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An Electromyographic Study of Lower Trapezius Muscle Activity during Exercise in Traditional and Modified Positions

Erika Engelstad
University of North Dakota

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AN ELECTROMYOGRAPHIC STUDY OF LOWER TRAPEZIUS MUSCLE
ACTIVITY DURING EXERCISE IN TRADITIONAL
AND MODIFIED POSITIONS

by

Erika D. Engelstad
Bachelor of Science in Physical Therapy
University of North Dakota, 1999

An Independent Study
Submitted to the Graduate Faculty
of the
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
2000
This independent study, submitted by Erika D. Engelstad in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

<table>
<thead>
<tr>
<th>Title</th>
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<td>Physical Therapy</td>
</tr>
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<td>Degree</td>
<td>Master of Physical Therapy</td>
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Signature

Date November 23, 1999
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ACKNOWLEDGEMENTS

I would like to thank Dr. Sue Jeno for her many hours of hard work assisting with this project as well as proofreading and editing this Independent Study Report. Without her, this accomplishment would not have been possible. I would also like to thank my partner, Rebecca Johnson, for her extra efforts and time in performing the data analysis and bringing this project to its final form.
DEDICATION

I would like to dedicate this Independent Study to my family. Thank you for all of the love and support you have given me throughout the years. Without you, I would not be the person I am today.
Shoulder rehabilitation commonly overlooks the influence of scapular muscles in providing the stability necessary for the shoulder to function properly. When considering muscles acting on the scapulothoracic articulation, literature suggests that the lower trapezius is a key stabilizer of this articulation. Traditionally, the lower trapezius is exercised while the patient is in a prone position with the humerus abducted 145° while performing forward elevation. Unfortunately, repeated overhead activity has been proven to increase the incidence of shoulder impingement. In an effort to avoid exercising the lower trapezius in a position that would compromise the shoulder complex, a modified position of 80° of abduction while performing prone external rotation was proposed.

**Purpose:** The purpose of this study was to determine whether the lower trapezius was more effectively recruited in the traditional or modified exercise position. **Methods:** Ten subjects, both male and female, between the ages of 21 and 24 years old, were tested. Electromyographical (EMG) data was collected from each subject's right lower trapezius muscle while he/she performed exercise in the traditional position without weight, the traditional position with weight, the modified position without weight, and the modified position with weight in random order. **Results:** A significant difference was found in lower trapezius muscle activity when comparing exercise in the traditional position without the weight to exercise in the modified position without the weight. No significant difference was found in lower trapezius muscle activity when comparing
exercise in the traditional position without weight to exercise in the modified position with weight and the traditional position with weight. There was also no significant difference in peak muscle activity across all four exercise conditions. Conclusion: Exercise in the modified position with weight effectively recruits the lower trapezius and allows the patient to exercise in a position that does not compromise the shoulder complex.
CHAPTER I
INTRODUCTION

Proper function of muscles controlling the scapulothoracic articulation is vital to normal biomechanics of the shoulder.\textsuperscript{1} However, when rehabilitating the shoulder complex, this functional articulation is frequently overlooked.\textsuperscript{2} The anterior, middle, and posterior deltoid as well as the rotator cuff, consisting of the supraspinatus, infraspinatus, teres minor, and subscapularis are key muscles focused on during shoulder rehabilitation. Unfortunately, as stated above, exercises meant to improve function and stability of the scapula are often forgotten. When the scapulothoracic articulation is not addressed during shoulder rehabilitation, patients may not be achieving normal shoulder biomechanics, which may then contribute to recurrent shoulder injuries, such as impingement syndrome.

Research suggests that the lower trapezius should be emphasized when considering the muscles acting on the scapulothoracic articulation. The lower trapezius is actively recruited during upward rotation of the scapula, especially with abduction beyond 90°.\textsuperscript{3,4,5} This upward rotation of the scapula allows the glenoid fossa to be oriented, so that a stable base may be provided for articulation with the humeral head, thus allowing the full 180° of abduction.\textsuperscript{1,3,4}

Although the lower trapezius is active during humeral abduction, research states that it serves mainly as a postural muscle due to a high percentage of Type I muscle
fibers. The lower trapezius is especially active in stabilizing the scapula during the initial two thirds of abduction. Because the lower trapezius acts as both a stabilizer and a mover of the scapula, appropriate timing of scapular motion during humeral abduction is crucial for proper biomechanics of the shoulder complex in order to avoid new or recurrent shoulder injuries, such as impingement syndrome.

Problem Statement

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

Purpose

The purpose of this study was to determine whether the lower trapezius is more effectively recruited in the traditional exercise position of forward elevation in 145° of abduction or a modified exercise position of external rotation while in 80° of abduction and 90° of elbow flexion.

Significance of Study

The results of this study were twofold. First, they would allow therapists to incorporate more effective lower trapezius exercises into shoulder rehabilitation programs, therefore, they would be able to provide more efficient and complete care. Also, if the lower trapezius was found to be significantly active in the modified position, the patient would not be required to achieve 145° of abduction during exercise of this muscle. Thus, the chance of aggravating shoulder impingement was reduced.
Research Questions

1) Is there a significant difference in recruitment of the lower trapezius between the traditional and the suggested alternative exercise positions when tested with or without resistance?

2) Is there a significant difference in peak electromyographic (EMG) activity of the lower trapezius between the traditional and the suggested alternative exercise positions when tested with or without resistance?

Hypotheses

Null Hypothesis₁: There is no significant difference in recruitment of the lower trapezius between the traditional and the suggested alternative exercise positions when tested with or without resistance.

Alternative Hypothesis₁: There is a significant difference in recruitment of the lower trapezius between the traditional and the suggested alternative exercise positions when tested with or without resistance.

Null Hypothesis₂: There is no significant difference in peak EMG activity of the lower trapezius between the traditional and modified exercise positions when tested with or without resistance.

Alternative Hypothesis₂: There is a significant difference in peak EMG activity of the lower trapezius between the traditional and modified exercise positions when tested with or without resistance.
CHAPTER II
LITERATURE REVIEW

The shoulder complex is composed of the glenohumeral, acromioclavicular, and sternoclavicular joints, as well as a fascial articulation known as the scapulothoracic joint. Proper function of the above components of the shoulder complex is required for normal upper extremity motion and stability.

Scapulohumeral rhythm is a particular function that is essential for normal biomechanics of the shoulder complex. Introduced by Codman, scapulohumeral rhythm is the term used to describe the sum of movements contributed by the glenohumeral, acromioclavicular, sternoclavicular, and scapulothoracic joints during upper extremity elevation. Scapulohumeral rhythm serves two purposes. First, the distribution of motion between the glenohumeral and scapulothoracic joints during abduction of the arm allows the humeral head to rest comfortably in the glenoid fossa, providing additional shoulder stability. Secondly, scapular motion during abduction maintains an optimal length/tension relationship between the muscles acting on the humerus.

Scapulohumeral rhythm is discussed during two phases of abduction. During the initial phase of 0°-30° of abduction, the amount of humeral motion is much greater than the amount of scapular motion. Research states that during this phase of abduction, humeral motion accounts for 20°-25° of abduction while upward rotation of the scapula
accounts for 5°-10° of abduction, resulting in a 4:1 ratio. The second phase of abduction occurs from 30°-180° of abduction. The amount of humeral motion is still greater than that of the scapula, however, the ratio is now reduced from 4:1 to 5:4, resulting in an overall ratio of 2:1.8

In order to achieve normal scapulohumeral rhythm, proper scapular motion and stability are essential. For example, when the humerus is beyond 90° of abduction, the lower trapezius acts as a mover of the scapula by upwardly rotating it. This upward rotation of the scapula is required in order to achieve the full 180° of shoulder elevation. Of 180° of possible shoulder elevation, 120° are allowed at the glenohumeral joint with the other 60° obtained through upward rotation of the scapula at various points during shoulder elevation.1,5,9

The lower trapezius is an important stabilizer of the scapula when in less than 90° of abduction.3,4,5 Ballantyne et al.4 examined EMG activity of several different muscles during exercise in many different positions. Out of all positions tested, the lower trapezius was found to display the most EMG activity during prone lateral rotation and the least amount of activity in the empty can position which is performed in scaption with maximal internal or external rotation.4 The position of scaption is considered to be halfway between flexion and abduction (30°-45° anterior to the coronal plane).10 During prone lateral rotation, each subject’s humerus was abducted 90°, and during exercise in the empty can position, each subject was instructed to remain below 90° of abduction.4 Because the lower trapezius was found to be more active when the humerus was abducted 90° than when it was abducted less than 90°, the authors concluded that the lower
trapezius functions as a mover of the scapula when beyond 90° of abduction and a stabilizer of the scapula when in less than 90° of abduction.

Other research states that the lower trapezius has a high percentage of Type I fibers, therefore it is primarily a postural muscle that serves to stabilize the scapula during all motions of the shoulder complex. The lower trapezius is thought to be especially active in stabilizing the scapula during the lower two thirds of abduction.

Although both scapulothoracic function and stability are essential for normal scapulohumeral rhythm, they are frequently overlooked during rehabilitation. This implies that scapulothoracic weakness may be a factor in recurrent shoulder injuries, such as impingement syndrome.

Impingement syndrome is most commonly referred to as an overuse syndrome that is caused by repetitive overhead activity. The supraspinatus tendon is most often affected. The supraspinatus tendon extends from the medial two thirds of the supraspinous fossa of the scapula, passes under a structure called the coracoacromial arch, and inserts onto the greater tuberosity of the humerus. The coracoacromial arch is formed by the coracoacromial ligament that attaches to the acromion process on one end and the coracoid process on the other, forming a bridge between the two structures (Figure 1).

When one is required to reach overhead, pressure on the supraspinatus tendon is increased, as the space under the coracoacromial arch decreases. This is because the supraspinatus tendon is required to pass under the coracoacromial arch along with many other structures including the greater tuberosity of the humerus, the tendon of the long head of the biceps brachii muscle, and subdeltoid bursa, to name a few (Figure 1).
Figure 1. During humeral elevation and abduction, several structures, including the supraspinatus tendon, must pass under the coracoacromial arch. The coracoacromial arch is formed by the coracoacromial ligament (CA LIGAMENT), which forms a bridge between the coracoid process and the acromion process. Reprinted with permission from Shoulder Pain, 3rd ed. Philadelphia, PA: F.A. Davis Co; 1991:55 (Appendix A).
Because of the course followed by the supraspinatus tendon and the small space it is allowed to function within, this tendon is often subject to compression during overhead activities (Figure 1). Therefore, repetitive overhead activity results in microtears of the supraspinatus tendon, which cause subsequent pain with elevation and abduction, and ultimately progress to impingement syndrome.¹¹

Improper biomechanics of the shoulder complex further aggravate impingement syndrome. For example, when a patient presents with a kyphotic posture (rounded shoulders), the ability of the scapula to upwardly rotate during humeral abduction is decreased. This reduction in upward rotation of the scapula compromises the biomechanics of the shoulder complex, thus aggravating shoulder pathology. Kyphosis also allows for increased microtearing of the supraspinatus tendon because the space under the coracoacromial arch is decreased, therefore, compression of the supraspinatus tendon during elevation and abduction is increased. Posture can be improved by strengthening the scapulothoracic muscles, including the lower trapezius, which, in turn, would enhance biomechanics of the shoulder complex.¹¹

The muscles that act on the scapulothoracic articulation include the levator scapula; rhomboid major; rhomboid minor; latissimus dorsi; pectoralis major; pectoralis minor; serratus anterior; and the upper, middle, and lower trapezius.¹,₅,¹⁰ The origins, insertions, and actions of these muscles are described below (Table 1).¹⁰

It is suggested that the trapezius and serratus anterior are among the most important muscles acting on the scapulothoracic articulation.¹,₅ Together, these muscles act as a force couple to allow the full 180° of humeral elevation by upwardly rotating the

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serratus Anterior</td>
<td>Ribs 1-8, Aponeurosis of intercostal muscles</td>
<td>Vertebral border of the scapula from superior to inferior angles</td>
<td>Scapular abduction and upward rotation; Adduction</td>
</tr>
<tr>
<td>Upper Trapezius</td>
<td>Occiput, C7 vertebrae, ligamentum nuchae</td>
<td>Clavicle (lateral one third of acromion)</td>
<td>Scapular elevation and upward rotation</td>
</tr>
<tr>
<td>Middle Trapezius</td>
<td>T1-T6 vertebrae, spinous processes and supraspinous ligaments</td>
<td>Acromion and spine of the scapula</td>
<td>Scapular adduction</td>
</tr>
<tr>
<td>Lower Trapezius</td>
<td>T7-T12 vertebrae, spinous processes</td>
<td>Spine of the scapula</td>
<td>Scapular adduction, depression and upward rotation</td>
</tr>
<tr>
<td>Levator Scapula</td>
<td>C1-C4 vertebrae, transverse processes</td>
<td>Vertebral border of the scapula</td>
<td>Scapular elevation</td>
</tr>
<tr>
<td>Rhomboid Major</td>
<td>T2-T5 vertebrae, spinous processes</td>
<td>Vertebral border of the scapula</td>
<td>Scapular adduction and downward rotation</td>
</tr>
<tr>
<td>Rhomboid Minor</td>
<td>C7-T1 vertebrae, spinous processes, ligamentum nuchae</td>
<td>Root of the spine of the scapula</td>
<td>Scapular adduction and downward rotation</td>
</tr>
<tr>
<td>Latissimus Dorsi</td>
<td>T6-T12, L1-L5, sacral vertebrae, Ribs 9-12, Inferior angle of the scapula, Iliac crest</td>
<td>Bicipital groove of the humerus</td>
<td>Shoulder extension, adduction, and medial rotation; Scapular adduction</td>
</tr>
<tr>
<td>Pectoralis Major</td>
<td>Sternal half of the clavicle, Sternum (anterior surface to rib 6), Costal Cartilages of ribs 1-7</td>
<td>Bicipital groove of the humerus</td>
<td>Shoulder horizontal adduction, medial rotation, flexion, extension, depression, and coronal adduction; Scapular adduction</td>
</tr>
<tr>
<td>Pectoralis Minor</td>
<td>Costal cartilages of ribs 3-5</td>
<td>Coracoid process of the scapula</td>
<td>Scapular depression and abduction</td>
</tr>
</tbody>
</table>
scapula, which orients the glenoid fossa, so that a stable base may be provided for articulation with the humeral head.\textsuperscript{1,3,4}

Separately, the lower trapezius is consistently found to be a vital muscle for humeral abduction. It plays an active role in upward rotation of the scapula when above 90\textdegree{} of abduction and an essential, stabilizing role when in less than 90\textdegree{} of abduction.\textsuperscript{1,3-5} Without proper scapular stability, normal biomechanics of the shoulder complex cannot be maintained, therefore the risk of new or recurrent shoulder injuries is increased.\textsuperscript{1,4-7}

Several articles have been published attempting to determine effective exercises for shoulder musculature.\textsuperscript{4,5,12,13} However, most information available on exercising shoulder girdle musculature is based on anatomic knowledge and not quantifiable data, such as electromyography (EMG). This is found to be especially true of the scapular muscles.\textsuperscript{13}

There is an especially high level of discrepancy as to which exercises most effectively elicit muscle activity from the lower trapezius.\textsuperscript{4,5,12,13} One study, by Saha and Chakravarty\textsuperscript{12} found the lower trapezius to display the most activity between 90\textdegree{} and 120\textdegree{} of abduction before demonstrating decreasing activity. A second study found the lower trapezius to be most active from 90\textdegree{}–120\textdegree{} of scaption.\textsuperscript{12} A final study evaluated concluded that there is a high level of variability in EMG patterns of the lower trapezius, which may help to explain the contradictions in previous investigations of lower trapezius activity.\textsuperscript{13}

Because of the amount of discrepancy as to which exercises most effectively elicited muscle activity from the lower trapezius, EMG activity of the lower trapezius in traditional and modified positions was examined. Traditionally, the lower trapezius is
tested in the prone position with the arm overhead and abducted to 145° with the thumb pointed toward the ceiling. If found deficient, or weak, the muscle is then exercised by performing forward elevation while in the previously described position. Because this position requires a high degree of abduction and places the glenohumeral joint in the impingement position, it may be difficult for an individual with shoulder pathology to obtain.

Prone external rotation while in a modified position of 80° of humeral abduction and 90° of elbow flexion was suggested as a possible alternative to strengthen the lower trapezius without increasing glenohumeral impingement. No conclusive data exists for the level of lower trapezius muscle activity in this position. Therefore, a pilot study was performed in order to examine EMG activity in the modified position and determine whether or not the lower trapezius was effectively recruited.
CHAPTER III
METHODOLOGY

Subjects

Ten normal, healthy students from the Department of Physical Therapy were voluntarily recruited to participate in this study. The mean age of the subjects was 22.3 years old. Seven subjects were female and three 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 patient questionnaire that was filled out prior to testing (Appendix B). Each subject signed a letter of informed consent prior to the testing procedure (Appendix C). A letter giving permission to use pictures of setup and positioning was also signed by the appropriate subject (Appendix D). This study was approved by the Institutional Review Board of the University of North Dakota (Project # IRB-9904-200; Appendix E).

Table 2. Characteristics of Subjects (n = 10)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Age (years)</th>
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<th>Height (inches)</th>
<th>Weight (pounds)</th>
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<td>F</td>
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<td>22</td>
<td>F</td>
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<td>24</td>
<td>F</td>
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<td>68.5</td>
<td>135</td>
</tr>
<tr>
<td>10</td>
<td>21</td>
<td>F</td>
<td>63</td>
<td>136</td>
</tr>
</tbody>
</table>
Instrumentation

The EMG data was collected using a Naraxon Telemyo8 telemetry unit (Noraxon USA, 13430 North Scottsdale Rd., Scottsdale, AZ, 85254). Information was collected, transmitted, and converted to a digitized form by an analog to digital interface board installed in the computer. The digitized EMG signals were analyzed using the MyoResearch '97 software package. EMG data was collected during four exercise trials of ten repetitions each.

Procedure

As shown in Figure 2, two hi-lo plinths, a homemade trapeze system, and a handswitch were set up and positioned before the subjects entered the room. A handswitch was attached to one 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 extreme 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 subject's age, gender, height, and weight was recorded on a patient questionnaire (Appendix B). Sensitivity to isopropyl alcohol was also recorded on the patient questionnaire. Each subject was then given a short training session (Appendix F) 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, defined as the mid-point of a line drawn from the seventh thoracic vertebrae to the inferior angle of the scapula, was located and marked with a felt tip pen.
Figure 2. Setup of study, including two hi-lo plinths, a homemade trapeze system, and a handswitch.
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 (Multi Bio-Sensory, El Paso, TX, 79913) were then applied to the skin at a point corresponding to the motor point of the lower trapezius muscle of the right upper extremity (Figure 4). The distance between surface electrodes was minimized in an attempt to decrease interference from surrounding muscles, thus, increasing the accuracy of specific muscular activity in the lower trapezius. A ground electrode was placed over the spinous process of the second lumbar vertebrae (Figure 5).

Four exercise trials of ten repetitions each were performed. They were as follows: external rotation with a two-pound handweight, external rotation without a two-pound handweight, forward elevation with a two-pound handweight, and forward elevation without a two-pound handweight. Please refer to Appendix F for specific descriptions of each exercise trial. Prior to beginning each exercise, the investigator assisted the subject into the correct starting position. The desired degree of abduction was obtained using a 360° universal goniometer. The order that the exercises were to be performed was determined by random selection.

Each subject practiced the exercises at a metronome cadence of 60 repetitions per minute for three to five repetitions in order to increase consistency in the timing of the exercises within each subject. Beginning on a cue from the investigator, the subject then performed ten repetitions of each exercise trial with two minutes of rest between each trial. The investigator counted each repetition out loud for the subject. No other encouragement was offered unless a technique was being performed incorrectly.
Figure 3. The motor point of the lower trapezius was defined as the mid-point of a line drawn from the seventh thoracic vertebrae to the inferior angle of the scapula.
Figure 4. Electrode placement over the motor point of the lower trapezius.
Figure 5. Electrode placement, with lead wires attached, over the motor point of the lower trapezius and the second lumbar vertebrae. The electrode over the second lumbar vertebrae served as a ground electrode.
If a technique was being performed incorrectly, the exercise was stopped, the correct technique was explained to the subject, and the exercise was begun again.

During exercise in the traditional position, the subject was prone with his/her humerus abducted 145° and thumb pointed toward the ceiling (Figure 6). One trial of forward elevation was performed with a two-pound handweight, and a second trial was performed without a two-pound handweight.

During exercise in the modified position, the subject was prone with his/her humerus abducted 80°, while resting in a sling, and elbow flexed to 90° with the palm facing the floor (Figure 7). External rotation was performed with a two-pound handweight, and a second trial was performed without a two-pound handweight.

For each subject, the EMG signals were transmitted to the receiver unit and then into a computer for display and recording of the data. The EMG information for each subject was recorded and stored on the computer hard drive for future analysis. The EMG equipment and electrodes were removed from each subject at the conclusion of the experiment, and the skin was cleansed with alcohol where electrodes had been attached. Each subject was advised that minimal redness around the electrode sites was normal for a couple of days following the testing, however, if this persisted or a rash developed, he/she should return for possible medical follow-up. Each subject was thanked for his/her participation and encouraged to call with any questions or concerns.

Data Analysis

Statistical analysis of the mean activity of the monitored muscle was performed on the EMG activity during the experimental trials using the Statistical Package for Social Sciences (SPSS) software program. Data from the experimental trials was
Figure 6. Exercise in the traditional overhead position while using the two-pound handweight.
Figure 7. Exercise in the modified position performed without the two-pound handweight.
analyzed by selecting three consecutive cycles of the exercise. In the traditional position, one cycle was defined as the period starting at zero (with the arm slightly below the plane of the table) progressing through maximal shoulder elevation and ending back at zero. In the modified position, one cycle was defined as the period starting at zero (with the forearm slightly below the plane of the table) progressing through maximal external rotation and ending back at zero. During each exercise, a handswitch was activated by the subject at maximal elevation and maximal external rotation respectively (Figures 6 & 7). The handswitch activation marked the amount of lower trapezius muscle activity at the extreme of external rotation or forward elevation and was used during analysis of data to determine the subject's place in the motion.

To determine the mean EMG activity during exercise, an average of the 100 highest peak amplitudes during the selected three cycles were calculated by computer. These calculations were completed for all four trials of each subject. The average EMG activity of all subjects were then compiled into an average curve of EMG activity for the specific exercise (traditional position with the weight, traditional position without the weight, modified position with the weight, or modified position without the weight). The resulting four curves were defined as the "normative" curve for each specific exercise.

According to Yang and Winter,16 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 two-pound handweight 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 Scheffe's test was performed to determine significance between trials. Statistics were considered to be statistically significant at $\alpha = .05$ level.
CHAPTER IV

RESULTS

The results of this study were determined from the collected EMG data from the subjects (n=10) and calculated means and standard deviations. The data for exercise in the traditional position without the weight, modified position without the weight, and modified position with the weight were then compared to the data for exercise in the traditional position without the weight by the use of a repeated-measures ANOVA. No subjects were excluded from this study. Subjects were tested one time, and all subjects were able to complete all of the exercise trials.

Entire Cycle

Comparisons of muscle activity for the lower trapezius in each exercise condition were performed, as shown in figures 8-11. The data points 0-100 represented one entire cycle of motion. For increased ease when reading the figures, the traditional position without weight was referred to as Trap 1, the traditional position with weight was referred to as Trap 2, the modified position without the weight was referred to as Trap 3, and the modified position with the weight was referred to as Trap 4.

The means and standard deviations for each subject during exercise throughout the entire range of motion are shown in Table 3. A repeated measures ANOVA indicated a significant difference between exercise trials (F(9,27) = 11.21, p<.05). Post hoc testing analysis revealed that lower trapezius muscle activity in the traditional position without
the weight was significantly greater than EMG activity of the lower trapezius in the modified position without the weight (p = .048). No significant difference was found when comparing the amount of lower trapezius muscle activity during exercise in the traditional position without the weight to the amount of activity during exercise in the traditional position with the weight (F(9, 27) = 11.21, p = .209) or the modified position with the weight (F(9, 27) = 11.21, p = .170).

Peak Muscle Activity

Peak lower trapezius muscle activity during each exercise trial was identified for additional comparison (figures 12 and 13). Out of 100 possible points during one cycle of motion, points 36-62 represented peak muscle activity.

The means and standard deviations for the sample of subjects during peak muscle activity are shown in Table 4. No significant difference was found when comparing peak lower trapezius muscle activity during exercise in the traditional position without the weight to muscle activity during exercise in the traditional position with the weight (F(9, 27) = 1.59, p = .583), the modified position without the weight (F(9, 27) = 1.59, p = .932), or the modified position with the weight (F(9, 27) = 1.59, p = .92.)
Figure 8. Comparison of lower trapezius muscle activity between the traditional and modified exercise positions both with and without the weight.
Figure 9. Comparison of lower trapezius muscle activity between the traditional position without the weight and the modified position with the weight.
Figure 10. Comparison of lower trapezius muscle activity between the traditional position without the weight and the modified position without the weight.
Figure 11. Comparison of lower trapezius muscle activity between the traditional position without the weight and the traditional position with the weight.
Table 3. Lower trapezius muscle activity from points 0-100, which are defined as the points representing an entire cycle of exercise.

<table>
<thead>
<tr>
<th></th>
<th>Traditional Position without the Weight</th>
<th>Modified Position without the Weight</th>
<th>Traditional Position with the Weight</th>
<th>Modified Positions with the Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>73.32</td>
<td>44.68</td>
<td>94.33</td>
<td>51.12</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>38.06</td>
<td>26.83</td>
<td>53.91</td>
<td>29.33</td>
</tr>
</tbody>
</table>
Figure 12. Definitions of boundaries of peak lower trapezius muscle activity.
Figure 13. Comparison of lower trapezius muscle activity between the traditional and modified exercise positions both with and without the weight.
Table 4. Lower trapezius muscle activity from points 36-62, which are defined as the points representing peak muscle activity.

<table>
<thead>
<tr>
<th>Position with the Weight</th>
<th>Traditional Position without the Weight</th>
<th>Modified Position without the Weight</th>
<th>Traditional Position with the Weight</th>
<th>Modified Position with the Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>136.49</td>
<td>153.48</td>
<td>100.25</td>
<td>118.57</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>61.56</td>
<td>79.89</td>
<td>57.62</td>
<td>67.07</td>
</tr>
</tbody>
</table>
CHAPTER V
DISCUSSION

Entire Cycle

Post hoc testing revealed that the lower trapezius displayed significantly more EMG activity when exercised in the traditional position without weight than with external rotation in the modified position without weight. Thus, the answer to research question #1, was there a difference in recruitment of the lower trapezius between the traditional and modified exercise positions when tested with or without resistance, was "yes", and the first null hypothesis was not supported. This was not unexpected as it has been documented that muscles display the greatest amount of activity when in their most lengthened positions. The lower trapezius was maximally lengthened when exercised in the overhead position as opposed to when exercised in the modified position. Research also stated that when above 90° of humeral abduction, the lower trapezius acted as a mover of the scapula. This would require more EMG activity than when the humerus was abducted less than 90° and the lower trapezius was acting as a stabilizer of the scapula. 3-5, 17

Next, results indicated that no significant difference was found between the amount of lower trapezius muscle activity in the traditional position without the weight and the amount of EMG activity recorded in the modified position with the weight. This proved that exercise in the modified position did effectively recruit the lower trapezius,
which could greatly benefit a patient with shoulder pathology as well as one with limited shoulder flexion and abduction range of motion.

Literature reports that an individual over the age of 65 demonstrates an increase in degeneration of the supraspinatus tendon, causing shoulder impingement and, thus, pain when assuming an overhead position.10 Also, an elderly individual often does not tolerate overhead activities simply due to limited range of motion. Therefore, exercising in the modified position with added resistance would allow one to effectively recruit the lower trapezius and exercise in a more comfortable, less compromising position.

Another benefit of exercising in the modified position is that external rotation is a motion that targets several muscles simultaneously. These include the infraspinatus and teres minor (acting to rotate the glenohumeral joint during external rotation) and the rhomboid major, rhomboid minor, middle trapezius, and lower trapezius (acting to stabilize the scapula during external rotation). Incorporating external rotation in the modified position into a shoulder rehabilitation protocol allows therapists to target several muscle groups at once, thus patient fatigue decreases and overall patient compliance increases.

Finally, no significant difference was found between lower trapezius muscle activity during exercise in the traditional position with the weight and lower trapezius muscle activity during exercise in the traditional position without the weight. These results indicated that the addition of resistance during exercise in the overhead position may not affect recruitment of the lower trapezius. This was relevant because certain occupations require excessive overhead activity that cannot be avoided.
As a result of the above, a patient whose occupation requires excessive overhead activity would be able to exercise effectively in the overhead position without added resistance that stresses an unstable glenohumeral joint. Unfortunately, due to the demands of most overhead occupations, it would be necessary to add gradual resistance to the exercise program, which would increase the risks of aggravating shoulder impingement. The modified position would provide an alternative to overhead activity early in the rehabilitation program. After the lower trapezius is strengthened, the patient may then progress to more demanding activities in the overhead position.

Peak Muscle Activity

When comparing peak lower trapezius muscle activity, no significant difference was found between muscle activity in the traditional position without the weight and muscle activity recorded in the other three trials. Thus, the answer to research question #2, was there a difference in peak EMG activity of the lower trapezius between traditional and modified exercise positions when tested with or without resistance, was "no", and the second null hypothesis was supported. The peak amount of muscle activity occurred at the end-ranges of each exercise (maximal forward elevation and maximal external rotation), suggesting that it may not be necessary to exercise the lower trapezius throughout the entire range of motion. By exercising only during the range when the lower trapezius is most active, the patient may actually fatigue faster because the muscle would be working harder, but fewer repetitions of the same exercise would be required to achieve the desired results. Therefore, the patient’s exercise program could be shortened, resulting in an increase in patient compliance and more effective rehabilitation.
Future Studies

It is hoped that this study will be expanded on in the future. Following are several suggestions to improve the results of this study. Because this was a pilot study, only ten subjects from the Department of Physical Therapy were asked to participate. In future studies, it is recommended that data be collected from more subjects across different age groups and occupations. It is also suggested to electronically find the motor point of the lower trapezius. This would decrease chances of error when placing the electrodes over the lower trapezius.

During the course of this study, the positioning and heights of the plinths were changed repeatedly due to the varying amounts of external rotation and forward elevation range of motion available within each subject. In the future, it would be beneficial to keep measurements of plinth heights and positioning for repeatability within subjects.

It is suggested that two handswitches be used (one placed at the beginning of the range and one at the end of the range) in order to keep each subject within a restricted range of motion. Also, trials in the modified position may be performed with the sling removed. This would be more practical for clinical use, and conscious retraction of the scapula during external rotation would increase the recruitment of the lower trapezius as well as other scapular stabilizers.

It may be beneficial to study EMG recruitment of the lower trapezius during external rotation in sidelying or even standing. The prone position may be uncomfortable for the patient, especially for a woman or an elderly individual. Adequate recruitment of the lower trapezius in the aforementioned positions may further increase patient comfort and compliance.
Finally, no studies were found that specifically examined lower trapezius muscle activity in traditional and modified positions. Some researchers are currently conducting a study in order to examine lower trapezius muscle activity in several different exercise positions, however results have not yet been published (T. Ellenbecker [tellenbecker/007306866@mcimail.com], e-mail, February 18 Thursday, 1999).

Clinical Implications

The results of this study indicate that external rotation 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 proper scapulohumeral rhythm. Also, those with limited overhead range of motion may still participate in a complete rehabilitation program. Finally, because of the ability of external rotation to target several muscles simultaneously, a shorter, yet complete exercise program may be initiated, causing less patient fatigue and increasing overall patient compliance.

Conclusion

Overall, lower trapezius muscle activity was the greatest in the traditional, overhead position. However, the amount of muscle activity in the modified position with the weight was not significantly different than the amount of muscle activity in the traditional position without the weight. The modified position with added resistance is a viable alternative to lower trapezius strengthening in the overhead position. The elderly population as well as patients with a history of shoulder pathology may exercise safely and comfortably in the modified position.
October 25, 1999

Permissions Editor
F.A. Davis Company
1915 Arch Street
Philadelphia, PA 19103
Fax # 1-215-568-5065

Dear Permissions Editor:

I am writing to request permission to reproduce copies of a figure in the book “Shoulder Pain.” The figure listed below would be used in my Independent Study report as part of my graduate requirements for a Master of Physical Therapy degree from the University of North Dakota, Grand Forks, North Dakota.

Reprint request:

Shoulder Pain

Figure 2-2, page 55 – Tissue within the suprahumeral joints space.

Three copies will be made for the following uses: Graduate School, Physical Therapy Library, and for my own copy of the Independent Study. The standard credit line will be used to give proper recognition for the figures used.

Thank you for your attention to this request.

Sincerely,

Erika Engelstad, S.P.T
815 39th St. No. #103E
Grand Forks, ND 58203
Fax # 1-701-777-4199

Approval is given to Erika Engelstad, Physical Therapy student at the University of North Dakota, for copying the above publication for educational purposes as outlined above.

Mary Ellen O’Drazi
Name of Permissions Editor
Permissions Coordinator
F.A. Davis Company
APPENDIX B
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
INFORMATION AND CONSENT FORM


You are being invited to participate in a study conducted by Erika Engelstad and Rebecca Johnson, physical therapy students at the University of North Dakota. The purpose of this study is to determine in which position the lower trapezius muscle is more actively recruited during manual muscle testing and exercise. The conclusions drawn from this study will allow you as a physical therapy student as well as other therapists to incorporate more effective lower trapezius exercises into a shoulder rehabilitation program, which will help to provide more efficient and complete care. Only normal, healthy subjects who have no history of shoulder problems will be asked to participate in this study.

You will be asked to perform manual muscle testing and a series of shoulder exercises with up to a two-pound weight. This study will take approximately one hour of your time. You will be asked to report to the Physical Therapy Department at the University of North Dakota at an assigned time. During the experiment, we will be recording the amount of muscle activity you have in your lower trapezius muscle while you perform manual muscle testing and resistive exercises. We will also videotape your performance in muscle testing and exercises.

Although the process of physical performance testing always involves some degree of risk, the investigators in this study feel that the risk of injury or discomfort is minimal. In order for us to record the muscle activity, we will be placing adhesive electrodes on your upper back. The recording electrodes are attached to the surface of the skin with an adhesive material. You will then be positioned for manual muscle testing and you will be asked to perform the test and several different exercises with your right upper extremity. We will also attach reflective markers to your right upper extremity and trunk with adhesive material. The markers will be photographed while we collect muscle activity and film your movements. The EMG and video analysis devices only record information from your muscles and joints, they do not stimulate the skin so adverse sensation should not be felt from these devices. Reddening of the skin in the areas where the electrodes are placed is possible due to the adhesion. The amount of muscle testing and exercise you will be asked to perform will be minimal. No costs to you are anticipated.

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

The investigators involved are available to answer any questions you have concerning this study. In addition, you are encouraged to ask any questions concerning this study that you may have in the future, including any interest in being informed of the study's findings. Questions may be asked by calling Susan Jeno at (701) 777-2831, Erika Engelstad (701) 772-2458, or Rebecca Johnson (701) 777-9520. A copy of this consent form is available to all participants in the study.

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

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

I have read all of the above and willingly agree to participate in this study explained to me by Erika Engelstad and Rebecca Johnson.

________________________________________
Participant’s Signature              Date

________________________________________
Witness (not the scientist)           Date
APPENDIX D
Consent for Taking and Publication of Photographs

Name: Christel Parvey

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

Date: May 26, 1999

In connection with Erika Engelstad and Rebecca Johnson's independent study project entitled, An Electromyographic Study of Lower Trapezius Muscle Activity During Exercise in Traditional and Modified Positions, 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, Erika Engelstad and Rebecca Johnson deems 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 such 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, Erika Engelstad and Rebecca Johnson may consider desirable.

Signed [Signature]

Christel Parvey

Witness [Signature]
APPENDIX E
REPORT OF ACTION: EXEMPT/EXPEDITED REVIEW
University of North Dakota Institutional Review Board

DATE: April 1, 1999 PROJECT NUMBER: IRB-9904-200
Sue Jeno, Erika Engelstad, NAME: Rebecca Johnson DEPARTMENT/COLLEGE: Physical Therapy

PROJECT NUMBER: IRB-9904-200

PROJECT TITLE: An Electromyographic and Motion Analysis Study of Lower Trapezius Muscle Activity During Manual Muscle Testing and Resistive Exercise

The above referenced project was reviewed by a designated member for the University’s Institutional Review Board on April 5, 1999 and the following action was taken:

☐ Project approved. EXPEDITED REVIEW No. 4
☐ Next scheduled review is on April 2000

☐ Project approved. EXEMPT CATEGORY No. No periodic review scheduled unless so stated in the Remarks Section.

☐ Project approved PENDING receipt of corrections/additions. These corrections/additions should 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.)

☐ Project denied. (See Remarks Section for further information.)

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

PLEASE NOTE: Requested revisions for student proposals MUST include adviser’s signature.

S. Jeno, Adviser
Dean, Medical School
Signature of Designated IRB Member
UND’s Institutional Review Board

Date: 4-5-99

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.
TRAINING TEMPLATE

You will be performing a series of four exercises in two different positions. In each position an exercise will be performed once with a two-pound handweight and once without a two-pound handweight. All exercises will be performed while lying on your stomach with two minutes of rest between each exercise. You will be instructed in the exercises in the order that you select them.

**Traditional Position without the Weight**

Your arm will be in 145° of abduction parallel to the plane of the table. Your elbow will be extended and your arm will be externally rotated so that your thumb is pointed toward the ceiling. You will then perform ten repetitions of forward elevation without a two-pound handweight beginning slightly below the plane of the table and continuing until the handswitch is activated, which will be positioned at your maximum level of forward elevation. One repetition will be completed when you return your arm to the starting position. The speed of your repetitions will be determined by a metronome.

**Traditional Position with the Weight**

This will be performed the same as in the traditional position without the weight with the exception that you will be holding a two-pound handweight.

**Modified Position without the Weight**

Your arm will be in 80° of abduction and held in a suspended sling in order for the arm to rest parallel to the plane of the table. Your elbow will be flexed to 90° with your palm facing the floor. You will perform ten repetitions of external rotation without a two-pound handweight while allowing your arm to roll in the sling. Your starting point will be with your arm slightly below the plane of the table and you will continue until the
handswitch is activated at your predetermined maximal external rotation. One repetition will be completed after you return to the starting position. The speed of your repetitions will be determined by a metronome.

**Modified Position with the Weight**

This will be performed the same as in the modified position without the weight with the exception that you will be using a two-pound handweight.
REFERENCES CITED


