

Spring 5-7-2010

# Effects of strengthening exercises on forward shoulder posture in division in competitive female swimmers

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Effects of Strengthening Exercises on Forward Shoulder Posture in Division I  
Competitive Female Swimmers

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A thesis submitted to the Graduate Faculty of

JAMES MADISON UNIVERSITY

In

Partial Fulfillment of the Requirements

for the degree of

Master of Science

Department of Kinesiology

May 2010

## Acknowledgments

I would like to recognize Dr. Kent Todd for not only his direction and support throughout this process, but also for instilling the will to appreciate the meticulous nature of research. Thank you for ensuring the completion of my thesis and for helping make this document successful, while aiding in personal, professional, and academic growth. I would also like to thank Dr. Michael Saunders and Dr. Connie Peterson for their suggestions and devotion of personal time to assist in the overall product of my thesis research amid the overwhelming amount of academic commitments both individuals are currently upholding.

A special thank you is warranted for those students who helped in my data collection, including Nina Szemis, Mike Puglia, Pat Deal, Jennifer Donnelly, and Jennifer Cusick. Without these individuals, my project would not have been possible.

Lastly, I would like to thank my family for providing the unconditional support that has enabled me to pursue my dreams and reach for new heights of perfection through expectation. I am truly blessed to have such a sturdy foundation of leadership, faith, and motivation that will continue to serve as a mold for my future endeavors.

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## Abstract

Forward shoulder posture in the repetitive overhead athlete has been isolated as a possible predisposition for injury. Shoulder strengthening and stretching programs have displayed benefits for overhead athletes such as swimmers to decrease risk of impingement, labral issues, and other shoulder pathology. The purpose of this study was to investigate the effects of strengthening exercises on forward shoulder posture in female overhead athletes. Thirty-one Division I female collegiate competitive swimmers were divided into 3 groups: control, strengthening, and combination of stretching and strengthening. The two intervention groups were assigned a 16 session strength-only or a combined strength and stretching protocol to complete over an 8-week period of time. Measurements of resting and adjusted shoulder posture, strength, and flexibility were taken pre- and post- intervention. Subjects had an average age of  $19.56 \pm 1.01$  years, height of  $168.10 \pm 5.05$  centimeters, and weighing  $66.31 \pm 6.71$  kilograms. The total swimming volume for the duration of the study averaged  $332.657 \pm 24,595$  meters or  $41,582 \pm 3,074$  meters/week among all the participants and there were no significant volume differences between the groups. Data analysis revealed no significant interactions between the groups for resting (control pre- $205.7 \pm 48.2$ , control post-  $254.9 \pm 22.3$ ; strength pre-  $183.9 \pm 33.2$ , strength post-  $254.5 \pm 28.0$ ; combination stretching/strengthening pre-  $185.0 \pm 39.9$ , combination stretching/strengthening post-  $255.2 \pm 21.8$ ) or adjusted shoulder posture(control pre-  $22.1 \pm 28.1$ , control post- $51.7 \pm$

21.3 ; strength pre-  $7.4 \pm 25.7$ , strength post-  $59.4 \pm 13.2$ ; combination stretching/strengthening pre-  $9.0 \pm 23.8$ , combination stretching/strengthening post-  $55.5 \pm 18.7$ ). The strength group improved strength ( $p=0.001$ ), while the combination strength and stretching group improved flexibility ( $p=0.006$ ). The intervention of shoulder stretching and strengthening programs is useful for shoulder maintenance/stability and overall joint mechanics, but may not be enough to overcome the volume of swim training or outside weight lifting adaptations. Given discrepancies between the results found in the present study and results reported by others, more research is warranted to investigate the effects of strengthening and stretching exercises on forward shoulder posture in repetitive overhead athletes.

# CHAPTER I

## INTRODUCTION

### Background

Postural abnormalities lead to problems at joint articulations, increase range of motion variability, impingement syndromes, and can ultimately produce rotator cuff related injuries for athletic populations involved in repetitive overhead movement sports. Forward shoulder posture occurs when tight pectoralis minor muscle and/or weak scapular muscles on the posterior aspect of the shoulder, result in a forward shift of shoulders in relaxed position (McClure, 2006). Correction of forward shoulder posture involves stretching of anterior shoulder structures and strengthening the posterior shoulder muscles. Successful correction may reduce the risk of injury.

In addition to postural abnormalities, scapular position relative to the shoulder girdle affects the glenohumeral range of motion and strength of rotation during sports-specific movement. (4°-6°) of upward scapular tipping and medial rotation due to decreasing the size of the subacromial space (Ludewig, 2000) are considered clinically significant shoulder impingement. Glenohumeral motions reaching 90° of shoulder abduction relative to the scapula, the subacromial space is accountable for the integrity of articular cartilage, capsular and ligamentous elements, tendons of the rotator cuff, and the subacromial bursa (Ludewig, 2000). Decrease in subacromial space, as altered through scapular position may predispose one to injury to these anatomical structures.

Scapular protraction, as seen in forward shoulder posture, can negatively impact the mechanical efficiency of shoulder musculature throughout various ranges of motion.

Smith et al. (2006) found protraction of the scapula reduced isometric internal rotation strength, regardless of arm position, while the isometric strength testing for external rotation produced variables for arm test position in relation to force production. Shoulder muscles responsible for internal rotation include subscapularis, latissimus dorsi, teres major, and pectoralis major (Smith, 2006). Protraction of the scapula lengthens the latissimus dorsi and causes a reduction in the rotary motion of internal rotation for the pectoralis major muscle, limiting the two most supportive internal rotators for the shoulder (Smith, 2006). In contrast, the supraspinatus, infraspinatus, teres minor, and posterior deltoid are categorized as the externally rotating muscle groups, which during scapular protraction, are shortened to a disadvantageous position based on length-tension curves (Smith, 2006). These changes in muscle length present issues of concern for repetitive overhead athletes in a sport that requires biomechanical efficiency against resistance during prolonged exercise. Early detection of forward shoulder posture may lead to early rehabilitation, stretching of anterior shoulder structures and posterior shoulder strengthening, in an effort to reduce the prevalence of shoulder injury and impingement. Identifying and correcting forward shoulder posture in athletes involved in sports requiring repetitive overhead motion may aid in injury reduction and may decrease impingement issues through rehabilitation programs.

#### Purpose of the Study

The purpose of this study is to analyze the impact of posterior shoulder strengthening as well as strengthening and stretching on the forward shoulder posture in female competitive collegiate swimmers. The strength and flexibility exercises in the

intervention groups in the study have been selected due to the commonality of the exercises in rehabilitation protocols, their likelihood of reducing risk of injury for the subjects and the ease of performance which allows proper form and use of the exercise equipment. These exercises may aid in developing rehabilitation programs focusing on postural correction of forward shoulder position, while decreasing risk of injury and prevalence of shoulder impingement symptoms for the repetitive overhead athlete.

#### Need for the Study

Excess forward shoulder posture is common among swimmers and is associated with joint injury, impingement syndromes and rotator cuff degeneration. Reducing the risk of injury associated with forward shoulder posture is believed to require stretching of shoulder musculature in conjunction with strengthening of the posterior shoulder muscles. Although Kluemper and associates (2006) reported that the combination of stretching and strengthening exercises improved forward shoulder posture, the researchers did not actually measure strength or flexibility and therefore did not provide evidence that their protocol had any impact on strength or flexibility. Moreover, in reporting their data the researchers suggested that quantifying the unique contributions of strengthening and stretching may lead to the refinement of shoulder maintenance programs to aid in the reduction of injuries related to postural, scapular, or kinematic abnormalities (Kluemper et al., 2006).

#### Hypotheses

1. The control group will experience no change in strength for horizontal abduction, experience no gains in flexibility, and will display no change in degree of forward shoulder posture.
2. The strengthening only group will experience an increase in shoulder horizontal abduction strength, increased flexibility for glenohumeral internal rotation and a decrease in forward shoulder posture when compared to the control group.
3. The combined stretching and strengthening group will experience an increase in shoulder horizontal abduction strength, increased flexibility for glenohumeral internal rotation, and a decrease in forward shoulder posture when compared to the control group.
4. There will be no difference in shoulder horizontal abduction strength between the strengthening only and combined strengthening and stretching groups.
5. The combined stretching and strengthening group will have greater flexibility for glenohumeral internal rotation and a greater reduction in forward shoulder posture when compared to the strengthening only group.

### Assumptions

The following assumptions are made for this study:

1. It is assumed that the responses on the Research Participant Questionnaire are truthful.
2. It is assumed that the Double-Square method is an accurate way to measure forward shoulder posture.

3. The assumption that maximum repetitions/repetitions to fatigue measurements for seated rows will accurately quantify strength gains is made.
4. It is assumed that repetition to fatigue attempts and values are the greatest individual effort each subject can produce at a given time.

### Delimitations

The following delimitations are made for this study:

1. All subjects included in the study are female Division I collegiate competitive swimmers attending James Madison University in Harrisonburg, Virginia.
2. Subjects have established health status without limitations to swimming or dryland activity as a result of shoulder pain.
3. No subject included in the study will have experienced any shoulder surgeries within the past year.

### Limitations

1. Research participant subject pool is restricted to the roster of the swim team comprised of 35 athletes and may not be generalized to other populations.
2. Due to some training modifications previously established, subjects will be assigned to groups in a pseudo-randomized fashion, indicating a lack of complete random sampling.
3. The study will only be partially blinded as the subjects will know which intervention group they are in.

## Definition of Terms

***Glenohumeral Internal Rotation*** - Passive movement of shoulder joint toward the midline, subject supine and shoulder joint at 90° or lateral elevation on table. Forearm is rotated forward with measurements taken from point of initial movement to point of limitation as a measurement of flexibility.

***Scapular Protraction*** – Distance measured from the midline of the spine over the spinous process of the vertebrae to the distal tip of the scapula. Farther distance indicates greater scapular protraction, or forward movement of the scapula along the thoracic cavity.

***Scapular Retraction*** - Distance measured from the midline of the spine over the spinous process of the vertebrae to the distal tip of the scapula. Smaller distance indicates scapular retraction, or closeness of scapula to midline of spine.

***Forward Shoulder Posture*** – Anatomical display of rounded shoulders as observed in many swimmers or repetitive overhead sport. Individual may produce a “slumped” appearance, allowing shoulders to roll forward and slouch posture of thoracic vertebrae.

***Double-square*** – Consists of a 40-cm combination square with a second level added in an inverted position to the frame and is used to quantify forward shoulder posture.

Measurements consisted of the distance from the wall (in millimeters) to the anterior tip of the acromion process of the subject. This method is illustrated in Figure 1.

***Theraband® resistance bands*** – Latex resistance bands at varying levels of difficulty. Each band is color-coded to reflect degree of resistance and are used in rehabilitation protocols.

***Cybox Seated Row machine*** – Exercise machine designed for subject comfort, trunk stability, upper extremity emphasis, and lower extremity stability. Subjects will perform a pulling motion with arms beginning in front of the body, fully extended with trunk in an upright position. Both legs will be placed firmly on the platform in front of the subject and knees will remain in a fully extended position. Subject will work to pull the handle bars directly toward hips in “row” motion, relative to trunk. Repetitions to fatigue will be determined for a baseline measurement in 1 trial with the weight set at 50% of subject body weight. Repetitions will not be considered if subject loses form and uses trunk or back to pull weight, rather than upper extremities.

***Theraband Pull-Apart*** – Strength measurement designed to emphasize posterior shoulder musculature strength. Subjects will stand facing a wall at 90° shoulder flexion, elbows in full extension, holding a theraband segment (12 inches in length) with hands 4 inches apart. Subject will complete repetitions to fatigue protocol for strength baseline measurement and must move hands 12 in apart in order for repetition to be considered, as designated by tape margins on the wall.

## CHAPTER II

### REVIEW OF LITERATURE

Shoulder impingement syndromes have become a common occurrence among athletes involved in repetitive overhead motion activities. Although some investigation into the effect of the narrowing of subacromial space has reflected conflicting results related to impingement symptoms and shoulder pain, further investigation of postural abnormalities has provided better understanding of the biomechanical effects in consideration of improper joint articulation. Early detection of improper posture, muscular imbalance, or biomechanical concern may lead to injury prevention programs for the repetitive overhead athlete.

A balance between anterior and posterior muscular strength, maintenance of flexibility, and postural correction within anatomically acceptable planes, are key elements of injury reduction and decreasing the prevalence of shoulder impingement syndromes in repetitive overhead motion athletes. Kinematic differences discovered in individuals with impingement syndrome may reflect compensatory efforts for glenohumeral weakness or loss of flexibility (McClure, 2006). Although scapular kinematics of swimmers with shoulder impingement syndrome may not display differences until post practice measurements, fatigue of posterior shoulder musculature is still illustrated as a determining factor in scapular movement and muscular balance (Su, 2004). Glenohumeral rotation has been reported to decrease over the course of a competitive season in repetitive overhead motion athletes as scapular protraction increased, preventing mechanically efficient force production within functional

movements (Thomas, 2009, McClure, 2006). Interventions of strength and flexibility have been shown to improve posture, but the degree of strength, flexibility, and scapular kinematics in relation to posture warrants further investigation.

Scapular motion has become an integral element in determining pre-existing or developmental complications in shoulder-related injuries, syndromes, and muscular imbalance. Ability to identify normative movement of the scapula within plane of motion through functional positioning may allow for screening and early application of corrective intervention. Scapular functioning and shoulder kinematics in relation to impingement and the repetitive overhead motion is reviewed in Table 1.

**Table 1: Scapular Functioning and Shoulder Kinematics**

<b>Title/Authors</b>	<b>Purpose</b>	<b>Participants</b>	<b>Instruments</b>	<b>Procedures</b>	<b>Results</b>
Alterations in Shoulder Kinematics and Associated Muscle Activity in People with Symptoms of Shoulder Impingement  Ludewig, Paula M. & Thomas M. Cook	To provide a 3-D analysis of scapulothoracic and glenohumeral kinematics with associated muscle involvement in subjects with impingement symptoms as compared with asymptomatic subjects	52 subjects involved in an occupational setting requiring repetitive overhead motion (construction workers) with (group 1) and without (group 2) shoulder impingement symptoms.	Electromyographic data collected with preamplified silver-silver chloride surface electrodes. 3-D position and orientation of subject's scapula, thorax, and humerus tracked using Polhemus FASTRAK electro-magnetic motion capture system.	Surface electrodes simultaneously tracked 3-dimensional movements of the trunk, scapula, and humerus during humeral elevation in the plane of scaption. Three conditions were examined: 1) no load, 2) 2.3-kg load, and 3) 4.6-kg load. ANOVA used to analyze data.	Subjects with impingement symptoms demonstrated decreased upward rotation of the scapula with humeral elevation and increased anterior tipping of the scapula. Scapular medial rotation was also demonstrated relative to the asymptomatic group and upper/lower trapezius engagements were increased during 4.6-kg load in subjects with impingement.
The effect of scapular protraction on isometric shoulder rotation strength in normal subjects  Smith, Jay MD, Dietrich, Christopher T. MD, Kotajarvi, Brian M. MS, PT, and Kenton R. Kaufman, PhD.	To measure the effects of scapular protraction on isometric shoulder rotation strength in normal subjects.	20 subjects, 10 men and 10 women between the ages of 18 to 35 years, consisting of Mayo Health System employee volunteers	Testing apparatus included an aluminum frame, adjustable strap attached to a load cell, and mobile rings attached to the cell. The load cell was bordered with data acquisition system monitored by a computer. A goniometer was used to confirm correct position of the subjects prior to gathering data.	Subjects first completed a 5-minute warm-up session on an upper body ergometer, along with PROM in flexion, abduction, and 90° abduction with internal rotation. Subjects were then seated in chair, immobilized with Velcro strap, with arm placed in 90° elevation in sagittal plane and elbow flexed to 90°. Subjects completed 2 isometric internal and external rotation contractions (30 sec rest in between) in two scapular positions (neutral and protraction), from 3 arm positions: 90° internal rotation, 45° internal rotation, and 90° external rotation.	Scapular protraction significantly reduced shoulder rotation strength in 5 of 6 test positions. Correlation found between scapular position and type of contraction (p<0.0001) and also between scapular position and starting position of arm (p<0.0001). The greatest change was found during protraction and mid-range internal rotation (24%), protraction and external rotation start on internal rotation strength (23%), and external rotation start, protraction, and external rotation strength (20%). Scapular protraction reduced isometric internal rotation strength regardless of arm test position.
Shoulder Function and 3-Dimensional Scapular Kinematics in People With and Without Shoulder Impingement Syndrome  McClure, Phillip W., Michener, Lori A., and Andrew R. Karduna	To compare 3-dimensional scapular kinematics in arm elevation, shoulder range of motion, muscle force, and posture (thoracic spine and shoulder) in subjects exhibiting impingement syndrome and also in subjects without impingement issues.	45 subjects diagnosed with shoulder impingement syndrome, recruited from university orthopedic facility 45 subjects with no known pathology or impairments	3-Dimensional kinematic data collected by Polhemus 3SPACE FASTRAK through surface electrodes.	Thoracic and humeral/scapular motion was evaluated by FASTRAK system throughout active range of motion. A Euler axis sequence was used to assess scapular orientation as active elevation in scaption, flexion in the sagittal plane, and humeral external rotation elevated to 90° in coronal plane were completed. Glenohumeral flexion, abduction, and internal/external rotation with GH joint in 90° abduction were measured by a plastic goniometer (average of 2 measures). Passive range of motion to joint endpoints were assessed by examiner. Break test method was used to assess strength and dynamometer assessed force. Average of 3 measurements recorded.	The subjects with impingement presented with less range of motion and a decrease in force for all directions in comparison to the control group. Impingement subjects produced slightly greater upward rotation of the scapula and elevation of the clavicle during flexion and slight posterior tilting of the scapula in with elevation in scaption. No differences were found at rest between the impingement group and the control group.
Scapular Rotation in Swimmers With and Without Impingement Syndrome: Practice Effects  Su, Ka Pik Eva, Johnson, Michael P., Gracely, Ed J., and Andrew R. Karduna	To investigate shoulder kinematics in swimmers with no known shoulder pathology in comparison with swimmers demonstrating signs of impingement syndrome.	20 Healthy swimmers with no shoulder pathology 20 swimmers demonstrating shoulder impingement symptoms	Pro-360 Inclinometer (Macklanburg Duncan, Oklahoma City, OK) used to assess scapular upward rotation in static position. Handheld dynamometer (Nicholas Model 01160) was used to assess muscle strength or maximum isometric force.	All testing was performed poolside as measurements were taken prior to getting into the water and immediately post practice. Static positions of upward scapular rotation were assessed by a Pro-360 inclinometer with the arm at rest, 45°, 90°, and 135° of humeral elevation. Strength measurements were assessed twice (shrug and punch). Distances and duration of swim practice were recorded. ANOVA used to assess data.	No differences were found between subjects during baseline measurements. Post swim practice, impingement subjects displayed decreases in scapular upward rotation (p<0.0082). Both groups exhibited significant reductions in force for the shrug and punch (p<0.001). When group descriptions were taken out of analysis, practice had no effect on healthy swimmers (p=0.21), while swimmers with impingement produced a significant effect (p<0.0001).

**Table 1: Scapular Functioning and Shoulder Kinematics (continued)**

Title/Authors	Purpose	Participants	Instruments	Procedures	Results
<p>Evaluation of general joint laxity, shoulder laxity, and mobility in competitive swimmers during growth and normal controls</p> <p>Jansson, Anna, Saartok, Tonu, Werner, Susan, and Per Renstrom</p>	<p>To evaluate general joint laxity, range of motion in the shoulder, and laxity of the glenohumeral joint in competitive swimmers and a reference group.</p>	<p>A total of 1, 277 school children (aged 9 and 12 years) served as the reference group Study group consisted of 120 age and gender matched competitive swimmers</p>	<p>General joint laxity assessed according to Brighton score. Myrin OB Goniometer used to assess range of rotation.</p>	<p>General joint laxity was assessed for five movements according to the Brighton Score. Anterior glenohumeral laxity was noted by the anterior drawer test, while inferior glenohumeral laxity was evaluated using the Sulcus test. Range of rotation was measured by a Myrin OB Goniometer for internal and external rotation. Subject was supine with shoulder in 90° of abduction and elbow in 90° of flexion. The same examiner recorded all measurements.</p>	<p>Both male and female competitive swimmers displayed decreased internal rotation in comparison to the reference group of both 9 and 12 years of age (p=0.000). External rotation at 9 years of age showed no differences between gender or reference group, but males displayed decreased external rotation at 12 years of age (p=0.000). At 9 and 12 years of age, female swimmers had significantly less internal rotation than that of the reference group (p=0.000 at 9 years, p=0.006 right, p=0.000 left at 12 years).</p>
<p>Glenohumeral Rotation and Scapular Position Adaptations After a Single High School Female Sports Season</p> <p>Thomas, Steven John Med, ATC, Swanik, Kathleen A., PhD., ATC, Swanik, Charles PhD., ATC, and Kellie C. Huxel, PhD., ATC</p>	<p>To conduct prospective measurements of glenohumeral internal and external rotation in conjunction with scapular positioning of female athletes throughout the competitive season</p>	<p>36 Female high school athletes involved in overhead sport</p>	<p>Saunders digital inclinometer was used to assess internal rotation, external rotation, and scapular upward rotation. Lateral scapular slide test assessed scapular protraction.</p>	<p>Pretest-posttest design used to gather data. Passive glenohumeral internal and external rotation was measured by digital inclinometer for both shoulders of the subjects in supine position, GH joint in 90° abduction. Measurements were taken 3 times by the same investigator. Scapular upward rotation measurements were taken with subjects standing in relaxed posture at 60°, 90°, and 120° of abduction. Scapular protraction measurements were taken in 3 positions (rest, 45°, and 90° of humeral abduction) and repeated 3 times bilaterally.</p>	<p>Internal and external rotation decreased in swimmers throughout the season (p=0.001), and also in tennis players (p=0.001). For all athletes involved in overhead sports, scapular protraction at 45° abduction at the glenohumeral joint decreased (p=0.007). Swimmers displayed and increased loss of internal rotation when compared to tennis players and volleyball athletes.</p>
<p>Effects of shoulder muscle fatigue caused by repetitive overhead activities on scapulothoracic and glenohumeral kinematics</p> <p>Ebaugh, D. David, McClure, Phillip W., and Andrew R. Karduna</p>	<p>To determine the effects of muscle fatigue involving the shoulder girdle on 3-dimensional kinematics focusing on scapulothoracic and glenohumeral movement.</p>	<p>20 subjects (10 male and 10 female) without a history of shoulder pathology or pain</p>	<p>Electromyographic surface electrodes (disposable bipolar Ag-AgCl) used to collect median power frequency and kinematic measures. Noraxon MyoSystem 1200 collected surface data which was linked to a personal computer and stored in LabView. A load cell was used to collect resistive force generated during isometric muscle contraction. Polhemus 3Space Fastrak determined 3-dimensional scapular kinematic data.</p>	<p>Electromyographic data was collected through surface electrodes on the upper and lower trapezius, serratus anterior, anterior deltoid, posterior deltoid, and infraspinatus muscle. Muscle strength was determined through isometric contraction to record median power frequency in normal muscle fatigue. Subjects were seated upright, elbows extended and arms elevated to 90° in scaption. Voluntary contractions were repeated 3 times with 30 seconds of rest between the trials as force was placed against the load cell. For median power frequency values, subjects placed 60% of maximum force on cuff for 5 seconds prior to and post fatigue protocol. 3-dimensional kinematics were measured for the thorax, humerus, and scapula. In the fatigue protocol, subjects manipulated objects for 2 minutes with arms elevated at 45°, then lifted weight in scaption for 20 repetitions, and lastly, subjects lowered the arm through a diagonal pattern against resistance. These 3 exercises were repeated until fatigue considerations were met.</p>	<p>Following the fatigue protocol, subjects produced more scapular upward rotation at 60°, 90°, and 120°, increased scapular external rotation at 90°, 120°, and maximum elevation, and also increased retraction of the clavicle at 60°, 90°, and 120°. Humeral external rotation decreased at all levels of elevation following the fatigue protocol. Fatigue of the musculature surrounding the shoulder girdle alters kinematics of the scapulothoracic and glenohumeral joints.</p>

Postural alterations have been examined as a factor in shoulder impingement syndrome and associated injuries such as rotator cuff degeneration. Narrowing of the space between the acromion and humerus are reported to correlate with tears of the rotator cuff tendons (Saupe, 2006). Forward shoulder posture exacerbates the narrowing of the joint space, further predisposing individuals for future complications within the shoulder girdle. Postural alterations and related issues of concern are highlighted in Table 2.

**Table 2: Postural alterations and Variables of Concern**

<b>Title/Authors</b>	<b>Purpose</b>	<b>Participants</b>	<b>Instruments</b>	<b>Procedures</b>	<b>Results</b>
Resting Position Variables at the Shoulder: Evidence to Support a Posture-Impairment Association  Borstad, John D.	To report postural measurements in relation to resting length of the pectoralis minor muscle and scapular biomechanics in conjunction with posture-impairment	50 subjects without shoulder pathology, divided into two groups of 25 subjects aged between 18 and 40 years.	Flock of Birds electromagnetic motion capturing system was used to measure multiple variables by way of 4 receivers. The orientation and position of measurements was analyzed through MotionMonitor software.	Pectoralis minor muscle measurements were completed with use of Flock of Birds motion capturing system. Resting length of pectoralis minor muscle was used to place subjects in 1 of 2 groups. 3-dimensional scapular kinematics were then analyzed as subjects performed active arm elevation and lowered in sagittal, scapular, and frontal planes. Postural measurements, including thoracic kyphosis were measured using a flexible ruler. Resting position of scapula was measured with soft tape measure. 3-dimensional scapular orientation measurements were completed using motion capturing system. Supine measurement of pectoralis minor muscle was taken.	Subjects with shorter pectoralis minor resting lengths exhibited increased scapular internal rotation and a shorter distance between sternal notch and coracoid process, with decreased posterior tilting in shoulder flexion, as compared to subjects with longer pectoralis minor muscles.
Subacromial impingement syndrome: The role of posture and muscle imbalance  Lewis, Jeremy S., PhD, Green, Ann, and Christine Wright	To investigate the relationship between forward head posture and other postural variables, along with the relationship between glenohumeral range of motion in accordance with postural differences in subjects with and without shoulder impingement problems	60 subjects without impingement problems (31 male, 29 female) and 60 subjects exhibiting shoulder impingement pathology (35 male, 25 female)	Olympus OM2 SLR camera, set at 100 ASA by use of a 28- to 50-mm adjustable lens was used to take lateral photographs to depict FHP. 100 ASA film was used. Inclinometers were used to determine degree of thoracic kyphosis	Postural measurements were taken on dominant of asymptomatic subjects and painful side of impingement subjects. Subjects stood 30 cm in front of designated line on floor as adhesive markers identified anatomic points (spine of scapula, post acromion, thoracic spinous process corresponding with root of spine, lateral midpoint humeral head, tragus of ear, and seventh cervical vertebrae). Subjects stood in neutral posture as lateral photographs were taken. Measurements of ankles were calculated 3 times. Inclinometers measured ankles 3 times for thoracic kyphosis. Glenohumeral flexion and abduction were performed 3 times, measured by inclinometer for range of motion and recorded.	6 postural variables analyzed: Forward head posture, forward shoulder posture, scapular protraction, thoracic kyphosis, glenohumeral flexion, and abduction. Neither asymptomatic or subjects with impingement issues display conformity in postural deviations initiated by forward head posture. Both groups demonstrated individual patterns of postural changes. Since no scapular change, postural defect, or head position affected symptoms, study suggests normal shoulder girdle development and osseous asymmetry is the culprit of impingement.
Association Between Rotator Cuff Abnormalities and Reduced Acromiohumeral Distance  Saupe, Nadja, Pfirrmann, Christian W. A., Schmid, Marius R., Jost, Bernhard, Werner, Clement M.L., and Marco Zanetti	To evaluate reduced acromiohumeral distance and the association with rotator cuff abnormalities	63 subjects (36 men, 27 women) aged 27-80 years, divided into 3 groups of 21 subjects according to acromiohumeral distance Group 1: ≤7 mm Group 2: 8-10mm Group 3: >10mm	Conventional antero-posterior radiographic views of shoulder were taken. MR arthrography on 1.0-T unit, 1.5-T MRI unit, with injection of 12mL of gadopentetate dimeglumine solution.	Antero-posterior radiographic views were taken of each subject. MR arthrography with injection were completed with shoulder in neutral position, thumb up. Two blinded radiologists read and measured the distances on the radiographs and on sagittal and coronal oblique views on the MR views. Fatty degeneration of muscle was graded according to Goutallier classification. Muscle atrophy was measured by use of tangent sign.	The size of rotator cuff tears and degree of degeneration in muscles displayed a significant negative correlation (p<0.05) with acromiohumeral distance. Group 1 displayed full-thickness tears in the supraspinatus tendon for 19/21 subjects, infraspinatus tears in 14/21 subjects, and subscapularis tendon tears in 9/21 subjects. Tears in tendons correlate with acromiohumeral space narrowing.

**Table 2: Postural Alterations and Variables of Concern (continued)**

Title/Authors	Purpose	Participants	Instruments	Procedures	Results
<p>Subacromial Impingement Syndrome: The Effect of Changing Posture on Shoulder Range of Movement</p> <p>Lewis, Jeremy S. PT, PhD, Wright, Christine, and Ann Green, MSc</p>	<p>To investigate the effect of changing posture on shoulder range of motion in the motion of shoulder flexion and abduction in scaption with asymptomatic subjects and subjects exhibiting shoulder impingement syndrome</p>	<p>60 asymptomatic subjects and 60 subjects with shoulder impingement syndrome</p>	<p>Forward head posture was assessed by a lateral photograph taken with an Olympus OM2 SLR camera. 100 ASA color photographic film was used and A4-sized graph paper was copied onto transparency paper to measure angles on photographs. Pocket calculator assisted in calculations. Inclometers were used to measure kyphosis. A pressure biofeedback device analyzed lumbar spine motion. Leukotape was used to correct posture and Fixomull tape was utilized in the placebo effect.</p>	<p>Postural measurements were taken on painful side of subjects' arms with symptoms, and the dominant arm of subjects without symptoms. 8 anatomical references were found and observed. Forward head posture was measured using photographs and an Olympus OM2 SLR camera. Angles were measured on A4-sized transparency graph paper. Measurements were then established between all landmarks, distance between acromion and SP corresponding to spine of scapula, and vertical displacement of inferior angle of the scapula above T12 spinous process. Inclometers were then used to establish degree of thoracic kyphosis over T1 and T2, T12 and L1. Scapular plane abduction and shoulder flexion measurements were completed 3 times throughout pain-free range of motion. Maximal pain experienced during activity was recorded using visual analogue scale (0-10). The pressure biofeedback device measured changes in lumbar spine curvature. Taping products (Leukotape and Fixomull Tape) were used to change posture. Subjects were asked to fully retract and depress their scapulas, while tape was applied from spine of scapula to T12 spinous process diagonally.</p>	<p>Measurements analyzed were: forward head posture, forward shoulder posture, thoracic kyphosis angle, lateral linear displacement of the scapula, scapular elevation, sagittal plane position of the acromion, pain-free ranges of sagittal plane shoulder flexion, and abduction in scaption, along with VAS pain-levels. For symptomatic subjects, taping produced significantly less FHP, less FSP, smaller kyphosis (mean, 5.8°), increased range of shoulder flexion (mean 16.2°), increased scapular plane abduction, and less elevated scapular position (mean, 1.7 cm). No statistical significance was found for placebo tape and symptomatic subjects. No significance was found for placebo taping and asymptomatic subjects.</p>

Postural correction interventions and tools for measuring the effects of the interventions are important components of identifying effective strategies for lowering risk of injuries related to forward posture. Significant strength gains through force production can be acquired through motions of internal rotation, external rotation, and horizontal abduction through the use of Theraband® resistance bands in a home exercise program (Wang, 1999). Implementation of strengthening protocols enables the production of postural correction techniques as examined in Table 3. Measurement techniques of postural improvement or impairment are valid areas of concern when determining a baseline for corrective protocols in rehabilitative application and injury prevention, as included in Table 3.

**Table 3: Postural Correction Interventions and Diagnostic Tools of Measurement**

Title/Authors	Purpose	Participants	Instruments	Procedures	Results
<p>The effect of manual treatment on rounded-shoulder posture and associated muscle strength</p> <p>Wong, Christopher Kevin PT, PhD, OCS, Coleman, Denise PT, DPT, DiPersia, Vincent PT, DPT, Song, Judi PT, DPT, and Denise Wright, PT, DPT, ATC/L</p>	<p>To determine the effects of soft tissue mobilization and self stretch of the pectoralis minor muscle on rounded-shoulder posture and strength of the lower trapezius muscle in comparison to self-stretch and a placebo touch</p>	<p>28 healthy volunteers (total 56 shoulders) of both genders, between the ages of 20 and 40 years, randomly assigned to either the control (25 shoulders) or experimental group (31 shoulders)</p>	<p>Straight ruler and goniometer used to assess angles of measurement. MicroFET2 digital muscle tester used to assess lower trapezius muscle strength.</p>	<p>Rounded shoulder posture was measured with subject supine on unpadded table with a straight ruler from the table to the posterior aspect of the lateral acromion process. The distance was recorded in millimeters. Lower trapezius muscular strength with the subject supine, hips and knees positioned at 45°, and 90°, shoulder positioned at 160°, and chest strapped to the table. A digital muscle tester was used to assess strength for two repetitions held for 3 seconds, with 10 seconds rest between trials. The experimental group was exposed to 3 minutes of STM of the pectoralis minor muscle, while the control group received passive placebo touch and stretching to pectoralis major muscle. Stretching was held for 30 seconds and repeated for 3 minutes.</p>	<p>The experimental group displayed slight decreases in rounded shoulder posture immediately following treatment (p&lt;0.001). Treatment directed to the pectoralis minor muscle and self-stretching displayed significant reductions in rounded shoulder posture as compared to the control group.</p>
<p>Stretching and Strengthening Exercises: Their Effect on Three-Dimensional Scapular Kinematics</p> <p>Wang, Che-Hsiang, MS, PT, McClure, Phillip PhD, PT, OCS, Pratt, Neal E. PhD, PT, and Robert Nobilini, MS</p>	<p>To determine the effects of a moderately aggressive program, including stretching and resistive exercise on forward shoulder posture.</p>	<p>20 subjects with forward shoulder posture, but asymptomatic for any shoulder pathology (9 men, 11 women)</p>	<p>A Metrecom, computerized, electro mechanical, 3-dimensional digitizer was used to measure posture.</p>	<p>Right upper limbs were measured. Isometric force production of shoulder was assessed through 3 trials of maximal contractions lasting 5 seconds each. The Metrecom was used to measure height, length, and tilting angle of pads on scapula through 7 points of measurement. Two trials for each position during elevation were performed. Internal rotation force was used to assign theraband resistance for strengthening exercises. Subjects performed 5 repetitions with theraband and determined if it was too easy or hard. The program was a 6-week duration of home exercise. Exercises included: scapular retraction, shoulder shrugging, shoulder abduction, shoulder external rotation, and corner stretching. Exercises were a home exercise program to be completed 3 times per week. The corner stretch was held for 10 seconds for each of the 10 repetitions. 5 repetitions were added to the protocol every 2 weeks.</p>	<p>Isometric strength variables were significantly increased following application of the home exercise program (p&lt;0.05), with the exception of horizontal abduction. No significant difference was found for tilting of the scapula before and after exercise. At 90° of shoulder abduction in scaption, significant difference was found, indicating less scapular upward rotation following strengthening. Significant strength gains for isometric force production were found in internal and external rotation, and horizontal abduction.</p>
<p>A Clinical Method for Identifying Scapular Dyskinesia, Part 1: Reliability</p> <p>McClure, Phillip PhD, PT, Tate, Angela R. PhD, PT, Kareha, Stephen DPT, PT, ATC, CSCS, Irwin, Dominic DPT, PT, and Erica Zlupko, DPT, PT</p>	<p>To determine interrater reliability of a scapular dyskinesia test based on visual assessment and dynamic physical loads.</p>	<p>142 NCAA athletes (111 males, 31 females) participating in water polo (89), swimming(19), baseball/softball (28), and other (volleyball/tennis = 6)</p>	<p>Two video cameras were used to record the actions of the participants throughout the motion.</p>	<p>Each participant underwent physical examination prior to testing. 5 repetitions of active, weighted shoulder abduction were performed bilaterally and recorded from posterior and superior views. These views comprised the Scapular Dyskinesia Test. Subjects were then asked to elevate arms overhead as far as possible in a 3-count with “thumbs up” and then lower in 3-second count. Dumbbells used for testing were assigned according to body weight. (3lb for those weighing less than 150lbs and 5lbs for those weighing more). Movement tests were observed and “visually scored” in a “live test” by professionals (certified athletic trainer/physical therapist).</p>	<p>Moderate interrater reliability was found when comparing live views/ratings of athletes and videotaped observation. Coefficients were found to be 0.57 for live raters and 0.54 for those viewing videotapes.</p>

**Table 3: Postural Correction Interventions and Diagnostic Tools of Measurement (continued)**

Title/Authors	Purpose	Participants	Instruments	Procedures	Results
<p>Accuracy of physical examination in subacromial impingement syndrome</p> <p>Silva, L., Andreu, J.L., Munoz, P., Pastrana, M., Millan, I., Sanz, J., Barbadillo, C., and M. Fernandez-Castro</p>	<p>To determine which clinical tests act as most reliable diagnostic tools for shoulder impingement syndrome as confirmed by an MRI.</p>	<p>14 males and 16 females who exhibited new onset shoulder pain, were seen in a rheumatology clinic and volunteered for the study.</p>	<p>MRI, using coronal oblique, sagittal, and axial planes</p>	<p>Each subject underwent physical exam and within 3 days of PE, completed an MRI screening. Active and passive ranges of motion were evaluated and special tests followed. Special tests included: Neer Impingement, Hawkins Test, Yocum Maneuvre, Jobe Maneuvre, Patte Maneuvre, and Gerber's Lift-off test. Lastly, subjects performed resisted abduction of the shoulder. An MRI was completed and results compared to findings of the physical exam.</p>	<p>Sensitivity of all special tests was reasonably good (above 58%), but specificity was low (10-60%). Yocum maneuver was most sensitive, followed by Hawkins and Jobe. Patte maneuver had best sensitivity, specificity, positive value (73.3%) and Yocum's was most accurate (65.5%).</p>

## CHAPTER III

### METHODOLOGY

#### Subjects

The subjects were volunteers from among the swimmers on the James Madison University Women's Swim Team. Permission to solicit participants was given by the Head Coach of the Women's Swim Team.

Subjects were included in this study only if they had no limitations in training as a result of shoulder pain and had not experienced any surgeries involving the upper extremities within the past year. All methods were approved by the James Madison University Internal Review Board. All subjects signed an Informed Consent Form prior to participation.

#### Interventions and group assignment

This study closely replicated the pre-test, post-test methodology utilized in Kluemper et. al. (2006). After signing a Research Participant Informed Consent Form and completing the Research Participant Questionnaire, subjects were assessed for degree of forward posture, matched with other subjects with similar forward posture measurements and randomly assigned to one of three groups. Subjects in the two intervention groups then participated in their assigned intervention for 18-training sessions (approximately 3 days per week for 8 weeks); whereas, subjects in the control group participated in normal swimming activities. One intervention group participated in

a combined stretching/strengthening program in addition to the normal swim training, and the other intervention group participated in strengthening only program in addition to the normal swim training program (Kluemper, 2006). These exercises were included in the study as a result of the commonality of stretching and strengthening implementation in rehabilitation protocols valuable to individuals involved in activities requiring repetitive overhead motion to decrease risk of injury and promote mechanical efficiency.

Pre- and post-intervention shoulder postures were measured with a double square, as the subjects stood against the wall, facing outward (Figure 1.). The distance between the anterior acromion and the wall was measured bilaterally in two different postural positions (resting and “upright military”) (Kluemper, 2006). Measurements were taken prior to and following the 18-session intervention, including flexibility and strength changes. In order to partially blind the study, all pre and post measurements were completed by trained personnel who were unaware of individual intervention group assignments. The researcher in charge of the interventions was not involved in the pre and post data collection.

### Testing Procedure

Measurements of the right and left shoulder of each subject were evaluated prior to and following the intervention. A Double –square apparatus (Model #420EM, Johnson Level and Tool Manufacturing, Inc, Mequon, Wisc) was used to enumerate forward shoulder posture as the distance (in millimeters) from the anterior acromion process of the subject to the wall (Kluemper, 2006).

## Forward Posture Measurement

The measurements, as detailed below, were taken in accordance with the procedures reported by Kluemper (2006). To mark the location on the left and right shoulders the subject stood in an “upright military posture” with the heels against the wall. The Double-square was positioned over the subject’s shoulder, maintaining complete congruency with one square against the wall, as the second square was adjusted until it touched the anterior tip of the acromion process. The procedures were repeated for three measurements on each shoulder. After measurements were completed in the “upright, military posture,” subjects assumed a normal resting posture, at which point, measurements were repeated. The military posture was incorporated to provide a baseline comparison method and to help ensure that abnormal alterations of resting posture did not inadvertently affect measurement processes in the resting postural state. Subjects were provided with verbal cues in order to assume the appropriate position for measurement of military posture. Subjects were instructed to:

1. Stand with the back of your head flat against the wall.
2. Make sure your heels are both pressed evenly against the wall, shoulder width apart (This position will be obtained as the subject stands with heels touching a floorboard that stands 2 feet in height, 2 inches from the wall)
3. Keep your buttocks pressed firmly against the wall.

4. Keep both arms at your side.
5. Try to touch the back of both shoulders to the wall and hold in position.
6. Take two deep breaths, inhaling and exhaling. On the second breath, hold the inhalation as the measurement is taken.
7. This was repeated 3 times on each shoulder.

Figure 1: Double-square method used to measure forward shoulder posture



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For each observation, pre- and post-intervention, the mean of three postural measurements were recorded, taken by the same investigator with the same equipment was utilized for statistical investigation. The measurements were taken on a day without scheduled practice to minimize the effects of fatigue factors, while assuming position in the same location against the wall to ensure accuracy and identical completion of procedures for all subjects (Kluemper, 2006).

#### Shoulder Flexibility Measurement

Internal rotation range of motion measurements were determined with a goniometer, while subjects were positioned supine on a table, with the upper arm abducted to 90° and the elbow flexed to 90° according to standards described by Norkin and White. Range of motion measurements were repeated three times and the average of the measurements recorded.

Scapular protraction was measured with subject standing in neutral position. Inferior angles of both scapulae was illustrated with a permanent marker dot and the distance between the spinous process of T7 and the inferior angle of the scapula was measured with a tape measure. Measurements were repeated three times for each scapula. The same measurements were completed as subject stood with hands on hips. Mean measurements were calculated and recorded.

#### Dynamic Shoulder Retraction Strength Measurement

Two strength measurements were completed to assess posterior shoulder musculature strength. A Theraband® Pull-Apart test was implemented to simulate the scapular retraction exercises included in the strength portion of this training protocol for the intervention group. Subjects stood facing a wall at 90° shoulder flexion, elbows in full extension, holding a heavy resistance Theraband® (gray) segment (12 inches in length) with hands 4 inches apart. Subject completed repetitions to fatigue protocol for strength baseline measurement. For repetitions to be counted, hands were moved at least 12 in apart, as designated by tape margins on a wall. The second strength measurement involved seated row repetitions to fatigue protocol in which the weight of resistance was set at 50% of subject's body weight.

#### Procedure training and reliability testing

Five research assistants were trained in the procedures detailed above. Following training, each assistant obtained 6 measurements (3 on either side of the body) on 6 to 10 subjects using each of the procedures they have trained to conduct. Each assistant returned and repeated the same measurements on the same subjects 2 to 3 days later. The Double-Square method used by Kluemper et al. twice by the same investigator, with a 4-day interval between measurements on 4 subjects, was used to calculate reliability of measurement. When 2 measurements were compared, measurements for bilateral shoulders produced an intraclass correlation coefficient of 0.99 and an SEM of 0.1mm for both sides (Kluemper, 2006). Reliability of measurement warranted duplicated use in the current study for postural observation.

## Exercise procedure

After the initial postural measurements were recorded, subjects in the strength only intervention group participated in an 18-session strength training program. The exercises were completed approximately three times per week prior to the scheduled swim practice and were monitored daily throughout the intervention. A time restriction of 15 minutes was implemented to minimize interference of the study with team practice time. Following the strength program, subjects in this group completed the normal swim practice. The second intervention group participated in an 18-session stretching and strengthening program prior to swim practice. A time restriction of approximately 25 minutes for the program was implemented to minimize interference of the study for this intervention group. A control group did no exercises prior to practice.

## Strength Exercises

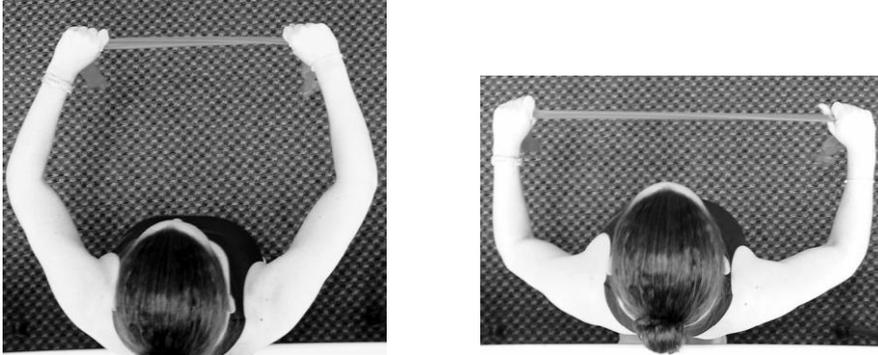
During the first session of intervention, the combined strength and stretching group were shown how to perform the strength development exercises using Theraband® exercise bands (Hygenic Corp, Akron, Ohio). The investigator demonstrated and explained the nature of each exercise (Table 1) and the subjects then completed 5 repetitions of each exercise. The investigator evaluated the subject's technique and gave feedback regarding the proper technique. When the appropriate individual resistance levels were determined, the first week exercise protocol of 3 sets of 10 repetitions of all strength exercises was completed (Kluemper, 2006). (See Figures 2-4 for illustrations of the exercises)

Table 4 Description of Theraband® Band Resistance Exercises Completed During  
6-week Strength Training Intervention

Exercise	Description
Scapular Retraction	With the shoulders abducted to 90° in the scapular plane, elbows flexed to 90°, and forearms horizontal, subject holds section of exercise band between right and left hands. Subject then retracts the scapulae, stretching the band. Subject must retain 90° position of shoulders and elbows and execute a controlled return to the starting position.
External Rotation	Upper arm is positioned at 90° of shoulder abduction and 90° of elbow flexion. The forearm begins in a horizontal position and externally rotates into a vertical position. Subject then executes a controlled return to starting position. Exercise band is fixed in front of the subject at approximately waist height at the beginning of the exercise.
Seated Rows	Subject seated, elbows fully extended, with Theraband® (3 feet in length) fixed around base of both feet. With trunk in upright position, subject pulls Theraband® toward hips, while retracting scapulae.
Shoulder Flexion for Lower Trapezius	With arms flexed to 90°, elbows fully extended, and palms facing down, subject fixes the shoulders at 180° against the resistance of the exercise band and then executes a controlled return to the starting position. The exercise band is fixed in front of the subject at approximately waist height for the beginning of the exercise.

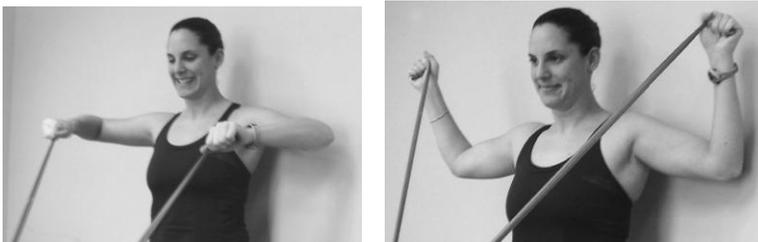
Kluemper, Mark, and Tim Uhl, and Heath Hazelrigg. "Effect of Stretching and Strengthening Shoulder Muscles on Forward Shoulder Posture in Competitive Swimmers." Journal of Sport Rehabilitation 15 (2006): 58-70.

Figure 2: Scapular Retraction



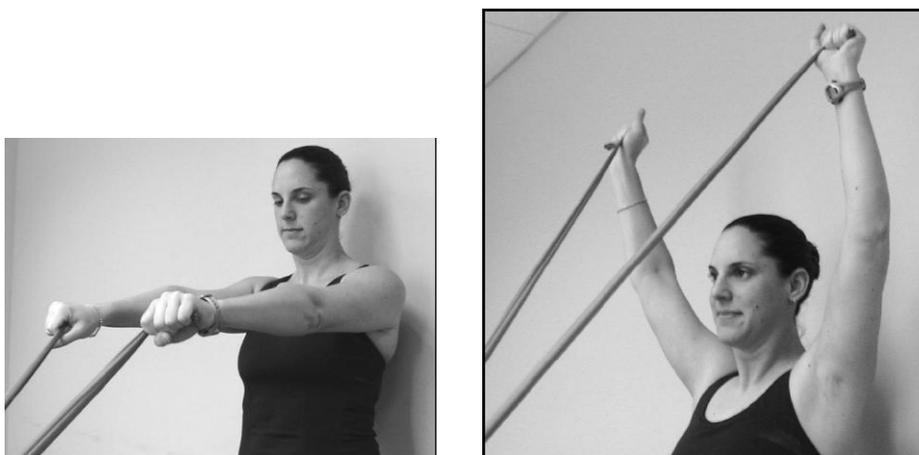
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Figure 3: External Rotation



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Figure 4: Shoulder Flexion for Lower Trapezius



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After the strength exercises, subjects were asked if the resistance bands chosen were too challenging (not able to complete the full 3 sets or began lacking proper technique due to fatigue), appropriately challenging (final 3 or 4 repetitions were a struggle, but proper technique was maintained), or not challenging enough (repetitions completed with little or no struggle). Resistance levels were adjusted according to subject feedback following session 1 of strength exercises. If the resistance was too great, the next lower level of resistance was implemented and if the resistance was not challenging enough, the next highest resistance was assigned (Kluemper, 2006). The exercise progression for the study (Table 2) was based on a study by Wang et al, in which a comparable protocol produced significant strength gains (Kluemper, 2006). The subjects were given an opportunity to ask questions about the exercises and then asked to

pair up with a teammate of similar body size to facilitate execution of the training protocol as described in the stretching exercises (Kluemper, 2006) (Figures 5-6).

Table 5: Exercise Progression

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Repetitions	3 x 10	3 x 15	3 x 20*	3 x 10	3 x 15	3 x 20

\*At the end of week 3, subjects progressed to next highest resistance level using the Theraband® resistance bands.

#### Stretching exercises

The investigator demonstrated and explained the nature of each stretching exercise (Kluemper, 2006) to the intervention group. A stretch for the anterior chest muscles required the subjects to lay supine on a 5-in-diameter foam roll which sat in the center of the back while the partner was required to grasp the subject's shoulders and slowly apply pressure towards the ground until instructed to stop and hold for 30 seconds (Kluemper, 2006). This stretch was repeated two times during each session. The stretch for the internal rotators required the subject to kneel in front of the standing partner and lace fingers behind the head. The partner reached in front of the arms of the subject and back behind the scapulae. The partner then applied a diagonal stretch, pulling up and away from the trunk of the subject until subject instructed the partner to stop and hold. The

stretch was held for 30 seconds and repeated two times during each session (Kluemper, 2006) (Figures 5-6).

The same partners were assumed for one experimental group duration of the 6-week study and the investigator was present for every exercise session. The control group did not participate in either the strength program, or the combination of stretching and strengthening protocols.

Figure 5: Pectoralis Minor Stretch



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Figure 6: Pectoralis Major Stretch



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#### Data Analysis

The change in forward-shoulder posture measurement with the double-square was calculated (post-test score – pre-test score = difference) for both shoulders in each test position (Kluemper, 2006). The posture scores were also adjusted for between subject anatomical differences by subtracting the double-square measurement taken with shoulders retracted and held against the wall from the measurement taken in the relaxed position. Separate statistical analyses were performed for the unadjusted and adjusted scores. Potential differences in horizontal abduction strength, flexibility, and degree of forward shoulder posture during the testing period were analyzed among the control group with paired sample t-tests. Separate 2 x 2 repeated measures ANOVA's with one within (pre- to post-) factor and one between (group) factor were used to compare

horizontal abduction strength, internal rotation and shoulder posture scores between 1) the strengthening only group and the control group, 2) the combined stretching and strengthening group and the control group, and 3) strengthening only group and the combined stretching and strengthening group. Comparisons were made using right side data only, left side data only, and combined right and left side data. All data is presented as the means +/- standard deviation. Alpha was set at a 0.05.

## CHAPTER IV

### RESULTS

Subjects participating in this study were all Division I female collegiate competitive swimmers with an average age of  $19.5 \pm 1.0$  years, height of  $168.1 \pm 5.1$  centimeters, and weighing  $66.3 \pm 6.7$  kilograms. The total swimming volume for the duration of the study averaged  $332,657 \pm 24,595$  meters or  $41,582 \pm 3,074$  meters/week among all the participants and there were no significant differences between the groups (Table 6)

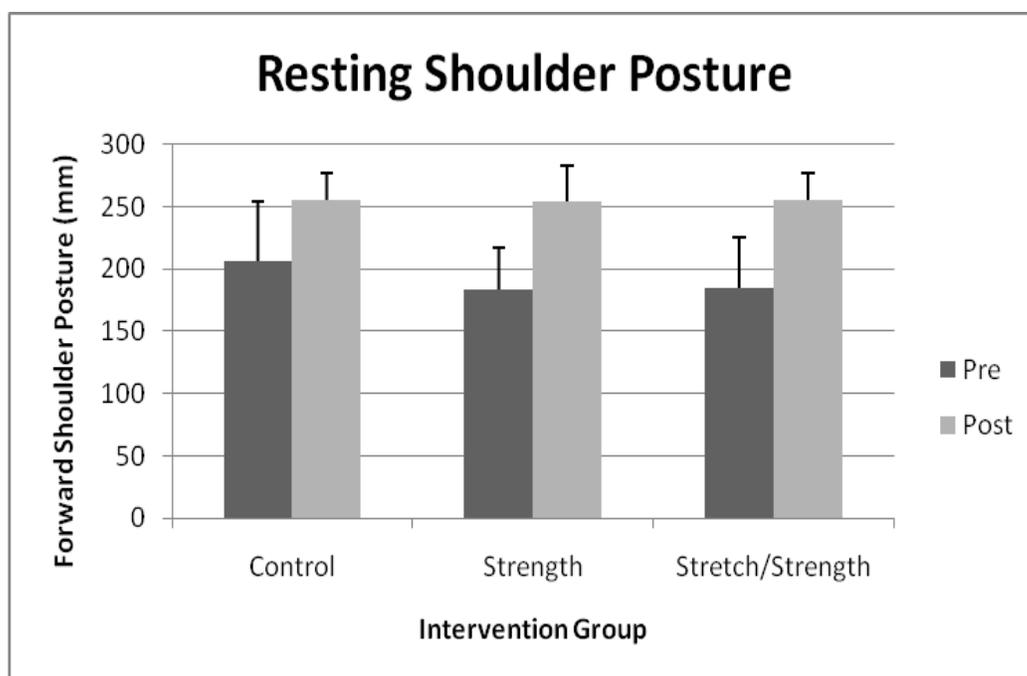
Table 6: Subject Demographics

	Subjects	Age (yrs)	Height (cm)	Weight (kg)	Total Swim Volume (meters)
Control	9	$19.91 \pm 1.04$	$168.50 \pm 4.29$	$68.12 \pm 6.54$	$318,957 \pm 19,625$
Strength	11	$19.5 \pm 0.85$	$167.64 \pm 4.75$	$63.45 \pm 6.62$	$329,009 \pm 25,426$
Strength/Stretching	11	$19.27 \pm 1.10$	$168.10 \pm 6.30$	$67.08 \pm 6.70$	$344,955 \pm 22,439$

Expected outcomes for the control group included no significant changes in forward shoulder posture or scapular positioning, no change in glenohumeral internal rotation, and no change in strength. Paired samples t-tests of the control group data revealed no significant changes in horizontal abduction strength ( $t=1.28$ ;  $p=0.24$ ), change in right glenohumeral internal rotation ( $t=-1.37$ ;  $p=0.21$ ), change in left glenohumeral

internal rotation ( $t=-1.42$ ;  $p=0.19$ ), total change in internal rotation for right and left shoulder internal rotation combined ( $t=-1.47$ ;  $p=0.18$ ) (Table 7), change in scapular positioning at rest ( $t = 1.30$ ;  $p=0.20$ ), or change in retracted scapular position ( $t = 1.44$ ;  $p=0.18$ ) from pre- and post- measurements (Table 8). Significant differences were observed between pre- and post- test values for bilateral resting shoulder postures ( $t=-2.96$ ;  $p=0.018$ ) and adjusted resting shoulder postures (resting posture - retracted posture) ( $t=-5.92$ ;  $p=0.000$ ) (Table 8).

Figure 7: Resting Shoulder Posture



No differences were found for seated row strength from pre- to post- intervention ( $t=-1.14$ ;  $p=0.29$ )

Table 7: Shoulder Strength and Flexibility Data

	Horizontal Abduction Theraband® (repetitions)		Internal Rotation (degrees)	
	Pre	Post	Pre	Post
Control	18.0 ± 8.9	15.1 ± 9.3	149.8 ± 30.9	158.8 ± 26.4
Strength	12.3 ± 6.3	23.6 ± 11.5	141.6 ± 26.0	150.9 ± 26.8
Strength/ Stretching	10.8 ± 3.4	9.8 ± 7.2	146.6 ± 9.7	158.6 ± 13.3

Table 8: Scapular Position and Shoulder Posture Data

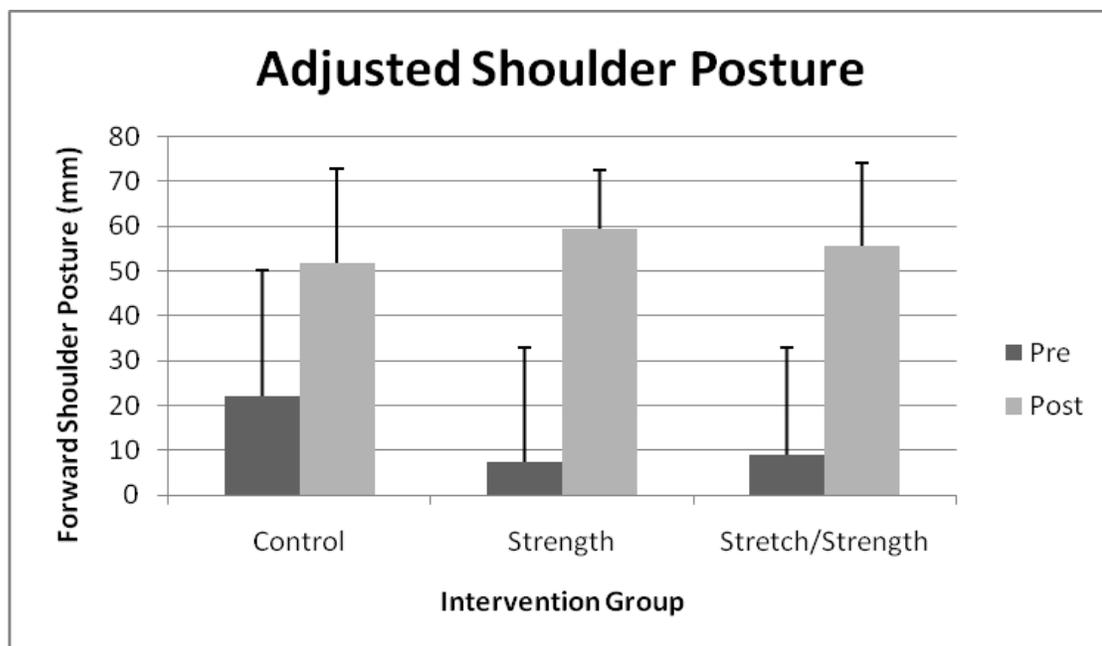
	Scapular Position Resting (mm)		Scapular Position Retracted (mm)		Resting Shoulder Posture (mm)		Adjusted Shoulder Posture (mm)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Control	222.2 ± 32.2	189.3± 15.3	205.0± 20.8	192.4± 11.5	205.7 ± 48.2	254.9 ± 22.3	22.1 ± 28.1	51.7 ± 21.3
Strength	238.4± 39.8	177.6± 25.7	187.9± 19.2	180.2± 27.6	183.9 ± 33.2	254.5 ± 28.0	7.4 ± 25.7	59.4 ± 13.2
Strength/ Stretching	242.8± 31.3	180.5± 25.2	199.5± 29.3	182.4± 22.7	185.0 ± 39.9	255.2 ± 21.8	9.0 ± 23.8	55.5 ± 18.7

The repeated measures ANOVA indicated a significant interaction between the strength only group and control group for horizontal abduction Theraband® repetitions ( $F=17.49$ ;  $p=0.001$ ). No significant interactions were observed between the strength

group and control group for total internal rotation ( $F=0.00$ ;  $p=0.971$ ), resting shoulder posture ( $F=1.20$ ;  $p=0.287$ ), adjusted shoulder posture ( $F=3.84$ ;  $p=0.066$ ), resting scapular position ( $F=1.45$ ;  $p=0.251$ ) or retracted scapular position ( $F=1.97$ ;  $p=0.177$ ). There were, however, main effects for changes in internal rotation ( $F=5.00$ ;  $p=0.038$ ), resting shoulder posture ( $F=37.81$ ;  $p<0.000$ ) and adjusted shoulder posture ( $F=50.72$ ;  $p<0.000$ ) over time. These main effects were characterized by increased internal rotation (Table 7) and the postural measures for both groups. ( $F=0.73$ ;  $p=0.400$ ) (Table 8).

No significant interactions between the combined strength and stretching group and the control group were found for horizontal abduction strength through Theraband® repetitions ( $F=0.807$ ,  $p=0.382$ ), bilateral internal rotation ( $F=0.194$ ;  $p=0.665$ ) (Table 7), resting scapular position ( $F=2.86$ ;  $p=0.108$ ), retracted scapular position ( $F=2.07$ ;  $p=0.127$ ) or for resting ( $F=1.31$ ;  $p=0.27$ ) or adjusted ( $F=4.237$ ;  $p=0.054$ ) shoulder posture (Table 8). Main effects, however, were found for increases in internal rotation ( $F=9.51$ ;  $p=0.006$ ) (Table 7), resting shoulder posture ( $F=42.5$ ;  $p<0.00$ ) and adjusted shoulder posture ( $F=85.72$ ;  $p<0.000$ ) indicating that both groups experienced gains in these measures (Table 8).

Figure 8: Adjusted Shoulder Posture



A significant interaction between the combined stretching and strength group and the strength only group was found for horizontal abduction strength using Theraband® repetitions ( $F=15.733$ ;  $p=0.001$ ). This interaction was characterized by a significant increase in the number of repetition performed by the strength only group following the training intervention; whereas, no change was found in the combined stretching and strength group. No interaction was found between the combined stretching and strengthening group when compared to the strength group for flexibility in bilateral internal rotation ( $F=0.172$ ;  $p=0.683$ ) (Table 7), resting shoulder posture ( $F=0.001$ ;  $p=0.980$ ), adjusted shoulder posture ( $F=0.239$ ;  $p=0.630$ ), resting scapular position ( $F=0.006$ ;  $p=0.938$ ) or retracted scapular position ( $F=0.031$ ;  $p=0.631$ ) (Table 8).

## CHAPTER V

### DISCUSSION

Participants were divided into three separate training groups according to mean postural measurements, consisting of a control group (n=9), strength only (n=11), and combined stretching and strengthening group (n=11). All exercises and stretches within the intervention groups were monitored daily by the investigator. The initial values for both resting forward posture and adjusted forward posture were not significantly different between the groups (resting shoulder posture,  $F=0.89$ ;  $p=0.424$ ; adjusted shoulder posture,  $F=0.94$ ;  $p=0.403$ ) although the control group values tended to be higher. The discrepancy was attributable to the inability to perfectly match the groups based on shoulder posture because of the low number of subjects in the control group. All exercises and stretches were monitored by investigator on a daily basis throughout the duration of the intervention.

Contrary to what was expected, the control group experienced a significant increase in forward shoulder posture and no significant change in flexibility or strength over the duration of the study. Significant increases from pre- to post-test measures were found for bilateral resting shoulder posture as well as adjusted resting shoulder posture (resting posture - retracted posture). The strength group gained strength as demonstrated by the seated row repetitions and Theraband® horizontal abduction repetitions to fatigue. The combined stretching and strengthening group produced improvements in bilateral shoulder internal rotation and seated row repetitions. However, there were no interactions or between-group differences, suggesting that, as compared to the control

group, the strength and strength/flexibility training may have been inadequate to cause changes in strength, flexibility, and posture.

In theory, stretching of the hypertrophied anterior shoulder muscles in combination with strengthening of the posterior scapular stabilizing muscles should result in a positive postural change due to the synergistic effect of muscular balance (Kluemper, 2006). This was not observed within the current study and the discrepancy from Kluemper's findings may have been a result of several factors. First, the subjects within the current study were all Division I collegiate females, whereas, in the study by Kluemper et al., male and female swimmers of varying experience (elite, collegiate, high school) were observed. The control group in Kluemper's study was comprised of 10 males and 14 females, whereas the experimental group consisted of 4 men and 11 women (Kluemper, 2006). A larger average frame size among males could result in a greater potential range of change scores from pre- to post- measurements within the group assignments (Kluemper, 2006). The current study measured female athletes only, without the integration of male swimmers which may have become outliers that offset the true mean of measureable changes.

The variation of swim experience in Kluemper's study was not specifically described, which may have added to discrepancies between the studies. Many competitive swimmers practice 6-7 days per week and accumulate 10,000 to 14,000 meters/day of swimming (Kluemper, 2006). The mileage of swimming may not be as elevated in high school settings as in collegiate or elite-level competitors. The use of strength exercises for postural correction was a familiar concept for the athletes in the

current study, as they regularly participated in weight lifting as a team with a program designed to address injury prevention (i.e. posterior shoulder strength) exercises.

However, if a large portion of the subjects in Kluemper's study were high school aged, introduction of strength exercises may have produced greater effects due to muscular adaptations.

Another possible explanation for the failure of the interventions to attenuate increases in forward shoulder posture was that any effect attributable to the intervention was relatively small compared to the effect of a high volume of swimming. To assess this question, training volume (meters swam) logs provided by the team's head coach were reviewed and showed that the average total training volume for the duration of the study was 340,736 (56,789 m/week) meters. The training volume ranged from a low of 303,780 meters (37,973 m/week) for the sprinters and a high of 364,960 meters (45,620 m/week) meters for the butterflyers. In contrast, Kluemper et al. (2006), showed significant improvement in forward shoulder posture with a similar intervention strategy despite the fact that the training volumes averaged 49,974 m/week for the control group and 51,966 m/week for the experimental group. Moreover, follow-up analysis of data from the present study indicated that there was no correlation between swimming volume or variations in the types of training (e.g. sprint, distance, medley, etc.) and measures of forward shoulder posture. Follow-up analysis included correlating (Pearson product moment correlation) individual swimming volumes with forward shoulder posture and rank ordering swimmers by type of training (lowest volume group = 1; second lowest volume group = 2; etc.) and conducting a non-parametric correlation (Spearman Rho)

with forward shoulder posture. The comparisons with Kluemper's data and post-hoc analysis suggest that the failure of the interventions to favorably alter shoulder posture during training was not a consequence of high training volumes or differences in training volumes between the study groups or training groups.

Further comparison of data obtained in the present study with the data reported by Kluemper et al. (2006) may help explain why improvements in forward shoulder posture were found in one study and not the other. Although Kluemper et al. did not report actual forward shoulder posture values, they found that strength and flexibility intervention decreased (improved) forward shoulder posture by approximately 9mm, whereas a minimal decrease (2 mm) was seen in the control group. In the present study, forward shoulder posture increased among all the groups and the change was three to five times more than the values reported by Kluemper et al. Further analysis of this data is limited by the fact that Kluemper et al only reported change scores, but the discrepancy suggests that differences in measurement technique and/or measurement error may have been a factor.

Although the interventions produced no change in posture, strength gains were obtained over the 8 week period of exercises for the strength only group. Increases in strength of the scapular musculature and external rotators is especially important because both muscle groups serve as decelerators for the humerus and act to center the humeral head in the glenoid throughout ranges of motion (Thomas, 2009). Deceleration is achieved through eccentric rotator cuff contractions, typically seen during the recovery phase of swimming (Thomas, 2009). The strength gains hypothetically aid in supporting

injury prevention, while stabilizing the shoulder girdle because repetitive overhead motions and excessive movement of the humeral head can lead to labral tears, impingement, and other pathology within the shoulder. Though strength gains were not observed for both groups completing the strength exercises, the strengthening program remains an important element within a maintenance protocol that should be implemented during preseason and throughout the competitive year to enhance muscle control and joint stability, while enabling proper joint biomechanics.

In contrast to the current study, Niederbracht et al demonstrates the strength gains obtained through a strength program involving external rotation at 90° shoulder abduction, seated row, and chest press with use of Theraband® resistance bands, completed 4 times a week for 5 weeks by two collegiate women's tennis teams. Statistical significance was found for gains in eccentric work performed by the experimental group, reflecting a decrease in shoulder rotator muscle imbalance (Niederbracht, 2008). Increased internal rotation strength can occur as an adaptation to frequent play, but external rotation strength may not increase proportionally, generating an imbalance that can predispose injuries (Niederbracht, 2008). The exercises within this protocol closely replicated functional movement of the tennis serve and focused on strengthening the eccentric movement of rotator muscles during the deceleration phase of the motion, similar to the concepts that can be applied to the swim stroke and the follow-through phase (Niederbracht, 2008). Supportive evidence for the application of strengthening programs for the repetitive overhead athlete provides a sturdy foundation to

illustrate the need for such programs to prevent or diminish the risk of injury for these individuals.

As a result of the demands of the sport, swimmers are often found to have not only weakened posterior musculature, but decreased internal rotation following training. This was illustrated by Thomas et al., who found altered (decreased) glenohumeral range of motion in high school swimmers, volleyball players, and tennis players following 12 weeks of competition. Internal rotation decreased in all overhead athletes (Thomas, 2009). Therefore, increased protraction of the scapula or decreased upward rotation, as controlled by the posterior musculature that serve as decelerators for the humerus during the recovery phase of the swimming stroke cycle, can result in decreased internal rotation and altered postural mechanics (Thomas, 2009).

Scapular dyskinesis or SICK (scapular malposition, inferior medial border prominence, coracoid pain and malposition, and dyskinesis) scapula, is often used to describe asymmetry of the scapula as it moves along the thoracic ribcage (Oyama, 2008). Repetitive overhead athletes such as baseball, volleyball, and tennis players, have been found to produce asymmetry between the scapula of dominant and non-dominant limbs (Oyama, 2008). The dominant side has shown more anteriorly tilted and internally rotated shoulders, confirming that scapular position can affect posture (Oyama, 2008). No statistically significant changes were noted in the current study between groups over time however, previous research supports the importance of noting scapular position in overhead athletes as part of injury assessments.

Increased scapular protraction, in conjunction with postural asymmetry, can result in gleno-humeral internal rotation deficits (GIRD) in the overhead athlete which has been noted as an adaptation leading to shoulder injuries (Thomas, 2010). GIRD is thought to be a product of chronic eccentric loading of the posterior shoulder capsule, while generating stress and healing responses from movement of the humeral head in the posterior-superior direction (Thomas, 2010). This movement over time can result in superior labrum anterior to posterior (SLAP) tears, rotator cuff pathology, and impingement issues (Thomas, 2010). The current study was not concurrent with previous research in noting a decrease in internal rotation. Although all three groups displayed increased internal rotation, the combined strengthening and stretching group produced the greatest increase in changes (Table 7). This lack of significant change could have been influenced by warm-up stretching completed in the water following warm-up or interventions in the weight room that resulted in posterior strengthening for all athletes, allowing for greater control of the humerus throughout ranges of motion. GIRD may inhibit the muscles that stabilize the scapula and can lead to scapular dyskinesis if left untreated, completing the kinematic effect of improper anatomical congruency, mechanical weaknesses, and loss of flexibility through motions of internal rotation in the repetitive overhead athlete (Thomas, 2010).

Athletes involved in other repetitive overhead sports such as baseball, are often observed to have similar injuries of rotator cuff degeneration, scapular dyskinesis, and shoulder impingement, requiring rehabilitation protocols similar to those of swimmers in regard to overuse injuries and general shoulder maintenance. The American Sports

Medicine Institute has developed a “Thrower’s 10” exercise program to prevent the maturation of these issues in the repetitive overhead athlete (Ellis, 2010). Similar to many rehab progressions, the “Thrower’s 10” program involves Theraband resistance bands for Diagonal Pattern D1 extension and Diagonal Pattern D2 flexion, internal and external rotation exercises at 0° shoulder abduction, and internal and external rotation at 90° shoulder abduction (Ellis, 2010). Hand weights were used to complete shoulder abduction to 90°, scaption with internal rotation, prone horizontal abduction, prone rowing, elbow flexion, elbow extension, wrist extension, wrist flexion, and wrist pronation/supination (Ellis, 2010). Push-ups and press-ups were also incorporated into the program to engage proprioceptive and stability properties of muscular control (Ellis, 2010). This program is simply one protocol that involves benefits for the repetitive overhead athlete. The exercises are not limited to posterior shoulder musculature alone, but rather incorporate the upper extremity as one kinetic chain. For this reason, exercise programs isolating individual muscles for the athlete may not provide as many benefits as a program comprised of exercises highlighting functional movement.

McMullen et. al investigated the clinical application of kinetic chain approaches for shoulder rehabilitation. Proximal to distal kinetic chain implementation of rehabilitation exercises were emphasized through movements involving trunk, scapular, and extremity control to enhance motor capabilities in closed chain activities of the glenohumeral joint (McMullen, 2000). This program composed a protocol of various exercises that gradually progress from dysfunction to full function highlighting kinetic chain activities, synergistic properties of shoulder musculature, scapular control and

rotator cuff activation, and closed kinetic chain activities in early stages of correction (McMullen, 2000). If the upper extremity in swimmers were treated for sport specific application, programs such as the “Thrower’s 10” protocol may produce greater benefits for the athletes and result in decreased risk of injury due to overall joint stability.

There were several noteworthy limitations that may have influenced the outcomes of data collection. First, a limited number of athletes (all female) participated in the study. These athletes complete both dryland and lifting sessions, which may have interfered with the strength and postural results due to an inability to completely control for just interventions. Due to coach’s request that the study not interfere with practice time, athletes were unable to swim a warm-up for 20 minutes prior to completing the strengthening and stretching exercises, as was completed in Kluemper’s study. This may have altered the ability of the muscle spindle fibers within the pectoralis minor and pectoralis major muscles to adapt to the stretches and obtain the greatest benefits from the techniques. Finally, forward shoulder posture in the present study increased among all the groups and the change was three to five times more than the values reported by Kluemper et al. and the discrepancy suggests differences in measurement technique and/or measurement error may have been a factor.

## CHAPTER VI

### CONCLUSION

As hypothesized, paired samples t-tests were not statistically significant for change in horizontal abduction strength, right glenohumeral internal rotation, left glenohumeral internal rotation change, or total change in internal rotation for right and left shoulder internal rotation combined among the control group. Pre- and post- bilateral resting shoulder postures were significantly different. Adjusted resting shoulder posture (resting posture - retracted posture) was significantly different from pre- to post-exercise. No differences were found for seated row strength pre- and post- intervention.

Compared to the control group, the strength only intervention group displayed significant increases in strength for Theraband® repetitions. No significant interactions between the strength group and control group were found for total internal rotation, resting or adjusted shoulder postures, although main effects for time were observed for the control and strength groups for internal rotation as well as resting and adjusted shoulder posture. No significant interactions between the combined strength and stretching group and the control group were found for horizontal abduction strength through Theraband® repetitions, bilateral internal rotation or for resting or adjusted shoulder posture. Main effects were found for increases in internal rotation as well as resting and adjusted shoulder posture characterized by gains in each of these measures.

A significant interaction between the combined stretching and strength group and the strength only group was found for horizontal strength through Theraband® repetitions. The interaction was characterized by a significant increase in the number of

repetitions performed by the strength only group and not the combined group. No interaction was found between the combined stretching and strengthening group when compared to the strength group for flexibility in bilateral internal rotation as well as resting and adjusted shoulder posture.

In conclusion, it appears that the interventions were appropriate for the goals of improving strength and flexibility, but were not significant enough to overcome the demands of training volume and modify posture. The interventions may be more beneficial if utilized as a shoulder maintenance program during pre-season and throughout the year to aid in muscle balance and shoulder stability, while enhancing the efficacy of biomechanical functioning. Although the protocols did not produce all the significant changes that were expected, it is important to note that the purpose of a maintenance program, composed of isolated exercises, to re-educate, enhance, and support proper musculoskeletal functioning for the benefit of sport-specific performance and injury prevention. While no statistical significance reflected change, subjects reported decreases in levels of shoulder pain during swimming and general feelings of relief anectdotally.

Future studies should incorporate the strengthening and stretching protocols throughout an entire competitive season with a single gender team. Attention should be focused on postural changes without additional workouts in the weight room. Two age-groups (one middle school/high school and one collegiate) should be compared to observe possible changes and adaptations, keeping in mind hormonal changes and the significance of adaptations during pubescent years. This will aid in determining whether

the maintenance programs are more beneficial if implemented during an age when muscles and joint stability are being established, or at an age when the mechanics of swimming and muscular function have already been instituted. More research is warranted to observe the effects of strengthening and stretching exercises on forward shoulder posture to create conclusive concepts in regard to muscle function and adaptation.

## Appendix I

### **Research Participant Informed Consent Form**

#### *Effect of Strengthening on Forward Shoulder Posture in Division I Competitive Female Swimmers*

#### ***Identification of Investigators & Purpose of Study***

You are being asked to participate in a research study conducted by Rachel Ondek from James Madison University. The purpose of this study is to analyze the impact of posterior shoulder strengthening on the forward shoulder posture in female competitive collegiate swimmers. This study will assist in the completion of a master's thesis.

#### ***Research Procedures***

Should you decide to participate in this research study, you will be asked to sign this consent form once all your questions have been answered to your satisfaction. This study consists of a stretching and strengthening protocol with the use of Theraband® resistance bands. You will be asked to wear a swim suit in order to appropriately measure upper body joint angles. Shorts may be worn over the swim suit. Markers will be placed on anatomical reference points on your back and shoulders. Once the markers are placed and resting measurements have been recorded you will be asked to assume two postural positions. The researcher will explain the appropriate positioning of your body near the wall. You will then be asked to lie on your back for two measurements of shoulder flexibility.

**\*\*\*If at any time you wish to stop testing, for any reason, you are allowed to do so with no consequences\*\*\***

#### ***Time Required***

Participation in this study will require approximately 30 minutes for the initial measurements and up to 15 minutes of your time 3 times per week for the duration of 6 weeks. Final measurements will be conducted after the 6-weeks of exercise, requiring approximately 30 minutes of your time.

#### ***Risks***

Although precautions have been implemented to minimize the risk, **the possible risks and injuries that may result from your participation includes: muscle soreness, muscle strain, mild joint injury, including ligamentous sprains that may impact levels of training due to repetition of exercise. If you sustain an injury during testing, you will assume all medical costs that may follow.** Any injury sustained as a result of participating in this study may affect your individual level of sport participation at James Madison University. Because scholarships are handed out on an individual basis by the coaching staff, if an injury were to occur during this study, the status of a scholarship would depend on the decision of the coaching staff of your given sport.

In order to minimize these risks, an Investigator will be present during all exercise sessions to ensure that proper form and technique is being implemented, while explaining all procedures clearly prior to the beginning of the study. The Investigator will also demonstrate and explain the exercises in detail prior to

the beginning of Theraband® use or stretching movement. The Investigator is a licensed, certified athletic trainer and will offer professional assistance as necessary.

### ***Benefits***

There are several benefits to the participant during this study due to the rehabilitative nature of the exercises. Participants may observe visual differences in posture and less forward shoulder posture, as well as strengthened muscles of the shoulder. As a direct benefit, individual and summary data will be made available to subjects upon request. If requested, the researcher will also review individual results with the subject to address questions related to general physical conditioning and other outcomes. This study will aid in the composition of future shoulder rehabilitative and maintenance programs for the JMU Women's Swimming and Diving Team as an aid in injury prevention.

### ***Confidentiality***

All collected data will remain anonymous and be kept in a locked cabinet or a password-protected computer. The results of this research may be presented at professional conferences, seminars and/or in the form of published papers. The results of this project will be coded to protect the identity of the research participant and will not be included in the final form of this study. The investigator retains the right to use and publish non-identifiable data. All data will be stored in a secure location accessible only to the investigator. Upon completion of the study, all information corresponding subjects with measurements will be destroyed.

### ***Participation & Withdrawal***

Your participation is entirely voluntary, as you are free to choose not to participate. Should you choose to participate, you can withdraw at any time without consequences.

### ***Questions about the Study***

If you have questions or concerns during the time of your participation in this study, or after its completion or you would like to receive a copy of the final results of this study, please contact:

Rachel Ondek, ATC

M. Kent Todd, PhD

Kinesiology

Kinesiology

James Madison University

James Madison University

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### **Questions about Your Rights as a Research Subject**

Dr. David Cockley

Chair, Institutional Review Board

James Madison University

(540) 568-2834

cocklede@jmu.edu

### **Giving of Consent**

I have read this consent form and I understand what is being requested of me as a participant in this study. I freely consent to participate. I have been given satisfactory answers to my questions. The investigator provided me with a copy of this form, and I certify that I am at least 18 years of age.

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Participant Name (Print)

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Date

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Participant Signature

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Date

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Investigator's Signature

---

Date

## Appendix II

**Research Participant Questionnaire***Effect of Strengthening Exercises on Forward Shoulder Posture in Division I Competitive Female Swimmers*

Rachel Ondek, ATC  
 Masters Thesis  
 Department of Kinesiology  
 Concentration in Exercise Physiology  
 Thesis Advisor : M Kent Todd, PhD.

Name: \_\_\_\_\_  
 Age: \_\_\_\_\_  
 Height: \_\_\_\_\_  
 Weight: \_\_\_\_\_  
 Phone Number: \_\_\_\_\_ - \_\_\_\_\_ - \_\_\_\_\_  
 Email: \_\_\_\_\_

Have you ever experienced shoulder pain during swim activity? Y / N

If Yes, explain the TYPE of pain (sharp, dull, shooting, pins and needles, etc.), which shoulder (dominant/non-dominant, L or R), and how long did these symptoms persist (minutes, hours, days, weeks, etc.)?

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Have you ever lost feeling in your shoulder/elbow/wrist/hand during or after swim activity? Y / N

If Yes, how long did loss of feeling persist (minutes, hours, days, etc.) and did it affect your ability to complete your "normal" swim stroke?

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Have you had any shoulder surgeries within the past year? Y / N

If so, when?

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**Are you currently limited in participation for swim training due to an existing shoulder problem?  
(limitations include both swimming and dryland exercise) Y / N**

**RESEARCHER USE ONLY**

Approved: \_\_\_\_\_ Initials: \_\_\_\_\_ ID# \_\_\_\_\_

## Appendix III

Name \_\_\_\_\_

**Pre-Test Data****1. Postural Assessment**

R - Normal Resting Posture: \_\_\_\_\_

Average: \_\_\_\_\_

R - Retracted Posture: \_\_\_\_\_

Average: \_\_\_\_\_

L - Normal Resting Posture: \_\_\_\_\_

Average: \_\_\_\_\_

L - Retracted Posture: \_\_\_\_\_

Average: \_\_\_\_\_

**2. Internal Rotation:**

Right Shoulder: \_\_\_\_\_

Average: \_\_\_\_\_

Left Shoulder: \_\_\_\_\_ Average: \_\_\_\_\_

### 3. Scapular Assessment

R - Neutral position: \_\_\_\_\_ Average: \_\_\_\_\_

R - Hands on Hips: \_\_\_\_\_ Average: \_\_\_\_\_

L - Neutral position: \_\_\_\_\_ Average: \_\_\_\_\_

L - Hands on Hips: \_\_\_\_\_ Average: \_\_\_\_\_

### 4. TB Strength Test:

\_\_\_\_\_ Average: \_\_\_\_\_

### 5. Seated Row:

\_\_\_\_\_ Average: \_\_\_\_\_

Plate #: \_\_\_\_\_

Weight: \_\_\_\_\_

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