Correlation between Lower Trapezius Weakness and the Incidence of Shoulder Pathology in Overhead Athletes

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ABSTRACT
Multiple shoulder sources indicate that scapular muscle weakness, or imbalance, are the primary causes of injury as well as the main focus of rehabilitation following an injury. The current research states that lower trapezius weakness can predispose to injury but is lacking data to reinforce these claims. The purpose of this study was to determine if in fact specific muscle weakness can predispose to injury, and if so what constitutes an at risk shoulder. Thirteen healthy female athletes were tested using a pivot prone pull fatiguing exercise protocol and dynamometry to measure lower trapezius muscle strength. Subjects were then ranked from weakest to strongest based on their strength data and were monitored for incidence of shoulder pathology for one year. We hypothesized that athletes with a faster rate of fatigue and lower strength scores would have a high incidence of shoulder pathology. Our results showed no correlation between lower trapezius fatigue and strength score and injury.

Keywords: lower Trapezius, shoulder imbalance, weakness, scapular imbalance, overhead athletes, overuse shoulder injury.

INTRODUCTION
When considering pathologies that effect overhead athletes, shoulder injury seems to stand out among the rest. Scapular dysfunction tends to be present in most of these injuries due to the fact...
that the scapula plays a vital role in glenohumeral joint stability. The scapula is the platform for which the shoulder moves. Therefore, if the scapula is not properly stabilized, the glenohumeral joint is at a greater risk for injury. According to Houglum, “The difference between a stable and an unstable scapula for the shoulder is similar to the difference between running on firm ground and running on a suspended wood and rope footbridge.”¹ This statement further demonstrates the importance of scapular stability. If the scapula is unstable, this can predispose the shoulder to injury the same way running on unstable ground increases the risk for ankle sprains.¹

Scapular dysfunction or scapular dyskinesis can be defined as abnormal motion or position of the scapula during motion.² These altered kinematics are usually caused by a “nonspecific response” to some type of shoulder injury.³ Other current research states that this dysfunction may be caused by “imbalanced” force couples or more specifically one or more “weak” muscles.⁴,⁵ According to Burkhart et al, scapular dysfunction is also apparent in asymptomatic overhead athletes.⁶ Therefore, dyskinesis can also be the causing factor of a wide array of shoulder injury not only a result.⁶ The most commonly addressed muscles in this field of study include the serratus anterior as well as the lower trapezius. The serratus anterior and the lower trapezius make up a force couple with the upper trapezius, pectoralis minor, levator scapulae, and rhomboids.¹ However, most research shows scapular dysfunction due to pathology of the lower trapezius and serratus anterior.⁶,⁷

Although the general consensus from current research states that the lower trapezius weakness can be a predisposing factor to shoulder injury, there is little data to reinforce this theory. The current research is also lacking information as to what qualifies as weakness or strength. Therefore, the purpose of this study was to look at asymptomatic shoulders for lower trapezius weakness and fatigue rate using hand held dynamometry and a fatiguing protocol. Our aim therefore was to determine if strength or endurance of the lower trapezius, specifically, has an effect on injury rate. It was hypothesized that lower dynamometry scores and quicker rates of fatigue would predispose the shoulder to injury.

METHODS

Prior to testing, all subjects signed an informed consent and completed a health history questionnaire to determine inclusion. All procedures were approved by the universities institutional review board prior to testing. Subjects were excluded from this research study if they had an existing upper extremity injury, an upper extremity injury in the preceding six months, or history of surgery, in their dominant arm. Subjects were also excluded from this study if they had previously used a scapular strengthening program. A scapular strengthening program can be defined as any exercise program used to balance and or strengthen the musculature surrounding the glenohumeral joint.

Thirteen (n=13) healthy, division I, overhead athletes were tested. All subjects were right hand dominant female college freshman with a mean age of 18.23 ± .60 years of age. Subjects had a mean weight of 143.23±14.15 pounds and a mean height of 67.69±3.20 inches. Subjects were all participating in softball, volleyball, or swimming. These sports were chosen because it is common clinical knowledge that these overhead sports often suffer from overuse injury. Recruitment was completed via word of mouth. All data was collected on the subjects’ dominant arm. Dominant arm was determined by handedness.
PROCEDURES

Upon obtaining consent, subjects were familiarized with the perceived exertion scale (PES) (Figure 1)\(^8\) and asked to rate their pretest level of fatigue. Subjects were then instructed to warm up for 5 minutes at resistance level 1 on the upper body ergometer (UBE). After the warm up was completed, the subject’s lower trapezius isometric strength was assessed using a hand held dynamometer (microFET2, Hoggan Scientific LLC, Salt Lake City, UT). The isometric hold was assessed 3 times and the average of the 3 trials was used as the athletes pre-fatigue strength score. The isometric hold position that was used for the lower trapezius is described in Kendall et al (Figure 2).\(^9\) Following dynamometry testing, subjects were given instructions on how to perform the pivot prone pull. This exercise was designed to isolate the lower trapezius muscle and was therefore used to facilitate fatigue. The starting position for the pivot prone pull was 150 to 170 degrees of shoulder flexion, full elbow extension, and the wrist in neutral (Figure 3). The ending position was 10 to 20 degrees of shoulder extension, full elbow flexion, and full wrist pronation (Figure 4).

Once the subjects were comfortable with the exercise, they were then instructed to complete this exercise for 2 minutes at a rate of 30 pulls per minute using the resistance bands. The rate of pull was set by a metronome and all subjects used the same resistance band tension. Subjects were asked to rate their level of fatigue using the PES every 15\(^{th}\) pull. The subjects were then given a one minute rest period before performing the exercise for another 2 minutes. This process was repeated until they could no longer perform the exercise, or reported a 20 on the PES. Although this fatiguing activity was bilateral, dynamometer data was only collected from the dominant shoulder. Once fatigue was reached, the subject’s lower trapezius isometric strength was again assessed using a hand held dynamometer. The isometric hold was assessed 3 times and the average of the 3 trials was then used as the athletes post-fatigue strength score.

In an effort to monitor all subjects’ health status that participated in this study, the primary investigator made contact with the subjects’ athletic trainers on the first of every month. Once a subject was reported as injured, the following information was recorded: length of time from test date to date of injury, and type of overuse injury (no traumatic injuries were included). The subject was then marked as injured in the data set. No further testing took place following injury.

RESULTS

With the data collected all subjects were placed on multiple continuums. The continuums ranked subjects in the following categories from least to most. The categories included pre-fatigue average dynamometry score, post fatigue average dynamometry score, range of pre and post test scores, and number of sets to failure (Table 1). These continuums can be viewed in figures 5, 6, 7, and 8. In total 3 subjects of 13 became injured. Sports participation of the injured athletes varied. However, the injuries occurred when the subjects were “out of season.” As we know in most division I sports the most trying time for the athletes is often the out of season period when conditioning, lifting, and practice seems to be the most difficult. When examining where the injured subjects fell on the continuum, it is evident that overall the injured athletes were rated average or strong on all the continuums. Therefore, the null hypothesis was met.

According to the data, there were no significant correlations between any of the categories and rate of injury. There was also no correlation between any of the categories and sets to failure. Therefore, neither time nor endurance was a factor in injury. All correlations can be found in Table 2.
DISCUSSION
As previously discussed, current research states that muscle weakness as well as muscle imbalance within a force couple can predispose a shoulder to injury.\textsuperscript{2,3,6} Although, physiologically this statement makes sense there is no data supporting these claims. Our research revealed that specific muscle strength or endurance does not have a direct effect on causing or preventing injury. Thus, leading us to surmise that injury could be more correlated with muscle imbalance rather than a specific muscle. When researching shoulder muscle imbalance it became apparent that although it is heavily discussed in the research there is a significant lack in objective numbers or ratios that describe what appropriate balance is recommended. Without these ratios objectively defined it is difficult for clinicians to understand what qualifies as balanced or imbalanced following injury.

When considering anterior cruciate ligament (ACL) prevention or repair, we have specific numbers for appropriate quadriceps to hamstring ratios. These ratios help clinicians to determine when an athlete is ready to return to play or at potential risk for an ACL tear. We can draw similar conclusions with the shoulder. When the musculature surrounding the glenohumeral joint are imbalanced the shoulder becomes vulnerable to injury. More research needs to be conducted in order to determine balanced ratios of the force couple consisting of the serratus anterior, lower trapezius, upper trapezius, pectoralis minor, levator scapulae, and rhomboids.

LIMITATIONS
A major limitation to this study was the use of a small subject pool. Using a larger subject pool could have produced greater results for the continuums as well as injury rates. The use of a non-athletic population would allow us to apply this research to a larger population as well as have given us a great sample size and therefore the use of greater numbers could have produced different results. Due to the low budget allotted for this study, another limitation was the use of the same bands throughout the study. Using new bands, of the same resistance, for each subject would have eliminated the possibility of the bands becoming weaker over the course of data collection. Also the use of an isokinetic testing machine such as a Biodex would have helped to lower the rate of human error in research study as well.

Despite its limitations, this research could be used as the foundation for further study. Our data revealing that one specific muscle does not have an effect on injury rate aids the research stating the muscle imbalance is the cause of overuse shoulder injury rather than specific muscle weakness. In order for clinicians to better prevent injury, future research needs to be conducted on a larger subject pool to determine objective muscle balance ratios of the force couples surrounding the glenohumeral joint.

CONCLUSION
Our research demonstrated that the lower trapezius alone, whether classified as strong or weak, cannot help clinicians determine if a shoulder is at risk for injury or not. More research on shoulder muscle balance ratios needs to be conducted to enable clinicians to prevent over use shoulder injury.

REFERENCES


APPENDIX

Table 1: Descriptive Statistics.

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<th>Variable</th>
<th>Uninjured</th>
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<th>Injured</th>
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<td></td>
<td>N</td>
<td>Mean</td>
<td>Std. Deviation</td>
<td>N</td>
<td>Mean</td>
<td>Std. Deviation</td>
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<td>0.9360</td>
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<td>Sets to Failure</td>
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<td>Weeks to Injury</td>
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<td>2.75882</td>
<td>3</td>
<td>10.3333</td>
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Figure 1: Perceived Exertion Scale.

<table>
<thead>
<tr>
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<th>Description</th>
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<tr>
<td>6</td>
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<tr>
<td>7</td>
<td>Very Light</td>
</tr>
<tr>
<td>8</td>
<td>Fairly Light</td>
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<tr>
<td>9</td>
<td>Somewhat Hard</td>
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<td>10</td>
<td>Hard</td>
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<td>Maximum exertion</td>
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<td>12</td>
<td>Very Hard</td>
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<tr>
<td>13</td>
<td>Very, Very Hard</td>
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<tr>
<td>14</td>
<td>Maximum exertion</td>
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Figure 1: Perceived Exertion Scale.
Figure 2: Lower trapezius manual muscle testing position.9

Figure 3: Start position of the pivot prone pull.
Figure 4: End position of the pivot prone pull.

Figure 5: Continuum showing pre-test strength score in pounds and injured subject markings.
Figure 6: Continuum showing post-test strength score in pounds and injured subject markings.

Figure 7: Continuum showing range strength score in pounds from pre-test to post test and injured subject markings.
Sets to Failure

Weak------------------------Average------------------------Strong

2------------------------4------------------------6------------------------8------------------------10

4------------------------9

---- = All Subject Scores
---- = Injured Scores

Figure 8: Continuum showing sets to failure or fatigue.

Table 2: Correlations between all tested variables.