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An Electromyographic Study of Lower Trapezius Muscle Activity during the Traditional Muscle Testing Position and a Modified Position

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AN ELECTROMYOGRAPHIC STUDY OF LOWER TRAPEZIUS MUSCLE ACTIVITY DURING THE TRADITIONAL MUSCLE TESTING POSITION AND A MODIFIED POSITION

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This Scholarly Project, submitted by Keri M. Doyle, Molly E. McDonald, Heather M. Partlow, and Eric R. Paur 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 Graduate School Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Graduate School Advisor)

(Chairperson, Physical Therapy)

PERMISSION

Title	An Electromyographic Study of Lower Trapezius Muscle Activity During the Traditional Muscle Testing Position and a Modified Position
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Signature Molly E McDonald Date 12-18-03

Signature [signature] Date 12-18-03

Signature Kari Day Date 12-18-03

Signature [signature] Date 12-18-03

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ABSTRACT

Many people use repeated overhead movements in their occupations or recreational activities. Literature has shown that this repeated overhead activity greatly contributes to the incidence of shoulder pathologies such as impingement syndrome. The purpose of this study was to establish whether the lower trapezius was more successfully recruited in the traditional muscle testing position of 145° of shoulder abduction or a modified position consisting of shoulder external rotation while in 80° of shoulder abduction and 90° of elbow flexion.

Forty-one subjects between the ages of 21 and 45 voluntarily participated in this study. One subject was excluded due to exceeding the 18- to 45-year-old age limit. EMG data were recorded and collected from the right lower trapezius of each subject while they completed 10 repetitions of each exercise in the traditional position with weight, the traditional position without weight, the modified position with weight, and the modified position without weight. The exercises were performed in a random order for each subject.

Results of this study showed a significant difference in total and average lower trapezius muscle activity between the traditional position without weight and the traditional and modified positions with weight. The traditional and modified positions with weight demonstrated a greater level of EMG activity than

the traditional position without weight. No significant difference was shown for total or average lower trapezius muscle activity between the traditional position without weight and the modified position without weight or between the traditional position with weight and the modified position with weight.

The results indicated that exercise in the modified position with weight effectively recruits the lower trapezius at a higher amount than traditional positions and allows the patient to exercise the lower trapezius muscle in a position that is potentially less detrimental to the shoulder complex.

CHAPTER 1

INTRODUCTION

The scapula plays several roles in producing optimal and efficient shoulder movement when scapular anatomy and biomechanics interact properly.[1] Although the proper functioning of the scapula depends on the surrounding musculature, these muscles are often neglected in the evaluation and treatment of shoulder pathology.[1] The muscles most commonly considered during evaluation and treatment of shoulder pathology are the rotator cuff muscles: supraspinatus, infraspinatus, teres minor, and subscapularis. While the action of the rotator cuff muscles is very important, it is the interaction between the dynamic muscles, such as the rotator cuff muscles and the scapular stabilizers, that warrants investigation. This interaction is what contributes to efficient movement of the shoulder and the ability to maintain scapulohumeral rhythm.[1,2] When abnormalities in the kinematics of the shoulder exist, shoulder injuries may occur, such as impingement.[3]

The lower trapezius has been found to be one of the main scapular stabilizers as well as one of the muscles most commonly found to be weak in scapular motion.[1] Scapular stabilization is of great importance with movements involving more than 90˚ of glenohumeral flexion or abduction. In order to avoid secondary impingement, it is vital that the scapular musculature remains strong

to allow for proper positioning of the scapula during shoulder motion.[1,3] Secondary impingement is defined as a decreased volume of the subacromial space due to glenohumeral joint instability and is known to result from repeated overhead movements in recreational and occupational activities.[1,3,4] Strengthening the scapular stabilizers, such as the lower trapezius, and avoiding repetitive overhead movements during exercise is very important for proper biomechanics of the shoulder joint and for decreasing the risk for impingement and other common shoulder injuries.

Problem Statement

There is limited conclusive evidence published that supports the most effective position in which to exercise or test the lower trapezius muscle. A pilot study has indicated that the modified position with weight may be as effective at creating muscle contraction in the lower trapezius as the traditional testing and strengthening position.

Purpose

The purpose of this study was to further establish whether the lower trapezius is more effectively recruited in the traditional muscle testing position of 145° of shoulder abduction or a modified position of shoulder external rotation while in 80° of shoulder abduction and 90° of elbow flexion.

Significance of Study

Since the lower trapezius was found to be significantly active in the modified position as compared to the traditional position without weight, 145˚ of abduction during exercise of the lower trapezius would not be a requirement.

This would reduce the chance of shoulder impingement by avoiding the positions that would irritate the shoulder complex.

Research Questions

1) Is there a significant difference in total electromyographic (EMG) activity/recruitment of the lower trapezius between the traditional muscle testing position and a modified position when tested with or without the resistance of a hand weight?
2) Is there a significant difference in average EMG activity of the lower trapezius between the traditional muscle testing position and a modified position when tested with or without the resistance of a hand weight?

Hypotheses

Null Hypothesis: There is no significant difference in the total EMG activity/recruitment of the lower trapezius between the traditional muscle testing position and a modified position when tested with or without the resistance of a hand weight.

Alternative Hypothesis: There is a significant difference in the total EMG activity/recruitment of the lower trapezius between the traditional muscle testing position and a modified position when tested with or without the resistance of a hand weight.

Null Hypothesis: There is no significant difference in average EMG activity of the lower trapezius between the traditional muscle testing position and a modified position when tested with or without the resistance of a hand weight.

Alternative Hypothesis: There is a significant difference in average EMG activity of the lower trapezius between the traditional muscle testing position and a modified position when tested with or without the resistance of a hand weight.

CHAPTER II

LITERATURE REVIEW

The shoulder complex is a highly mobile joint, resulting in over 16,000 positions available to the upper extremities. This mobility necessitates a stable base which is largely dependent on the relationship of the scapula and the humerus.[5] The shoulder complex is comprised of the glenohumeral, acromioclavicular, and sternoclavicular joints, as well as the scapulothoracic articulation which is not a true joint, but a fascial articulation.[2,6] The glenohumeral joint is designed for mobility, which in turn sacrifices bony and ligamentous stability. It is, therefore, highly dependent on the surrounding musculature for stability and normal motion.[1,4]

The scapulothoracic articulation allows a stable base for the articulation of the head of the humerus and the scapula. One of the major roles of the scapula is to maintain dynamic stability yet, at the same time, the scapular musculature must provide controlled mobility for the glenohumeral joint. Movement and proper function of the muscles surrounding the scapulothoracic articulation are key for normal biomechanics of the shoulder.[1,7,8] The muscles of the scapulothoracic articulation include the levator scapulae; rhomboid major and minor; pectoralis major and minor; serratus anterior; and the upper, middle, and lower portions of the trapezius.[2,5,6] The actions of these muscles are outlined in

Table 1. Weakness of the trapezius and serratus anterior may lead to abnormal scapular position, which can then lead to shoulder dysfunction. It has been suggested in the literature that the trapezius and serratus anterior are the most important muscles acting on the scapulothoracic articulation.[7]

Table 1. Actions of Scapulothoracic Muscles*; Adapted from *Handbook of Manual Muscle Testing*; New York, NY: McGraw-Hill; 1999:13-37.

Muscle	Action												
	Humerus							Scapula					
	Flexion	Extension	Adduction	Abduction	IR	ER	Horiz Add	Depression	Elevation	Retraction	Protraction	Rotation	↑ Rotation
Trapezius													
Upper									X	X			X
Middle										X			
Lower								X		X			X
Rhomboid Major									X	X		X	
Rhomboid Minor									X	X		X	
Levator Scapula									X	X		X	
Serratus Anterior								X	X		X		X
Latissimus Dorsi		X	X		X			X					
Pectoralis Major	X		X		X		X	X			X	X	
Pectoralis Minor								X			X	X	

*IR indicates internal rotation; ER indicates external rotation; ↓ indicates downward; and ↑ indicates upward.

Muscles of the scapulothoracic articulation act as scapular stabilizers, permitting the musculature surrounding the glenohumeral joint to function

properly.[1,7] Inman et al[10] claims the trapezius muscle serves an entirely supportive role for the upper extremity in the resting position and in the first 35˚ of shoulder elevation. They believe the trapezius is a more effective rotator once the shoulder reaches 90˚ of elevation, but again resumes a supportive role at 140˚ of elevation. A study completed by Ballantyne et al[11] further supported the role of the lower trapezius as a scapular stabilizer, agreeing that the lower trapezius participates minimally in glenohumeral elevation below 90˚. As a result, it seems the lower trapezius acts as a scapular stabilizer during the first 90° and again after 140° of shoulder elevation.

In addition to scapular stabilization and rotation, the lower trapezius and other scapulothoracic muscles are believed to have a postural function. A study completed by Inman et al[10] showed muscle activity in the lower trapezius while the arm was at rest. Kamkar et al[7] also believed it could be hypothesized that the scapulothoracic muscles serve primarily a postural function. The authors based this hypothesis on data which suggest scapulothoracic muscles are not required to produce a large amount of force or to contract powerfully in short periods of time, and therefore they must serve a postural, supportive role.

Differences in muscle fiber composition is one way to differentiate between postural and dynamic muscle types. Postural muscles contain larger portions of Type I muscle fibers.[7,10] Type I, or slow twitch, fibers have a low strength of contraction, low anaerobic capacity, and are small in size, but have a high capillary density and are highly resistant to fatigue.[4,8] Consequently, Type I fibers are designed to withstand prolonged activities which require greater

muscular endurance. Whereas Type II, or fast twitch, fibers have great contraction strength, fast contraction speed, are large in size, and have a medium to low aerobic capacity, they fatigue quickly. Type II fibers are designed for short-term, intermittent, high-force production, as in sprinting, rather than prolonged activities requiring endurance.[4] The lower trapezius was found to contain 80% Type I fibers in autopsy reports, further supporting the hypothesis of the postural function of scapulothoracic musculature.[7] Scapular stabilization through postural support must occur to allow for appropriate motion at the glenohumeral joint.

Normal range of motion at the glenohumeral joint also requires a normal kinematic relationship between the scapula and the humerus, commonly referred to as the scapulohumeral rhythm.[4,6-8,12] Codman[5,12] originally defined the term scapulohumeral rhythm for the combined motions of the glenohumeral joint, scapulothoracic articulation, sternoclavicular joint, and acromioclavicular joint. Scapulohumeral rhythm serves 2 main purposes. First, scapular motion during shoulder elevation permits an optimal length/tension relationship between each of the muscles acting on the humerus during elevation. Secondly, the distribution of motion during shoulder elevation allows the humeral head to rest comfortably in the glenoid fossa, providing additional stability of the shoulder.

During the initial phase of shoulder elevation, 0-30˚, the scapula and humerus are not well coordinated. At this point, humeral motion is much greater than scapular motion causing shoulder elevation to be an irregular motion of the scapula and humerus. As shoulder elevation reaches the second phase of

scapulohumeral rhythm, 30-180˚, coordination improves between the humerus and the scapula. However, at approximately 120˚ of shoulder elevation, the motion becomes irregular once again because scapular motion is now greater than humeral motion.[6,13] Literature suggests that for every 1˚ of scapular upward rotation, there is 2˚ of humeral elevation. It can be stated then that with a total of 180˚ of shoulder elevation, 120˚ are provided by humeral motion and the other 60˚ are provided by scapular upward rotation (2:1 ratio). Therefore, 60˚ of upward scapular rotation should always accompany the 120˚ of humeral elevation to equal 180˚, or normal range of motion, of shoulder elevation.[5,6,8] If one joint or articulation of the shoulder complex is not aligned correctly due to pathology or dysfunction, the scapulohumeral rhythm will be disrupted, and the individual will be unable to attain normal shoulder joint range of motion.

To complete the scapulohumeral rhythm, the scapula must upwardly rotate 60˚ during shoulder elevation. This upward rotation of the scapula during shoulder elevation is accomplished by the force couple of the serratus anterior and trapezius muscles.[1,4-7] A force couple is 2 equal forces acting in opposite directions to rotate a part about its axis of motion.[6] The upper and lower portions of the trapezius and the serratus anterior musculature complete different functions as the shoulder elevates. The upper portions of the trapezius and serratus anterior are considered the upper portion of the force couple acting on upward rotation of the scapula (Figure 1). During the initial 90˚ of shoulder

elevation, the scapula rotates a total of 30°; the upper portion of the force couple between the serratus anterior and upper trapezius is responsible for the completion of this motion. The lower portion of the force couple acting on upward rotation of the scapula is composed of the lower trapezius and lower portions of the serratus anterior. During the final 90° of shoulder elevation, the

lower portion of the force couple joins the upper portion to upwardly rotate the scapula an added 30˚, permitting a total upward rotation of 60˚.[6]

As the lower trapezius and serratus anterior muscles stabilize the scapula, they also serve as a stabilizing synergist for the deltoid muscle which acts on the glenohumeral joint.[7] As shoulder elevation is completed, the action of the deltoid will lead to downward rotation of the scapula. The upward scapular rotation from the trapezius and serratus anterior force couple stops this downward rotation and maintains an optimal length/tension ratio necessary for the deltoid to perform normally.[6] If any part of the force couple between the serratus anterior and trapezius muscles is not functioning appropriately, the scapulohumeral rhythm and glenohumeral joint movement will be abnormal.[1]

The shoulder complex is one of the most common peripheral joints to be treated in the physical therapy clinic.[14] Normal scapular positioning and mechanics may be altered when weakness or dysfunctions are present in scapular musculature.[1,7,15] If scapular positioning and mechanics are altered, the scapulohumeral rhythm may become compromised, leading to pain and dysfunction of the shoulder complex. Further, if the scapula fails to perform its role as a shoulder girdle stabilizer, shoulder function may become inefficient which can then predispose an individual to injury. Primary or secondary shoulder impingement may materialize if the scapulohumeral rhythm is disrupted.[1]

Primary impingement occurs from repeated mechanical impingement of structures in the subacromial space. Secondary impingement occurs due to a relative decrease of the subacromial space caused by instability of the

glenohumeral joint itself.[4,7] Impingement occurs from the compression of structures between the humeral head and coracoacromial arch, the acromion, or the acromioclavicular joint.[4,7] The subacromial space is approximately 1 cm wide, allowing very little space for any needed adaptation for inflamed structures within this space (Figure 2).[4] Motions that involve overhead lifting or shoulder elevation greater than 90˚ can produce impingement symptoms or be the direct cause of the impingement dysfunction in the first place.[3,16] Impingement dysfunction can be caused by a chain-like effect: weakness of the scapulothoracic muscles causes abnormal positioning of the scapula, which then leads to the disruption of the scapulohumeral rhythm, finally causing changes in the motion capabilities of the shoulder joint and impingement at the subacromial space.[7] Additional symptoms may be incurred when shoulder pain from the impinged shoulder complex leads to the inhibition of scapular muscles, triggering additional impingement. A decrease in range of motion secondary to posterior capsule tightness from shoulder impingement may also transpire, causing an even greater decrease in the functional capabilities of the individual. All 4 major articulations of the shoulder must act together in order for proper shoulder motion to occur, and in return, to avoid shoulder impingement, pain, and dysfunction. Therefore, it is important for the clinician to include all articulations, including the scapulothoracic musculature, in both evaluation and treatment of the shoulder complex.

Even though literature emphasizes the importance of the scapulothoracic articulation and musculature for normal biomechanics of the shoulder joint, scapular muscles are often neglected in the evaluation and treatment of shoulder injuries.[1] There is limited scientific data from which to devise an appropriate shoulder exercise program, and such programs vary widely throughout physical therapy practice.[3] Most protocols available to exercise specific shoulder girdle muscles are based on anatomical knowledge, rather than being based on

scientific evidence or quantifiable data, such as electromyography (EMG) data. Moseley et al[7] believe this is particularly true with scapular muscles.

Electromyography allows the electrical activity of muscles to be monitored while they respond to nervous stimuli during movement. EMG involves the placement of surface electrodes over a muscle or muscles of interest. Surface electrodes detect electrical activity of the muscle as it contracts during movement. The record of muscle activity, the electromyogram, may then be used to describe the relative amount of muscle activity during exercise or activity performance.[4] In biomechanics and kinesiology, surface EMG is used as an indicator for the initiation of muscle activity and as a measure of force produced by the muscle.[17] Therefore, EMG data of shoulder and scapulothoracic musculature may give quantifiable, evidence-based data necessary to develop an appropriate plan of care for patients with shoulder girdle impairments.

Traditionally, shoulder impingement rehabilitation protocols have stressed strengthening of individual rotator cuff muscules (supraspinatus, infraspinatus, teres minor, and subscapularis).[7] Kamkar et al[7] stated that several protocols have been designed for the rehabilitation of shoulder injuries; most of these focus on strengthening the rotator cuff muscles in addition to restoration of normal range of motion, endurance, and pain control. These shoulder protocols focus on the proper function of the rotator cuff muscles ignoring the scapulothoracic muscles all together.

Proper function of scapulothoracic musculature is a necessary focus in the rehabilitation of the shoulder girdle.[1,7,13] However, no studies have quantifiably

determined which exercises generate the most muscle activity for the vital and individualistic scapular muscles.[5] Literature continues to debate which exercises most efficiently recruit the lower trapezius muscle, which is, as stated previously, one of the most important muscles acting on the scapulothoracic articulation. Moseley et al[1,5] determined rowing and horizontal abduction in neutral optimally exercise the lower trapezius and reported peak muscle activity between 120° and 150˚ of abduction. Ballantyne et al[11] reported the greatest EMG activity during prone lateral rotation and the least amount while exercising in the empty can position (scapular plane elevation with maximal shoulder internal rotation); whereas, Bagg and Forrest[5] reported the most EMG activity during 90° and 120˚ of scaption. Finally, Saha and Chakravarty[5] found the lower trapezius to be most active between 90° and 120˚ of abduction. Currently, the overhead position is the traditional position for strength testing of the lower trapezius. It was this variability in literature and the current strength testing position that led to the design of a pilot research study. It was the pilot research study's intension to find a position to strengthen the lower trapezius muscle without placing the shoulder in an overhead and, therefore, a potentially impinging position.[18]

The lower trapezius manual muscle test is completed with the patient lying prone with the arm placed diagonally (approximately 145˚ of abduction) overhead and the shoulder externally rotated, so that the forearm is in mid-position and the thumb is pointed toward the ceiling.[9] In the clinic, exercises completed to strengthen the lower trapezius are commonly based on the manual muscle testing position, such as repeated forward elevation from this position, with and

without weight. This position does allow the individual to strengthen the lower trapezius; however, it places the shoulder in a compromising position, especially for those with shoulder pathology. It is important to keep the glenohumeral joint of individuals with shoulder impingement below 90˚ of shoulder elevation to avoid further impingement and/or irritation to the shoulder joint. Patients with impingement syndrome may also have a decrease in range of motion, secondary to pain or change in joint structure, which prohibits them from placing their arms in the overhead position to complete strengthening of the lower trapezius.

Further research needs to be completed to determine a position which safely and effectively recruits and exercises the lower trapezius muscle. This study proposed a modified position of shoulder external rotation while in 80˚ of shoulder abduction and 90˚ of elbow flexion to allow examination of whether or not this position will effectively recruit the lower trapezius while maintaining a position which does not compromise the shoulder complex by impingement.

CHAPTER III

METHODS

Subjects

Forty-one healthy students from the University of North Dakota voluntarily participated in this study. The mean age of the subjects was 25.03 years old. Twenty-three subjects were female and 18 were male. Characteristics of the subjects are summarized in Table 2. Individuals with a previous history of right shoulder pathology requiring medical attention were excluded from the study. This was determined by a questionnaire that was filled out prior to the testing (Appendix A). Subject number 22 was excluded due to her age which was missed originally in the patient questionnaire. Each subject signed a letter of informed consent prior to the testing procedure (Appendix B). This study was approved by the Institutional Review Board of the University of North Dakota (Project IRB-200306-270; Appendix D).

Instrumentation

The EMG data were collected using a Noraxon Telemyo8 telemetry unit (Noraxon USA, 13430 North Scottsdale Rd., Scottsdale, AZ, 85254). Information was collected, transmitted, and converted to a digital form by an analog to a digital interface board installed in the computer. The digitized EMG signals were

Table 2. Characteristics of Subjects (n=41)

Subjects	Age (years)	Gender (M/F)	Height (inches)	Weight (pounds)	Dominant Hand
1	25	M	72	210	R
2	23	F	63	130	R
3	43	M	68	177	R
4	22	M	69	190	R
5	22	M	70	220	R
6	22	M	73	215	R
7	28	M	75	190	R
8	26	M	67	140	R
9	24	F	70	150	R
10	24	F	62	150	R
11	23	F	67	125	L
12	21	F	64	140	R
13	22	M	73	205	R
14	23	M	70	160	L
15	22	F	65	128	R
16	23	F	65	125	R
17	24	F	62	135	R
18	25	M	71	215	L
19	22	F	65	135	R
20	23	M	66	180	R
21	25	F	67	145	R
22	48*	F	62	150	R
23	21	F	61	130	R
24	22	F	63	145	R
25	25	F	70.5	160	R
26	45	F	61	135	R
27	34	F	68	130	R
28	23	M	71	165	R
29	22	F	68	150	R
30	24	F	62	110	R
31	32	M	70	185	R
32	22	M	71	170	R
33	30	M	68	165	L
34	27	M	75	187	L
35	22	F	67	145	R
36	23	F	72	155	R
37	22	F	65	130	R
38	22	F	66	150	R
39	23	M	70	155	R
40	28	M	67	162	R
41	22	F	65	140	R

analyzed using the MyoResearch '97 software package. EMG data were collected during 4 exercise trials of 10 repetitions each.

Procedure

As shown in Figure 3, 2 hi-lo plinths, a specially designed U-shaped positioning guide, and a handswitch were set up before the subjects entered the room. A handswitch was attached to a plinth with a 2 X 4 and a metal clamp. The plinth was then adjusted during each exercise trial to allow the subject to strike the handswitch at his/her end range of elevation or external rotation. The subject was instructed to lay prone on a second plinth and remained in this position throughout the exercise trials.

After giving consent, each subjects' age, height, weight, and dominant hand were recorded on a patient questionnaire (Appendix A). Sensitivity to isopropyl alcohol was also recorded on the patient questionnaire. Each subject was then given a short training session to learn the proper procedure and technique to be used during the exercise trials. The subject's right upper extremity was used for data collection.

In order to prepare the subject for data collection, he/she was instructed to lay prone. Being sure to maintain each subject's modesty, the mid-back area was exposed. The motor point of the lower trapezius, defined as the mid-point of the line drawn from the seventh thoracic vertebrae to the inferior angle of the scapula, was located and marked with a felt tip pen (Figure 4). The skin over the motor point of each subject was prepared by cleansing the area with alcohol before attachment of the EMG surface electrodes. Two pre-gelled, self-adhesive electrodes (Blue Sensor®, Medicotest, Inc. 1-888-310-3247) were then applied to the skin at a point corresponding to the motor point of the lower trapezius

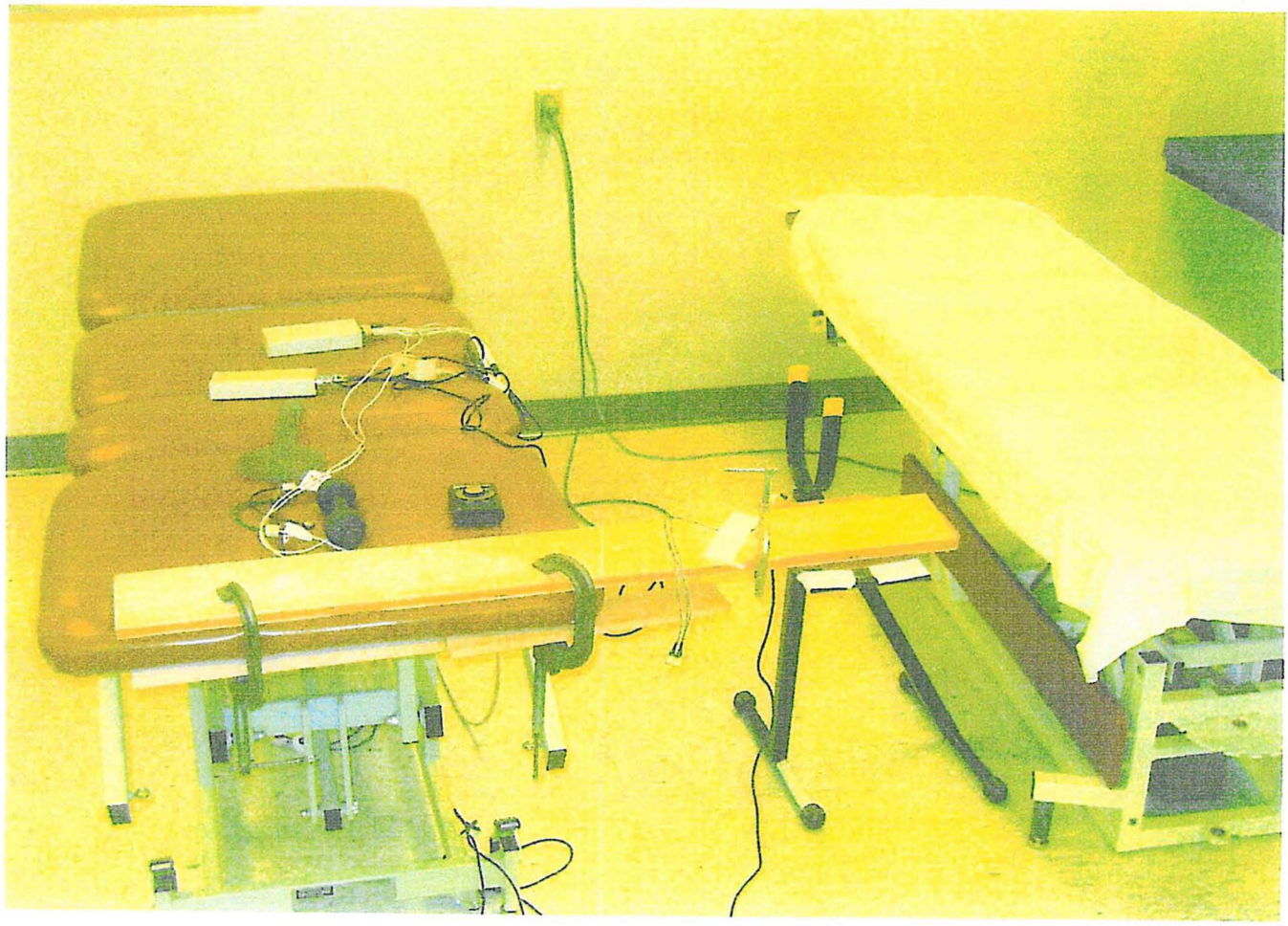

Figure 3. Test equipment set-up, including two hi-lo plinths, a specially designed U-shaped positioning device and a hand switch.

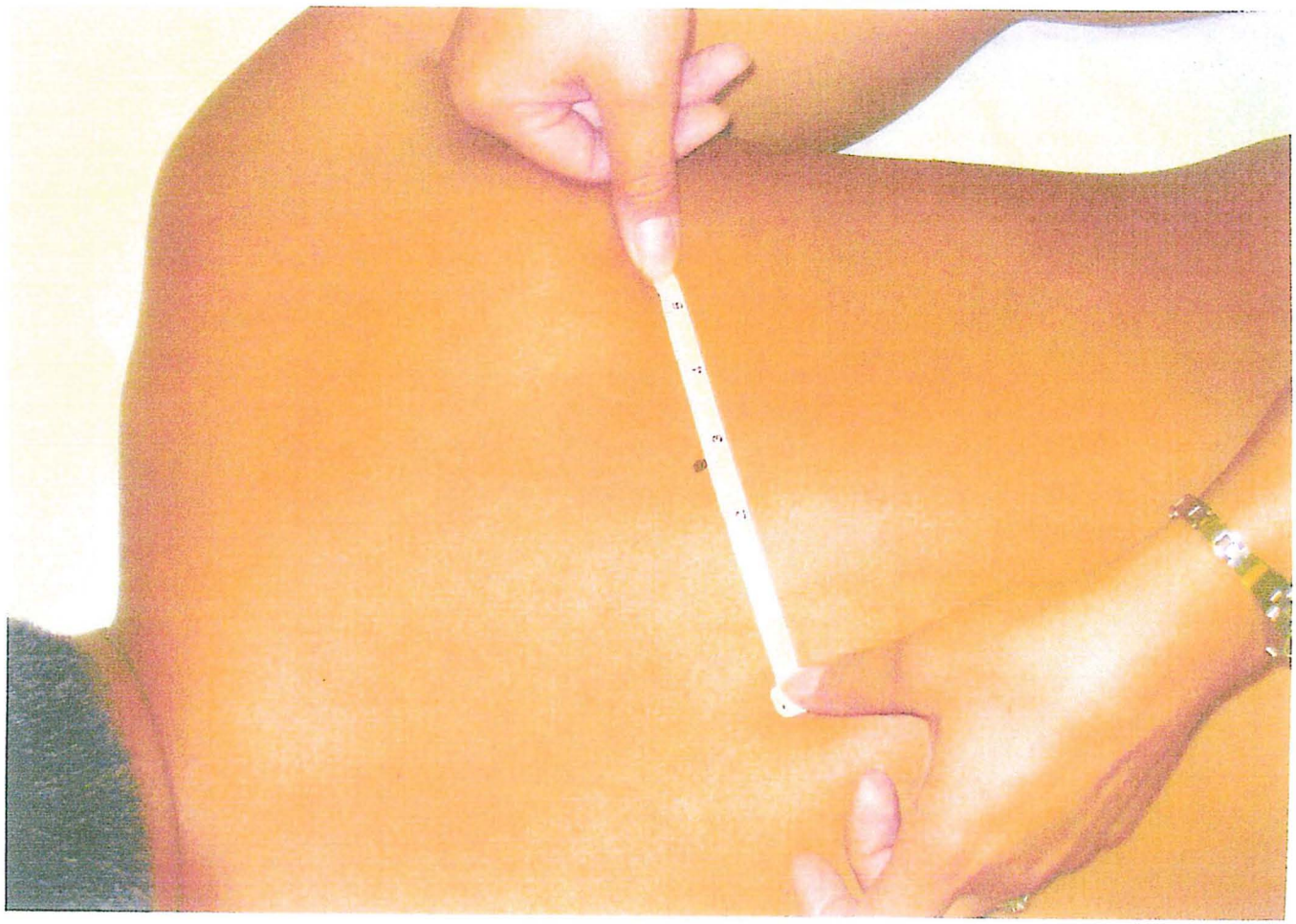

Figure 4. The motor point of the lower trapezius was defined as the mid-point of a line from the seventh thoracic vertebrae to the inferior angle of the scapula.

muscle of the right upper extremity (Figure 5). The distance between surface electrodes was minimized in an attempt to decrease interference from surrounding muscles, thus increasing the accuracy of specific muscle activity in the lower trapezius. Care was taken to be sure the electrodes did not touch, however, as this would short out the electrodes. A ground electrode was placed over the spinous process of the second lumbar vertebrae (Figure 5). When necessary for electrode placement, subjects' mid-thoracic and/or lumbar area(s) were shaved using an electric shaver.

Four exercise trials consisting of 10 repetitions each were performed. They were as follows: external rotation with a 2-lb hand weight, external rotation without the 2-lb hand weight, forward elevation with a 2-lb hand weight, and forward elevation without a 2-lb hand weight. Please refer to Appendix F for specific descriptions of each exercise trial. Prior to the start of each exercise, the investigator assisted the subject into the correct position for that trial. The desired degree of abduction was obtained using a universal 360° goniometer. The elbow was placed in full extension for the traditional exercise and at 90° for the modified position (Figures 6 and 7). The order in which these exercises were performed was determined by random selection.

Each participant had 3 to 5 practice repetitions of the exercises at a metronome cadenced of 60 repetitions per minute in order to increase the consistency in the timing of the exercises within each subject. Starting on a cue from an investigator, the subject then performed 10 repetitions of each exercise trial with 2 minutes of rest between each trial. The investigator counted each

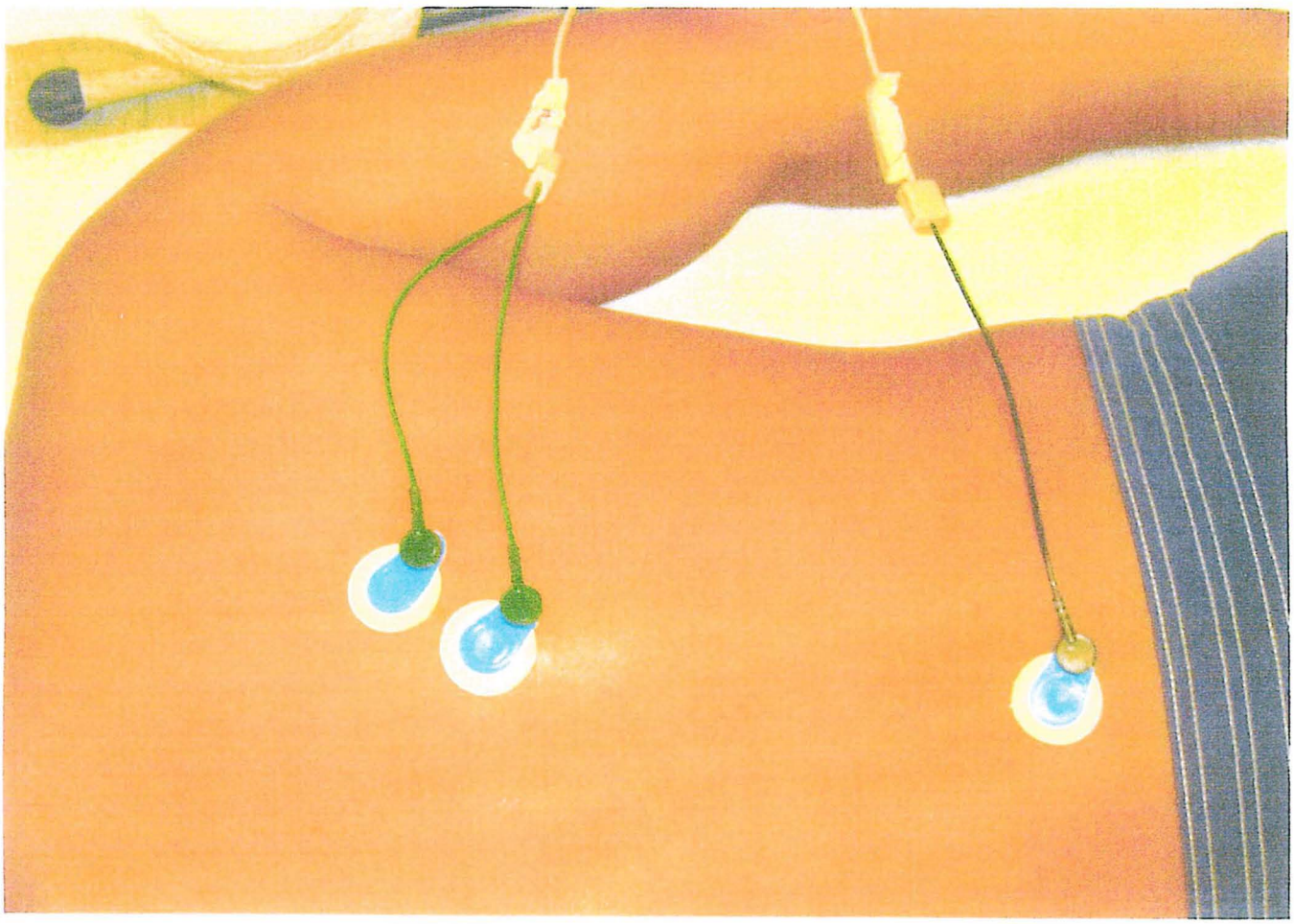

Figure 5. Electrode placement over the motor point of the lower trapezius. A ground electrode was placed over the spinous process of the second lumbar vertebrae.

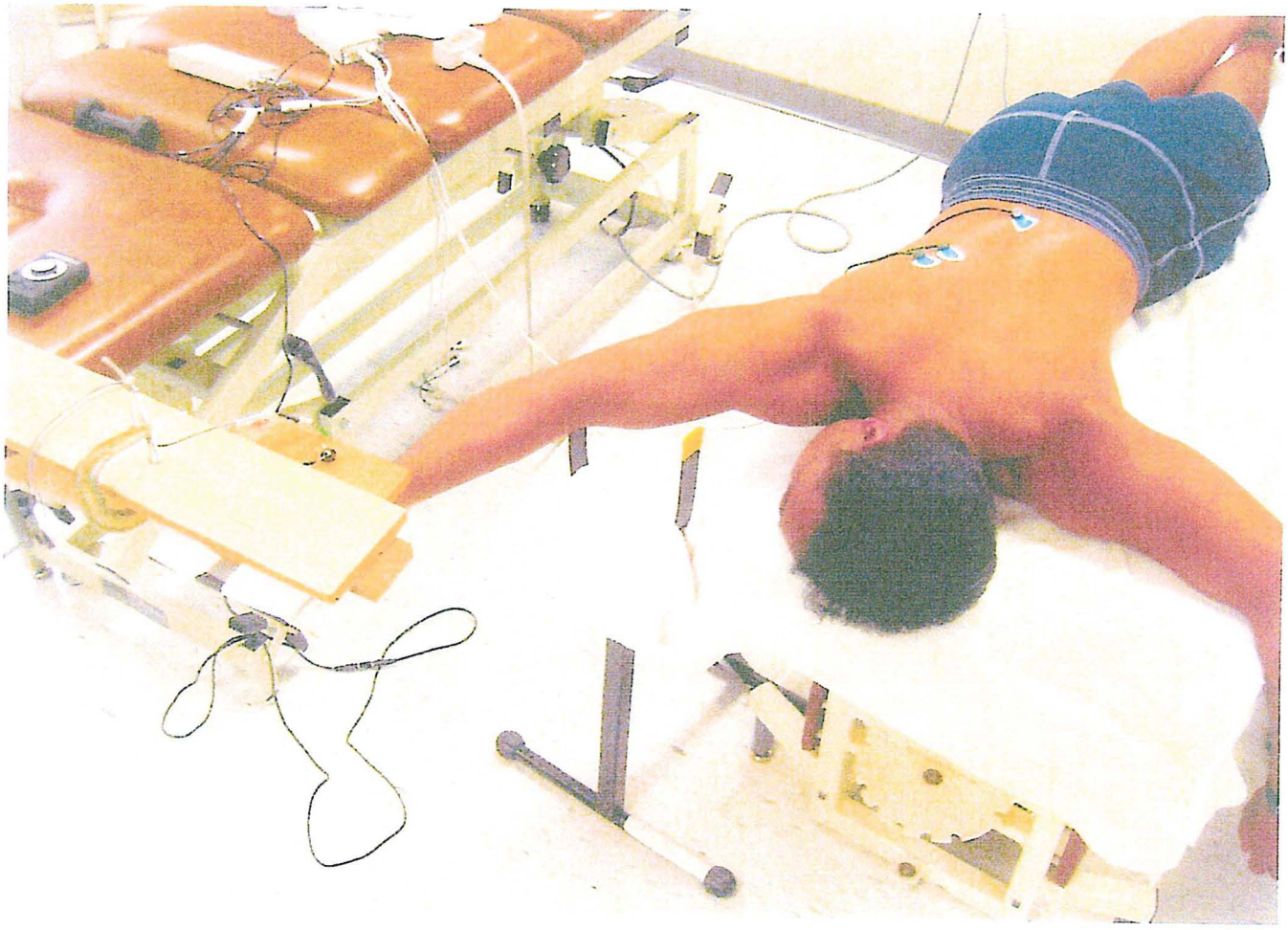

Figure 6. Exercise in the traditional overhead position without the 2-lb hand weights.

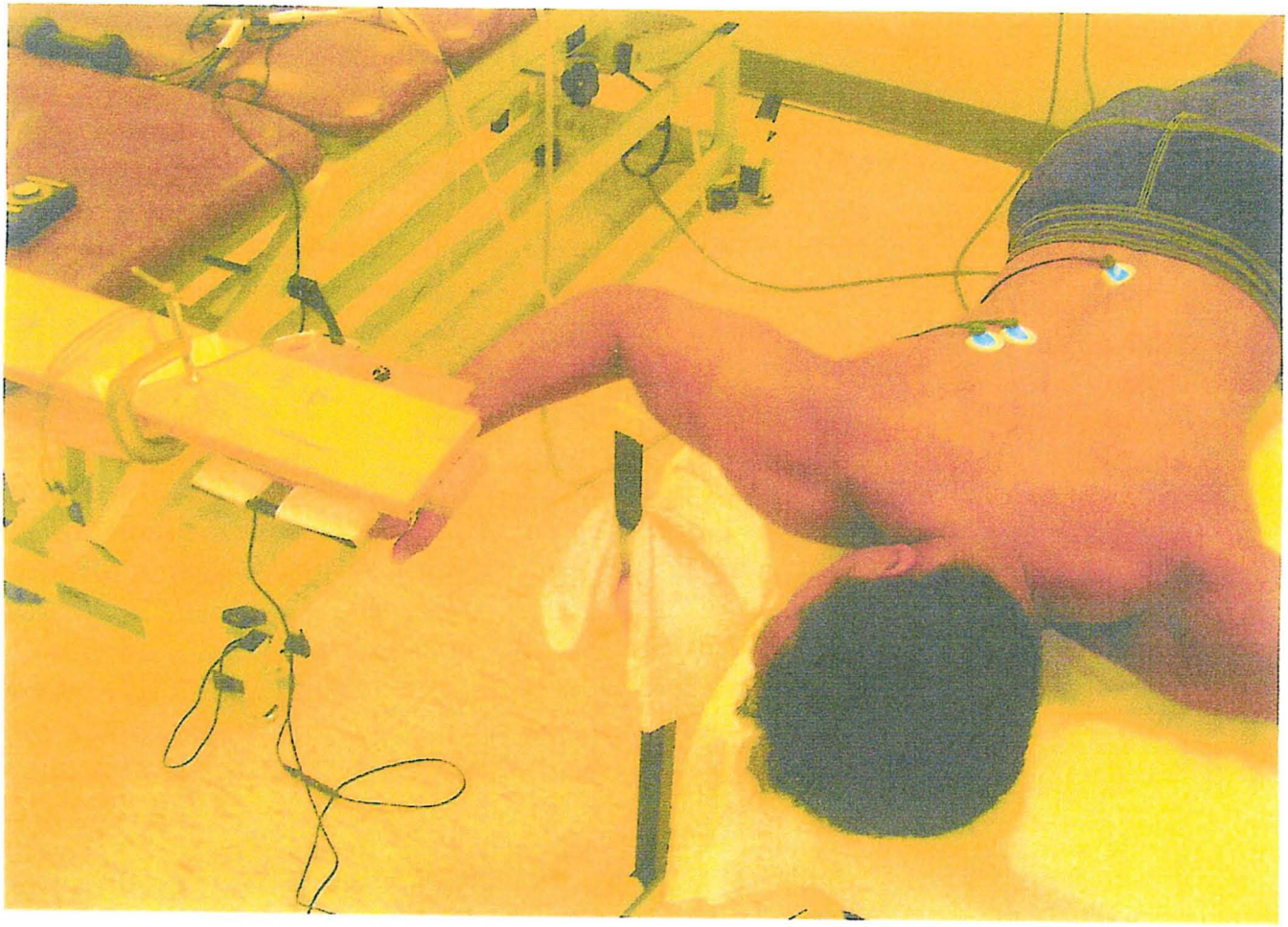

Figure 7. Exercise in the modified position performed without the 2-lb hand weights.

repetition out loud for each participant. No other encouragement was given unless a technique was being performed incorrectly. If a technique was being performed incorrectly, the exercise session was stopped, the correct technique was explained to the subject, and that exercise was started again.

During the exercise in the traditional position, the subject was prone while having his/her head facing toward the right side. The subject's right humerus was abducted to 145 ° with the thumb pointed toward the ceiling. The arm was placed into a specially designed U-shaped positioning guide to keep the arm in the correct position (Figure 3). The patients were instructed not to rest on or touch the sides of the guide in order to standardize the data. One trial of forward elevation was performed with a 2-lb hand weight and a second trail was performed without a 2-lb hand weight.

During the exercises in the modified position, the subject was prone with his/her head facing toward the right side. The subject's right humerus was abducted to 80°, and the elbow was flexed to 90° with the palm facing the ground. The arm was then placed in the U-shaped guide to maintain this position throughout the trial. External rotation was performed with a 2-lb hand weight and a second trial was performed without the 2-lb hand weight.

For each subject, the EMG signals were transmitted to the receiver unit and then displayed and recorded into a computer. The EMG data for each subject were recorded on the computer hard drive for future analysis. The EMG electrodes and equipment were removed from the subjects at the conclusion of the testing and the skin was cleaned where the electrodes were attached. Each

subject was informed that the skin under the areas where the electrodes were placed may possibly be red after removal due to the self-adhesive material. Each subject was thanked for his/her participation and encouraged to contact the study conductors if any questions or concerns arose.

Data Analysis

Data analysis of the mean activity of the lower trapezius was performed on the EMG activity during the experimental trials using the Statistical Package for Social Sciences (SPSS) software program.[19] The data from the experimental trials were analyzed by selecting 3 consecutive cycles of the exercise. In the traditional position, a cycle was defined as the period starting at zero (with the arm slightly below the plane of the table) progressing through maximum shoulder elevation and ending back at zero. In the modified position, a cycle was determined as the period starting at zero (with the arm slightly below the plane of the table) progressing through maximal external rotation and ending back at zero. During each exercise, the handswitch was placed in each subject's maximal external rotation and maximal elevation, respectively. The handswitch activation marked the amount of lower trapezius muscle activity at the maximum of shoulder elevation and external rotation and was used during the analysis of data to determine the subject's place in the motion.

To determine the mean EMG activity during each exercise, an average of the 100 highest peak amplitudes during the selected 3 cycles were calculated by computer. These calculations were completed for all 4 trials of each subject. The average EMG activity of all subjects was then compiled into an average

curve of EMG activity for the specific exercise (traditional position without the weight, traditional position with the weight, modified position without the weight, or modified position with the weight). The resulting 4 curves were defined as the "normative" curve for each specific exercise.

According to Yang and Winter,[20] intersubject variability was significantly less when using the peak ensemble or mean ensemble of walking trials in gait analysis rather than during 50% maximal voluntary contraction or the EMG per unit moment. For this reason, the normative curve of the exercise trial in the traditional position without the weight was considered the baseline EMG activity for the lower trapezius. The normative curves of the EMG activity with and without the weight in the remaining positions were then compared to the baseline activity. The independent variables of this study include each specific exercise trial and the dependent variable is the muscle activity recorded. A repeated measures analysis of variance (ANOVA) statistical test was used to determine significant differences between each trial using the SPSS software program. Post hoc Turkey HSD analysis was performed to determine significance between trials. Statistics were determined to be statistically significant at $\alpha = .05$ level.

CHAPTER IV

RESULTS

The results of this study were determined from the collected EMG data and calculated means and standard errors from the subjects (n=40). After rectification and quantification of the EMG data, the data for exercises in the traditional position with weight, modified position without weight, and modified position with weight were compared to the data for traditional position without weight using a repeated measures ANOVA. One subject was excluded from the study due to exceeding the 18- to 45-year age limit. Subjects were tested singly and all subjects were able to complete all the exercise trials required for the data collection.

An entire cycle is considered to be a repetition of the exercise from the designated starting position through maximum elevation or maximum external rotation, depending on the position, with a return to the starting position. For testing and graphing purposes, the traditional position without weight was referred to as position 1, the traditional position with weight was referred to as position 2, the modified position without weight was referred to as position 3, and the modified position with weight was referred to as position 4.

Linear representation of the comparisons of muscle activity for the lower trapezius in each exercise position are shown in Figures 8 through 12 (see

Appendix F). The data points, 0 to 97, represent an entire cycle of the exercise. The exercise positions are referred to as position 1 through 4 as described previously. The linear graphs allow a visual comparison to be made between the rise to maximum muscle activity and return to baseline between the 4 exercise positions. The vertical lines on the graphs represent the standard errors for each point throughout the entire cycle.

Total EMG Activity/Recruitment Throughout an Entire Cycle

Area Under the Curve

Total muscle activity for the lower trapezius muscle during each exercise position was compared and graphically depicted in Figure 13 (Appendix F). Descriptive statistics for the area under the curve for all the subjects tested are shown in Table 3. A significant difference was found between the 4 exercise trials using a repeated measures ANOVA ($F(3,156) = 15.79$, $p < .001$). Post hoc, Turkey HSD analysis showed that the lower trapezius muscle activity in the traditional position without weight was significantly lower than the total amount of muscle activity of the lower trapezius in the traditional position with weight ($F(3,156) = 15.79$), ($p < .001$) and the modified position with weight ($F(3,156) = 15.79$), ($p = .004$). No significant difference was found between the total amount of muscle activity between the traditional position without weight and the modified position without weight ($F(3,156) = 15.79$), ($p = .778$) or between the traditional position with weight and the modified position with weight ($F(3,156) = 15.79$), ($p = .455$).

Table 3. Total EMG Activity/Recruitment of the Lower Trapezius Muscle Throughout an Entire Cycle of Exercise.

	Traditional Position Without Weight	Modified Position Without Weight	Traditional Position With Weight	Modified Position With Weight
Mean	143.42	134.83	188.32	174.97
Standard Error	1.85	7.55	8.29	11.17

Average EMG Activity Throughout an Entire Cycle

Mean Percent of Norm

Average EMG activity of the lower trapezius muscle during each exercise position was compared and graphically depicted in Figure 14. An entire cycle is defined the same way and positions were still referred to as 1, 2, 3, and 4 as described previously.

The descriptive statistics for the mean percent of norm for all the subjects tested are shown in Table 4. A significant difference was found between the exercise trials using a repeated measures ANOVA ($F(3,156) = 14.56$, $p < .001$). Post hoc, Turkey HSD analysis revealed that average lower trapezius muscle activity in the traditional position without weight was significantly lower than the average EMG activity of the lower trapezius in the traditional position with weight ($F(3,156) = 14.56$, ($p < .001$) and the modified position with weight ($F(3,156) = 14.56$, ($p = .001$). No significant difference was found in the average amount of lower trapezius muscle activity between the traditional position without weight

Table 4. Average EMG Activity of the Lower Trapezius Muscle Throughout an Entire Cycle of Exercise

	Traditional Position Without Weight	Modified Position Without Weight	Traditional Position With Weight	Modified Position With Weight
Mean	72.13	67.45	92.82	90.92
Standard Error	.91	3.80	3.88	6.51

and the modified position without weight ($F(3,156) = 14.56$, ($p = .761$) or between the traditional position with weight and the modified position with weight ($F(3,156) = 14.56$, ($p = 9.79$).

Discussion

Previous studies have found that motions involving overhead lifting or shoulder elevation greater than 90˚ can produce impingement symptoms or be the direct cause of the impingement dysfunction.[3,16] As the lower trapezius is a key muscle in normal scapulothoracic motion, weakness of this muscle may be a contributing factor in impingment dysfunction.[7] Without proper strength in the lower trapezius, the scapula may be placed in a compromised position causing shoulder dysfunction. A pilot study was conducted to find an alternate position for strengthening the lower trapezius which did not require placing the shoulder in an overhead, and therefore, potentially impinging position. The pilot study compared positions in which the lower trapezius was more successfully recruited: the traditional muscle testing position of 145° of shoulder abduction or the

modified position consisting of shoulder external rotation while in 80° of shoulder abduction and 90° of elbow flexion. The results showed that the modified position with a 2-lb hand weight recruited the lower trapezius equally to the traditional position without weight.[18] This study was conducted to replicate the pilot study with a greater number of subjects in order to verify those results. As the results of this study indicate, in the modified position, the lower trapezius was recruited at a similar or greater level in the modified position as compared to the traditional position.

The entire cycle of the muscle activity for the lower trapezius in each exercise position was graphically compared to the traditional position using a linear representation to show the entire cycle of each exercise position. The traditional manual muscle testing position without weight was compared to the other 3 positions. The graphs show that for each exercise trial, when compared to the traditional position, similar patterns of recruitment throughout the cycle were demonstrated for each position. There was no significant difference between the traditional position without weight and the modified position without weight which indicates that, with this sample, exercise in the modified position recruited the lower trapezius equally as well as in the traditional position. The results also indicate that when a 2-lb hand weight was added to the exercise in either position, the lower trapezius was recruited more effectively than the traditional position without weight. The addition of the hand weight replicates activities used when strengthening this muscle and, as shown, demonstrates

greater activity in the targeted muscle. These findings are consistent with those of the pilot study.

The shoulder complex is one of the most common peripheral joints to be treated in the physical therapy clinic.[14] Traditionally, shoulder impingement rehabilitation protocols have stressed strengthening of individual rotator cuff muscles (supraspinatus, infraspinatus, teres minor, and subscapularis).[7] These shoulder protocols focus on the proper function of the rotator cuff muscles, ignoring the scapulothoracic muscles all together. However, proper functioning of the scapulorthoracic musculature is a necessary focus in the rehabilitation of the shoulder girdle.[1,7,13] Furthermore, the traditional muscle testing position is most often the position used to complete exercises to strengthen the lower trapezius. This places the shoulder in a compromising position, especially for those with shoulder pathology. It is important for those with impingement of the shoulder to keep the glenohumeral joint below 90˚ of shoulder elevation as well as strengthen the scapulothoracic musculature. Literature has suggested that the trapezius is one of the most important muscles acting on the scapulothoracic articulation.[1] This study demonstrates that the lower trapezius can be recruited just as effectively in a less compromising, alternative position. This means that the lower trapezius can be strengthened with a lowered risk of developing impingement or in cases of already present pathology, prevention of the reoccurrence or progression of impingement.

Total muscle activity (area under the curve) was then shown in bar graph form to give a single number to compare the 4 positions. This graph reiterated

the results of the linear graphs showing that performing external rotation in the modified position of 80° of shoulder abduction is a viable alternative to the traditional position of 145° of abduction for lower trapezius muscle recruitment. Average EMG activity was also analyzed and compared to the total EMG activity. This was done to ensure that there were not any outlying subjects who may have altered the results. The outcomes were similar indicating this did not happen, further substantiating our findings from the total EMG analysis. Therefore, based on the results of this study, the lower trapezius can be recruited just as or more effectively in the modified position. It would follow, then, that there is no reason to put the shoulder in the compromising traditional position unless overhead activity is required of occupational or recreational activities.

Future Studies

It is hoped that this study will be expanded in the future. Following are several suggestions to improve this study. For this study, a sample of convenience was done that included only subjects who attended the University of North Dakota at the time of data collection. It is recommended that future studies encompass a broader range of ages, occupations, and backgrounds. It is also suggested to electronically find the motor point of the lower trapezius. This would decrease the chances of error when placing the electrodes over the lower trapezius.

Throughout the data collection, the positioning device and heights of the plinths were changed repeatedly due to the varying amounts of available external rotation and forward elevation range of motion among subjects. An exact

measurement was not recorded prior to the first trial. The plinth height was adjusted for each trial after finding the subject's end range of motion. In the future, it would be beneficial to record the plinth heights for each subject, for each position, so that the trials are repeatable, if needed.

It is also suggested that a platform be added to the positioning device so that the subject can relax in the neutral position and also to restrict motion to the desired range. These authors cannot be certain that head position was consistent (toward the arm tested) for all subjects. It is speculated that muscle recruitment may be altered if the head is turned away or the subject is face down. It is recommended that future studies standardize head position prior to beginning each trial with every subject.

This study compared recruitment of the lower trapezius muscle in healthy individuals. However, future studies could expand and compare which position more effectively strengthens the muscle in weak individuals over a period of time and not just the amount of recruitment demonstrated in a single session.

Clinical Implications/Conclusions

The results of this study indicate that external rotation in 80° of shoulder abduction is a valid alternative to overhead exercise for recruitment of the lower trapezius. By keeping the humerus in less than 90° of abduction, the possibility of compromising the glenohumeral joint is reduced. Those recovering from conditions such as impingement syndrome may safely strengthen the scapular stabilizers, thus increasing the chance of achieving the proper scapulohumeral rhythm. Also, those with limited range of motion may still participate in a

complete rehabilitation program. Finally, the modified position recruits several muscles simultaneously allowing for a more concise rehabilitation protocol that will decrease muscle fatigue and increase patient compliance with the exercise program.

APPENDIX A

ID # _____

Patient Questionnaire

Name: _____

Age: _____ Height: _____ Weight: _____

Dominant Arm: _____ Isopropyl (Rubbing) Alcohol skin sensitivity? Y N

Do you have any history of shoulder problems for which you sought medical attention (i.e. instability, impingement, rotator cuff tear)? Y N

If yes, please explain:

_____

_____

_____

_____

_____

Do you have any history of shoulder pain during or after daily activities or exercise? Y N

If yes, please explain:

_____

_____

_____

_____

ALL INFORMATION PROVIDED IN THIS QUESTIONNAIRE HAS BEEN ANSWERED ACCURATELY TO THE BEST OF MY KNOWLEDGE.

_____

Signature of participant Date

APPENDIX B

ID # _____

CONSENT FORM

TITLE: An Electromyographic Study of Lower Trapezius Muscle Activity During Traditional Manual Muscle Testing and a Modified Position.

You are being invited to participate in a study conducted by Keri Doyle, Molly McDonald, Heather Partlow, Eric Paur, and Dr. Sue Jeno from the Physical Therapy Department at the University of North Dakota. The purpose of this study is to determine whether the lower trapezius muscle, a muscle in the mid-back, is stronger in the traditional overhead position or in a second position with the arm 80° away from the side of the body. The results of this study will let physical therapists choose the best position to exercise this muscle during a shoulder rehabilitation program. Only normal, healthy subjects with no history of shoulder problems will be asked to participate in this study.

For this study, you will first be asked lie on your stomach and to hold your right arm in the overhead position. The tester will then push down on your arm to determine the strength of the muscle. Following this, you will be asked to perform 4 separate exercises while lying on you stomach with your arm in the 2 different exercise positions. You will be asked to perform 2 exercises in each of the positions, one with a 2-pound weight and one without any weight. Ten repetitions will be done with each of the 4 exercises, totaling 40 repetitions. During the experiment, we will be recording the amount of muscle activity in your lower trapezius muscle. The study will take approximately 1 hour of your time. You will be asked to come to the Physical Therapy Department at the University of North Dakota at an assigned time.

Although physical exercise testing always involves a slight amount of risk, the investigators in this study feel that the risk of injury or discomfort is minimal. In order for us to record muscle activity, we will be placing small, self-stick electrodes on the right middle portion of your back. The recording electrodes are attached to the skin with a self-stick material. Before placing the electrodes, the skin over each placement site will be cleaned with alcohol and any excess hair will be shaved (if necessary) with an electric clipper. You will then be correctly positioned for testing. At this time you will be asked to perform the exercises with your right arm in the 2 different positions, with and without the 2-pound weight. The electrodes only record information from your muscles. They do not effect the skin, so uncomfortable feelings should not occur from these devices. The skin under the areas where the electrodes are placed may possibly be red after removal due to the self-stick material. The amount of muscle testing that you will be asked to due is minimal. No costs to you are expected.

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 that can be connected

with you will remain private and will be revealed only with your permission. A number known only to the investigators will identify the data. The consent forms will be kept separate from the data in a locked cabinet in the Physical Therapy Department at the University of North Dakota. They will be placed in a secured cabinet for a period of 3 years from the date of completion of the study. After this period of time, the information will be shredded.

You or the investigators may stop the experiment at any time if you experience discomfort, pain, fatigue, or any other symptoms that may be harmful to your health. Your decision whether or not to participate will not damage 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 investigators involved are available to answer any questions you have about this study. In addition, you are encouraged to ask any questions about this study you may have in the future, including any interest in being informed of the study's findings. If you have questions about the research please call Dr. Sue Jeno at (701) 777-2831 or Heather Partlow at (218) 773-2242. If you have any other questions or concerns, please call the Office of Research and Program Development at (701) 777-4279. A copy of the consent form is available to all participants in the study.

In the event that this research activity results in 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. You and your third party payer (insurance company), if any, must provide payment for any such treatment.

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 one of the investigators. I have received a copy of this informed consent for my records.

_____

Participant's Signature Date

University of North Dakota
Institutional Review Board
Approved on 6-11-03
Expires on 6-10-04

APPENDIX C

Consent for Taking and Publication of Photographs

Name: Delbert Peralta

Location: University of North Dakota School of Medicine and Health Science

Date: September 9, 2003

In connection with Keri Doyle, Molly McDonald, Heather Partlow and Eric Paur's scholarly project entitled, An Electromyographic Study of Lower Trapezius Muscle Activity During the Traditional Muscle Testing Position and A Modified Position, I consent That photographs may be taken of me and may be published under the following conditions:

1. The photographs shall be used if the researchers, Keri Doyle, Molly McDonald, Heather Partlow and Eric Paur, deem that medical research, education or science will be benefited by their use. Such photographs may be published and republished, either separately or in connection with each other, in professional journals or medical books; provided that it is specifically understood that in any publication or use I shall not be identified by name.

2. The aforementioned photographs may be modified or retouched in any way that the researchers, Keri Doyle, Molly McDonald, Heather Partlow or Eric Paur, may consider desirable.

Signed Delbert Peralta

Delbert Peralta

Witness Molly E McDonald

APPENDIX D

REPORT OF ACTION: EXEMPT/EXPEDITED REVIEW

University of North Dakota Institutional Review Board

Date: 6/11/2003 **Project Number:** IRB-200306-270

Principal Investigator: Jeno, Sue; Doyle, Keri; McDonald, Molly; Partlow, Heather; Paur, Eric

Department: Physical Therapy

Project Title: An Electromyographic Study of Lower Trapezius Muscle Activity During the Traditional Muscle Testing Position and a Modified Position

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on June 11, 2003 and the following action was taken:

☒ Project approved. **Expedited Review** Category No. 4
Next scheduled review must be before June 10, 2004
☒ **Copies of the attached consent form with the IRB approval stamp dated June 11, 2003 must be used in obtaining consent for this study.**

☐ Project approved. **Exempt Review** Category No. _____
This approval is valid until _____ as long as approved procedures are followed.
No periodic review scheduled unless so stated in the Remarks Section.
☐ **Copies of the attached consent form with the IRB approval stamp dated _____ must be used in obtaining consent for this study.**

☐ Minor modifications required. The required corrections/additions must be submitted to ORPD for review and approval. **This study may NOT be started UNTIL final IRB approval has been received.**
(See Remarks Section for further information.)

☐ Project approval **deferred. This study may not be started until final IRB approval has been received.**
(See Remarks Section for further information.)

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

Any changes in protocol or Consent Forms must receive IRB approval prior to being implemented. You must submit a memo with a copy of the Consent Form and a revised Human Subjects Review Form, with the appropriate signatures, to the Office of Research and Program Development for review and approval.

PLEASE NOTE: Requested revisions for student proposals MUST include adviser's signature. All revisions MUST be highlighted.

☒ Education Requirements Completed. (Project cannot be started until IRB education requirements are met.)

cc: Chair, Physical Therapy

Cindy J. Resick 6-11-2003
Signature of 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 310 Form may be required. Contact ORPD to obtain the required documents.

(Revised 10/2002)

University of North Dakota Human Subjects Review Form

All research with human participants conducted by faculty, staff, and students associated with the University of North Dakota, must be reviewed and approved as prescribed by the University's policies and procedures governing the use of human subjects. It is the intent of the University of North Dakota (UND), through the Institutional Review Board (IRB) and the Office of Research and Program Development (ORPD), to assist investigators engaged in human subject research to conduct their research along ethical guidelines reflecting professional as well as community standards. The University has an obligation to ensure that all research involving human subjects meets regulations established by the United States Code of Federal Regulations (CFR). When completing the Human Subjects Review Form, use the "IRB Checklist" for additional guidance.

Please provide the information requested below:

Principal Investigator: Dr. Sue Jeno, Keri Doyle, Molly McDonald, Heather Partlow and Eric Paur

Telephone: (701) 777-2831 E-mail Address: sujeno@medicine.nodak.edu

Complete Mailing Address: University of North Dakota, P.O. Box 9037, Grand Forks, ND 58202

School/College: School of Medicine and Health Science Department: Physical Therapy

Student Adviser (if applicable): Dr. Sue Jeno

Telephone: (701) 777-2831 E-mail Address: sujeno@medicine.nodak.edu

Address or Box #: University of North Dakota, P.O. Box 9037, Grand Forks, ND 58202

School/College: School of Medicine and Health Science Department: Physical Therapy

Project Title: An Electromyographic Study of Lower Trapezius Muscle Activity During the Traditional Muscle Testing Position and a Modified Position.

Proposed Project Dates: Beginning Date: May 15, 2003 Completion Date: May 15, 2004 (Including data analysis)

Funding agencies supporting this research: None

(A copy of the funding proposal for each agency identified above MUST be attached to this proposal when submitted.)

___ YES or _X_ NO Does the Principal Investigator or any researcher associated with this project have a financial interest in the results of this project? If yes, please submit, on a separate piece of paper, an additional explanation of the financial interest (other than receipt of a grant)

If your project has been or will be submitted to another Institutional Review Board(s), please list those boards below along with the status of each proposal.

_____ Date submitted: _____ Status: ___ Approved ___ Pending

_____ Date submitted: _____ Status: ___ Approved ___ Pending

Type of Project: Check "Yes" or "No" for each of the following.

_X_ YES or ___ NO New Project

___ YES or _X_ NO Continuation/Renewal

___ YES or _X_ NO Dissertation/Thesis

_X_ YES or ___ NO Student Research Project

___ YES or _X_ NO Is this a Protocol Change for previously approved project? If yes, submit a signed copy of this form with the changes bolded or highlighted.

___ YES or _X_ NO Does your project include Genetic Research? If yes, refer to Chapter 3 of the Researcher Handbook for additional guidelines regarding your topic.

___ YES or _X_ NO Does your project include Internet Research? If yes, refer to Chapter 3 of the Researcher Handbook for additional guidelines regarding your topic.

___ YES or _X_ NO Will subjects or data be provided by Altru Health Systems? If yes, submit two copies of the proposal. A copy of the proposal will be provided to Altru.

Will research subjects be recruited at another organization (e.g., hospitals, schools, YMCA) or will assistance with the data collection be obtained from another organization?

___ YES or _X_ NO

If yes, list all institutions: _____

Letters from each organization must accompany this proposal. Each letter must illustrate that the organization understands their involvement in that study, and agrees to participate in the study. Letters must include the name and title of the individual signing the letter and, if possible, should be printed on letterhead.

Subject Classification: This study will involve subjects who are in the following special populations: Check all that apply.

_____ Minors (< 18 years)
_X_ UND Students
_____ Prisoners
_____ Pregnant Women/Fetuses
_____ Persons with impaired ability to understand their involvement and/or consequences of participation in this research
_____ Other _____

For information about protections for each of the special populations, refer to Chapter 5 of the Researcher Handbook.

This study will involve: Check all that apply.

_____ Deception
_____ Radiation
_____ New Drugs (IND)
_____ Non-approved Use of Drug(s)
_____ Recombinant DNA
_X_ None of the above will be involved in this study
_____ Stem Cells
_____ Discarded Tissue
_____ Fetal Tissue
_____ Human Blood or Fluids
_____ Other
_____

I. Project Overview

Please provide a brief explanation (limit to 200 words or less) of the rationale and purpose of the study, introduction of any sponsor(s) of the study, and justification for use of human subjects and/or special populations (e.g., vulnerable populations such as minors, prisoners, pregnant women/fetuses).

There is little published research that clearly establishes the most effective position in which to exercise the lower trapezius muscle.

The purpose of this study is to determine whether the lower trapezius is more effectively recruited in the traditional exercise position of forward shoulder elevation in 145° of shoulder abduction verses a modified position of shoulder external rotation while in 80° of shoulder abduction and 90° of elbow flexion. The muscle activity of 40-50 recruited subjects will be collected via electromyographic (EMG) procedures using surface electrodes.

Normal, healthy, adult (18-45 years of age) subjects will be used in this research project. Human subjects are needed for this research study in order to measure muscle activity of the lower trapezius in two different positions.

II. Protocol Description

Please provide a succinct description of the procedures to be used by addressing the instructions under each of the following categories. Individuals conducting clinical research please refer to the "Guidelines for Clinical-Research Protocols" on the Office of Research and Program Development website.

1. Subject Selection.

a) Describe recruitment procedures (i.e., how subjects will be recruited, who will recruit them, where and when they will be recruited and for how long) and include copies of any advertisements, fliers, etc., that will be used to recruit subjects.

It will be anticipated that we will recruit 40-50 subjects (both male and female) between 18-45 years of age. The subjects for the study will be recruited from the University of North Dakota student population by the principle investigators by placing flyers explaining the study at various locations on campus (see attached flyer).

b) Describe your subject selection procedures and criteria, paying special attention to the rationale for including subjects from any of the categories listed in the "Subject Classification" section above.

Subjects will be chosen because of their age, health status and availability.

c) Describe your exclusionary criteria and provide a rationale for excluding subject categories.

Only subjects with no history of right shoulder pathology will be used in this study because only healthy individuals will be tested to obtain optimal data. Shoulder pathology will be defined as any condition that required physician intervention. Subjects who are allergic to latex and alcohol will also be excluded from this study.

d) Describe the estimated number of subjects that will participate and the rationale for using that number of subjects.

It will be anticipated that we will recruit 40-50 subjects (both male and female) between 18-45 years of age. The number of subjects will be used to add power and validity to the statistical analysis.

e) Specify the potential for valid results. If you have used a power analysis to determine the number of subjects, describe your method.

With 40-50 subjects and a standardized protocol for electrode placement and data collection, the risk for errors is reduced and the potential for valid results will be high. Also contributing to validity and reduction of training effects is the randomization of the order of testing the exercises.

2. Description of Methodology.

a) **Describe the procedures used to obtain informed consent.**

Informed consent will be obtained by asking each subject to read and complete an informed consent form (see attached form). All individuals participating in this study will be capable of individual decision making and will sign a consent form stating their understanding and willingness to participate in this study. A copy of the consent form will be provided to each participant.

b) Describe where the research will be conducted.

The research will be conducted in the Physical Therapy Department at the University of North Dakota.

c) **Indicate who will carry out the research procedures.**

The research will be conducted by Sue Jeno, PT, PhD and four graduate students: Keri Doyle, Molly McDonald, Heather Partlow and Eric Paur.

d) Briefly describe the procedures and techniques to be used and the amount of time that is required by the subjects to complete them.

EMG data will be collected during 4 exercise trials of 10 repetitions each on the right shoulder. Each subject will be given a short training session to learn the proper procedure and technique to be used during the trials. The subject will lay prone on a hi-lo plinth with a handswitch attached to a second hi-lo plinth with a 2X4 clamp. To prepare for data collection, the subjects mid-back will be exposed being sure to maintain the subject's modesty. Adhesive electrodes will be placed on the lower trapezius motor point that will be defined as the mid-point of a line drawn from the 7^{th} thoracic vertebrae to the inferior angle of the scapula or found with the use of a biofeedback device. This point will be marked with a felt tip pen. Prior to placing the electrodes the area will be cleaned with isopropyl alcohol and any excess hair will be shaved using an electric razor if necessary.

The subjects will perform a voluntary maximal isometric contraction of the lower trapezius in the traditional test position previous to beginning the exercises. This information will be used for normalization of the data. Four exercise trials of 10 repetitions each will be performed in prone as follows: shoulder external rotation with a 2 pound handweight, shoulder external rotation without a 2 pound handweight, forward shoulder elevation with a 2 pound handweight and forward shoulder elevation without a 2 pound handweight. The shoulder external rotation position will be: 80° of shoulder abduction with the elbow flexed to 90°, and palm facing the floor. The forward shoulder elevation position will be: 145° of shoulder abduction with thumb pointed toward the ceiling. The order of exercises will be randomly selected to avoid training effects. The exercises will be performed at a metronome cadence of 60 repetitions per minute for 10 repetitions to increase consistency in timing. The subject will be given 2 minutes rest between each trial. All trials will be compared to

the traditional position of forward elevation without the 2 pound weight because this is the standard position for manual muscle testing of the lower trapezius.

The EMG signals will be transmitted to the receiver unit and into a computer for display and analysis. At the conclusion of data collection, the electrodes will be removed and the skin will be cleaned with alcohol. This will end the subject's participation in the study. The study will require no longer than 1 hour of each of the subjects' time.

e) **Describe audio/visual procedures and proper disposal of tapes.**

No video tapes will be used in this study, however, digital photographs will be taken for illustration purposes. We will receive consent for use of these pictures prior to the procedure.

f) **Describe the qualifications of the individuals conducting all procedures used in the study.**

All the individuals who are conducting the procedures are currently faculty or Graduate Physical Therapy Students at the University of North Dakota, who have all completed an instrumentation course in Electromyography.

g) **Describe compensation procedures (payment or class credit, etc.).**

Subjects will receive no payment or class credit for participation in this study.

Attachments Necessary: Copies of all instruments (such as survey/interview questions, data collection forms completed by subjects, etc.) must be attached to this proposal.

3. **Risk Identification.**

a) **Clearly describe the anticipated risks to the subject/others including any physical, emotional, and financial risks that might result from this study.**
The risks involved in this research project are minimal. The EMG equipment causes no discomfort to the subject, since it is a monitoring device. The process used in this study may impose a potential for minimal risk of injury to the muscle, but not greater than would be anticipated with light exercise. The testing will occur in a controlled setting, and because only healthy subjects will be used, the risk of any injury is low. There is minimal risk the participant may experience discomfort, pain, fatigue or other symptoms associated with light exercise such as increased heart rate, sweating or dizziness. Because of exposure of the back, there is some risk to the modesty of the subject during electrode placement, but properly draping the subject with sheets and having the female subjects wear halter-tops will control this risk. There may be a slight redness of the skin following the removal of the electrodes, but this should only be temporary.

In the event that this research activity (conducted at the University of North Dakota's 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 the subject or by the subject's third party payer, if any.

b) **Indicate whether there will be a way to link subject responses and/or data sheets to consent forms, and if so, what the justification is for having that link.**
The subject's 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 the subject will remain confidential and will be disclosed only with permission from the subject. The research data and the subject's consent form will be connected by a single number, which will be known only by the investigators. At the completion of the study the research data and the subject's consent forms will be stored at separate, locked locations in the Physical Therapy Department for a minimum of 3 years, then shredded. Data will be reported in aggregate form only.

4. **Subject Protection.**

a) **Describe precautions you will take to minimize potential risks to the subjects (e.g., sterile conditions, informing subjects that some individuals may have strong emotional reactions to the procedures, debriefing, etc.).**
The participant will be closely observed throughout the procedure to decrease the potential of harm. 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 or her health. To avoid risk to the subject's modesty, each subject will be in a private room during the placement of the electrodes by an investigator. All electrodes will be disposable and each subject will be given a separate set for personal use only. The electrodes are used for recording only, therefore there is no potential risk of injury from the electrodes specifically.

b) **Describe procedures you will implement to protect confidentiality (such as coding subject data, removing identifying information, reporting data in aggregate form, etc.).**
The subjects' names will not be used in any results of this study. Any information that is obtained in connection with this study that can be identified with the subject will remain confidential and will be disclosed only with that individual's permission. A number known only to the investigator will identify the data, and the data will only be presented in aggregate form.

c) **Indicate that the subject will be provided with a copy of the consent form and how this will be done.**
All subjects will be given a separate copy of the consent form for their own records at the start of this study.

d) **Describe the protocol regarding record retention. Please indicate that research data from this study and consent forms will both be retained in separate locked locations for a minimum of three years following the completion of the study.**

Describe: 1) the storage location of the research data (separate from consent forms and subject personal data)
2) who will have access to the data
3) how the data will be destroyed
4) the storage location of consent forms and personal data (separate from research data)
5) how the consent forms will be destroyed

Signed consent forms and data collected will be kept in a separate locked filing cabinets in the Physical Therapy Department for a minimum of 3 years. Only people with a need to know basis for this information will be allowed access to these files. After the forms and data are no longer needed, they will be shredded for final disposition.

e) **Describe procedures to deal with adverse reactions (referrals to helping agencies, procedures for dealing with trauma, etc.).**
The investigators or participants 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 or her health. The decision whether or not to participate will not prejudice the individual's future relationship with the Department of Physical Therapy at the University of North Dakota. If subjects decide to participate, they are free to discontinue participation at any time without prejudice.

f) **Include an explanation of medical treatment available if injury or adverse reaction occurs and responsibility for costs involved.**
In the event that this research activity results in injury, medical treatment will be as available as it is to a member of the general public in similar circumstances. The person and their third party payer must provide payment for any such treatment

III. Benefits of the Study

Clearly describe the benefits to the subject and to society resulting from this study (such as learning experiences, services received, etc.). Please note: payment is not a benefit and should be listed in the Protocol Description section under Methodology.

The data collected through this research study will be analyzed to determine if there is any difference in muscle activity of the lower trapezius muscle in the traditional manual muscle testing position and the alternate position. With the data this study will provide, we anticipate to find a lower trapezius strengthening and/or testing position that will allow the same amount of muscle activity as the traditional testing position but without risk of shoulder impingement. The benefit to the participant will be the experience of being involved in a scientific study, and knowing that they will be contributing to the body of knowledge of exercise physiology and physical therapy.

IV. Consent Form

A copy of the consent form must be attached to this proposal. If no consent form is to be used, document the procedures to be used to protect human subjects. Refer to the ORPD website for further information regarding consent form regulations. Please note: Regulations require that all consent forms, and all pages of the consent forms, be kept for a minimum of 3 years after the completion of the study, even if subject does not continue participation. The consent form must be written in language that can easily be read by the subject population and any use of jargon or technical language should be avoided. It is recommended that the consent form be written in the third person (please see the examples on the ORPD website). A two inch

by two inch blank space must be left on the bottom of each page of the consent form for the IRB approval stamp. The consent form must include the following elements:

a) An introduction of the principal investigator

b) An explanation of the purposes of the research

c) The expected duration of subject participation

d) A brief summary of the project procedures

e) A description of the benefits to the subject/others anticipated from this study

f) A paragraph describing any reasonably foreseeable risks or discomforts to the subject

g) Disclosure of any alternative procedures/treatments that are advantageous to the subject

h) An explanation of compensation/medical treatment available if injury occurs.

i) A description of how confidentiality of subjects and data will be maintained. Indicate that the data and consent forms will be stored separately for at least three years following the completion of the study. Indicate where, in general, the data and consent documents will be stored and who has access. Indicate how the data will be disposed of. Be sure to list any mandatory reporting requirements that may require breaking confidentiality.

j) The names, telephone numbers and addresses of two individuals to contact for information (generally the student and student adviser). This information should be included in the following statement: "If you have questions about the research, please call (insert Principal Investigator's name) at (insert phone number of Principal Investigator) or (insert Adviser's name) at (insert Adviser's phone number). If you have any other questions or concerns, please call the Office of Research and Program Development at 777-4279."

k) If applicable: an explanation of who to contact in the event of a research-related injury to the subject.

l) If applicable: an explanation of financial interest must be included.

m) Regarding Participation in the study:

1) An indication that participation is voluntary and that no penalties or loss of benefits will result from refusal to participate.

2) An indication that the subject may discontinue participation at any time without penalty, with an explanation of how they can discontinue participation.

3) An explanation of circumstances which may result in the termination of a subject's participation in the study.

4) A description of any anticipated costs to the subject.

5) A statement indicating whether the subject will be informed of the findings of the study.

6) A statement indicating that the subject will receive a copy of the consent form.

By signing below, you are verifying that the information provided in the Human Subjects Review Form and attached information is accurate and that the project will be completed as indicated.

Signatures:

_____

(Principal Investigator) Date:

_____

(Student Adviser) Date:

Requirements for submitting proposals:
Additional information can be found at the ORPD website at **www.und.nodak.edu/dept/orpd**

Original Proposals and all attachments should be submitted to the Office of Research and Program Development, P.O. Box 7134, Grand Forks, ND 58202-7134, or brought to Room 105, Twamley Hall.

Prior to receiving IRB approval, researchers must complete the required IRB human subjects' education. Please go to http://www.und.nodak.edu/dept/orpd/regucomm/irb/Default.htm for more information.

The criteria for determining what category your proposal will be reviewed under is listed on page 3 of the IRB Checklist. Your reviewer will assign a review category to your proposal. Should your protocol require full Board review, you will need to provide additional copies. Further information can be found on the ORPD website regarding required copies and IRB review categories, or you may call the ORPD office at 701 777-4279.

In cases where the proposed work is part of a proposal to a potential funding source, one copy of the completed proposal to the funding agency (agreement/contract if there is no proposal) must be attached to the completed Human Subjects Review Form if the proposal is non-clinical; 7 copies if the proposal is clinical-medical. If the proposed work is being conducted for a pharmaceutical company, 7 copies of the company's protocol must be provided.

Please Note: Student Researchers must complete the "Student Consent to Release of Educational Record".

Revised 4/14/03

STUDENT RESEARCHERS: As of June 4, 1997 (based on the recommendation of UND Legal Counsel) the University of North Dakota IRB is unable to approve your project unless the following "Student Consent to Release of Educational Record" is signed and included with your "Human Subjects Review Form."

STUDENT CONSENT TO RELEASE OF EDUCATIONAL RECORD[1]

Pursuant to the Family Educational Rights and Privacy Act of 1974, I hereby consent to the Institutional Review Board's access to those portions of my educational record which involve research that I wish to conduct under the Board's auspices. I understand that the Board may need to review my study data based on a question from a participant or under a random audit.

The study to which this release pertains is

An Electromyographic Study of Lower Trapezius Muscle Activity During the Traditional Muscle Testing Position and a Modified Position.

I understand that such information concerning my educational record will not be released except on the condition that the Institutional Review Board will not permit any other party to have access to such information without my written consent. I also understand that this policy will be explained to those persons requesting any educational information and that this release will be kept with the study documentation.

Date

Signature of Student Researcher

[1]Consent required by 20 U.S.C. 1232g.

APPENDIX E

TRAINING TEMPLATE

You will be asked to complete a series of four exercises with your arm in two different positions. All exercises will be completed while lying on your stomach. While in each position you will perform ten repetitions of an exercise once without a two-pound weight and once with a two-pound weight. You will be given two minutes rest in between each set of ten repetitions. You will randomly select the order of the exercises and be instructed on the exercises in the order that you have selected them.

Traditional Position without the Weight

Your arm will be placed in 145° of abduction parallel to the plane of the table. Your elbow will be straight with your arm rotated out so your thumb is pointed towards the ceiling. You will then complete ten repetitions of forward elevation without a two-pound hand weight to a cadence determined by a metronome. Each repetition will begin with your arm slightly below the table and proceed through maximum elevation where a hand switch will be placed and activated with each repetition. A repetition will be considered complete when your arm is returned to the beginning position of slightly below the level of the table.

Traditional Position with the Weight

This exercise will be performed in the same position as the traditional position without weight except that you will be holding a two-pound hand weight.

Modified Position without the Weight

Your arm will be placed in 80° of abduction in a plane parallel to the table. A support device will be placed under your arm and adjusted to allow your arm to rest in between sets and to prevent your arm from moving too much forward, backward or down below the plane of the table during the exercises. Your elbow will be flexed to 90° and your palm will be facing the floor. You will then complete ten repetitions of external rotation without a two-pound hand weight while stabilizing your arm in 80° of abduction. A metronome will determine the cadence of the exercises. The starting position will be with your arm in slight internal rotation and you will proceed with external rotation until you reach and activate a hand switch placed at your maximum external rotation. A repetition will be considered complete when your arm is returned to the starting position.

Modified Position with the Weight

This exercise will be performed in the same position as the modified position without weight except that you will be holding a two-pound hand weight.

APPENDIX F

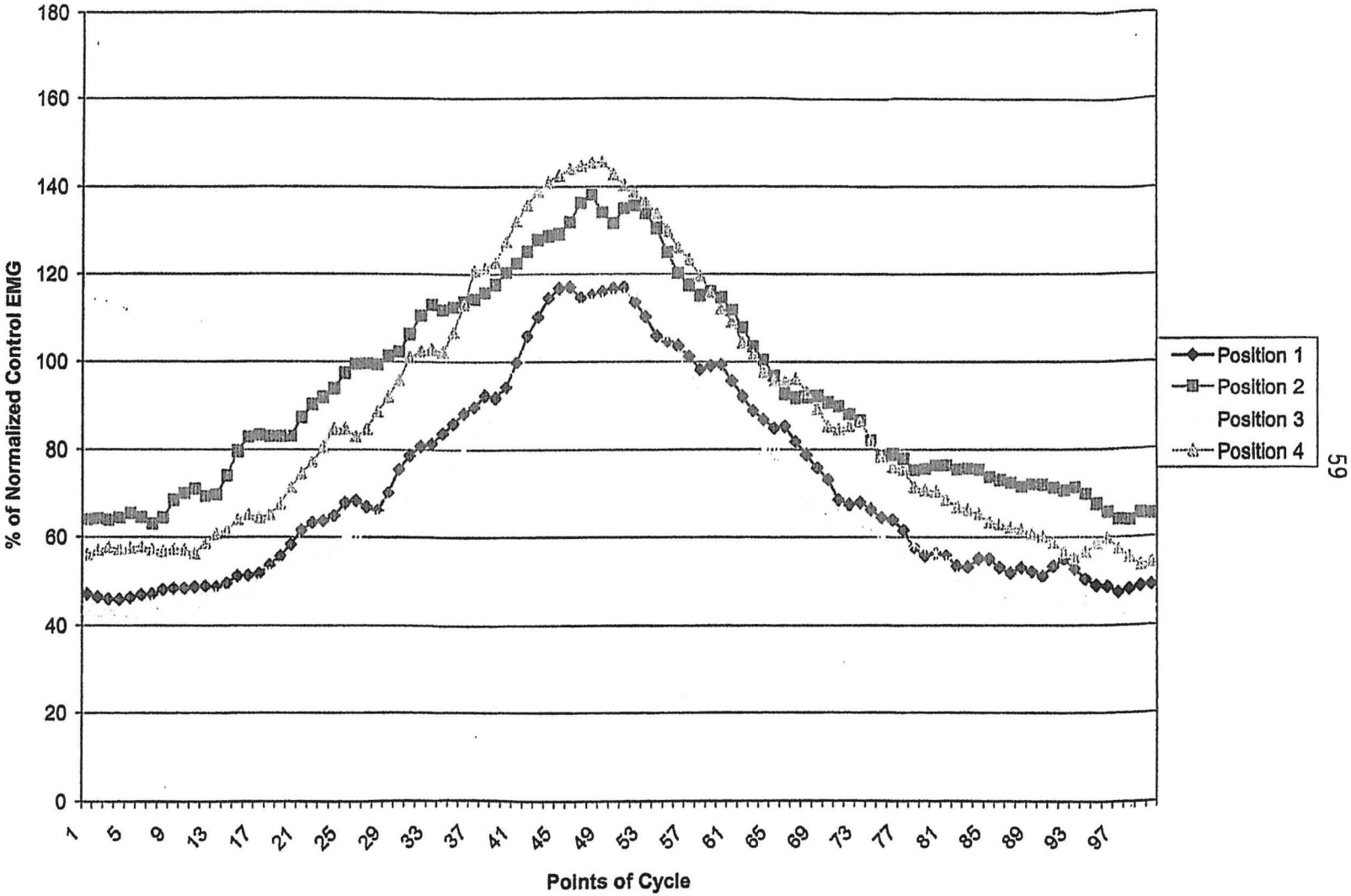

Figure 8. Comparison of lower trapezius muscle activity between all 4 exercise positions.

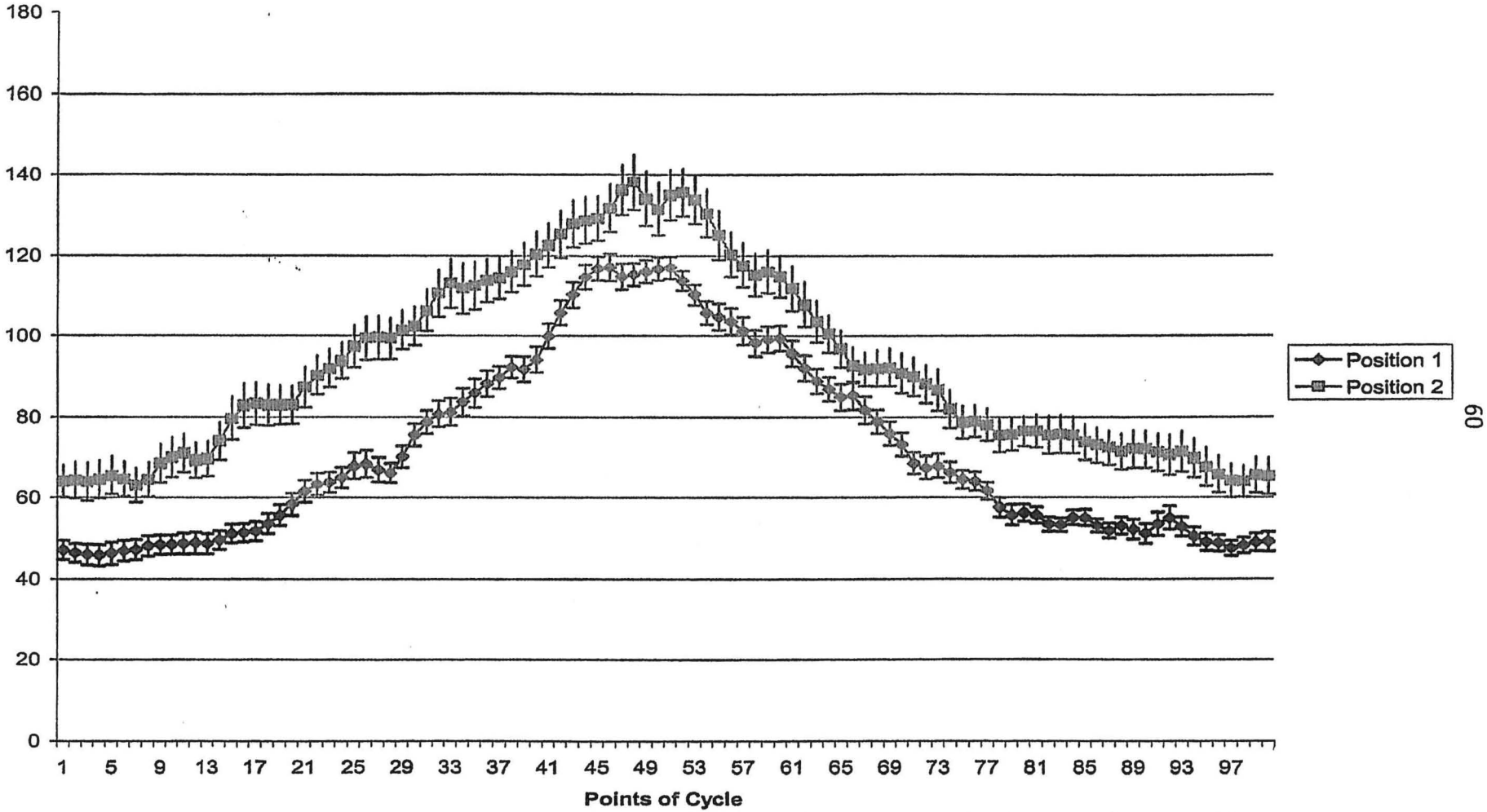

Figure 9. Comparison of lower trapezius muscle activity with standard errors between the traditional position without weight and the traditional position with weight.

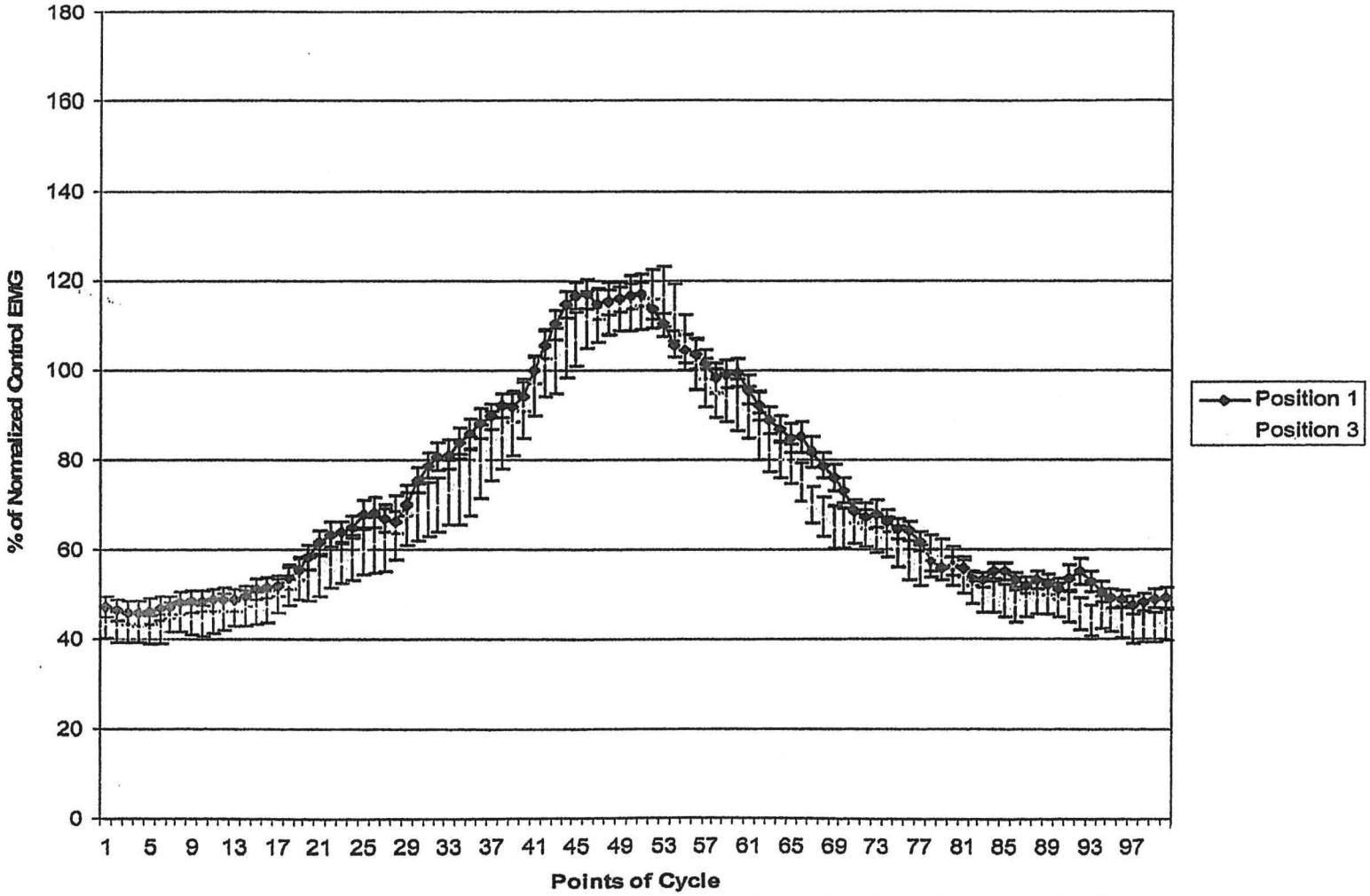

Figure 10. Comparison of lower trqpezius muscle activity with standard errors between the traditional position without weight and the modified position without weight.

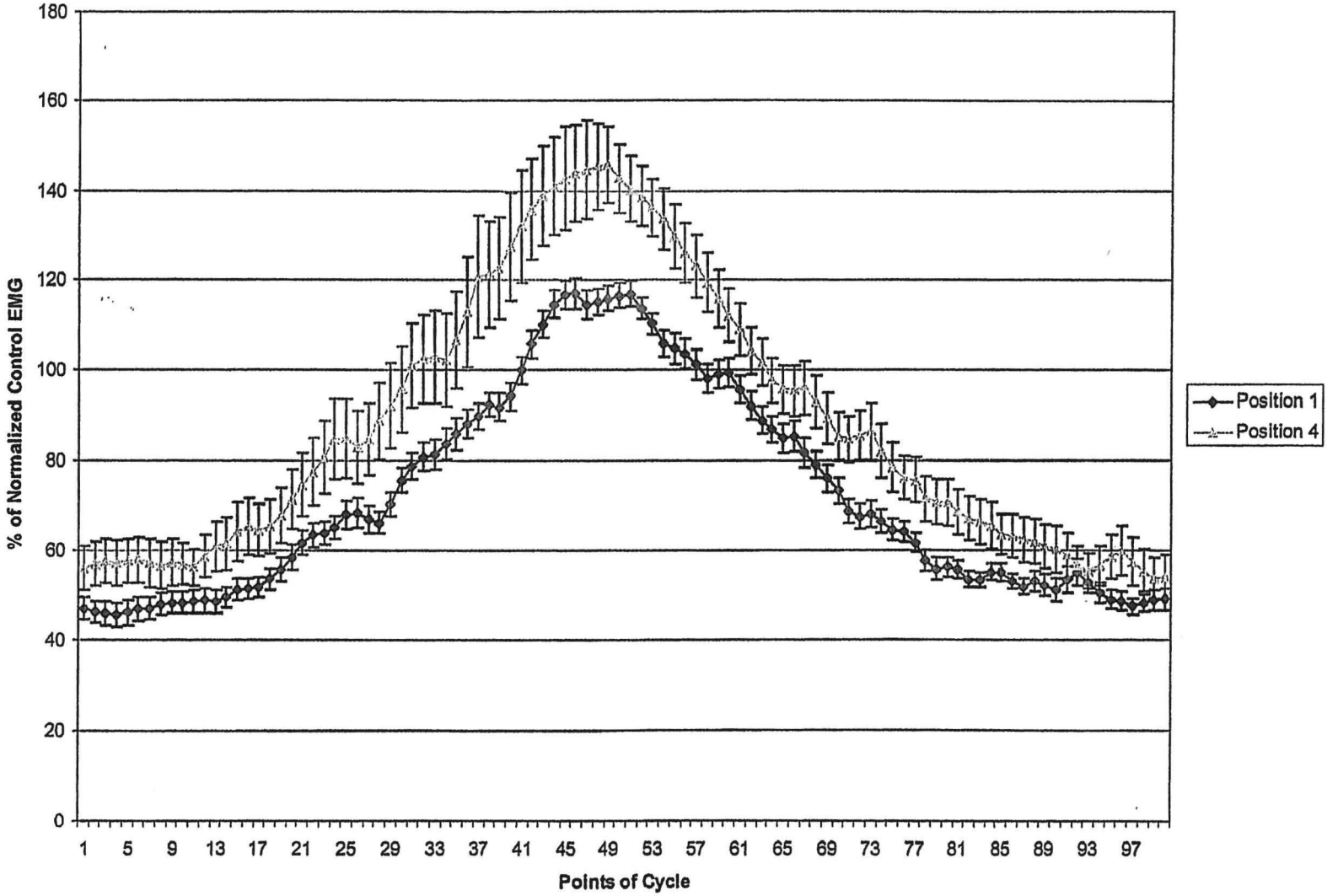

Figure 11. Comparison of lower trapezius muscle activity with standard errors between the traditional position without weight and the modified position with weight.

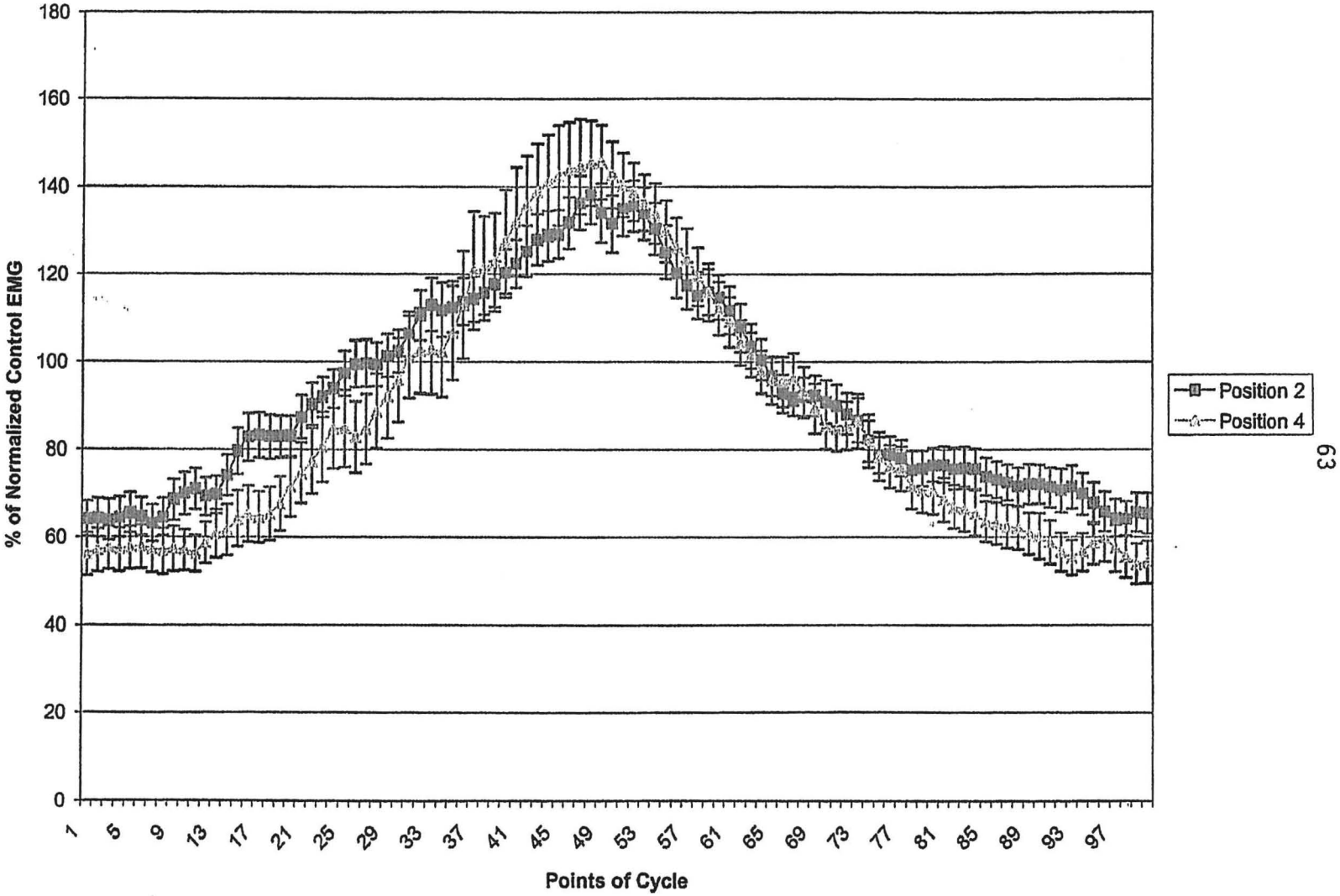

Figure 12. Comparison of lower trapezius muscle activity with standard errors between the traditional position with weight and the modified position with weight.

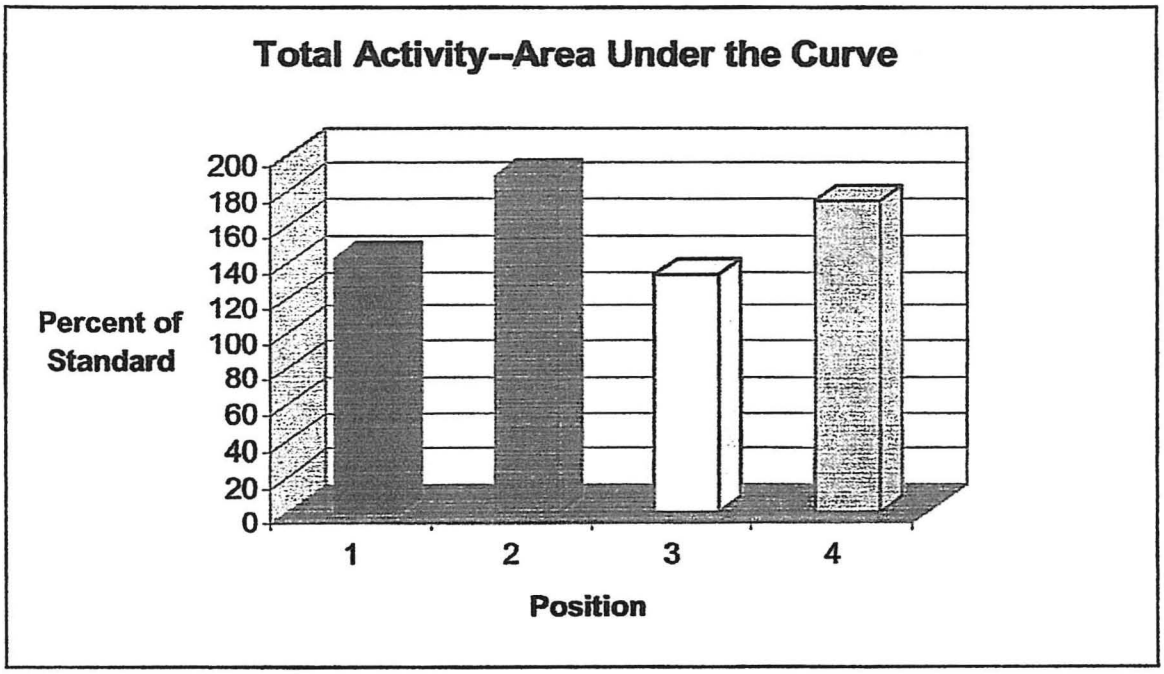

Figure 13. Comparison of total EMG activity of lower trapezius between the 4 exercise positions.

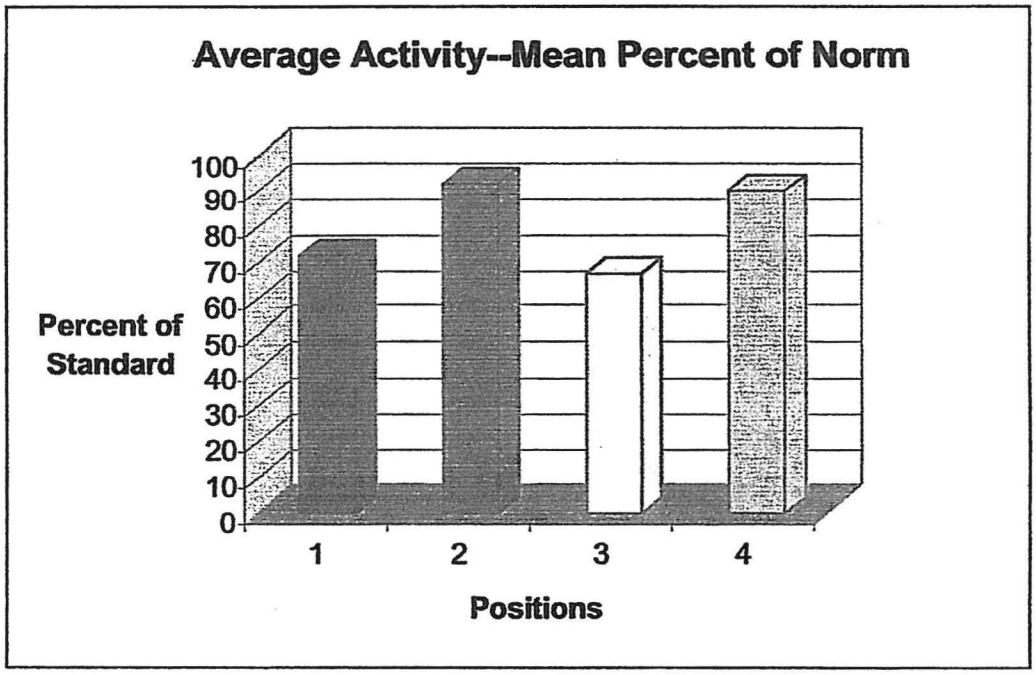

Figure 14. Comparison of average EMG activity of the lower trapezius between the 4 exercise positions.

APPENDIX G

RECEIVED

September 29, 2003

Heather Hawkins
Allyn and Bacon
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Dear Ms. Hawkins,

I am writing to request permission to reproduce copies of a figure in the book "Biomechanics, A Qualitative Approach for Studying Human Movement." The figure listed below would be used in our Scholarly Project as part of our graduate requirements for a Master of Physical Therapy degree form the University of North Dakota, Grand Forks, North Dakota.

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Fourth Edition, copyright 1996, ISBN 0-205-18651-3
Authors: Ellen Kreighbaum and Katherine M. Barthels

Figure 5-9, page 178—Structures important in shoulder impingement syndrome.

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Thank you for your attention to this request.

Sincerely,

Keri Doyle, SPT
Keri M. Doyle, SPT

Heather Partlow, SPT
Heather M. Partlow, SPT

Molly E McDonald, SPT
Molly E. McDonald, SPT

Eric R. Paur, SPT

Physical Therapy Department
University of North Dakota
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Dear Permissions Editor:

We are writing to request permission to reproduce copies of a figure in the book "Joint Structure and Function: A Comprehensive Analysis. The figure listed below would be used in our Scholarly Project as part of our graduate requirements for a Master of Physical Therapy degree from the University of North Dakota, Grand Forks, North Dakota.

Reprint request:

Joint Structure and Function: A Comprehensive Analysis
Third Edition, copyright 2001, ISBN 0-8036-0710-5
Authors: Pamela K. Levangie and Cynthia C. Norkin

Figure 7-28, page 216—The action lines of the upper trapezius, lower trapezius upper serratus anterior and lower serratus anterior combine to produce almost pure upward rotation of the scapula.

Six copies will be made for the following uses: Graduate School, Physical Therapy Library and for our own copies of the Scholarly Project. The standard credit line will be used to give proper recognition for the figures used.

Thank you for your attention to this request.

Sincerely,

Keri Doyle, SPT
Keri M. Doyle, SPT

Heather Partlow, SPT
Heather M. Partlow, SPT

Molly E McDonald, SPT
Molly E. McDonald, SPT

Eric R. Paur, SPT

Physical Therapy Department
University of North Dakota
PO Box 9037
Grand Forks, ND 58202
Fax # 1-701-777-4199

<<...OLE_Obj...>>
F. A. DAVIS COMPANY / PUBLISHERS

Dear Keri Doyle, Molly McDonald, Heather Partlow, and Eric Paur:

The Permissions Committee has met and considered your request to use Figure 7-28 from the F. A. Davis book entitled Joint Structure and Function: A Comprehensive Analysis, 3rd Edition by Levangie and Norkin in a scholarly project as part of the requirement for a Master of Physical Therapy degree from the University of North Dakota.

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