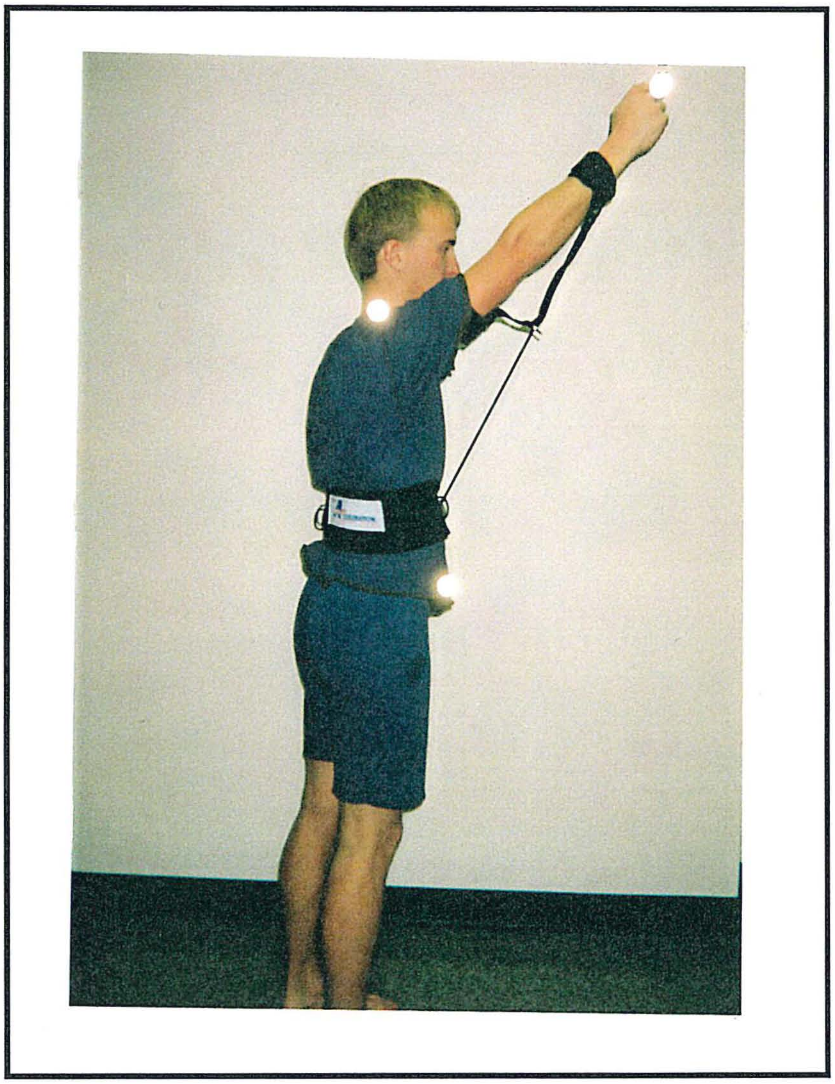


Figure 7. Flexion and Placement of Reflective Markers

RESULTS

Chapter 3

All subjects completed the study. The results from Subject 2's performance of sidelying external rotation could not be analyzed due to a technical error with the software. The qualitative analysis of sidelying external rotation, therefore, represents the results from the other four subjects.

Sidelying External Rotation (Figures 8 through 11)

With both the Multi Sport Cord (MSC) and the free weight, the highest level (μV) of EMG activity occurred in the posterior deltoid and the infraspinatus. However, the pattern of recruitment differed between the MSC and the free weight. With the MSC, the highest level of activity occurred between approximately 10-20% of the cycle; whereas with the free weight, the peak activity occurred at the first 10% of the cycle. There was a slower build up to peak activity with the MSC compared to the free weight.

Prone External Rotation (Figures 12 through 16)

With both the Multi Sport Cord and the free weight, the highest level (μV) of EMG activity occurred in the infraspinatus and the posterior deltoid. Again, the pattern of recruitment differed between the MSC and the free weight. There was a trend toward the highest level of EMG activity with the MSC occurring slightly after the peak activity of the free weight. This difference was not as marked as noted during the sidelying external rotation exercise.

Standing External Rotation (Figures 17 through 21)

The infraspinatus was active in all subjects during standing external rotation with the free weight. However, both the posterior deltoid and the infraspinatus were active in all subjects during performance of this exercise with the Multi Sport Cord. Furthermore, the EMG activity elicited from the Multi Sport Cord ranged from 2-4 times the amount of activity elicited from the free weight.

Scaption (Figures 22 through 26)

With both the Multi Sport Cord and the free weight, the highest level (μV) of EMG activity occurred in the anterior deltoid and the upper trapezius. Once more, the pattern of recruitment differed between the MSC and the free weight. There was a trend toward the highest level of EMG activity with the MSC occurring slightly after the peak activity of the free weight.

Flexion (Figures 27 through 31)

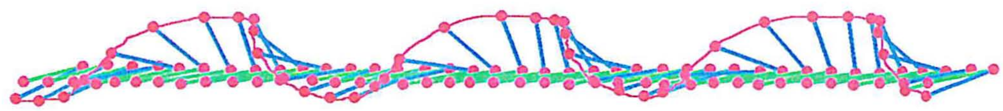
Both the Multi Sport Cord and the free weight elicited the highest level (μV) of EMG activity in the upper trapezius and the anterior deltoid. Again, there was a trend toward the highest level of EMG activity with the MSC occurring slightly after the peak activity of the free weight.

Figure 8. Subject 1: Sidelying External Rotation

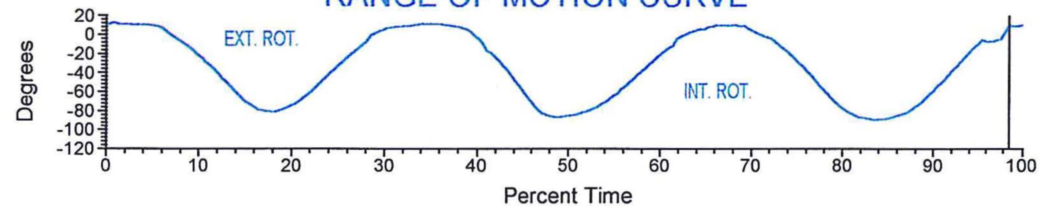
(Full External Rotation = -90^0)

SIDELYING EXTERNAL ROTATION: SUBJECT 1
MULTI SPORT CORD

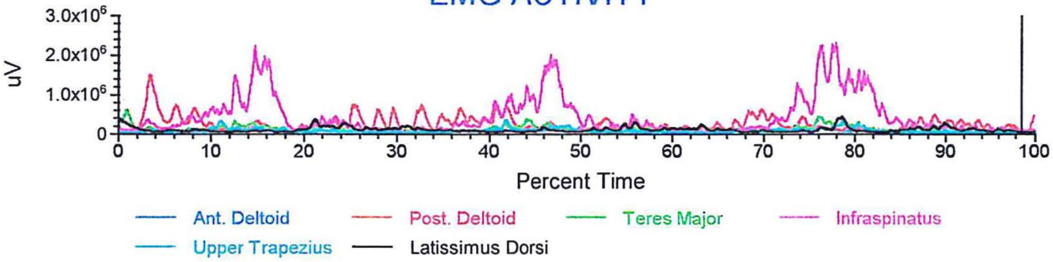
STICKMAN FIGURE



RANGE OF MOTION CURVE

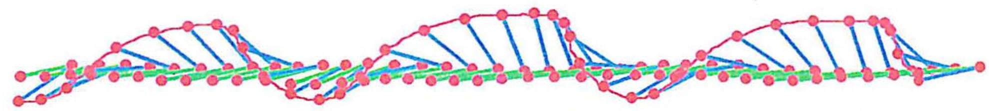


EMG ACTIVITY

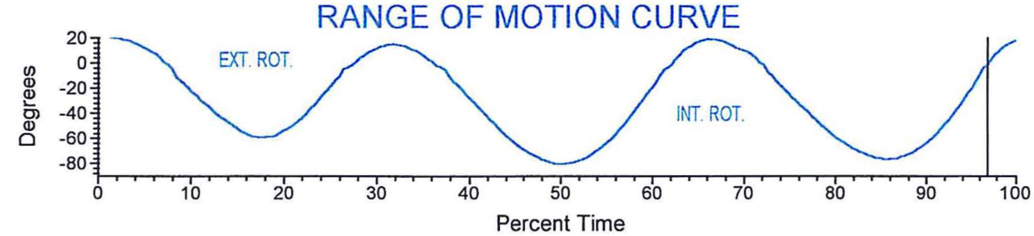


SIDELYING EXTERNAL ROTATION: SUBJECT 1
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

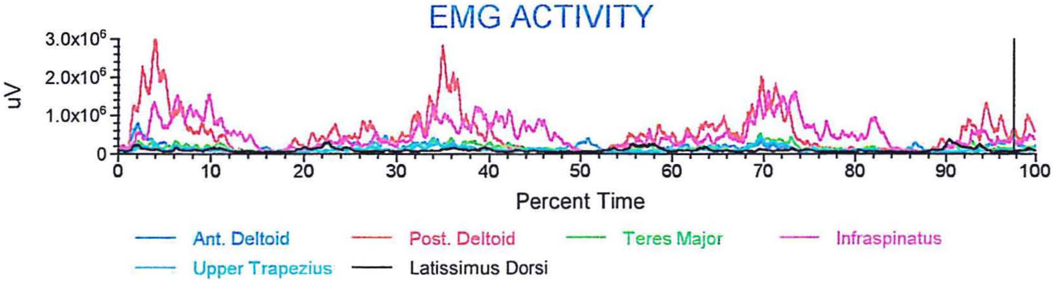
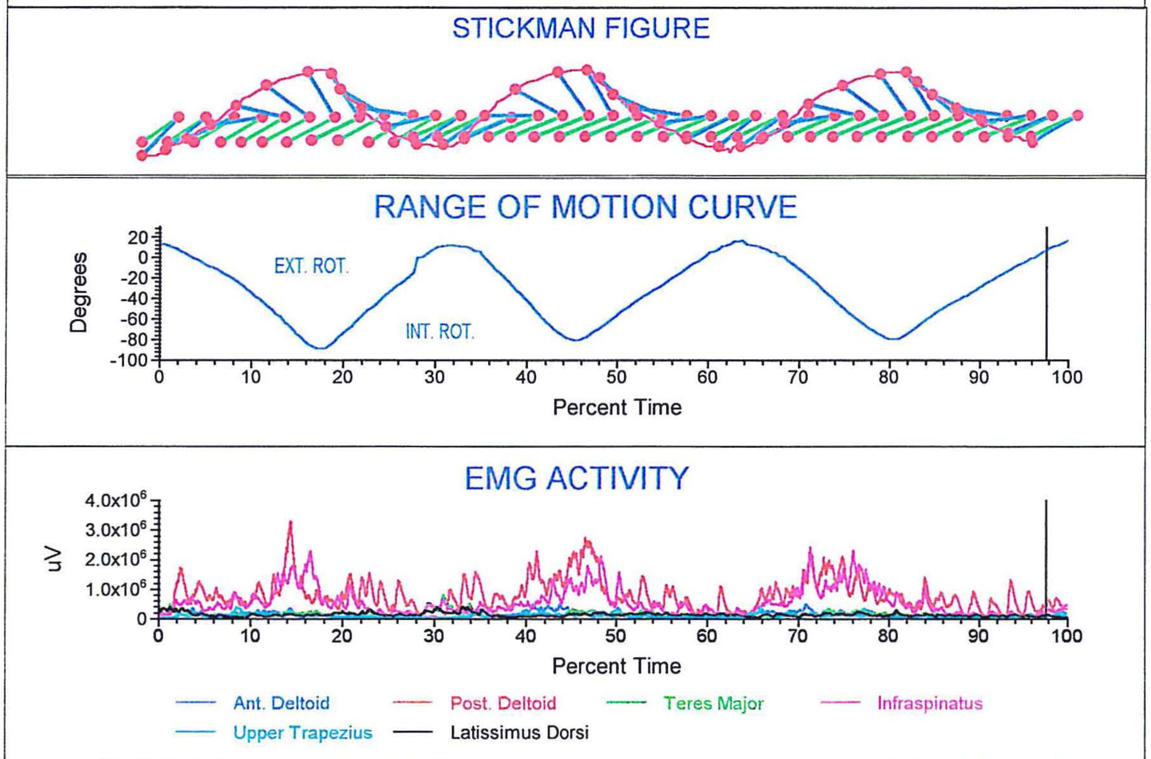


Figure 9. Subject 3: Sidelying External Rotation

(Full External Rotation = -90^0)

SIDELYING EXTERNAL ROTATION: SUBJECT 3
MULTI SPORT CORD



SIDELYING EXTERNAL ROTATION: SUBJECT 3
FREE WEIGHT

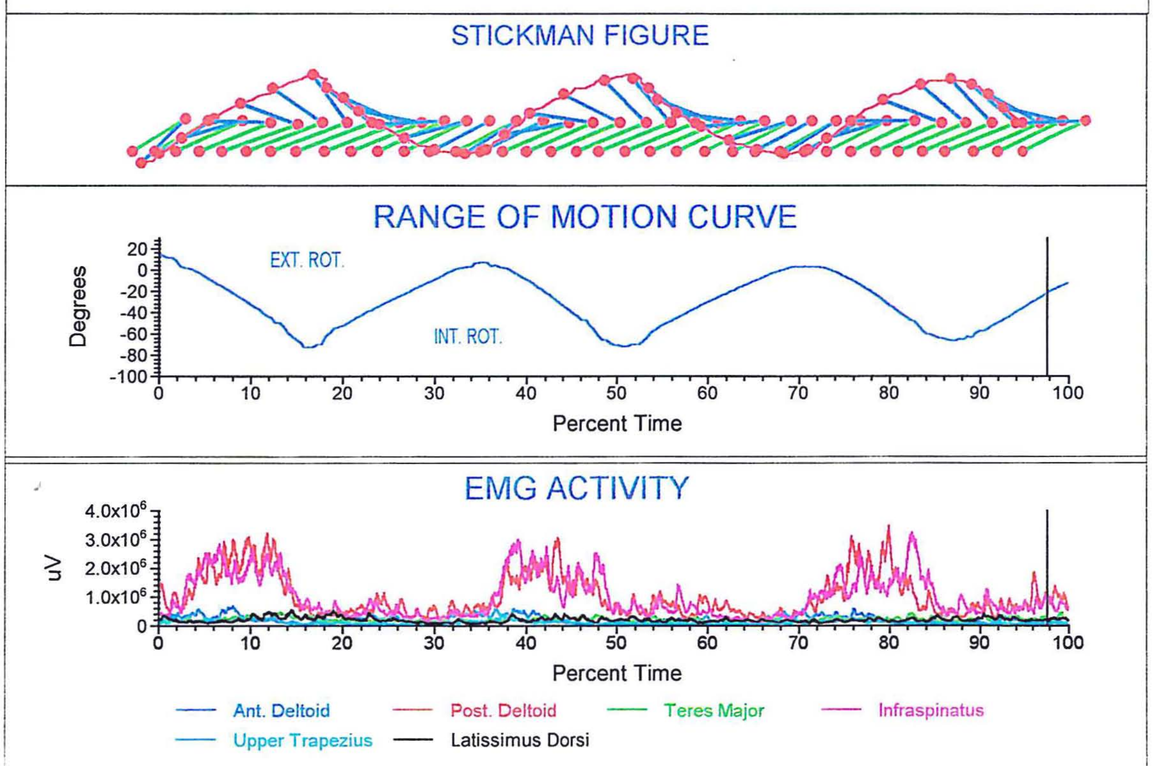
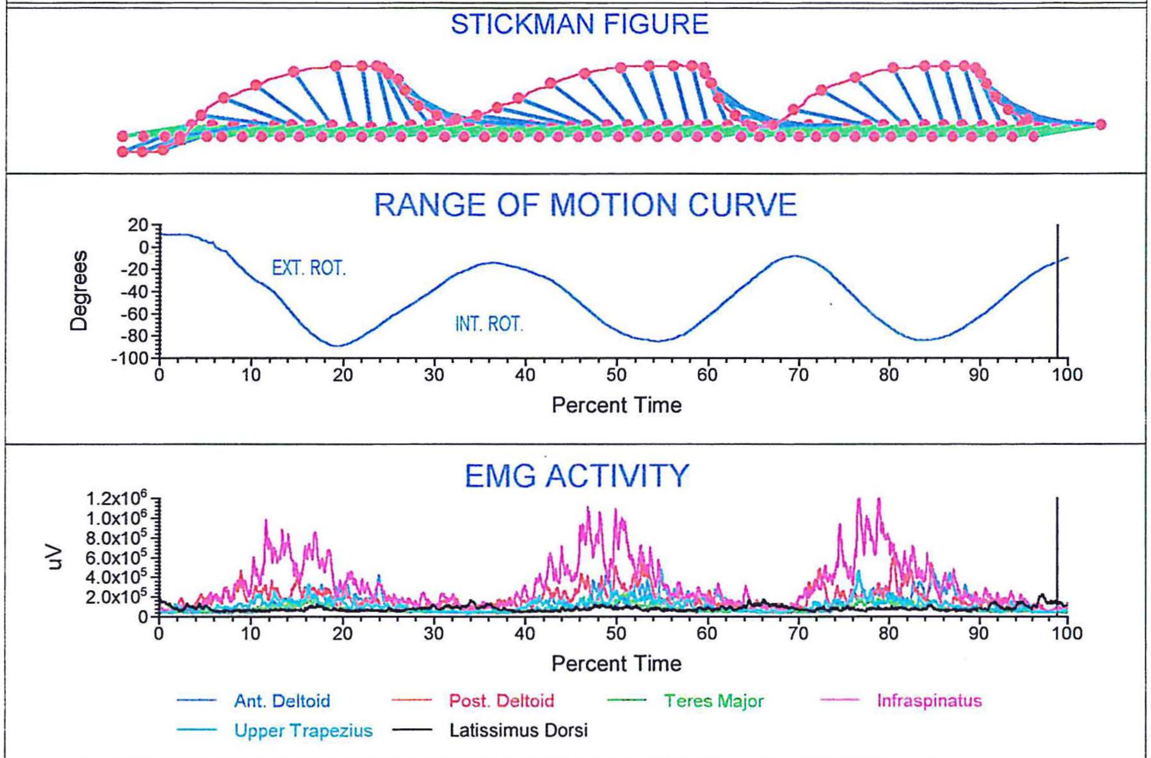


Figure 10. Subject 4: Sidelying External Rotation

(Full External Rotation = -90^0)

SIDELYING EXTERNAL ROTATION: SUBJECT 4
MULTI SPORT CORD



SIDELYING EXTERNAL ROTATION: SUBJECT 4
FREE WEIGHT

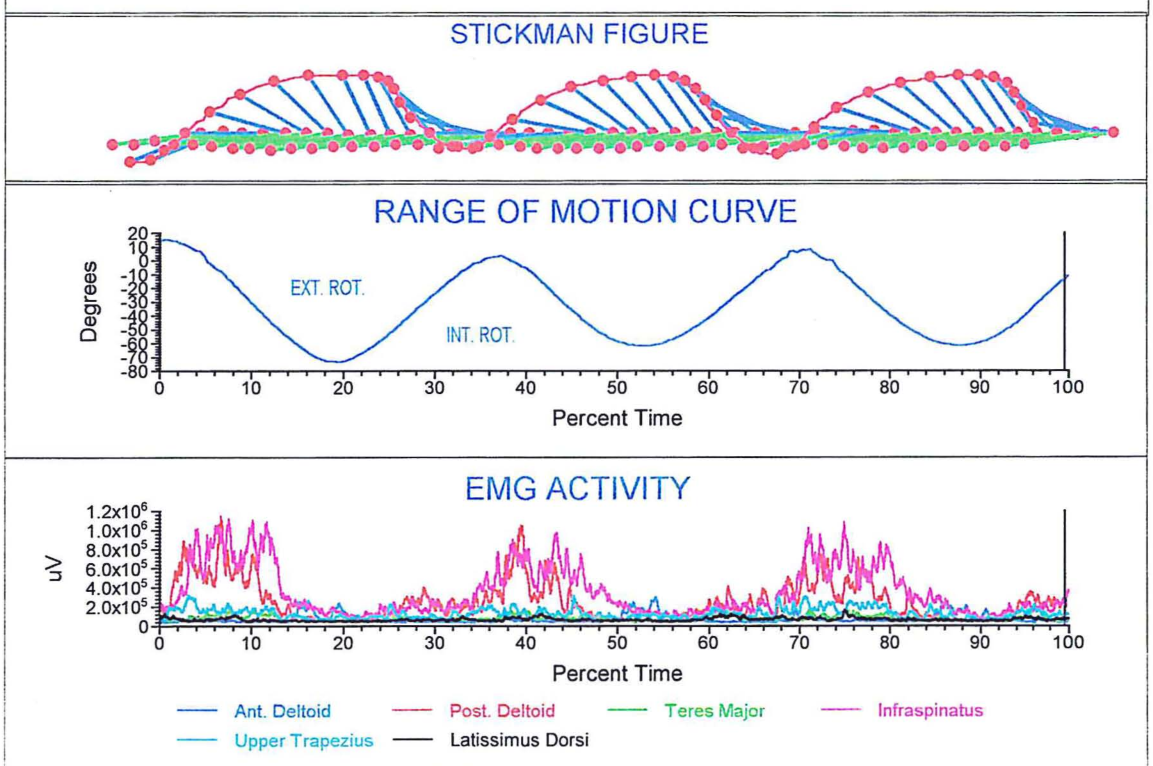
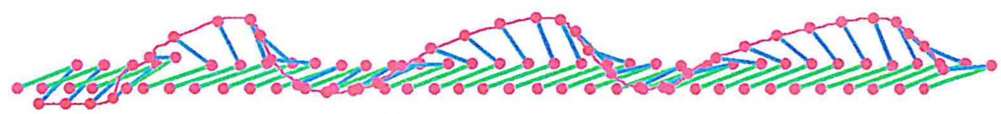


Figure 11. Subject 5: Sidelying External Rotation

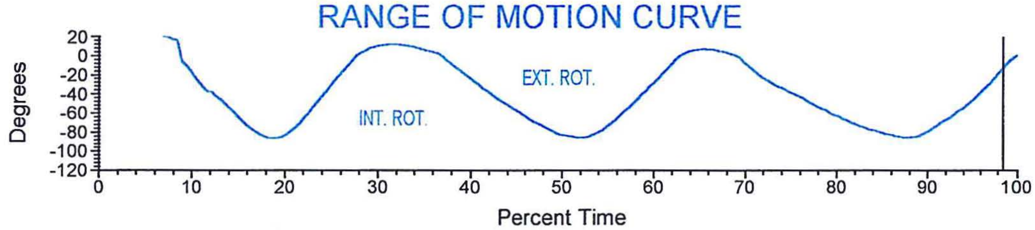
(Full External Rotation = -90^0)

SIDELYING EXTERNAL ROTATION: SUBJECT 5
MULTI SPORT CORD

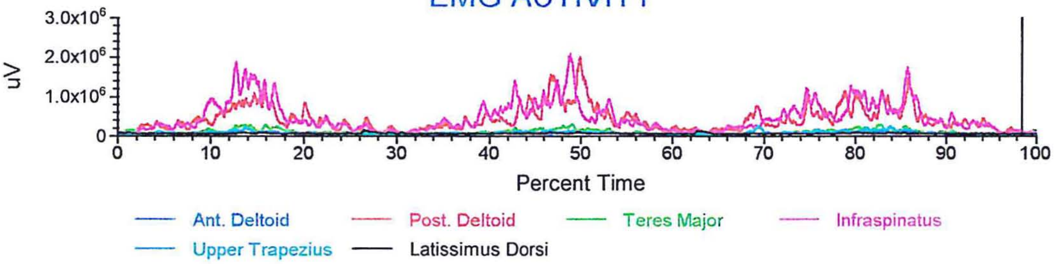
STICKMAN FIGURE



RANGE OF MOTION CURVE

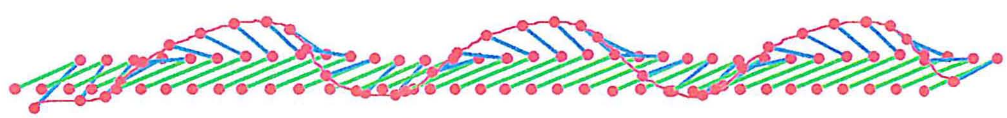


EMG ACTIVITY

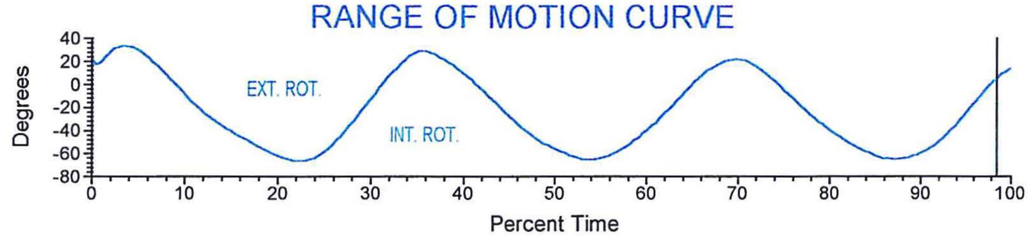


SIDELYING EXTERNAL ROTATION: SUBJECT 5
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

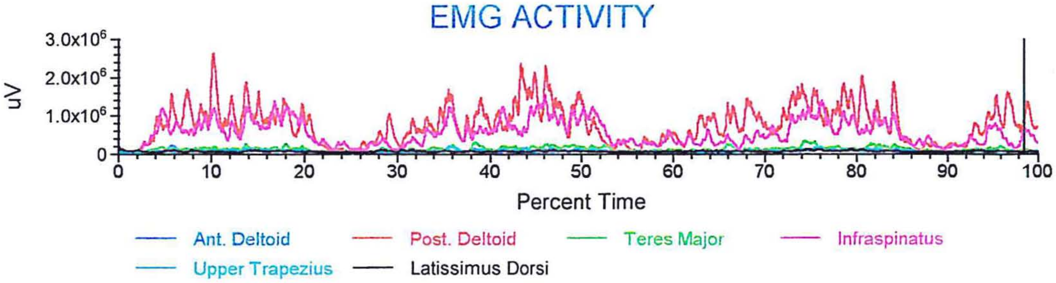
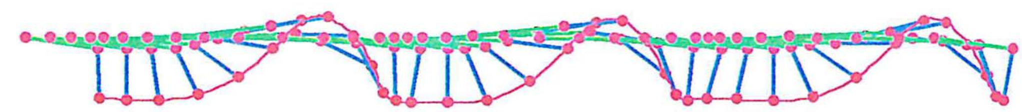


Figure 12. Subject 1: Prone External Rotation

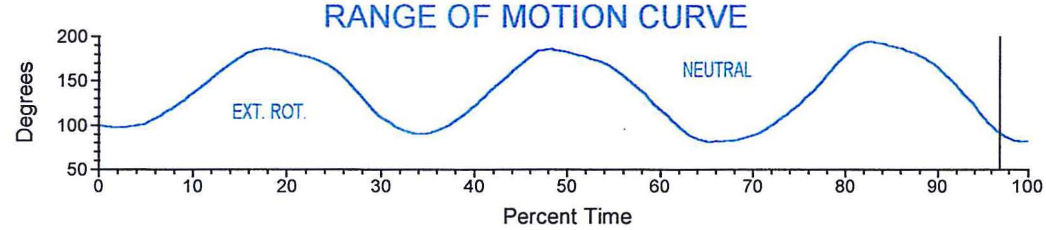
(True ROM = y-100)

PRONE EXTERNAL ROTATION: SUBJECT 1
MULTI SPORT CORD

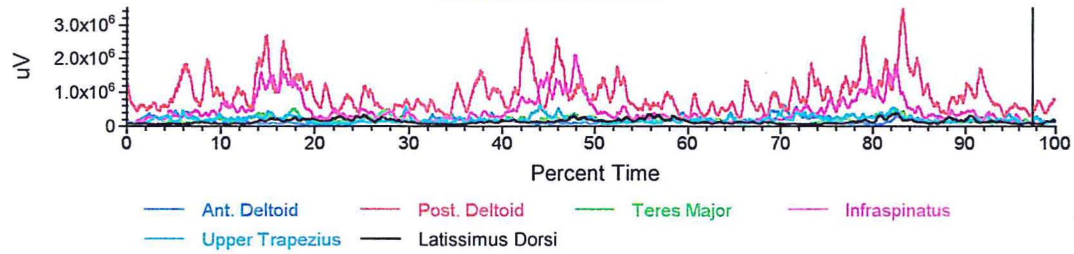
STICKMAN FIGURE



RANGE OF MOTION CURVE

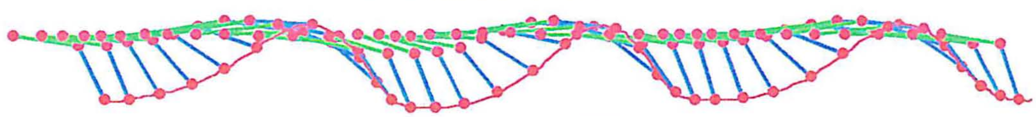


EMG ACTIVITY

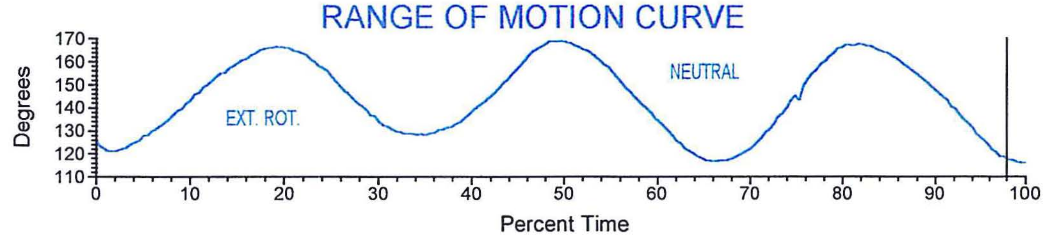


PRONE EXTERNAL ROTATION: SUBJECT 1
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

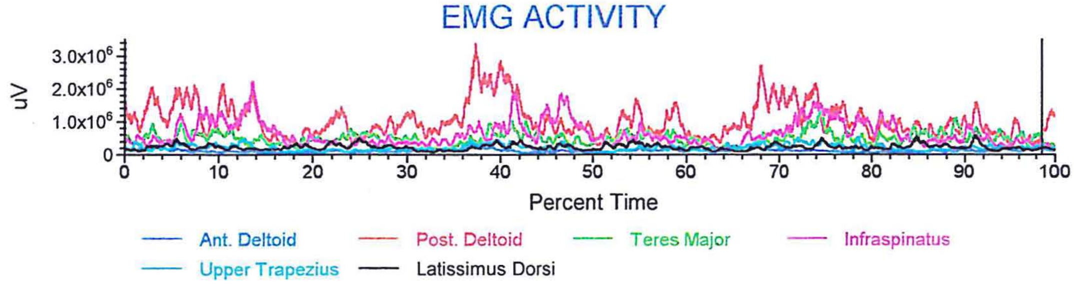
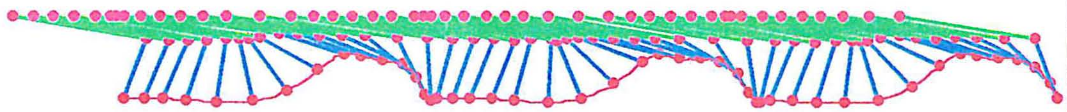


Figure 13. Subject 2: Prone External Rotation

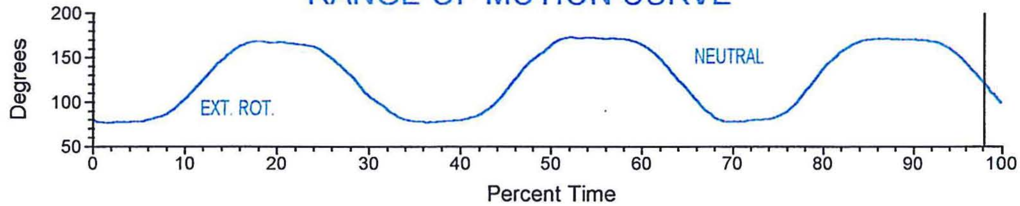
(True ROM = y-100)

PRONE EXTERNAL ROTATION: SUBJECT 2
MULTI SPORT CORD

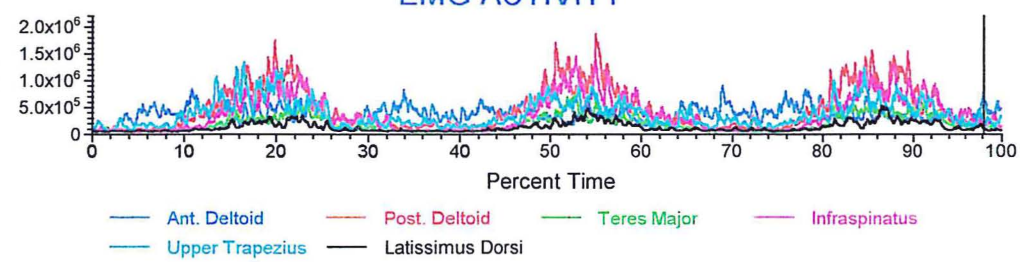
STICKMAN FIGURE



RANGE OF MOTION CURVE

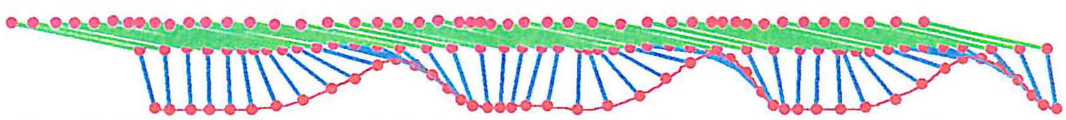


EMG ACTIVITY

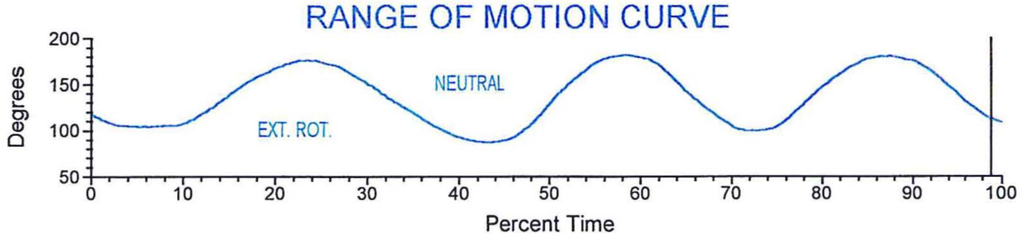


PRONE EXTERNAL ROTATION: SUBJECT 2
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

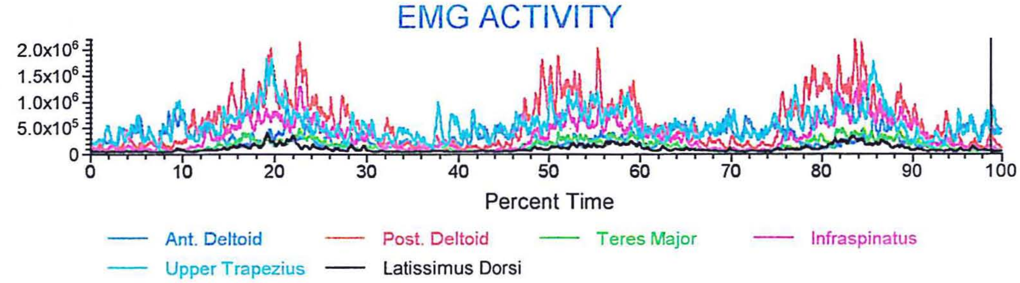
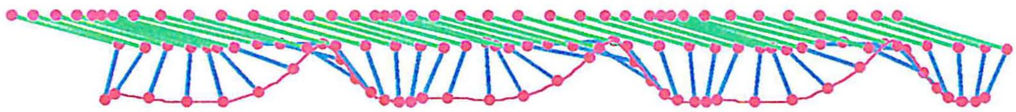


Figure 14. Subject 3: Prone External Rotation

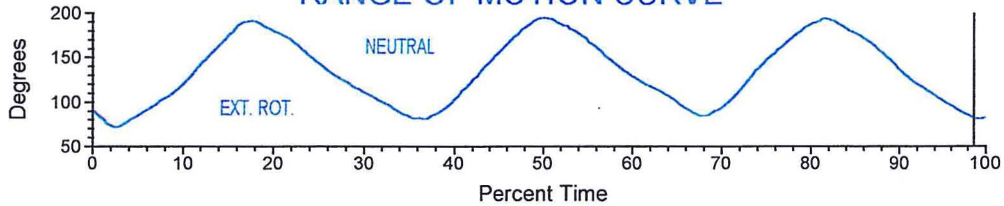
(True ROM = y-100)

PRONE EXTERNAL ROTATION: SUBJECT 3
MULTI SPORT CORD

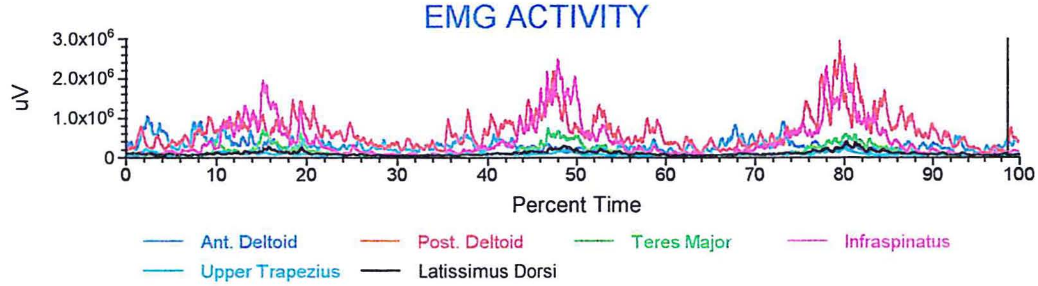
STICKMAN FIGURE



RANGE OF MOTION CURVE

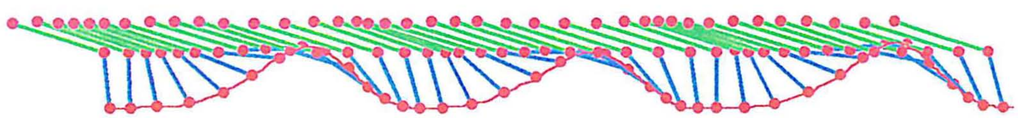


EMG ACTIVITY

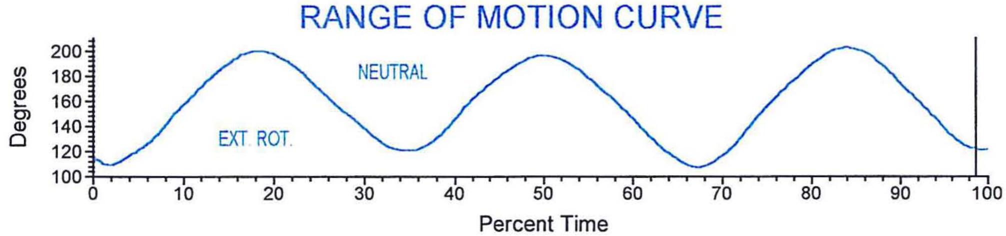


PRONE EXTERNAL ROTATION: SUBJECT 3
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

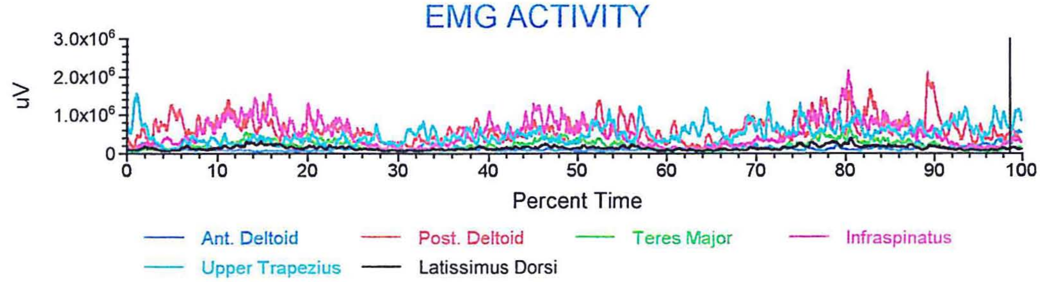
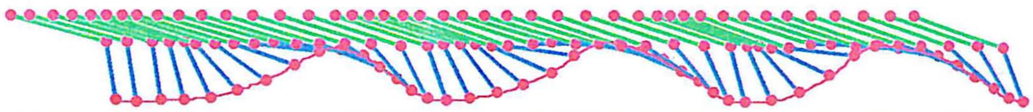


Figure 15. Subject 4: Prone External Rotation

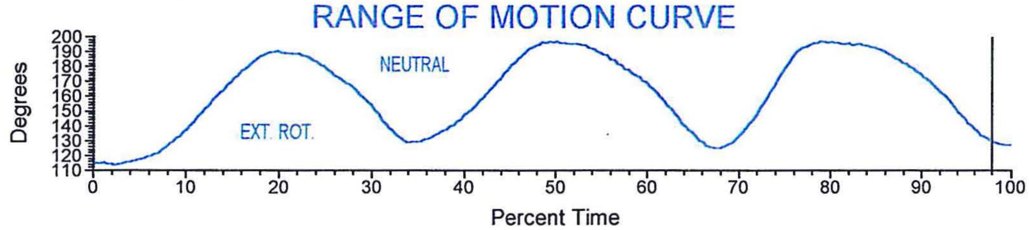
(True ROM = y-100)

PRONE EXTERNAL ROTATION: SUBJECT 4
MULTI SPORT CORD

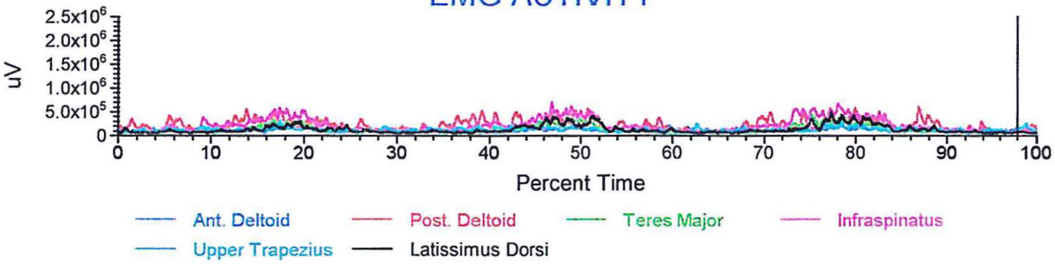
STICKMAN FIGURE



RANGE OF MOTION CURVE

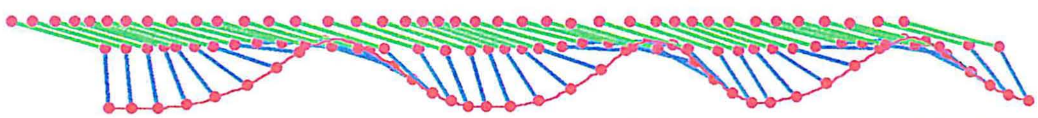


EMG ACTIVITY

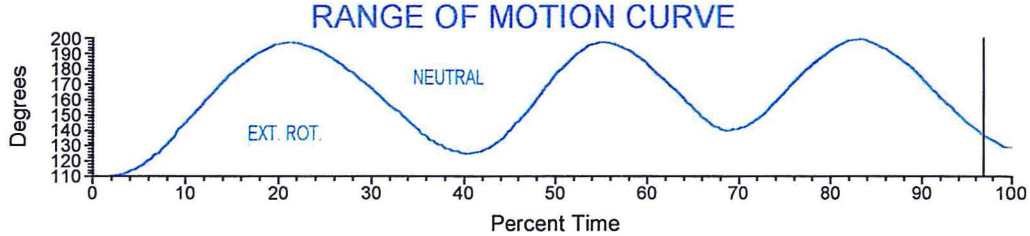


PRONE EXTERNAL ROTATION: SUBJECT 4
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

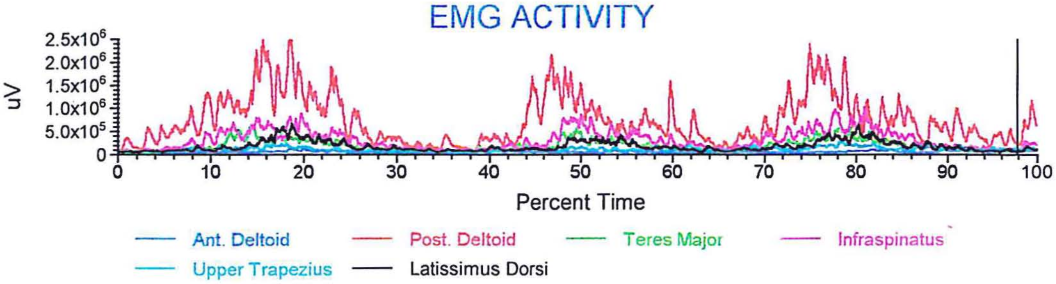
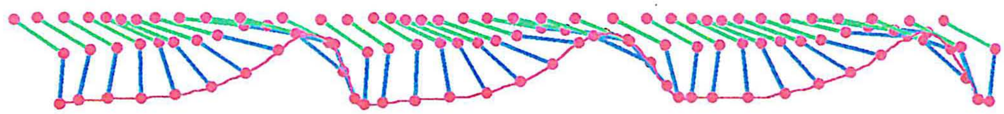


Figure 16. Subject 5: Prone External Rotation

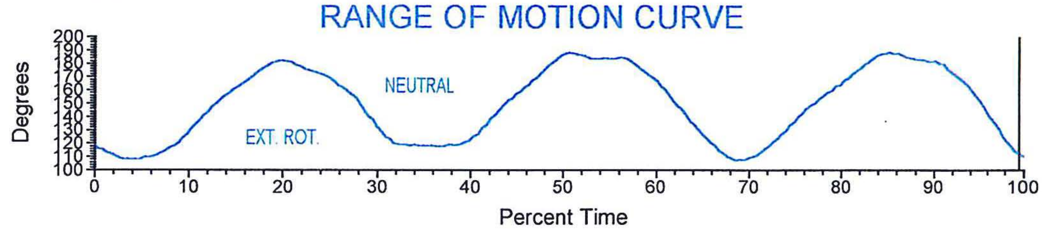
(True ROM = y-100)

PRONE EXTERNAL ROTATION: SUBJECT 5
MULTI SPORT CORD

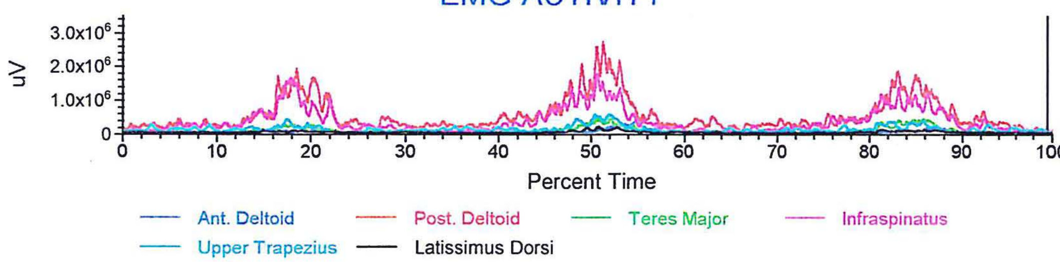
STICKMAN FIGURE



RANGE OF MOTION CURVE

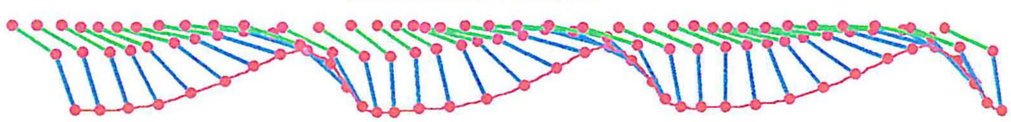


EMG ACTIVITY

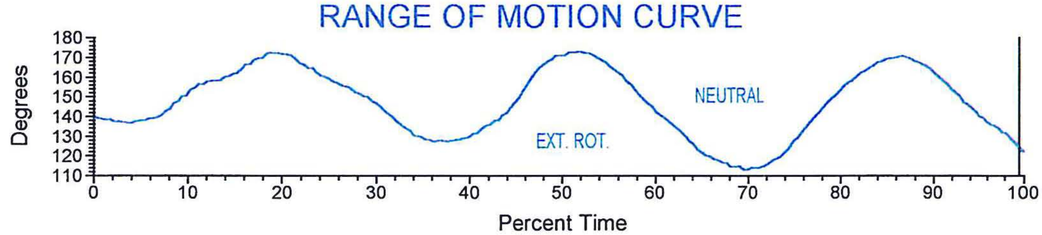


PRONE EXTERNAL ROTATION: SUBJECT 5
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

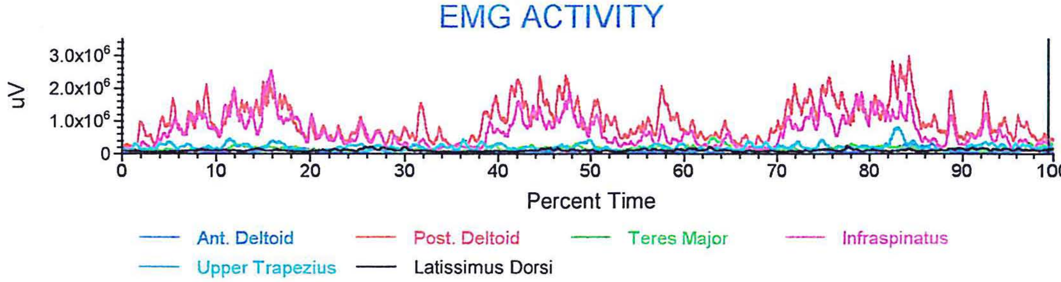
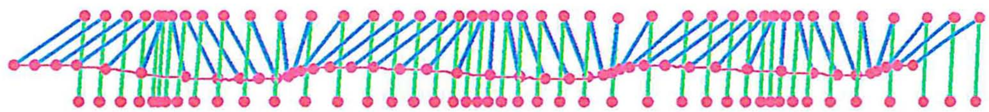


Figure 17. Subject 1: Standing External Rotation

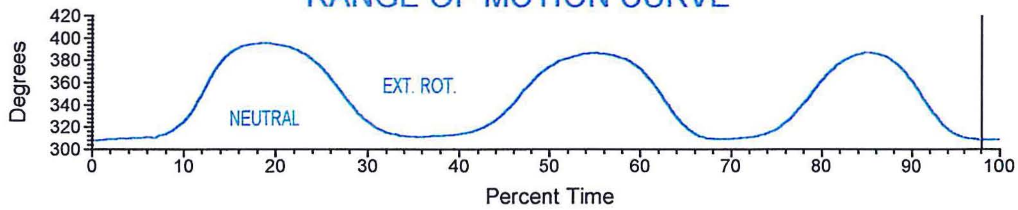
(True ROM = y-350)

STANDING EXTERNAL ROTATION: SUBJECT 1
MULTI SPORT CORD

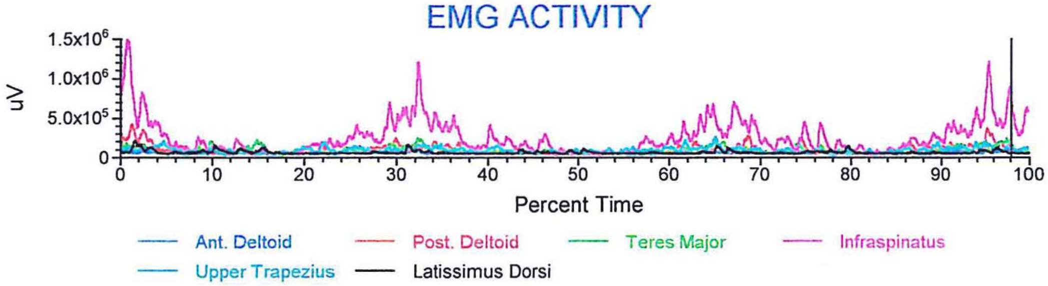
STICKMAN FIGURE



RANGE OF MOTION CURVE

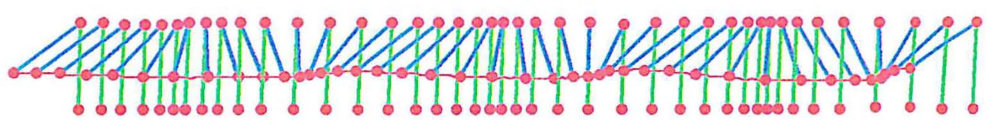


EMG ACTIVITY

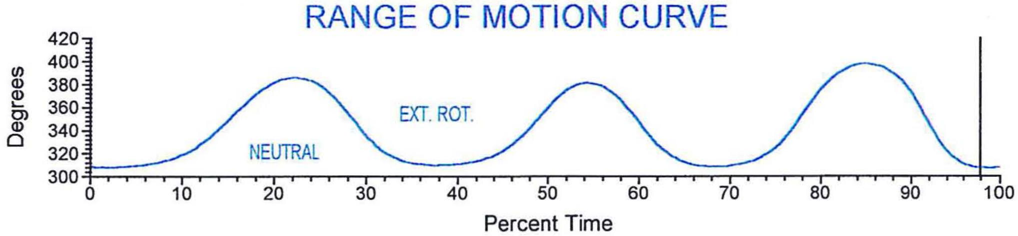


STANDING EXTERNAL ROTATION: SUBJECT 1
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

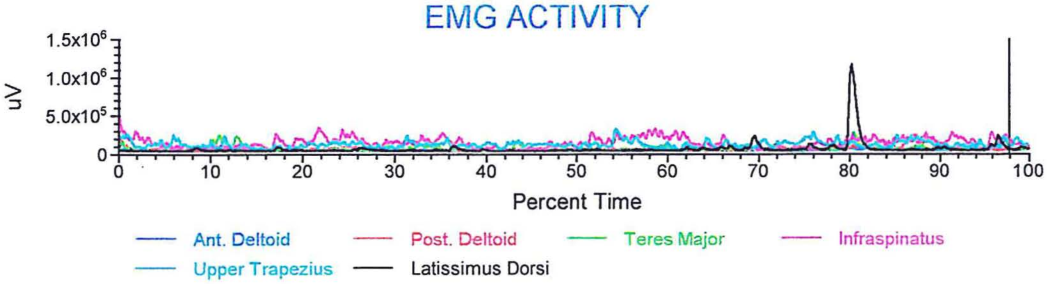
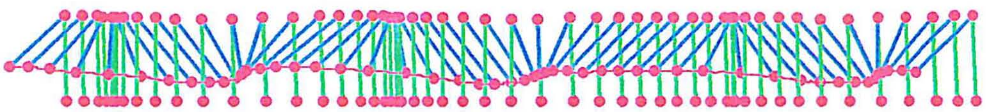


Figure 18. Subject 2: Standing External Rotation

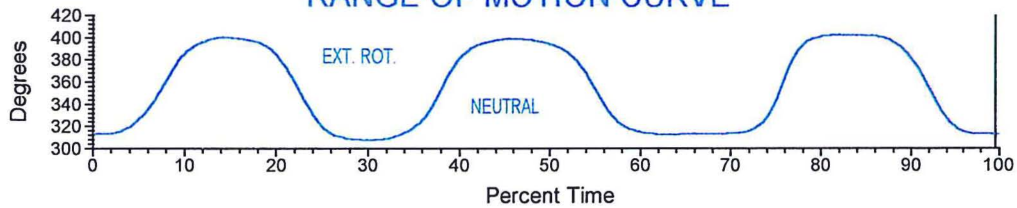
(True ROM = y-350)

STANDING EXTERNAL ROTATION: SUBJECT 2
MULTI SPORT CORD

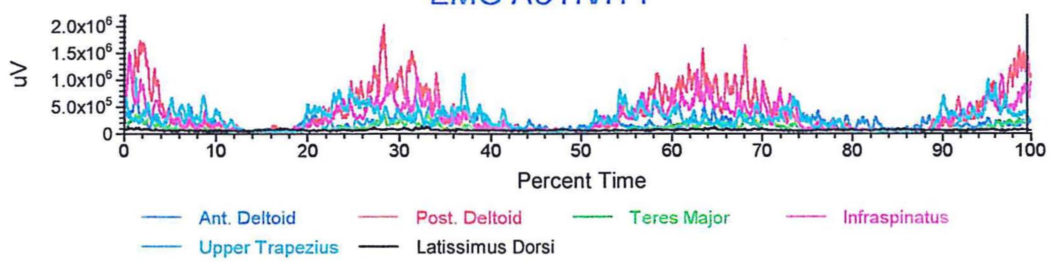
STICKMAN FIGURE



RANGE OF MOTION CURVE

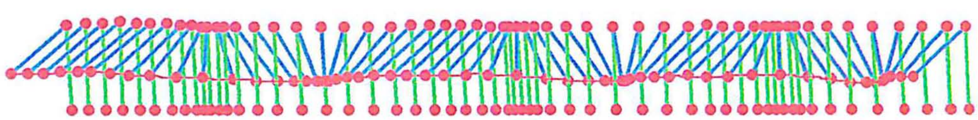


EMG ACTIVITY

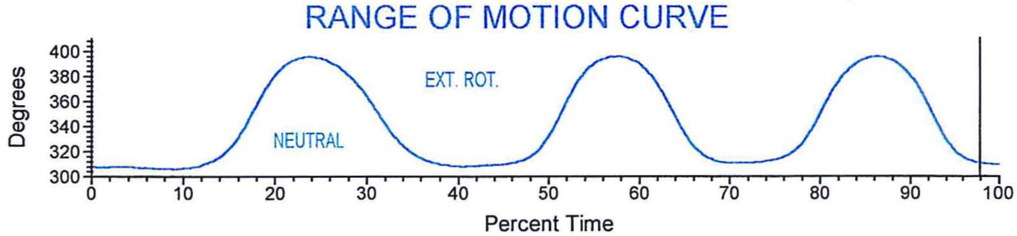


STANDING EXTERNAL ROTATION: SUBJECT 2
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

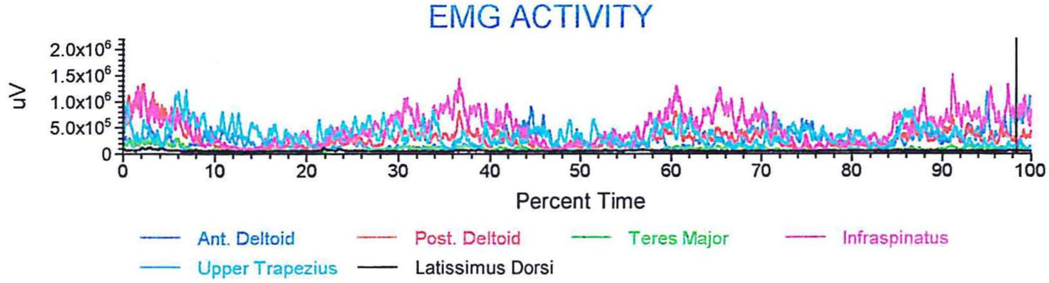
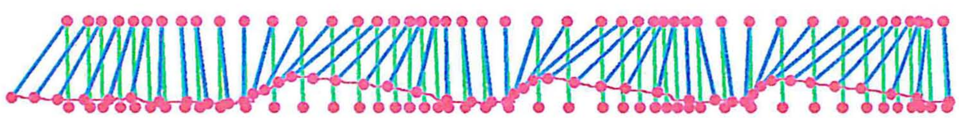


Figure 19. Subject 3: Standing External Rotation

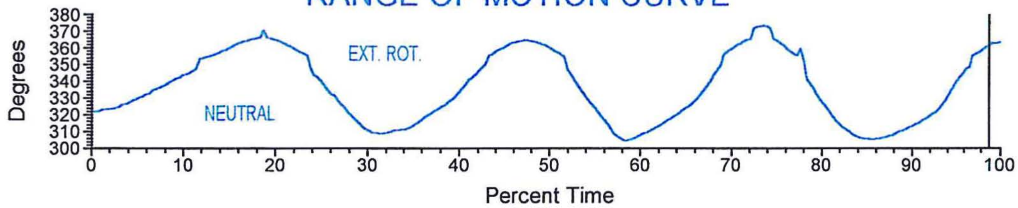
(True ROM = y-350)

STANDING EXTERNAL ROTATION: SUBJECT 3
MULTI SPORT CORD

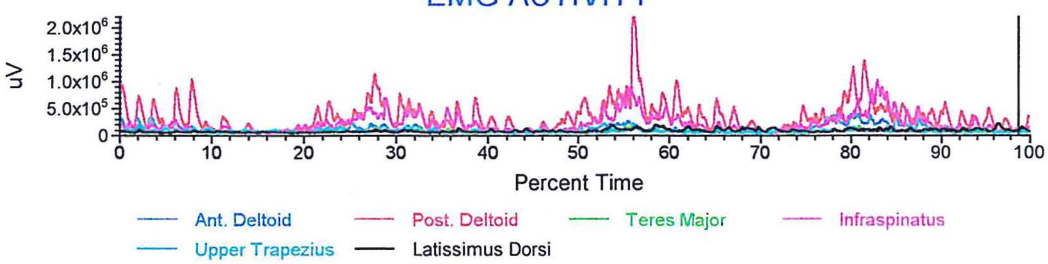
STICKMAN FIGURE



RANGE OF MOTION CURVE

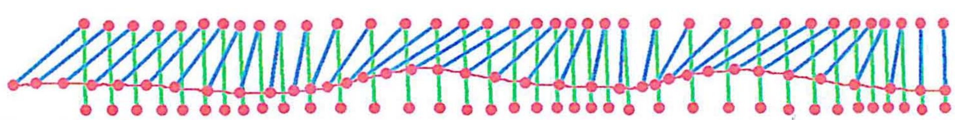


EMG ACTIVITY

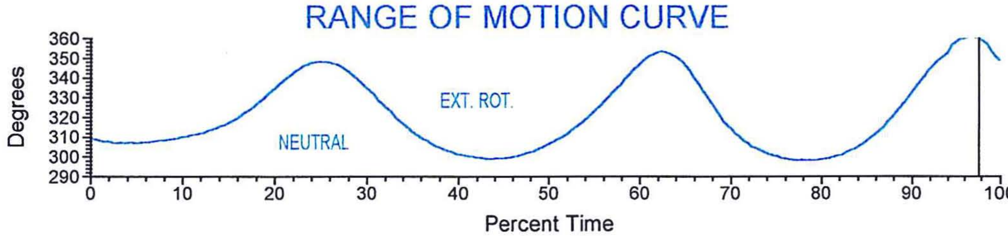


STANDING EXTERNAL ROTATION: SUBJECT 3
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

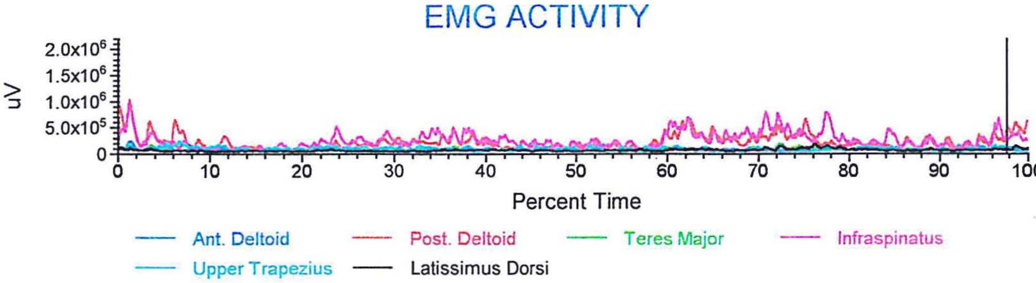
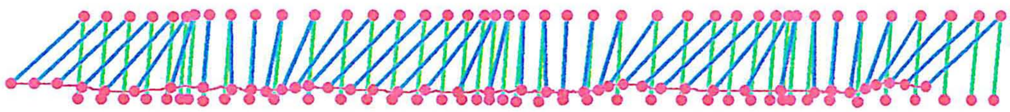


Figure 20. Subject 4: Standing External Rotation

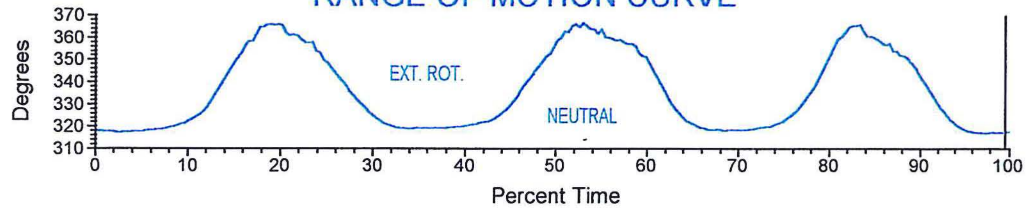
(True ROM = y-350)

STANDING EXTERNAL ROTATION: SUBJECT 4
MULTI SPORT CORD

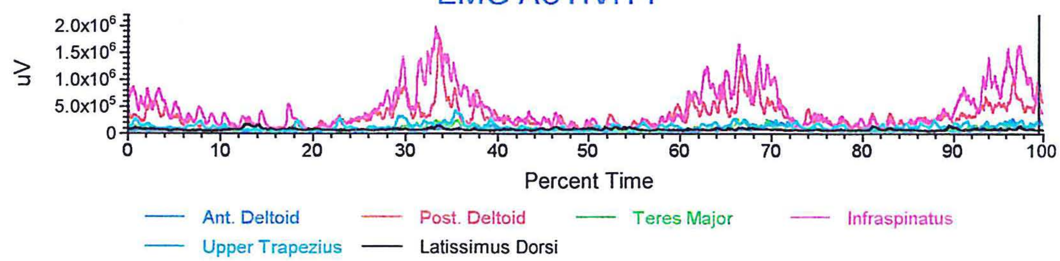
STICKMAN FIGURE



RANGE OF MOTION CURVE

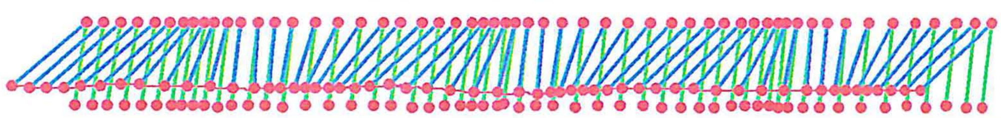


EMG ACTIVITY

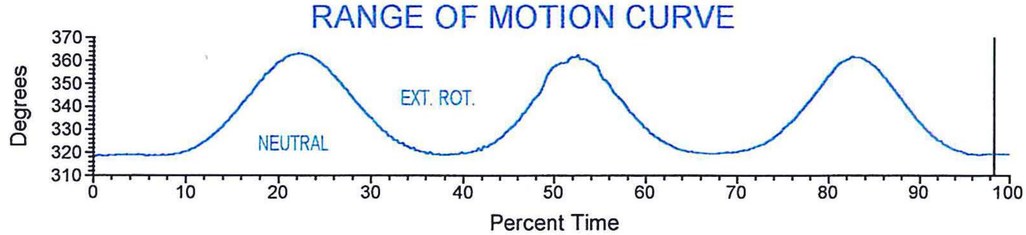


STANDING EXTERNAL ROTATION: SUBJECT 4
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

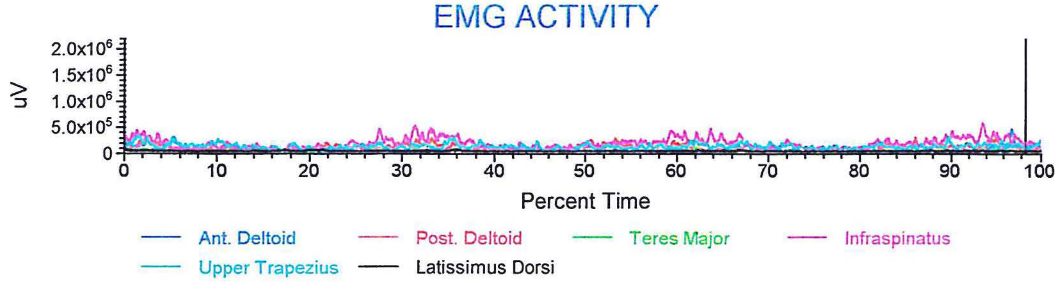
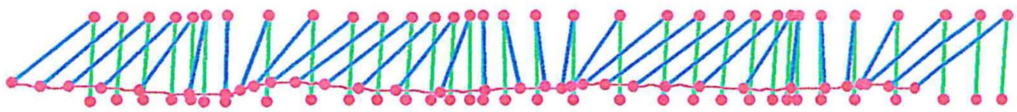


Figure 21. Subject 5: Standing External Rotation

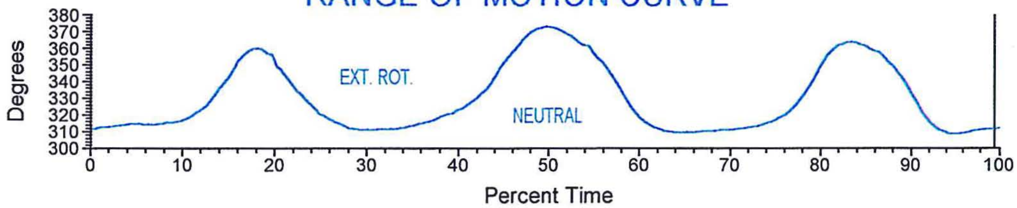
(True ROM = y-350)

STANDING EXTERNAL ROTATION: SUBJECT 5
MULTI SPORT CORD

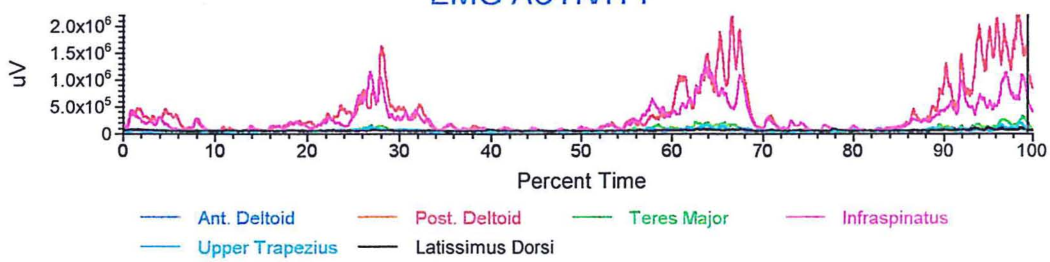
STICKMAN FIGURE



RANGE OF MOTION CURVE

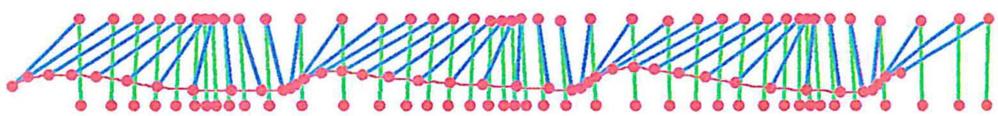


EMG ACTIVITY

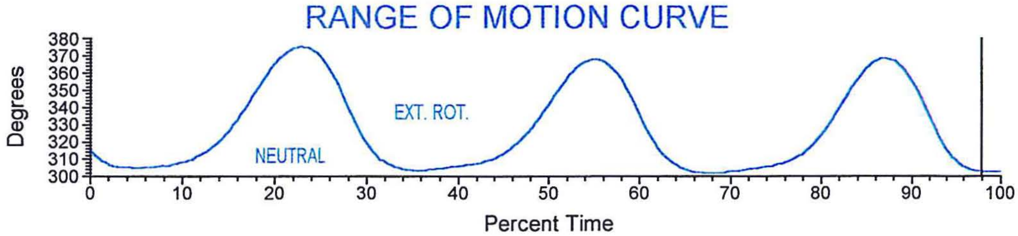


STANDING EXTERNAL ROTATION: SUBJECT 5
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

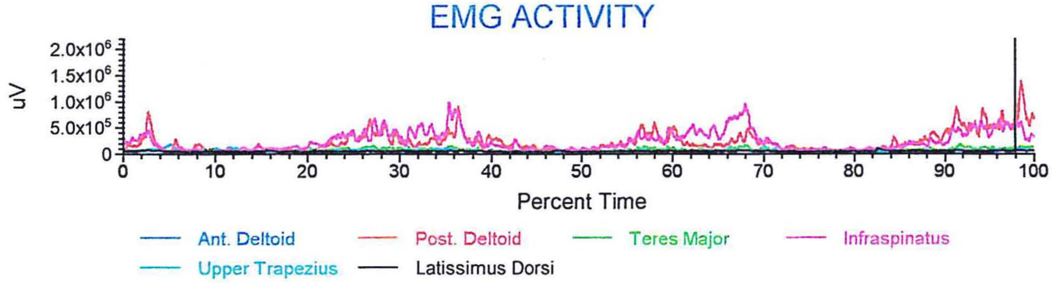
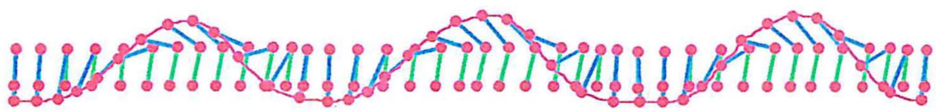


Figure 22. Subject 1: Scaption

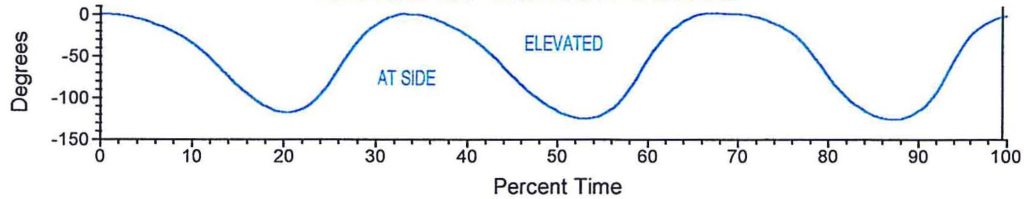
(True ROM = absolute value of y)

SCAPTION: SUBJECT 1
MULTI SPORT CORD

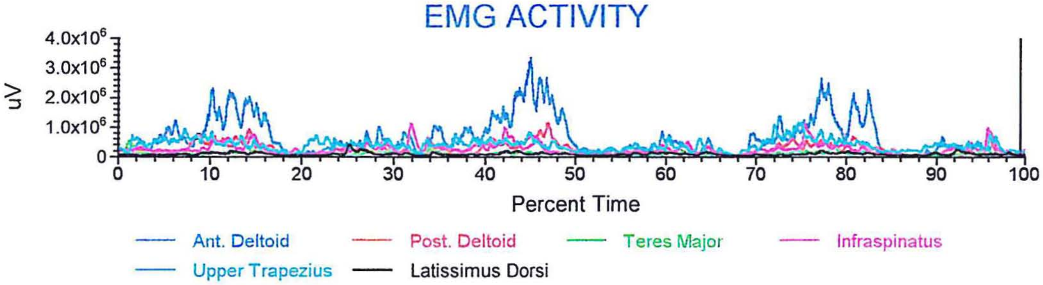
STICKMAN FIGURE



RANGE OF MOTION CURVE

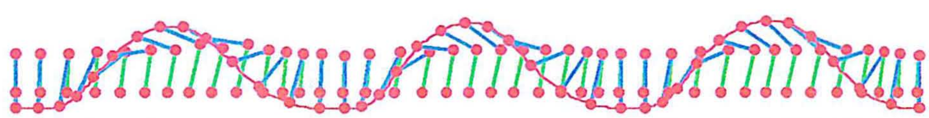


EMG ACTIVITY

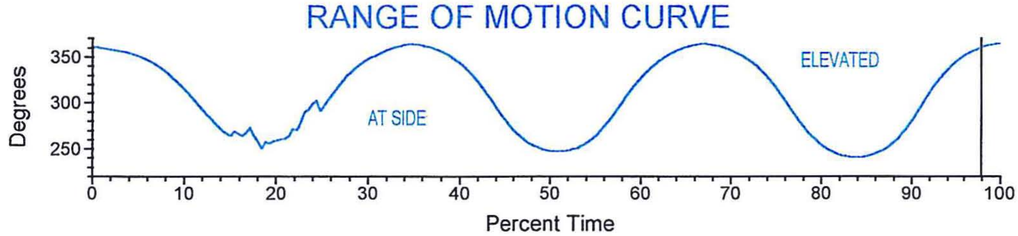


SCAPTION: SUBJECT 1
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

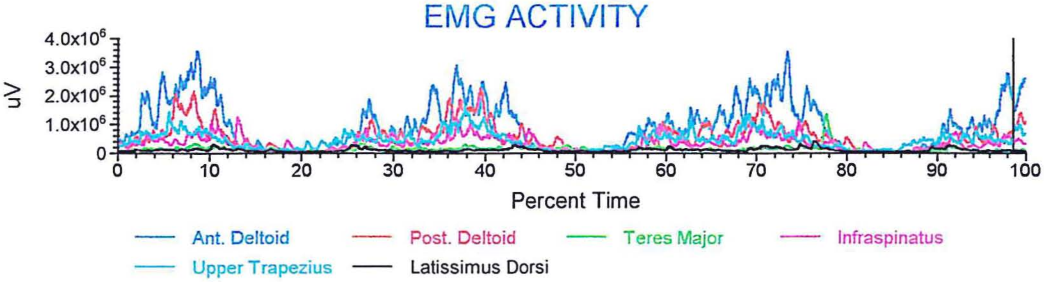
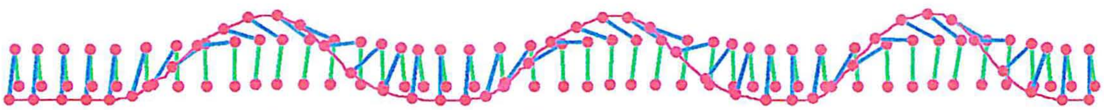


Figure 23. Subject 2: Scaption

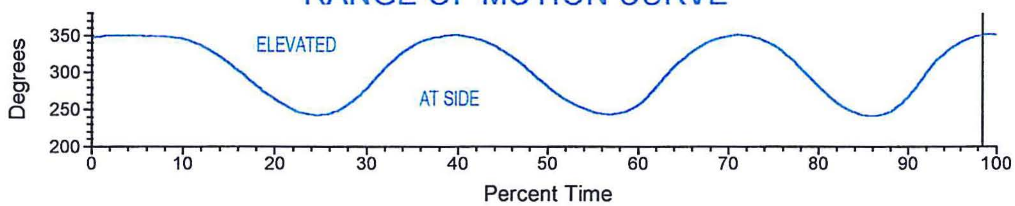
(True ROM = absolute value of (y-350))

SCAPTION: SUBJECT 2
MULTI SPORT CORD

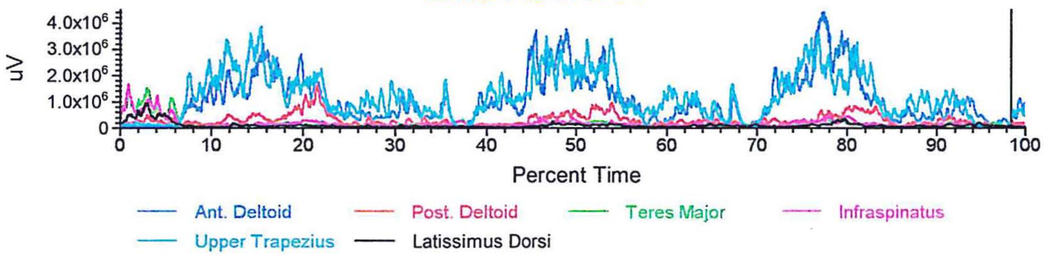
STICKMAN FIGURE



RANGE OF MOTION CURVE

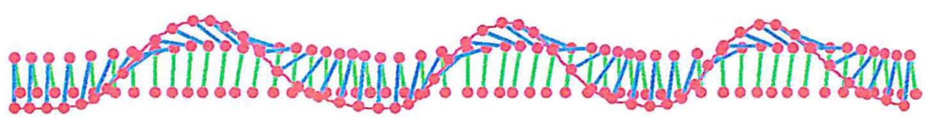


EMG ACTIVITY

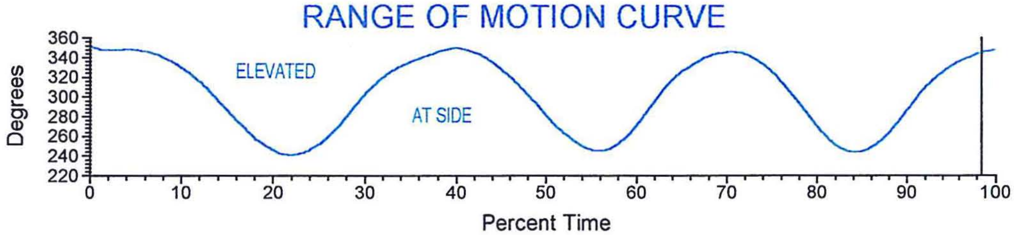


SCAPTION: SUBJECT 2
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

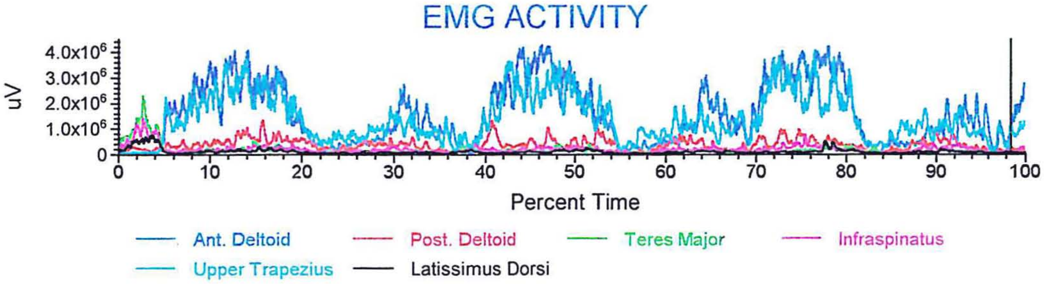
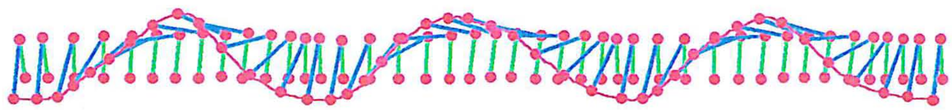


Figure 24. Subject 3: Scaption

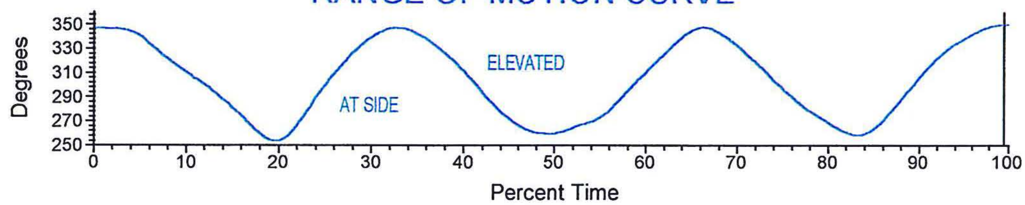
(True ROM = absolute value of (y-350))

SCAPTION: SUBJECT 3
MULTI SPORT CORD

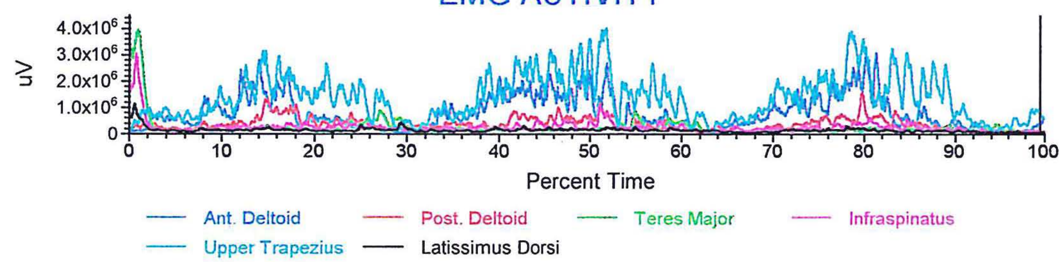
STICKMAN FIGURE



RANGE OF MOTION CURVE

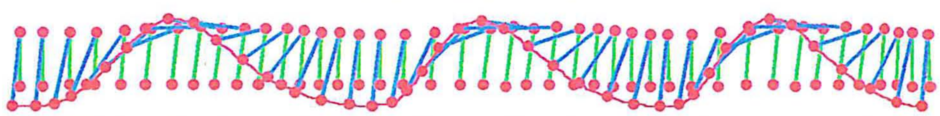


EMG ACTIVITY

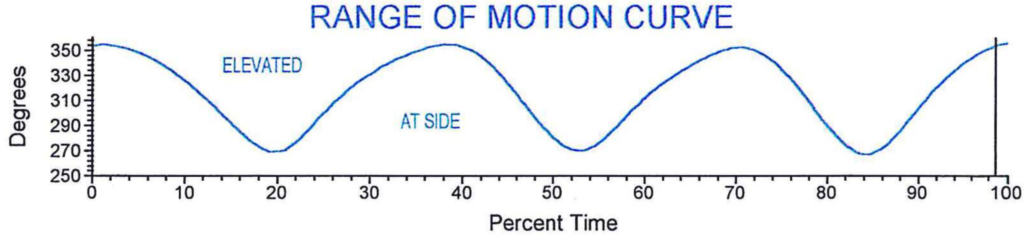


SCAPTION: SUBJECT 3
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

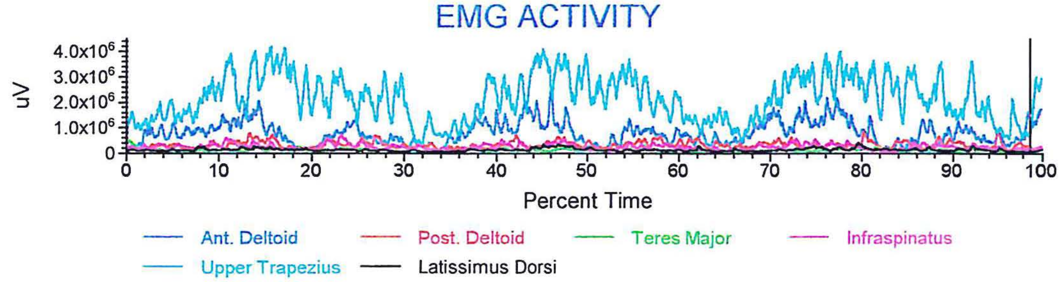
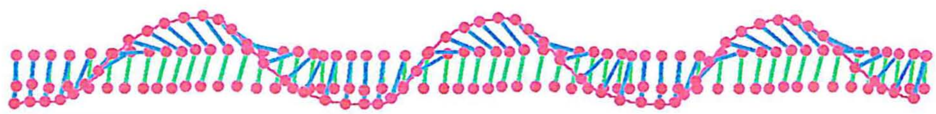


Figure 25. Subject 4: Scaption

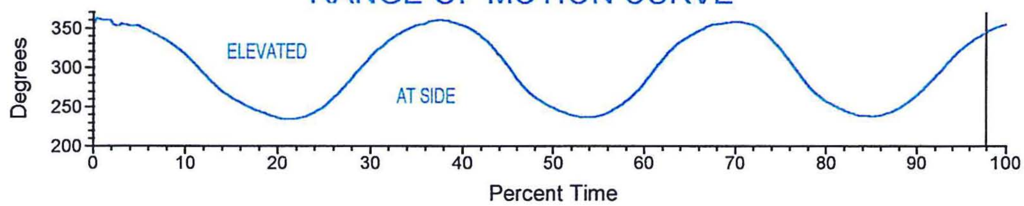
(True ROM = absolute value of (y-350))

SCAPTION: SUBJECT 4
MULTI SPORT CORD

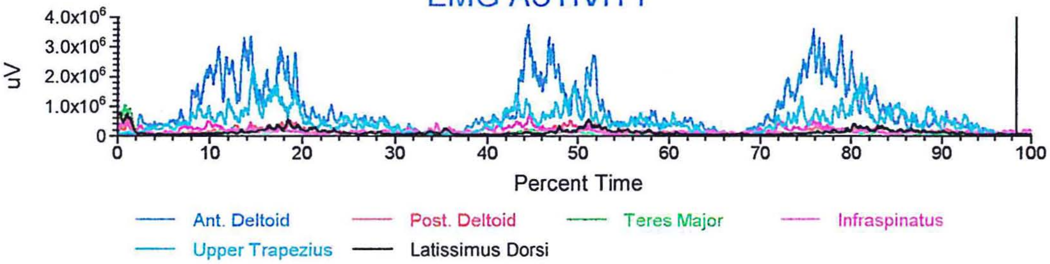
STICKMAN FIGURE



RANGE OF MOTION CURVE

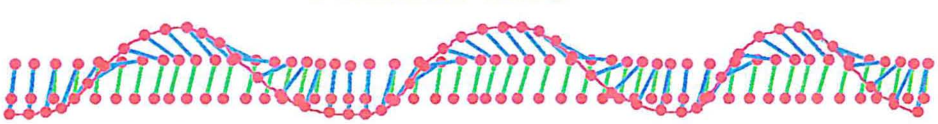


EMG ACTIVITY

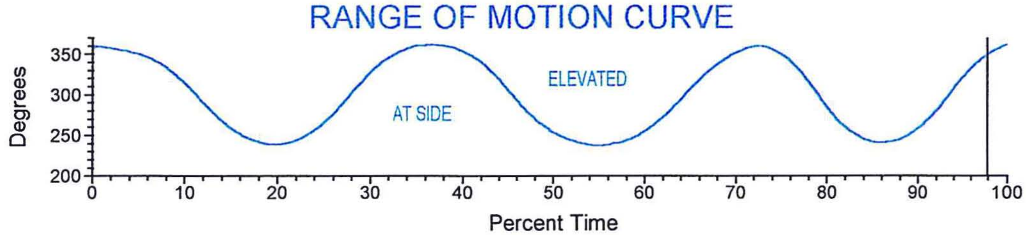


SCAPTION: SUBJECT 4
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

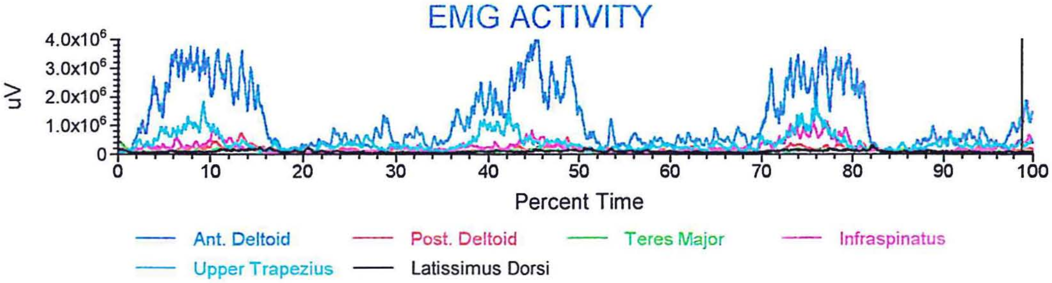
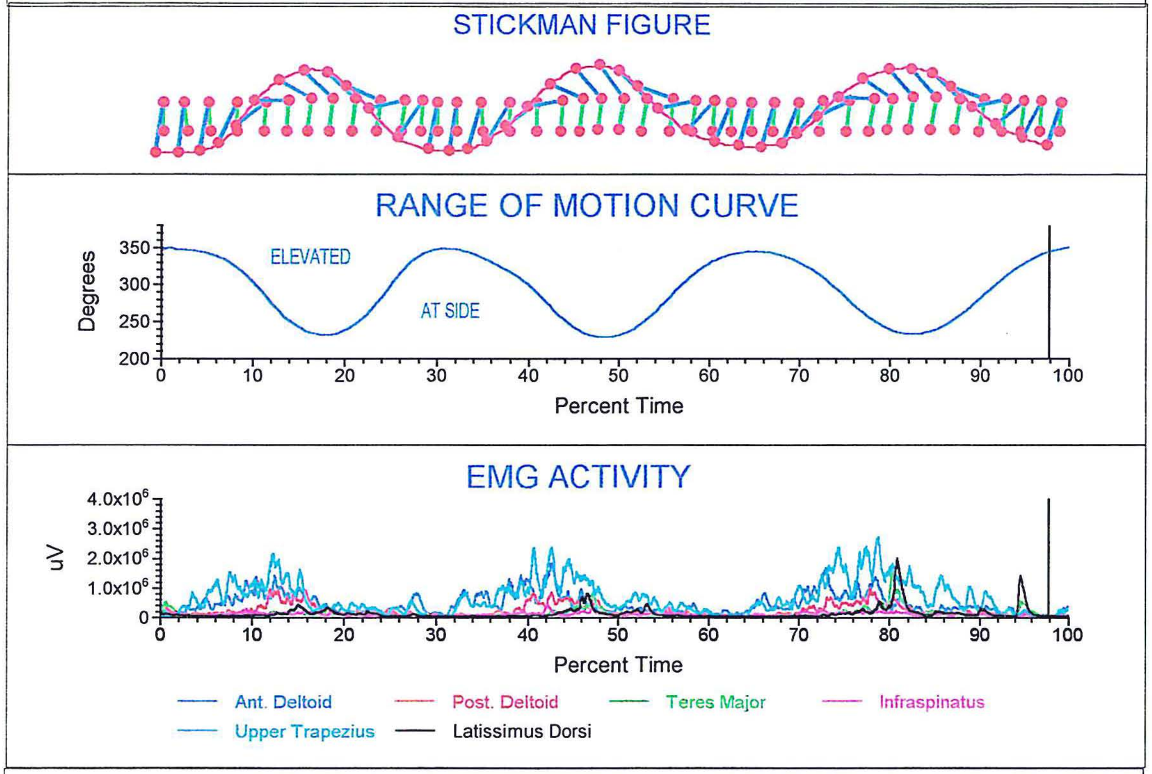


Figure 26. Subject 5: Scaption

(True ROM = absolute value of (y-350))

SCAPTION: SUBJECT 5
MULTI SPORT CORD



SCAPTION: SUBJECT 5
FREE WEIGHT

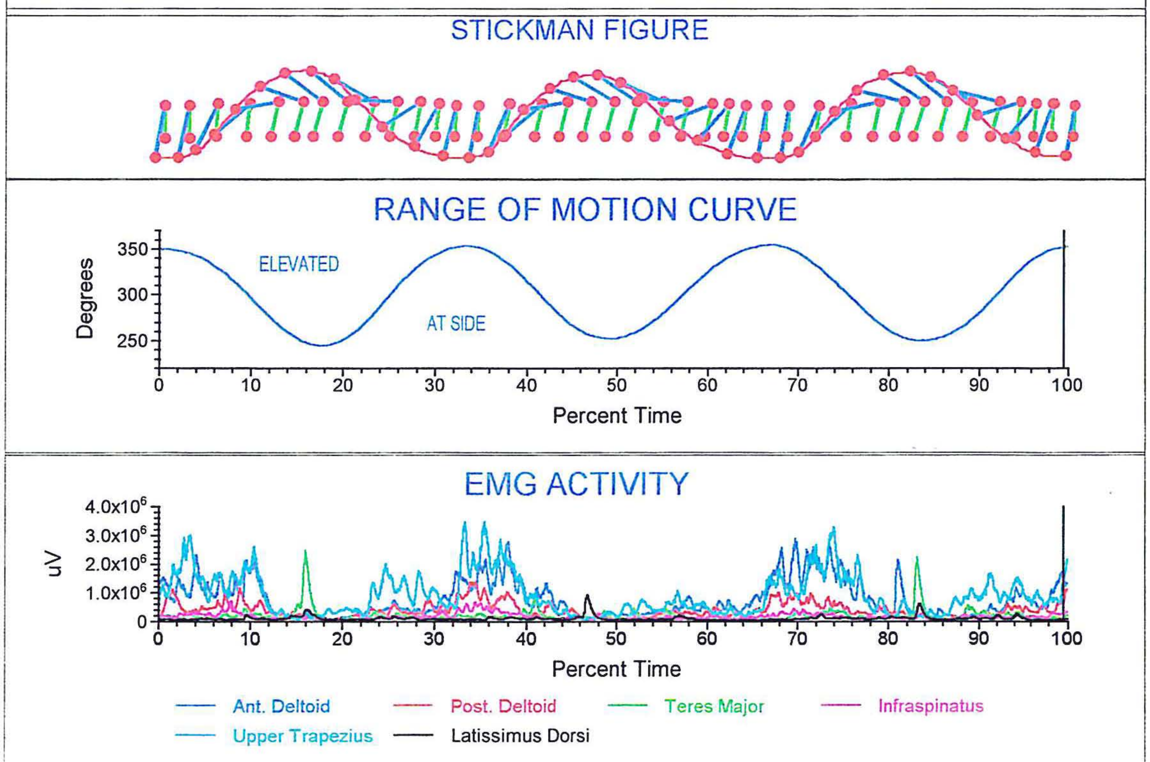
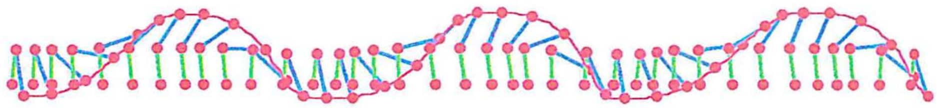


Figure 27. Subject 1: Flexion

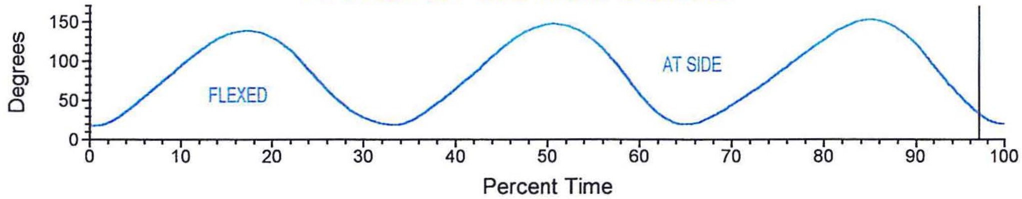
(True ROM = y value)

FLEXION: SUBJECT 1
MULTI SPORT CORD

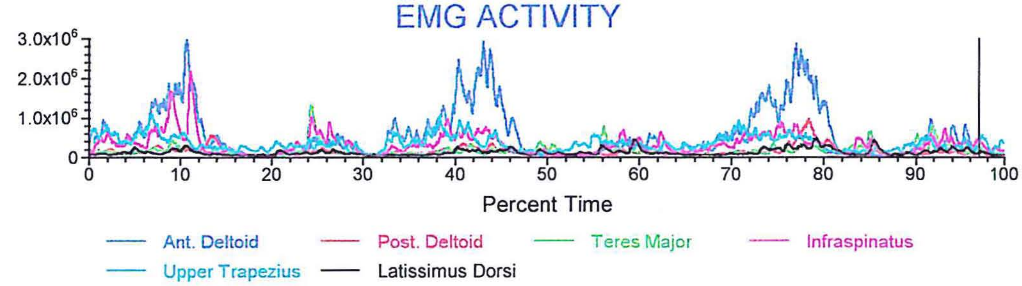
STICKMAN FIGURE



RANGE OF MOTION CURVE

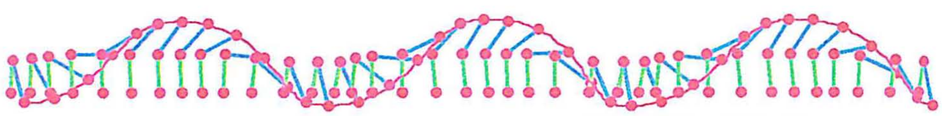


EMG ACTIVITY

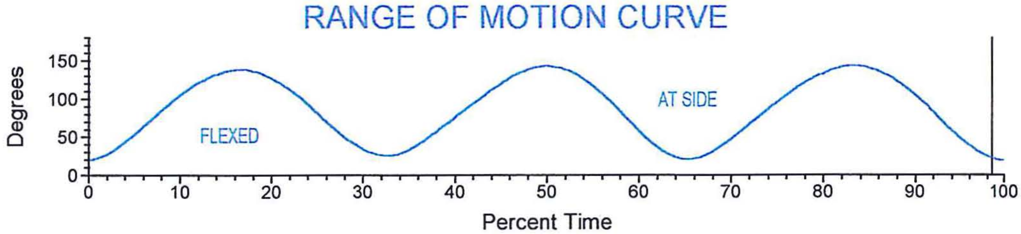


FLEXION: SUBJECT 1
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

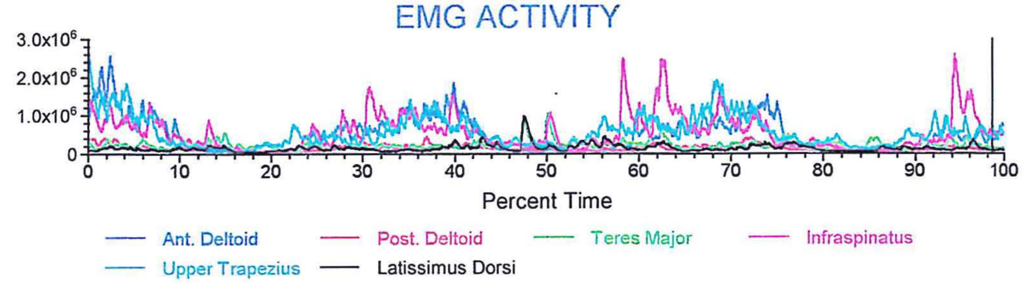
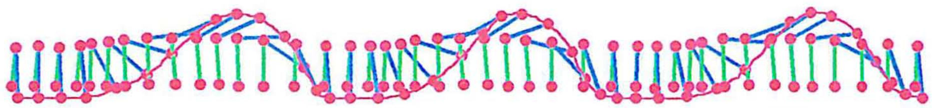


Figure 28. Subject 2: Flexion

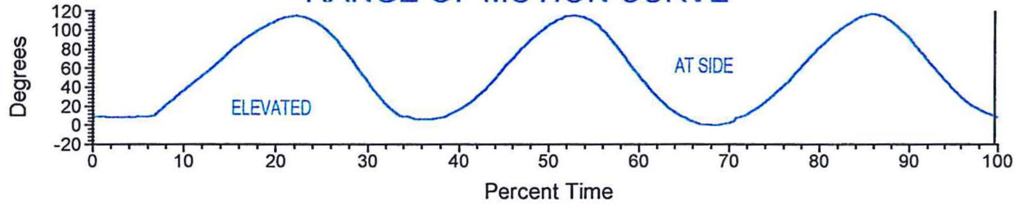
(True ROM = y value)

FLEXION: SUBJECT 2
MULTI SPORT CORD

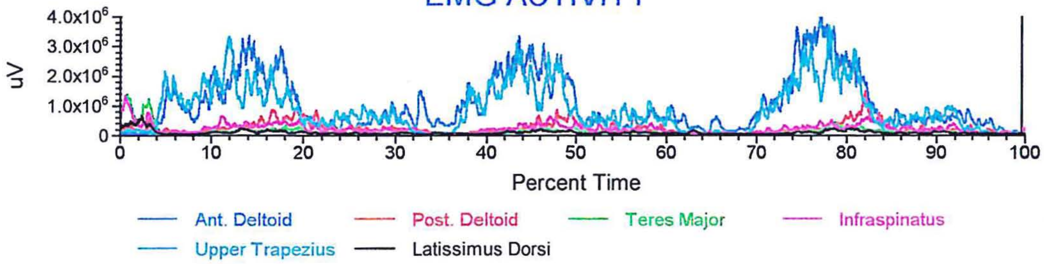
STICKMAN FIGURE



RANGE OF MOTION CURVE

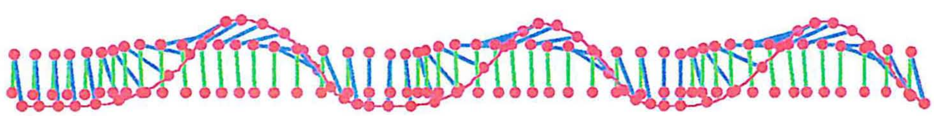


EMG ACTIVITY

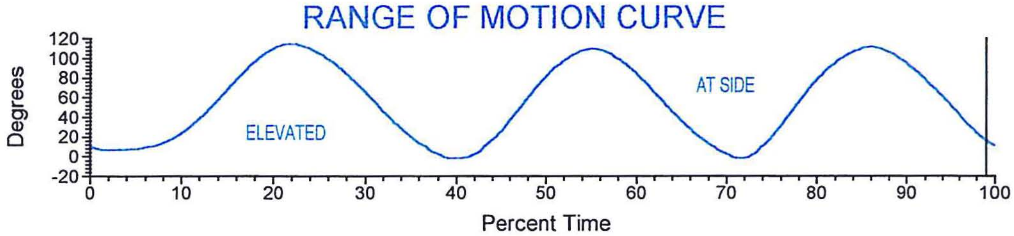


FLEXION: SUBJECT 2
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

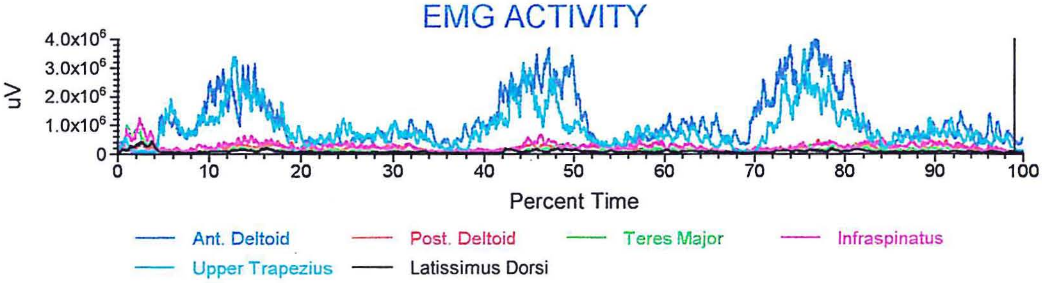
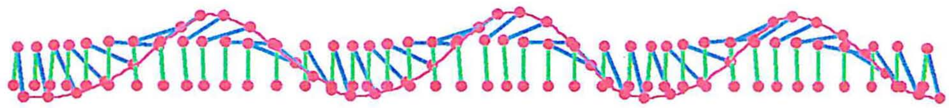


Figure 29. Subject 3: Flexion

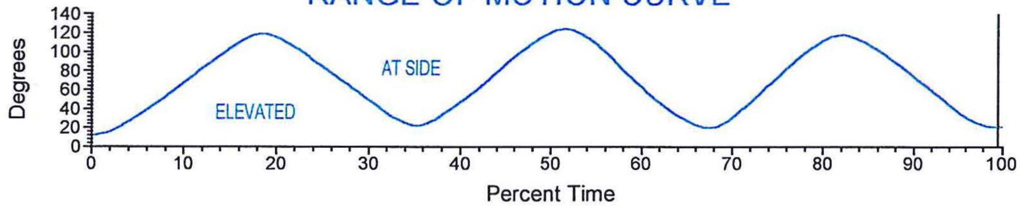
(True ROM = y value)

FLEXION: SUBJECT 3
MULTI SPORT CORD

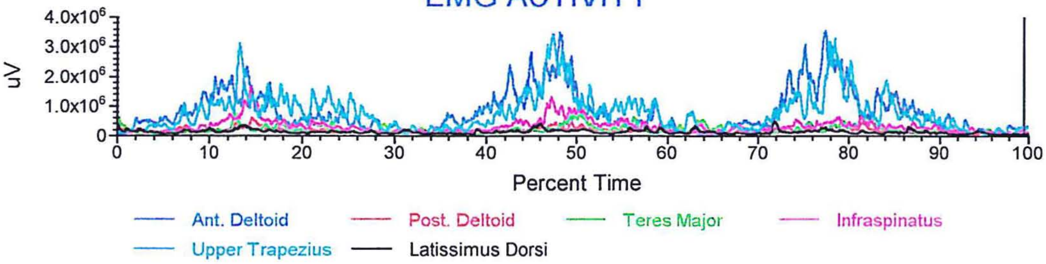
STICKMAN FIGURE



RANGE OF MOTION CURVE

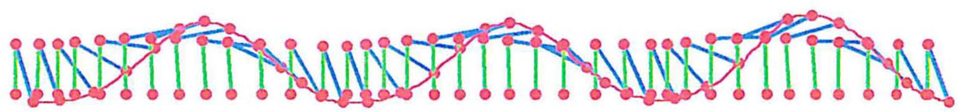


EMG ACTIVITY

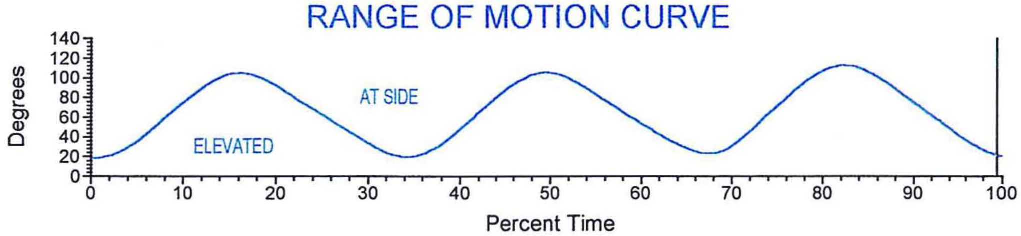


FLEXION: SUBJECT 3
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

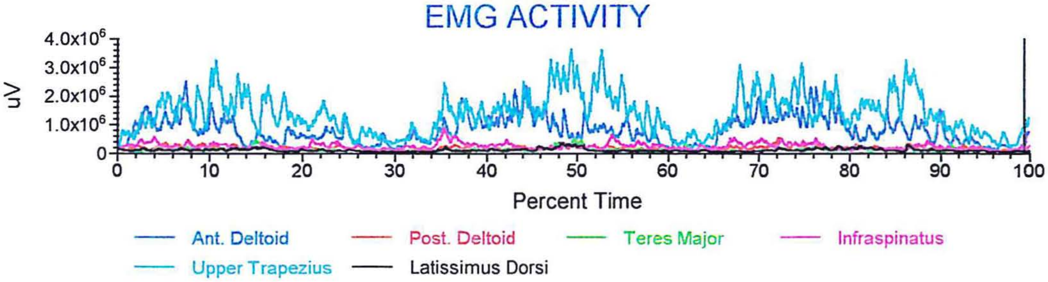
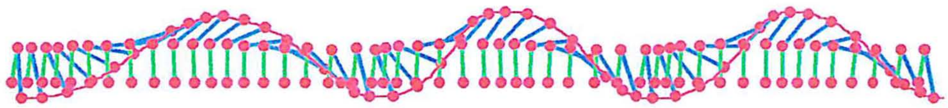


Figure 30. Subject 4: Flexion

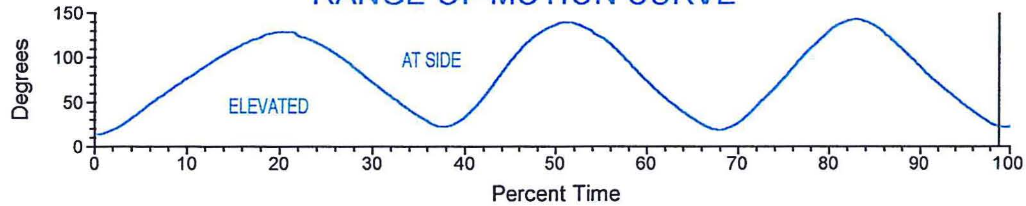
(True ROM = y value)

FLEXION: SUBJECT 4
MULTI SPORT CORD

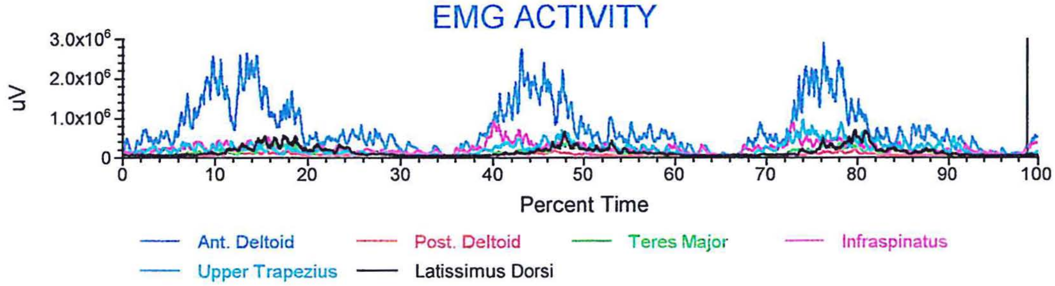
STICKMAN FIGURE



RANGE OF MOTION CURVE

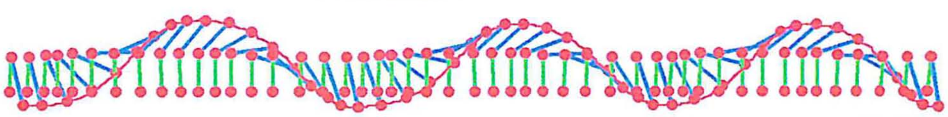


EMG ACTIVITY

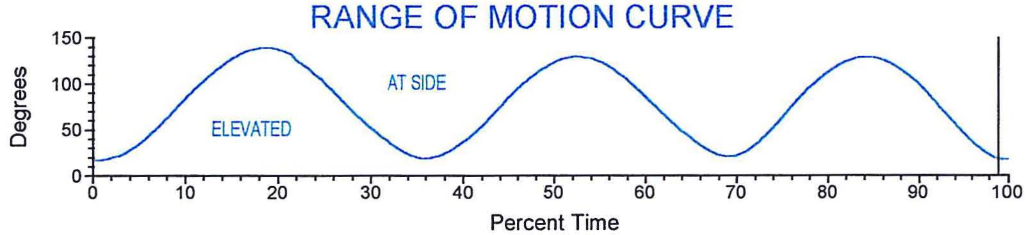


FLEXION: SUBJECT 4
FREE WEIGHT

STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY

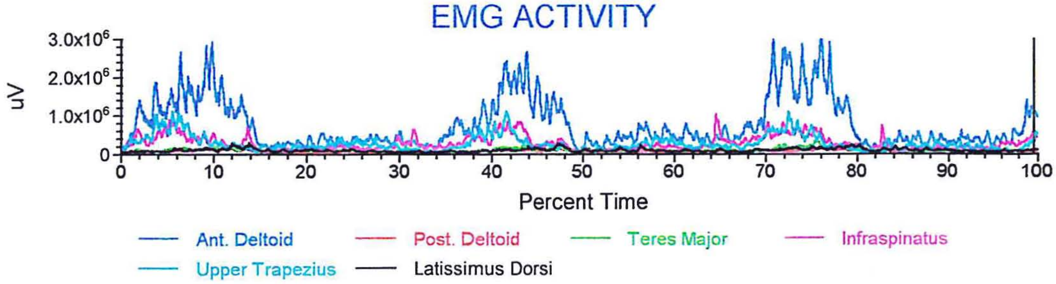
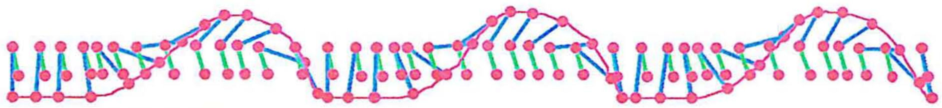


Figure 31. Subject 5: Flexion

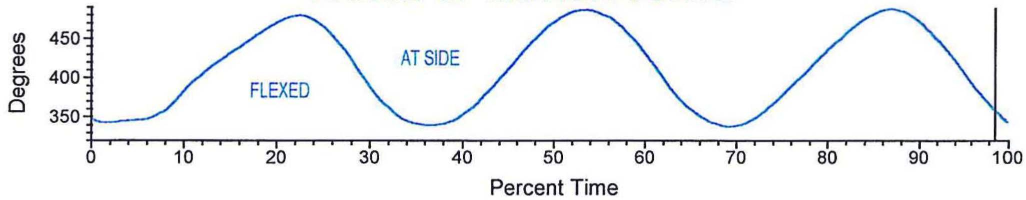
(True ROM = y value)

FLEXION: SUBJECT 5
MULTI SPORT CORD

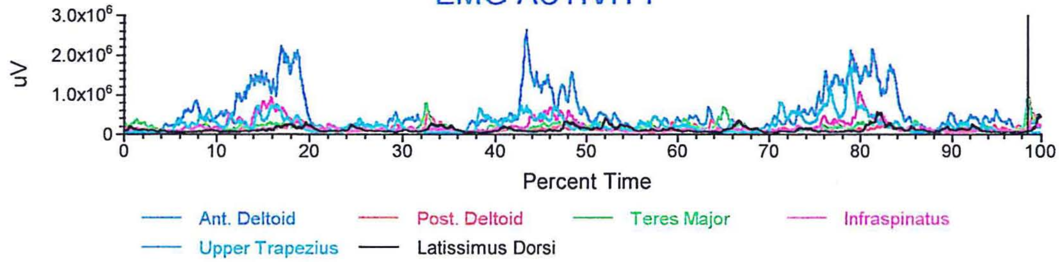
STICKMAN FIGURE



RANGE OF MOTION CURVE

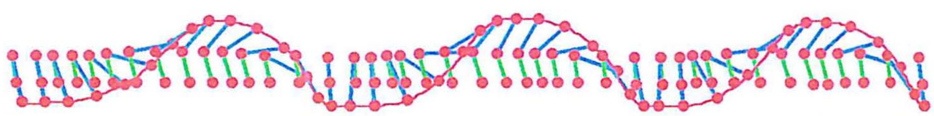


EMG ACTIVITY

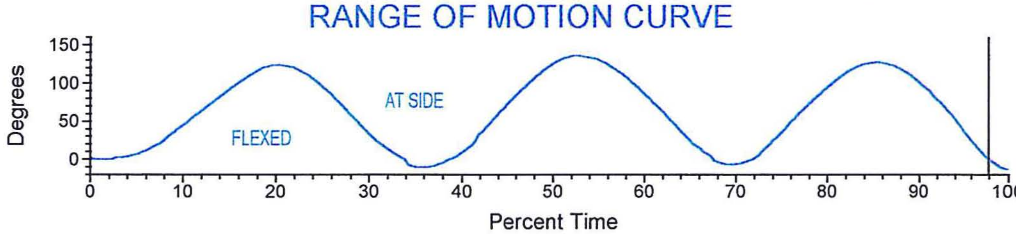


FLEXION: SUBJECT 5
FREE WEIGHT

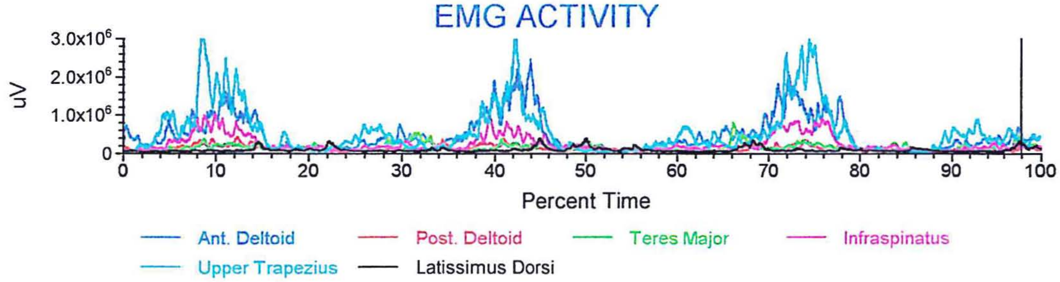
STICKMAN FIGURE



RANGE OF MOTION CURVE



EMG ACTIVITY



DISCUSSION

Chapter 4

The results indicate that the Multi Sport Cord does activate the same muscles as the free weight does. However, there was a difference in the recruitment pattern between the two resistive devices. The Multi Sport Cord tended to elicit the peak activity from the muscles later in the cycle when compared to the free weight. This can be explained by the elastic properities of the theratube. Hooke's Law states $F=k(x)$, where F is the amount of force, k is a constant, and x is the deformation of the elastic object[17]. The more the elastic object is deformed, or stretched, the more force that is generated. As the subjects reached the outer limits of their range of motion, the Multi Sport Cord became stretched more and created a greater force of resistance to the active muscles.

The results indicate that the Multi Sport Cord and the free weight produced equivocal amounts of EMG activity from the active muscles during activities performed in an anti-gravity position (sidelying external rotation, prone external rotation, scaption, and flexion). However, the Multi Sport Cord elicited 2-4 times the amount of EMG activity from the active muscles as compared to the free weight during the gravity-eliminated exercise (standing external rotation).

CLINICAL IMPLICATIONS

Chapter 5

The Multi Sport Cord and the free weight elicit comparable muscle activity. There are advantages of the Multi Sport Cord over the traditional free weights.

The main advantage of the Multi Sport Cord in a clinical setting is the insignificance of the patient position when performing exercises with this device. The patient does not need to be placed in an anti-gravity position to achieve optimal muscle activity and recruitment during an exercise. This is quite beneficial for patients who are wheelchair-bound or for patients who are intolerant of recumbent positions.

The second advantage of the Multi Sport Cord over free weights or other traditional resistive devices is that it is easy to use and it is adjustable. The problem with more traditional resistive devices, such free weights or theraband, is that it is often difficult or expensive to increase the resistance offered by these devices. Additionally, securing these types of devices to the individual can pose problems, as well. Individuals may demonstrate increased compliance with a home program using the Multi Sport Cord since increasing the amount of resistance offered by the device and the overall use of the device is relatively simple.

APPENDIX A

INFORMATION AND CONSENT FORM

TITLE: An Electromyographic and Video Analysis Study of Shoulder Girdle Musculature Activity During Exercise with the Multi Sport Cord

You are being invited to participate in a study conducted by Melanie Michaels, a physical therapy student at the University of North Dakota. The purpose of this study is to study muscle activity in your upper extremity, shoulder, and trunk while performing exercises with the Multi Sport Cord. We hope to describe the muscle activity to determine which muscles are active and when they are active while performing upper extremity exercises with the Multi Sport Cord. Only normal, healthy subjects who have no history of shoulder problems will be asked to participate in this study.

You will be asked to perform a series of upper extremity exercises with the Multi Sport Cord in place. The study will take approximately one hour of your time. You will be asked to report to the Physical Therapy Department at the University of North Dakota at an assigned time. During the experiment, we will be recording the amount of muscle activity you have in different shoulder muscles while you perform resisted upper extremity motions with the Multi Sport Cord in place. We will also be videotaping your performance of the exercises with the Multi Sport Cord.

Although the process of physical performance testing always involves some degree of risk, the investigator in this study feels that the risk of injury or discomfort is minimal. In order for us to record the muscle activity, we will be placing adhesive electrodes on your upper arm. Before we can apply the electrodes, we will use a small stimulator to electrically stimulate the muscles to locate the best spot to place the electrodes. The stimulator will cause a mild tingling sensation. The recording electrodes are attached to the surface of the skin with an adhesive material. The Multi Sport Cord will then be attached to the upper extremity and you will be asked to perform several different movements with your upper extremity. We will also attach reflective markers to your upper extremity and trunk with adhesive material. The markers will be photographed, using a video camera, during the exercises. You will then be asked to perform several exercises while we collect muscle activity and film your movements. The EMG and video analysis devices only record information from your muscles and joints, they do not stimulate the skin , so adverse sensation should not be felt with these devices. The amount of exercise you will be asked to perform will be minimal.

Your name will not be used in any reports of the results of this study. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. The data will be identified by a number known only be the investigator. In order to synchronize EMG activity, all subjects will be videotaped and confidentiality will be maintained. The investigator or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health. Your decision whether or not to participate will not prejudice your future relationship with the Physical Therapy Department or the University of North Dakota. If you decide to participate, you are free to discontinue participation at any time without prejudice.

The investigator involved is available to answer any questions you have concerning this study. In addition, you are encouraged to ask any questions concerning this study that you may have in the future. Questions may be asked by calling Dr. Thomas Mohr at (701) 777-2831 or Melanie Michaels at (701) 746-6311. A copy of this consent form is available to all participants in the study.

In the event that this research activity (which will be conducted at the UND Physical Therapy Department) results in a physical injury, medical treatment will be available, including first aid, emergency treatment and follow up care as it is to a member of the general public in similar circumstances. Payment for any such treatment must be provided by you and your third party payment, if any.

ALL OF MY QUESTIONS HAVE BEEN ANSWERED AND I AM ENCOURAGED TO ASK ANY QUESTIONS THAT I MAY HAVE CONCERNING THIS STUDY IN THE FUTURE. MY SIGNATURE INDICATES THAT, HAVING READ THE ABOVE INFORMATION, I HAVE DECIDED TO PARTICIPATE IN THE RESEARCH PROJECT.

I have read all of the above and willingly agree to participate in this study explained to me by Melanie Michaels.

____

Participant's Signature Date

____

Witness (not the scientist) Date

APPENDIX B

_X_ EXPEDITED REVIEW REQUESTED UNDER ITEM _3_ (NUMBER[S]) OF HHS REGULATIONS
___ EXEMPT REVIEW REQUESTED UNDER ITEM ____ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA
HUMAN SUBJECTS REVIEW FORM
FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED PROJECTS INVOLVING HUMAN SUBJECTS

PRINCIPAL INVESTIGATOR: Thomas Mohr and Melanie Michaels **TELEPHONE:** (701) 777-2831 **DATE:** 9/11/96

ADDRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT: UND Physical Therapy

SCHOOL/COLLEGE: University of North Dakota School of Medicine **DEPARTMENT:** Physical Therapy

PROPOSED PROJECT DATES: September 1996 through September 1997

PROJECT TITLE: An Electromyographic Study of Shoulder Girdle Musculature Activity During Exercise with the Multi Sport Cord

FUNDING AGENCIES (IF APPLICABLE): ______________________

TYPE OF PROJECT:

__ NEW PROJECT __ CONTINUATION __ RENEWAL __ DISSERTATION OR THESIS RESEARCH _X_ STUDENT RESEARCH PROJECT

__ CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

DISSERTATION/THESIS ADVISER, OR STUDENT ADVISER: Tom Mohr

PROPOSED PROJECT: __ INVOLVES NEW DRUGS (IND) __ INVOLVES NON-APPROVED USE OF DRUG
__ INVOLVES A COOPERATING INSTITUTION

IF ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATIONS, PLEASE INDICATE THE CLASSIFICATION(S):

_ MINORS (<18 YEARS) _ PREGNANT WOMEN _ MENTALLY DISABLED _ FETUSES _ MENTALLY RETARDED

_ PRISONERS _ ABORTUSES _X_ UND STUDENTS (>18 YEARS)

IF YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL MATERIALS, CHECK HERE ___

1. ABSTRACT: (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.

Shoulder maladies, both post-injury and post-surgical, represent a significant amount of a therapist's caseload in an outpatient or sports medicine setting. Therapists rely on several different types of resistive equipment to successfully rehabilitate the injured shoulder back to an optimal functional status. One device designed to aid in the strengthening of the shoulder girdle musculature is called the Multi Sport Cord. The Multi Sport Cord consists of a neoprene waist belt with theratube attached to it. The theratube is then attached to cuffs that wrap around the wrist and distal arm, just proximal to the elbow. The Multi Sport Cord is designed to minimize the amount of "cheating" occurring with shoulder rehabilitation exercises. The design also allows the shoulder rehab candidate to take it anywhere.

The purpose of this research study is to determine which shoulder girdle muscles are active, as well as when they are active, while using the Multi Sport Cord. This data will be collected via electromyographic procedures using surface electrodes. Motion analysis video equipment will be utilized simultaneously. This will allow us to compare the EMG data with joint movement.

The information learned from this study will be used to develop shoulder rehabilitation protocols to be used in conjunction with the Multi Sport Cord.

Normal, healthy subjects will be used in this research project. Human subjects are needed for this EMG research study in order to determine which muscles are active and when they are active when performing resisted exercise with the Multi Sport Cord.

2. PROTOCOL: (Describe procedures to which humans will be subjected. Use additional pages if necessary.)

SUBJECTS:

It is anticipated that we will recruit 10 to 15 male individuals between the ages of 19 to 45 years old. These subjects will be recruited as volunteer subjects. The subjects will have no history of shoulder problems.

METHOD:

We will measure electromyographic (EMG) activity in selected shoulder girdle, trunk, and upper extremity muscles. We propose to measure EMG activity in the following muscles during exercise activity with the Multi Sport Cord in place: 1) deltoid, 2) biceps, 3) triceps, 4) supraspinatus, 5) rhomboids, 6) infraspinatus, 7) trapezius, 8) erector spinae, 9) serratus anterior, and 10) abdominals.

To record EMG activity, the motor points of the above muscles will be located using a small electrical stimulator. Adhesive surface electrodes will then be placed on the subject's skin over the motor point. The EMG signals will be transmitted to a receiver unit and then fed into a computer for display and recording of data. Prior to beginning the experimental trial, the researcher will apply manual resistance to the subject's upper extremity in order to elicit a maximal voluntary contraction from each muscle being monitored in this study. The muscle activity recorded during the maximal voluntary contraction will be considered as a 100% EMG activity level to which the EMG activity during exercise activity with the Multi Sport Cord can be compared. This procedure is done to normalize the EMG data for later analysis.

Video analysis will be used to measure upper extremity range of motion during the activity. Reflective markers will be attached to the trunk and upper extremity using double-sided adhesive tape. Video cameras will be placed around the subject and will film the subject's upper extremity movements during the experimental trial. This will be recorded on videotapes and will be transferred to a computer for analysis.

Prior to the trials, each subject's age, height, and weight will be recorded. During the experimental trials, the right upper extremity will be used for data collection. Before beginning the experiment, each subject will be given a short training session on the proper use of the Multi Sport Cord.

For the actual experiment, each subject will be fitted with the Multi Sport Cord. The skin of the upper extremity of each subject will be prepared by cleansing the skin with alcohol before attachment of the EMG adhesive electrodes over the motor point. The subject will then be asked to elicit a maximal voluntary contraction (MVC) of each of the monitored muscles, which will be recorded on the computer as a reference voltage level. EMG activity measured during performance of exercises with the Multi Sport Cord will then be recorded on the computer. During the exercises the subject will also be videotaped.

DATA ANALYSIS

Descriptive statistics describing the subjects' anthropometric profiles will be provided. Statistical analysis of the mean activity of each monitored muscle will be performed on the EMG activity. The EMG data collected during the experimental trials will be expressed as a percentage of the EMG activity recorded during the MVC prior to the experimental trials (i.e. normalized). The video image will be converted to a stickman-like figure, from which we can determine joint angles, limb velocity, and limb motion. The EMG data can be synchronized with the video data to determine the level of EMG activity during the various exercise motions.

3. BENEFITS: (Describe the benefits to the individual or society.)

The data collected throughout this research study will be analyzed to determine which muscles are active and when they are active while performing shoulder exercises with the Multi Sport Cord. This information will provide the basis for developing

4. RISKS: (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self-respect, as well as psychological, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to

the subject if associated with him or her, then describe the methods to be used to insure the confidentiality of data obtained, including plans for final disposition or destruction, debriefing procedures, etc.)

The risks involved in this research project are minimal. The subjects may experience a tingling discomfort while the investigator is using the electrical stimulator to elicit a muscle contraction in order to locate the motor point of the muscle to be monitored. The EMG and video analysis equipment causes no discomfort to the subject, since they are both monitoring devices. Because the video information is converted to stickman-like diagrams, the actual subject's video is not used in data reporting. Therefore, the subject is not recognized.

The process of physical performance testing does impose a potential risk of injury to the muscle. The subjects in this study will only perform maximal voluntary contraction for comparison purposes. The testing for maximal voluntary contraction will occur in a controlled setting , and the investigator feels that the potential for injury to the muscle is very minimal. The remainder of the trial will consist of submaximal muscular contractions with the Multi Sport Cord in place. The investigator or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health.

The subjects' names will not be used in any reports of the results of this study. Any information that is obtained in connection with this study and that can be identified with the subject will remain confidential and will be disclosed only with the subject's permission. The data will be identified by a number known only by the investigator.

5. **CONSENT FORM:** A copy of the **CONSENT FORM** to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no **CONSENT FORM** is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.
Describe where signed consent forms will be kept and for what period of time.

Consent forms will be kept in the Physical Therapy department at the University of North Dakota for 2 years.

6. For **FULL IRB REVIEW** forward a signed original and thirteen (13) copies of this completed form, and where applicable, thirteen (13) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:

Office of Research & Program Development
University of North Dakota
Box 8138, University Station
Grand Forks, North Dakota 58202

On campus, mail to: Office of Research & Program Development, Box 134, or drop it off at Room 101 Twamley Hall.
For **EXEMPT** or **EXPEDITED REVIEW** forward a signed original and a copy of the consent form, questionnaires, etc. and any supporting documentation to one of the addresses above.

The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University's policies and procedures governing the use of human subjects.

SIGNATURES:

____________________________ **DATE:** ____________
Principal Investigator

____________________________ **DATE:**
Project Director or Student Adviser

____________________________ **DATE:** ____________
Training or Center Grant Director

UNIVERSITY OF NORTH DAKOTA'S
INSTITUTIONAL REVIEW BOARD

DATE: September 12, 1996 **PROJECT NUMBER** IRB-9609-040

NAME: Thomas Mohr and Melanie Michaels **DEPARTMENT/COLLEGE** Physical Therapy

PROJECT TITLE: An Electromyographic Study of Shoulder Girdle Musculature Activity During Exercise with the Multi Sport Cord

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on September 19, 1996 and the following action was taken:

- [x] Project approved. **EXPEDITED REVIEW** NO. 3.
Next scheduled review is on September 1997.

- [ ] Project approved. **EXEMPT CATEGORY** NO. ______. No periodic review scheduled unless so stated in REMARKS SECTION.

- [ ] Project approved **PENDING** receipt of corrections/additions in ORPD and approval by the IRB. **This study may NOT be started UNTIL IRB approval has been received.** (See REMARKS SECTION for further information.)

- [ ] Project approval **deferred. This study may not be started until IRB approval has been received.** (See REMARKS SECTION for further information.)

- [ ] Project **denied.** (See REMARKS SECTION for further information.)

REMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairman or ORPD.

c: T. Mohr, Adviser

AM Cooley MD 9/19/96

Signature of ~~Chairperson~~ or designated IRB Member Date
UND's Institutional Review Board

If the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 596 Form may be required. Contact ORPD to obtain the required documents.

(7/93)

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