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Core stability and overuse shoulder injuries in female collegiate swimmers

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**CORE STABILITY AND OVERUSE SHOULDER
INJURIES IN FEMALE COLLEGIATE SWIMMERS**

**A Thesis Presented to
the Department of Kinesiology
San Jose State University**

**In Partial Fulfillment
of the Requirements for the Degree
Master of Arts**

**By
Rachael A. Rolle
May 2006**

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ABSTRACT

CORE STABILITY AND OVERUSE SHOULDER INJURIES IN FEMALE COLLEGIATE SWIMMERS

By Rachael A. Rolle

The purpose of this study was to assess the difference between core stability of female collegiate swimmers with and without overuse shoulder injuries by comparing core stability values and self-reported shoulder injuries. Three collegiate women's swimming teams with 24 total participants were examined. All participants completed a shoulder injury history questionnaire prior to testing. Testing consisted of three core stability tests: the side-bridge, lateral medicine ball toss, and 1-minute sit-up test. Nine of the 24 participants indicated that they had a previous or current shoulder injury. No significant difference was identified for core stability among the injured and uninjured groups. The injured group scored higher on the 1-minute sit-up test and the side-bridge test, while the uninjured group scored higher on the lateral medicine ball toss. This is similar to previous research findings which indicated no difference in postural endurance of the trunk in injured individuals compared to uninjured individuals.

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TABLE OF CONTENTS

CHAPTER ONE – INTRODUCTION.....	1
Statement of Purpose.....	4
Research Hypothesis.....	4
Limitations.....	5
Delimitations.....	5
Operational Definitions.....	5
Summary.....	6
CHAPTER TWO – REVIEW OF LITERATURE.....	8
Core Stability Function.....	8
Measuring Core Stability.....	11
Shoulder Anatomy.....	12
Swimming Injuries and Biomechanics.....	12
Shoulder Injuries	15
Women and Overuse Shoulder Injuries.....	16
Summary.....	17
CHAPTER THREE – METHODS.....	19
Sample Selection.....	19
Instrumentation.....	19
Data Collection/Procedures.....	21
Statistical Design.....	23
Summary.....	23

CHAPTER FOUR- RESULTS AND DISCUSSION.....	24
Participants, Results, and Discussion.....	24
Demographics.....	24
Multivariate Analysis of Variance.....	31
Core Stability and Extremity Injuries.....	32
Core Stability and Back Injuries.....	33
Correlation.....	34
Conclusion.....	36
CHAPTER FIVE – SUMMARY AND CONCLUSIONS.....	38
Summary.....	38
Conclusions.....	39
Recommendations for Future Research.....	40
REFERENCES.....	41
APPENDICES.....	45
Appendix A - Shoulder Injury Questionnaire	45
Appendix B – San Jose State University Human Subjects Approval Form.....	49
Appendix C – Consent Form.....	50

LIST OF TABLES

Table 1. Background Information for Female Collegiate Swimmers.....	25
Table 2. Mean Core Stability Comparison Between Participants With and Without Shoulder Injury.....	30
Table 3. MANOVA for the Three Core Stability Tests and Shoulder Injuries.....	32

LIST OF FIGURES

Figure 1. Frequency Distribution of the Total Number of Years in Swimming.....	26
Figure 2. Frequency Distribution of the Percent of Freestyle Used Per Practice.....	26
Figure 3. Frequency Distribution of the Type of Injury Reported.....	28
Figure 4. Frequency Distribution of How Injury Was Sustained.....	28
Figure 5. Mean Core Values for Injured and Uninjured Participants.....	31

CHAPTER ONE

INTRODUCTION

Repetitive overuse trauma-related shoulder injuries are a significant factor that limits swimmers in practice and games (Kammer, Young, & Niedfeldt, 1999; Swanik, Swanik, Lephart, & Huxel, 2002). Swimmers have the highest rate of shoulder injuries compared to all other overhead athletes and perform ten times the number of movements (Wetzler, Rubenstein, Gillespie, Schenck, & Gloystein, 2002). In fact, competitive swimmers receive more shoulder injuries per year than professional baseball players (Wetzler et al., 2002). A large percentage, 40 to 80%, of competitive swimmers complain of shoulder pain that interferes with training or competition, making shoulder injuries the most common pathology experienced by competitive swimmers (Kammer et al., 1999; Swanik et al., 2002).

Several factors may contribute to the occurrence of shoulder injuries among swimmers including extensive, year-round training and a lack of core stability (Kammer et al., 1999). The purpose of this study was to assess the effect of core stability on shoulder injuries in female collegiate swimmers by examining core stability and comparing those values to self-reported shoulder injuries. Competitive swimmers have approximately 11, 2-hour practices per week with typical daily training distance averages of more than 10,000 meters (Kammer et al., 1999; Wetzler et al., 2002). Due to extensive practice schedules and subsequent muscle fatigue, alterations in swimming mechanics may contribute to overuse injuries (Wetzler et al., 2002). Regardless of the swimmers' specific competitive stroke, 75-90% of training is conducted using a freestyle stroke

(Kammer et al., 1999). When the freestyle stroke is not performed properly, such as not rolling the body correctly due to fatigue from weak core musculature, the shoulder is placed at greater risk of overuse injuries (Kammer et al.). Thus, an investigation into the effect of core stability on overuse shoulder injuries was warranted.

Core stability in athletes is essential to stabilize the trunk during activity; thus, sports professionals, such as athletic trainers, coaches, and strength and conditioning specialists, are integrating the core stability element of athletic movement into conditioning and rehabilitation programs (Larsen, 2003). Core stability typically includes abdominal and lumbar back strength, although additional muscles may be included depending on the sport (Leetun, Ireland, Willson, Ballantyne, & Davis, 2004). For the purpose of this study, core stability is defined as the strength and endurance of the abdominal, lateral abdominal, and lumbar back, which includes the rectus abdominis, external oblique, internal oblique, transverse abdominis, erector spinae, and the quadratus lumborum muscles (Hermann & Barnes, 2001; Larsen, n.d.; Leetun et al., 2004; Ng, Kippers, Parnianpour, & Richardson, 2002). Decreased core stability may contribute to an increase in the frequency of shoulder injuries in athletes who use their arm(s) in a repetitive overhead motion (Ellenbecker & Roetert, 2004). Athletes who are at the highest risk of shoulder injuries compete in sports such as baseball, softball, volleyball, gymnastics, and swimming (Richardson, 1983).

The majority of those who compete in overhead sports spend much of their training with their arms in a position above shoulder level. The use of the arms above shoulder level entails a strong core in order to allow for stability while the upper

extremities are in motion. A lack of core stability will create less stability, excess movement in the core or trunk and, therefore, a burden on shoulder musculature to act as stabilizers in addition to primary movers. The dual responsibility of the shoulder musculature when the core is weak can create overuse injuries (Kammer et al., 1999).

The shoulder joint has the most mobility of any articulation in the body, which allows for a greater range of motion (DePalma & Johnson, 2003). Stability of the shoulder joint is sacrificed for greater range of motion, and in an overhead position the shallow articulation of the humeral head with the glenoid of the scapula exaggerates the poor stability of the glenohumeral joint. Because of this instability during overhead activity, it becomes important to stabilize the shoulder joint with other structures, mainly the core or trunk musculature. The stability and strength of the core/trunk helps to generate large amounts of force while decreasing the load on the shoulder during repetitive overhead movements (Rubin & Kibler, 2002). During overhead activity, 54% of the force is generated by the legs and trunk (Rubin & Kibler, 2002; Yeager, n.d.).

A strong core is especially important in competitive swimming. Swimmers' legs help to propel them in the water since they are not in contact with the ground. Thus, the base of the kinetic chain for each stroke is their core (Rubin & Kibler, 2002). In addition, during the pull phase of the freestyle stroke, a closed kinetic chain is created when the hand meets the water. When this occurs, the torque at the shoulder joint increases requiring more force to be generated from within the body, and further emphasizing the need for a strong core (Rubin & Kibler).

Few studies have been conducted on core stability. There is a lack of literature that specifically examines overhead athletes and relationships between core stability and overuse shoulder injuries. Specifically, one study on core stability suggested no change in the incidence of low back pain after the initiation of a core stabilization program; however, only data from hip strength was gathered and few athletes actually developed low back pain, making conclusions on the effects of core stabilization difficult (Nadler et al., 2002). More research needs to be performed in the area of core stabilization and, specifically, the effect core stability has on the incidence of overuse shoulder injuries. Currently, core stability and the association with overhead injuries is based on educated speculation that decreased core stability will increase the frequency of overuse shoulder injuries. Thus, the purpose of this study was to assess the effect of core stability on shoulder injuries in female collegiate swimmers by examining core stability and comparing those values to self-reported shoulder injuries.

Statement of Purpose

The purpose of this study was to assess the difference between core stability of female collegiate swimmers with and without overuse shoulder injuries by comparing core stability values and self-reported overuse shoulder injuries.

Research Hypothesis

There will be a statistically significant negative correlation between core stability and overuse shoulder injuries.

Limitations

This study will be limited by:

1. The willingness of the participants to answer the questionnaire honestly.
2. The willingness of the participants to perform strength testing to the best of their ability.
3. The pain threshold of the participants, which may skew their perception of an injury or may affect the actual time lost due to an injury.
4. The ability of the participants to understand or remember their specific shoulder injuries.
5. The assumption that current core stability reflects previous core stability.
6. The functionality of the core testing being performed in non-sport specific positions and environment.

Delimitations

This study will be delimited to:

1. Three colleges from the San Francisco Bay Area
2. Sixty female collegiate swimmers

Operational Definitions

Acute injury. Any injury that occurs as the result of a single traumatic event or a catastrophic failure of a structure (Hutchinson & Ireland, 2003). For the purposes of this study, acute injuries will not be considered for analysis.

Competitive swimming. Organized swimming performed while competing against an opponent(s).

Core. Abdominal, lumbar back and hip/pelvis muscles make up the core of the body (Allen, Dudley, Iosia, Stanforth, & Steuerwald, 2002; Nadler et al., 2002; Yesko, 1998)

Core stability. Core stability is defined as the ability of the core muscle group to maintain proper postural control during functional movement tasks and includes the components of both core strength and endurance (Allen et al., 2002).

Core strength. Core strength is the ability of the core muscle group to generate the strength needed for the transfer of energy to the extremities of the body during sport activities (Allen et al., 2002).

Core endurance. Core endurance is the ability of the core muscle group to generate the force needed for repeated functional movements (Allen et al., 2002).

Overhead athlete. Athletes who perform the majority of their sport using their arm or arms in a position above their shoulder level (Yeager, n.d).

Overuse injury. An injury that takes place over time due to a repetitive load and stress is considered an overuse injury (Hutchinson & Ireland, 2003).

Swimming athlete. Anyone who competes in a collegiate program utilizing freestyle swimming techniques and attends the majority of practices and competitions throughout the year is considered a swimming athlete for the purpose of this study.

Summary

Sports medicine experts agree that core stability is important to decrease the frequency of overuse shoulder injuries and increase the force produced by the shoulder (Bahamonde, 2003; Bieze, 2004; Ellenbecker & Roetert, 2004; Larsen, 2003; Rubin & Kibler, 2002). The greater awareness of the importance of core stability has led to the

use of conditioning programs to improve core stability, enhance performance, and prevent injury. The majority of high school, college, and professional athletic conditioning programs include some form of core stabilization training. Core stabilization is especially important in competitive swimming because the forces generated by the shoulder and arms to perform a freestyle stroke are initiated by the core muscles of the body (Rubin & Kibler, 2002).

A lack of research exists regarding the relationship between overuse shoulder injuries and a weak core. In addition, there is a lack of research on the proper design of core stabilization programs. Lastly, standard methods of identifying individuals with deficient core stability are lacking. This study examined the difference between female collegiate swimmers with and without overuse shoulder injuries using a combination of core stability tests, utilizing methods adapted from previous research.

CHAPTER TWO

REVIEW OF LITERATURE

Recent research has indicated that weak core stability may be a contributing factor of many different types of athletic injuries (Bahamonde, 2003; Ellenbecker & Roetert, 2004; Leetun et al., 2004). The types of injuries linked to deficiencies in core stability include both overuse and acute injuries, which can occur in the extremities or the lumbar region (Larsen, 2003; Nadler et al., 2002; Yeager, n.d.). Core stability is believed to be an important tool in preventing overuse shoulder injuries; if the core is not stable, then extra strain will be placed on the shoulder joint, which can lead to overuse shoulder injuries (Larsen, 2003). The purpose of this study was to assess the difference between core stability of female collegiate swimmers with and without overuse shoulder injuries by comparing core stability values and self-reported overuse shoulder injuries. Literature related to core stability testing, shoulder mechanics, and injury prevalence in swimmers will be examined. This chapter will be divided into six sections, (a) core stability function, (b) measuring core stability, (c) shoulder anatomy, (d) swimming injuries and biomechanics, (e) women and overuse shoulder injuries, and (f) shoulder injuries.

Core Stability Function

Core stability training focuses on abdominal and spinal muscles to provide better stability and control for athletic movements (Allen et al., 2002; Nadler et al., 2002). The primary abdominal and spinal muscles involved in the core include the rectus abdominis, external oblique, internal oblique, transverse abdominis, quadratus lumborum, and erector spinae (Hermann & Barnes, 2001; Larsen, n.d.; Leetun et al., 2004; Ng et al.,

2002). Some researchers will include the hip musculature, latissimus dorsi, and serratus anterior in the core muscle group; however, for this study the hip and shoulder stabilizers will not be included (Allen et al., 2002; Rubin & Kibler, 2002).

The core muscles each have direct movement responsibilities. During athletic movements, the core muscles are responsible for the stability of the body as well as generating the majority of the power (Rubin & Kibler, 2002). The transverse abdominis is responsible for abdominal compression. The rectus abdominis is responsible for flexion and lateral flexion of the trunk. The external and internal obliques are responsible for lateral flexion and rotation of the trunk. The erector spinae are responsible for extension of the trunk. One particular study suggests that the transverse abdominis, in particular, is consistently activated first to stabilize the body and extremities during both acceleration and deceleration for extremity movement (Rubin & Kibler).

An open-ended kinetic chain with proximal-to-distal muscle activation presides in activities that include throwing or overhead motions, originating with the legs or core region (Rubin & Kibler, 2002). Due to the nature of overhead activity, the core muscles create more than 54% of the force generated (Rubin & Kibler, 2002; Yeager, n.d.). In swimming, the legs are not in contact with the ground, leaving the initiation of power and movement entirely with the core muscles (Rubin & Kibler, 2002). If the core muscles do not activate, or activate insufficiently, then excess extremity movement may strain muscles that are not meant to provide stability, thus creating injury.

Bieze (2004) found that the peak torque of the shoulder of high school and college-aged baseball pitchers is 16 to 28 Newton meters (Nm) more than that of a

professional baseball player. This disparity among the ability groups was attributed to improper timing and core stability. The torque on the shoulder and elbow during overhead motion with proper mechanics and a strong core already tests the limits of the anatomical structures involved. Without the force generated by the core muscle group, the shoulder joint would fail rapidly under the overwhelming torque placed on the joint (Bieze, 2002). Proper trunk biomechanics and training are important for the development of efficient overhead mechanics to decrease injury and increase power (Bahamonde, 2003). Core muscular fatigue or general core weakness may cause the athlete to perform without proper mechanics due to the decrease of power available from the core (Kammer et al., 1999). When core stability output is decreased, the incidence of extremity injuries to the shoulder and knee increase (Kammer et al., 1999; Larsen, 2003; Leetun et al., 2004).

In a study performed on the lower extremity, researchers found that decreased core stability increases the risk for lower extremity injury (Leetun et al., 2004). A study performed on elite tennis players cites an increased risk for injury with a deficient core (Ellenbecker & Roetert, 2004). According to Larsen (2003), deficiencies of core stability are associated with overuse shoulder injuries because pain inhibits the postural muscles. Other researchers have stated their belief that weak core stability is correlated to a higher incidence of athletic injuries, but few have studied the relationship of injuries to a weak core, and no researchers have looked specifically at overuse shoulder injuries in overhead athletes due to a weak core (Larsen, 2003; Rubin & Kibler, 2004; Yeager, n.d.).

Measuring Core Stability

A variety of tests are used to measure core stability, including sit-ups, various medicine ball exercises, bridges or planks, straight leg lowering test, isokinetic machines, back extensions, and many others (Allen et al., 2002; Ellenbecker & Roetert, 1998; Ellenbecker & Roetert, 2004; Leetun et al., 2004; McGill, Childs, & Liebenson, 2004; Semenick, 1990). Among the many tests, three core stability tests were most often utilized in the research: the side-bridge, medicine ball toss, and 1-minute sit-up test. All three core stability tests have been found to be valid and reliable measures of core stability (Allen et al., 2002; Ellenbecker & Roetert, 1998; Ellenbecker & Roetert, 2004; Leetun et al., 2004; McGill, Childs, & Liebenson, 2004; Semenick, 1990).

Side-bridge test scores were significantly correlated ($p < .05$) with core stability and with the performance of other postural muscle tests when used to assess the core stability of 140 male and female collegiate basketball and track athletes (Leetun et al., 2004). McGill, Childs, & Liebenson (1999) previously documented that there was no significant difference between right and left side-bridge endurance times.

The lateral medicine ball toss had a correlation of .830 (forehand) and .820 (backhand) with isokinetic trunk rotation parameters of peak torque (Ellenbecker & Roetert, 2004). No statistical difference was found between forehand and backhand rotation strength in both males and females (Ellenbecker & Roetert).

The 1-minute sit-up test is well established as a measure of obtaining abdominal muscular endurance (Semenick, 1990). The 1-minute sit-up test has been used on a wide range of participants for more than 15 years in settings varying from grade school

physical education classes to collegiate athletics (Semenick).

Shoulder Anatomy

The anatomy of the shoulder allows for extreme mobility, which is both beneficial and necessary, but the extra mobility is at the expense of shoulder stability (Yeager, n.d.). A shallow ball and socket joint comprised of the humeral head articulating with the glenoid of the scapula contributes to the mobility of the shoulder (Larsen, 2003). The stability of the shoulder relies mostly on a group of four small muscles, referred to as the rotator cuff, which surround the glenohumeral (GH) joint (Larsen). The rotator cuff is comprised of the supraspinatus, infraspinatus, teres minor, and subscapularis. These small muscles and the shallow articulation of the shoulder joint are unable to withstand the repetitive stresses placed on the shoulder during repetitive overhead movements, increasing the vulnerability of overhead athletes to overuse shoulder injuries (Yeager, n.d.).

Swimming Injuries and Biomechanics

In swimming, a strong core is important because the base of the kinetic chain is the lumbopelvic or core region (Rubin & Kibler, 2002). Although the legs propel the athlete through the water, the majority of the force necessary for forward propulsion is initiated from the core region (Rubin & Kibler). The trunk and upper extremity are responsible for generating 80% to 90% of the power strokes in swimming (Wetzler et al., 2002). The majority of competitive swimmers, 40% to 80%, complain of shoulder pain which interferes with training or competition, making shoulder injuries the most common pathology experienced by competitive swimmers (Kammer et al., 1999; Swanik et al.,

2002). Deficiencies in core stability or improper mechanics significantly increase a swimmer's risk for shoulder injury (Rubin & Kibler, 2002).

Swimmers have the highest rate of shoulder injuries compared to all other overhead athletes and perform 10 times the number of movements (Wetzler et al., 2002). Competitive swimmers will routinely swim more than 10,000 meters per day, 7 days per week (Kammer et al., 1999; Wetzler et al., 2002). Due to extensive practice schedules and subsequent muscle fatigue, poor swimming mechanics are thought to contribute to overuse injuries (Wetzler et al., 2002). Competitive swimmers commonly have increased shoulder laxity. While being a mechanical advantage during swimming, this laxity places the swimmer at an increased risk for shoulder injury (Wetzler et al.).

Competitive swimmers, regardless of their specific stroke, will perform 75% to 90% of their daily training using a freestyle stroke (Kammer et al., 1999). If the freestyle stroke is not performed properly, the shoulder can be heavily stressed and placed at greater risk for injury (Kammer et al.). Specifically, a failure to roll the body sufficiently from side to side promotes impingement of the rotator cuff and decreases the amount of force generated by the core, which increases the torque placed on the shoulder joint (Bieze, 2004; Kammer et al., 1999). Improper biomechanics commonly occur when fatigue has set in due to muscle imbalances in both the shoulder and core musculature (Kammer et al., 1999; Swanik et al., 2002).

Swimming strokes have two phases, the pull-through phase and the recovery phase (Wetzler et al., 2002). During the pull-through phase, the swimmers propel themselves through the water. This phase assumes an S-shaped pattern and includes

body rotation or roll (Wetzler et al.). The roll of the body should be approximately 70° to 100° per stroke cycle. Failure to properly roll the body may lead to shoulder impingement (Kammer et al., 1999). In the recovery phase, the arm exits the water to begin the pull-through phase again. During this phase, the elbow should be above the hand and out of the water. If the elbow drops, the rotator cuff may be irritated and may cause rotator cuff impingement, tendonitis, or tears (Kammer et al., 1999).

“Swimmer’s shoulder” is the most common orthopedic pathology in competitive swimming (Bak, Bue, & Olsson, 1989; McFarland & Wasik, 1996; Richardson, Jobe, & Collins, 1980; Swanik et al., 2002). “Swimmer’s shoulder” presents with symptoms similar to rotator cuff tendonitis, impingement syndrome, and instability. Common symptoms will include pain that interferes with swimming, dull aching pain at night, a feeling of weakness or fatigue in the shoulder, a feeling of instability, and point tenderness of the supraspinatus and/or biceps tendon (Kammer et al., 1999; Swanik, et al., 2002).

Because competitive swimmers have a high risk of shoulder injury, experts emphasize the importance of performing core stability exercises and teaching proper swimming mechanics (Kammer et al., 1999; Rubin & Kibler, 2002; Wetzler et al., 2002). When fatigue occurs during a competition or practice, the core and arms become fatigued. Once the shoulder stabilizers and the core become fatigued, proper mechanics are quickly lost and the swimmer becomes susceptible to many different overuse shoulder injuries, including impingement of the rotator cuff and rotator cuff tendonitis (Kammer, et al., 1999). This occurs because of a lack of core stability, which creates less stability

and excess movement in the core or trunk and, therefore, places a burden on shoulder musculature to act as stabilizers in addition to primary movers. The dual responsibilities of the shoulder musculature when the core is weak can create overuse injuries (Kammer et al.).

Shoulder Injuries

Many different shoulder injuries exist which affect overhead athletes. Some of the most common injuries among overhead athletes include rotator cuff tendonitis, rotator cuff impingement, bursitis, bicipital tendonitis, rotator cuff tear, and labral tears (Rubin & Kibler, 2002). The most common injury seen in swimming is “swimmer’s shoulder”, which is a combination of rotator cuff tendonitis, rotator cuff impingement, and/or bicipital tendonitis (Kammer et al., 1999). The combination of rotator cuff tendonitis, impingement, and bicipital tendonitis injuries is not uncommon.

Rotator cuff tendonitis is inflammation of the supraspinatus from repetitive microtraumatic episodes that cause impingement of the supraspinatus tendon between the acromion process and the coracoacromial ligament (Anderson, Hall, & Martin, 2000). The impingement of the rotator cuff is caused during abduction, forward flexion, and medial rotation of the shoulder. This condition is also called “painful arc” syndrome because an individual with this condition is pain free before 70° of abduction and after 120° of abduction, but painful between 70° and 120° (Anderson et al.). A typical time frame for return to activity is approximately 4 to 6 weeks (Anderson et al.).

Bicipital tendonitis is a repetitive overuse injury that occurs during rapid overhead movements such as throwing or swimming (Anderson et al., 2000). Irritation of the

tendon occurs as it passes back and forth in the bicipital groove of the humerus (Anderson et al.). Bicipital tendonitis will present with pain and tenderness over the bicipital groove. (Anderson et al.). A typical time frame for return to activity is approximately 4 to 6 weeks (Anderson et al.).

All three of these injuries are caused by an excessive amount of overhead movements, muscular imbalances, and poor biomechanics (Anderson et al., 2000). However, overuse injuries can be reduced with proper core stability training to assure that during repetitive stresses, the core is able to produce sufficient power to maintain proper biomechanics during overhead movements (Bahamonde, 2003; Kammer et al., 1999).

Women and Overuse Shoulder Injuries

Women, in general, are weaker in all muscle groups, and the core musculature is not an exception (Leetun et al., 2004). Women, ages 20-29 years, average five sit-ups less than men in the same age group (Baechle & Earle, 2000). Overuse injuries of the shoulder are the most common group of injuries affecting athletes involved in baseball, tennis, swimming, and gymnasts (Richardson, 1983). Weakness in the core musculature may make women more susceptible to overuse shoulder injuries (Leetun et al., 2004).

Evidence of an association between core stability weakness and overuse shoulder injuries is suggested by several studies performed on both men and women in a variety of sports containing overhead activities (Hill, Humphries, & Weidner, 2004; Kelly, Barnes, & Powell, 2004; Sallis, Jones, Sunshine, Smith, & Simon, 2001; Wadley & Albright, 1993). For instance, a 4-year study on female collegiate gymnastics found that 43% of the injuries sustained were from overuse injuries to the ankle, shoulder, knee, and low

back (Wadley & Albright, 1993). A 1-year study on female collegiate softball pitchers showed that 70% of the injuries sustained during the season were overuse injuries and 41% of the injuries were shoulder related (Hill et al., 2004). In a study comparing sports injuries in men and women competing in seven similar collegiate sports, the researchers found that female swimmers and water polo players reported significantly more shoulder injuries than their male counterparts. Female athletes, in general, reported more hip, lower leg, and shoulder injuries than the males in the study (Sallis et al., 2001).

The previous studies provide a variety of reasons for the high incidence of overuse injuries among females and, most importantly, female swimmers. However, core stability is not listed as a possible reason for injury in any of the studies. Thus, core stability in relation to overuse shoulder injuries should be studied as one of the possible variables contributing to overuse shoulder injuries in female swimmers.

Summary

Core stability is important for all overhead athletes because over half of the power generated during overhead movements is produced from the core (Rubin & Kibler, 2002; Yeager, n.d.). In competitive swimming, athletes have no contact with the ground, making core stability even more important to generate the appropriate force needed to be a successful competitive swimmer and stay injury free. If the core is not producing an adequate amount of force, then the shoulder must produce more force, placing the structures of the shoulder at a higher risk of injury (Bieze, 2004; Rubin & Kibler, 2002).

Core stability has become more popular in both athletic and nonathletic arenas in the last decade (Larsen, 2003). Most sport medicine professionals who work with

athletes in any capacity believe that core stability is important for both injury prevention and increased power within the sport (Bahamonde, 2003; Bieze, 2004; Ellenbecker & Roetert, 2004; Larsen, 2003; Leetun et al., 2004; Rubin & Kibler, 2002). However, there is a lack of research comparing core stability and the occurrence of overuse shoulder injuries, and no research comparing core stability and the occurrence of overuse shoulder injuries among swimmers. Therefore, the purpose of this study was to assess the difference between core stability of female collegiate swimmers with and without overuse shoulder injuries by comparing core stability values and self-reported overuse shoulder injuries.

CHAPTER THREE

METHODS

The purpose of this study was to assess the difference between core stability of female collegiate swimmers with and without overuse shoulder injuries by comparing core stability values and self-reported overuse shoulder injuries. Chapter three includes four major sections: (a) sample selection, (b) instrumentation, (c) data collection/procedures, and (d) statistical design. The variables in this study included self-reported overuse shoulder injuries, side-bridge testing results, medicine ball toss results, and 1-minute sit-up testing results.

Sample Selection

Participants in the study included competing members of three Bay Area women's collegiate swimming programs (N=24). Ages ranged from 18 to 26 years. All participants completed the shoulder injury questionnaire (see Appendix A). All participants were included in the study regardless of past or present shoulder injuries, provided that the participants did not have any acute injuries. All participants were cleared to participate in swimming by their respective team physician or certified athletic trainer.

Instrumentation

Shoulder injuries were self-reported by each athlete using a Shoulder Injury Questionnaire (see Appendix A) adapted from a study by Fullerton, Borckardt, and Alfano (2003). The questionnaire contains questions pertaining to demographic information, swimming experience, past and present shoulder injuries, previous shoulder

surgery, and core stability training experience.

Three tests were used to examine core stability: the side-bridge, medicine ball toss, and 1-minute sit-up test. These tests were used by and have been found to be valid and reliable measures of core stability (Allen et al., 2002; Ellenbecker & Roetert, 1998; Ellenbecker & Roetert, 2004; Leetun et al., 2004; McGill, Childs, & Liebenson, 2004; Semenick, 1990).

The side-bridge test is a measure of lateral core muscle capacity and was timed using a Sportline 240™ stopwatch. The time began when the participants made a straight bridge and were only in contact with the ground on their right foot and right forearm. The results were recorded in seconds, and raw scores were used for analysis.

The medicine ball toss is a measure of core rotational strength. Participants maximally threw a 6 lb. (2.7 kg) Century 2484™ medicine ball using both hands in a forehand pattern from a stationary start position with the medicine ball at their waist opposite the direction of the throw. The medicine ball toss was measured using a 30 ft (9.144 meter) Stanley 464™ measuring tape. The measurements began at the participant's front foot and ended at the front of the ball on its first contact with the ground. The best distance out of three trials was the indicator of rotational core strength. Data from the forehand only was collected and analyzed.

The 1-minute sit-up test was timed using a Sportline 240™ stop watch. The number of sit-ups performed was counted out loud by the researcher or research assistants. All research assistants were Certified Athletic Trainers and completed an educational session on the proper sit-up position prior to testing. The norms for the

1-minute sit-up test for women age 20-29 years were obtained from Ellenbecker & Roetert (1998) (see Appendix A). The raw scores collected were used for statistical analyses.

Data Collection/Procedures

Prior to the collection of data, the study was approved by the San Jose State University Institutional Review Board and all participants provided informed consent (see Appendix B). A copy of the informed consent form can be found in Appendix C.

Each participant completed a shoulder injury questionnaire prior to testing (see Appendix A). Each strength test was administered by the researcher or research assistant. The participants performed all three strength tests on the same day and were randomly assigned the order in which they performed each of the strength tests. Data for the study were collected during the beginning of the collegiate competitive season, prior to a regularly scheduled weekly practice.

The side-bridge test is a measure of lateral core muscle capacity and was performed by maintaining contact on the ground with the right foot and right forearm only. Participants maintained a straight diagonal off the ground for as long as possible (Allen et al., 2002). The athlete's left foot was positioned on top of the right; the left arm was placed across the chest and rested on top of the right shoulder. The participant lifted the hips off the ground to establish the bridge. Time began when the participant established the proper form and ended when the participant broke the proper form. The total time the participant was able to perform this test was recorded using a Sportline 240™ stopwatch. Both left and right side-bridge endurance times were recorded, and the

raw scores were used for analysis.

The lateral medicine ball toss is a measure of core rotational strength. The participants maximally threw a 6 lb. (2.7 kg) Century 2484™ medicine ball using both hands in a forehand pattern from a stationary start position with the medicine ball in front of their torso. The medicine ball toss was measured using a 30 ft. (9.144 meter) Stanley 464™ measuring tape. The measurement began at the participant's front foot and ended at the front of the ball on its first contact with the ground. The best of three trials were recorded and raw scores were used for analysis.

Directions for the 1-minute sit-up test were established using the American Alliance for Health, Physical Education, Recreation and Dance guidelines published in a study by Sparling, Millard-Stafford and Snow (1997). All participants lay in a supine position on the ground with their knees bent, feet on the floor; 12-18 inches from the buttocks; and arms crossed at the chest with the hands on opposite shoulders. Participants performed a full sit-up to the upright position with their elbows touching their thighs and then returned to the down position. Participants' arms remained in contact with their chest throughout the sit-up, and any sit-up not performed properly was not counted. Participants had a research assistant holding their feet and counted the number of sit-ups they performed in a 1-minute time period. The objective was to perform as many sit-ups as possible in 1 minute. The researcher started and stopped the 1-minute sit-up test.

Statistical Design

For the purpose of this study; descriptive statistics were used to determine the mean and ranges for all demographic data; a Multivariate Analysis of Variance (MANOVA) was used to examine the difference in core stability between swimmers with and without overuse shoulder injuries; and correlation analyses were used to determine if any relationships existed among the core stability and demographic data. The statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS for Windows). The significance level was set at $p < .05$.

Summary

Female collegiate swimmers were studied to assess the core stability difference among individuals with and without overuse shoulder injuries. Prior to testing, each participant filled out a shoulder injury questionnaire (see Appendix A). Each participant completed three core stability tests, randomly assigned, so that the participants completed the tests in a different order.

Three tests were used to attain core stability results for anterior, lateral, and rotational core muscles. The tests included the side-bridge test used to assess lateral core muscular endurance, the lateral medicine ball toss used to assess lateral and rotational core muscular strength and power, and the 1-minute sit-up test used to assess anterior core muscular endurance. Differences in core stability tests between collegiate swimmers with and without overuse shoulder injuries were analyzed using a MANOVA.

CHAPTER FOUR

RESULTS AND DISCUSSION

The purpose of this study was to assess the difference between core stability of female collegiate swimmers with and without overuse shoulder injuries by comparing core stability values and self-reported overuse shoulder injuries. Three tests were used to determine core stability: the 1-minute sit-up test, lateral medicine ball toss, and side-bridge. A shoulder injury questionnaire (see Appendix A) adapted from a study by Fullerton, Brockardt, and Alfano (2003) was used to collect demographic and shoulder injury information prior to testing. Chapter four presents descriptive statistics used to determine the mean and ranges for all demographic data; a Multivariate Analysis of Variance (MANOVA) used to examine the difference in core stability between swimmers with and without overuse shoulder injuries; and correlation analyses were used to determine if any relationships existed among the core stability and demographic data, followed by a discussion of the results.

Participants, Results, and Discussion

Demographics

Twenty-four participants were tested, whose ages ranged from 18 to 26 years. The mean age was 19.7 years, the mean height was 167.9 cm., and the mean weight was 65.2 kg. The majority of the participants were right hand dominant (70.8%). The average number of hours swam per day was 2.4 hours, with 58.3% of the participants averaging three hours per day (see Table 1). The total number of years in competitive swimming ranged from 1 to 15 years, with participants averaging 8.5 years (see Table 1,

Figure 1). The average amount of training performed in a freestyle stroke per day was 81%, which is similar to findings in a study performed by Kammer et al. (1999) that found 75-90% of swimming practice typically consists of a freestyle stroke (see Table 1, Figure 2).

Table 1. *Background Information for Female Collegiate Swimmers (N=24)*

Variables	Mean	SD	Range
Age	19.7	1.8	18-26
Height (cm)	167.9	6.9	156.2-180.3
Weight (kg)	65.2	9.9	49.1-86.4
Years of Swimming (total)	8.5	4.1	1-15
Freestyle per Practice (%)	81	10	65-100
Daily Practice Length (Hrs.)	2.4	.62	2-4

Figure 1. Frequency Distribution of the Total Number of Years in Swimming (N=24)

Figure 2. Frequency Distribution of the Percent of Freestyle Used Per Practice (N=24)

Nine of the 24 participants reported having a previous or current shoulder injury (37.5%). Injury data were similar to previous research reporting that 40-80% of competitive swimmers complain of shoulder pain (Swanik et al., 2002). For the majority of the injured participants both shoulders were involved (55.6%). The most common injury was tendonitis (44.4%), followed by a labral tear (22.2%), and a combination of a labral tear, tendonitis, and bursitis (22.2%). The majority of the injuries were sustained while swimming (55.6%), followed by water polo (33.3%), and other (11.1%).

According to Swanik et al. (2002), swimmer's shoulder is the most common orthopedic pathology in competitive swimming, which most commonly includes tendonitis, instability, and bursitis. The types of injuries reported in this study and the manner in which they were sustained are similar to injuries reported in other studies (see Figures 3 and 4) (Kammer et al., 1999; Swanik, et al., 2002).

Figure 3. Frequency Distribution of the Type of Injury Reported

Figure 4. Frequency Distribution of How the Injury Was Sustained

The majority of participants reported that they currently perform core stability training (87.5%). Three of the 24 participants had not performed any core stability training (12.5%). Of the nine individuals who reported having a shoulder injury, three individuals were not performing core stability training prior to injury or as a part of rehabilitation after injury (33.3%). Three of the nine participants who were injured had not been performing core stability training at the time of the shoulder injury, but had performed core stability training as a part of a rehabilitation protocol and were currently performing core stability training (33.3%).

The uninjured group scored higher on the lateral medicine ball toss compared to the injured group (20.28 ft.(618.13 cm.) vs. 18.25 ft.(556.26 cm.), respectively) (see Table 2, Figure 6). The injured group scored higher compared to the uninjured group on the 1-minute sit-up test (35.6 reps vs. 33.2 reps, respectively), right side-bridge (96.3 sec. vs. 81.3 sec., respectively), and left side-bridge (74.4 sec. vs. 70.1 sec., respectively) (see Table 2, Figure 6). However, none of the differences in core data were statistically significant.

Thus, the injured group may have performed better on the two endurance tests, but not on the strength/power test. One possible explanation for the injured group scoring higher on the 1-minute sit-up test and side-bridge is best explained by Leetun et al. (2004), who identified that core endurance times between injured and uninjured athletes are similar. Further research should be performed utilizing power/strength tests to study whether individuals are able to maintain postural stability of the trunk regardless of injury status.

Results for the side-bridge performed on the left side were considered average when compared to results from previous research performed on university level healthy individuals (McGill et al., 1999). The average number of repetitions for the 1-minute sit-up test performed by both groups are considered poor for both groups compared to previous research performed on women tennis players (Ellenbecker & Roetert, 1998). The lateral medicine ball toss data for both groups are considered below average compared to previous research performed on women tennis players (Ellenbecker & Roetert, 2004). The results for the side-bridge performed on the right side are considered above average for both groups compared to previous research performed on university level healthy individuals (McGill et al., 1999).

Table 2. *Mean Core Stability Comparison Between Participants With and Without Shoulder Injury*

	1-Minute Sit-ups (Reps)	Medicine Ball (Feet)	R-Side Bridge (Sec.)	L-Side Bridge (Sec.)
Injured	35.6 (+/-11.8)	18.25 (+/-3.3)	96.3 (+/-76.3)	74.4(+/-33.1)
Non-injured	33.2 (+/-8.5)	20.28 (+/-4.5)	81.3 (+/-41)	70.1 (+/-43.8)

Figure 5. Mean Core Values for Injured and Uninjured Participants

Multivariate Analysis of Variance

Results of the MANOVA indicated no significant difference between the core stability of individuals with and without overuse shoulder injuries (see Table 3). The findings of this study support previous research that has been performed on core stability and back and lower extremity injuries, which suggest muscles other than the abdominal and lower back muscles may have a higher correlation with back, shoulder, and lower extremity injuries (Leetun et al., 2004; Nadler et al., 2002; Ng et al., 2002; Rubin & Kibler, 2002; Swanik et al., 2002).

Table 3. *MANOVA for the Three Core Stability Tests and Shoulder Injuries (N=24)*

Dependent Variable	Mean Square	F	Sig.
1-min. Sit-up Test (reps)	3.429	.033	.858
Lateral Med. Ball Toss (ft.)	.030	.002	.967
Side Bridge-Right Side (sec.)	5293.943	1.779	.197
Side Bridge-Left Side (sec.)	88.052	.053	.821

Core Stability and Extremity Injuries

Leetun et al. (2004) determined that the only significant risk factor for lower extremity injury were hip external rotation and hip abduction values. The possibility exists that traditional core muscles tested in this study are not significantly related to overuse shoulder injuries and that other muscles should not only be tested in the future, but should also be strengthened as a part of conditioning programs for swimmers and overhead athletes, in general.

Swanik et al. (2002) determined that strength training of the rotator cuff and rhomboids significantly decreased the incidence of shoulder pain in intercollegiate swimmers. The trained group averaged 1.8 incidents of shoulder pain in comparison with the untrained group, which averaged 4.6 incidents of shoulder pain over the 6-week training session (Swanik et al.). The possibility exists that the upper extremity core musculature (rotator cuff and rhomboids) may have a greater effect on overuse shoulder injuries than the middle core musculature of the body, which was assessed in this study. Some experts agree that the rotator cuff and rhomboids should be included in daily core

stability training programs to better stabilize the body and shoulder joint (Rubin & Kibler, 2002; Swanik et al.)

Rubin & Kibler (2002) stated that rehabilitation of shoulder injuries should include strength training of the hip, trunk, and periscapular regions. Since this study focused primarily on muscles of the trunk, it is possible that core stability testing may relate more significantly to overuse shoulder injuries if the rhomboids, latissimus dorsi, and rotator cuff were tested, as well as the muscles of the hip. Further research should be performed testing other postural muscles and how they relate to the incidence of overuse shoulder injuries.

Core Stability and Back Injuries

Two studies which performed core stability training to treat low back pain identified no significance between core stability values and low back pain (Nadler et al., 2002; Ng et al., 2002). The first study focused on a variety of NCAA athletes and incorporated core stability training with participants having low back pain. In this study, the percentage of women experiencing low back pain increased slightly (1.6%) following the core stability program, and the incidence of low back pain in men decreased only slightly (3.7%). Both data sets for men and women were nonsignificant, and the researchers suggested that further studies should be performed to determine how the core stability programs could be modified to better accommodate the needs of men and women (Nadler et al., 2002). In this study, middle core musculature was used for strength testing, and no significant data were discovered to indicate that core muscle strength is directly related to back pain.

The possibility exists that due to the varying role of core muscles as stabilizers and initiators of a majority of the body's force needs (54%), coupled with the variety of muscles which are categorized as core muscles, that these muscles are beyond testing with traditional means (1-minute sit-up test) or technological means (electromyography) (Ng et al., 2002; Rubin & Kibler, 2002; Yeager, n.d.). Perhaps a different battery of tests, which better represent the dual responsibility of core muscles, would be better suited to provide more accurate data when analyzing core stability for a relationship with back and extremity injuries.

In another study performed on subjects with back pain, the researchers discovered no differences in normalized core muscle electromyographic activity between healthy and back-pain groups (Ng et al., 2002). The specific muscles tested included the rectus abdominis, external oblique, internal oblique, latissimus dorsi, iliocostalis lumborum, and multifidus. While all muscles tested had excellent reliability ($ICC = .90+$), the researchers indicated it was possible that maximal contraction of those muscles may not be the best method of testing to determine a significant difference between participants with and without back injury. The possibility exists that other variables not yet defined may be responsible for decreased core stability values and that different core tests could more clearly assess core stability.

Correlation

Correlation analyses were conducted to determine if any relationships existed among the core stability and demographic data collected from the participants ($N=24$). The age of the participant was significantly correlated with the number of repetitions

completed during the 1-minute sit-up test ($r=.471$) ($p<.05$). The older the participant, the more likely they have performed sit-ups and the 1-minute sit-up test before, so it is possible that due to their greater familiarity with the test, they performed better than those participants who are younger in age.

The right side-bridge was significantly correlated to the left side-bridge ($r=.542$) ($p<.01$), which is similar to other studies that utilized the side-bridge and found that the left and right side-bridge were significantly correlated (Leetun, 2004; McGill et al., 1999). The amount of time that the left side-bridge was held was significantly correlated with the amount of sit-ups performed in 1-minute ($r=.447$) ($p<.05$). Since both the 1-minute sit-up test and side-bridge are core endurance tests, their correlation might be assumed, however, the amount of time that the right side-bridge was held was not significantly correlated to the number of sit-ups performed. This lack of statistical significance could be due to the small, homogeneous population.

The lateral medicine ball toss was significantly correlated to the 1-minute sit-up test ($r=.634$) ($p<.01$). The 1-minute sit-up test is a well established test utilizing both core strength and endurance; as such, this test may correlate well with both the side-bridge, which tests lateral core endurance and the lateral medicine ball toss, which tests rotational core strength and power. Due to the small, homogeneous population of this study, it is difficult to make any generalizations.

An inverse relationship was found between the amount of practice spent performing a freestyle stroke and the number of sit-ups performed, which indicates that the less time the participant spent using a freestyle stroke during practice, the more sit-

ups they were able to perform ($r=-.409$) ($p<.05$). The 1-minute sit-up test was the only test found significantly correlated to the percent of time spent utilizing a freestyle stroke during practice, however, the lack of correlation for the remaining core stability tests may be due to the small population size.

The possibility exists that an individual who spends less time using a freestyle stroke, which the research indicates is the stroke most responsible for injuries to swimmers' shoulders, could have a healthier, stronger shoulder and core, due to a decreased amount of practice fatigue (Bieze, 2004; Kammer et al., 1999; Swanik et al., 2002). Due to the 70° to 100° roll of the body during the pull through phase of a freestyle stroke, the core can become severely fatigued during the repetitive contraction necessary to maintain proper body position (Wetzler et al., 2002). When fatigue sets in and the individual is unable to roll the body sufficiently from side to side, impingement of the shoulder is likely to occur as well as other injuries to the shoulder joint due to the increased demand placed on the rotator cuff to produce force (Bieze, 2004; Kammer et al., 1999; Swanik et al., 2002).

Conclusion

Although no significance was found for the three core tests utilized in this study having an effect on the incidence of overuse shoulder injuries, it is possible that this was due to the specific muscles tested and the tests which were utilized. Due to the utilization of two endurance tests and only one power/strength test, the injured group scored higher on all three endurance scores and scored lower on the power/strength test, however, it should be noted that no significant difference was found among the data. This

phenomenon becomes clear by assessing research performed by Leetun et al. (2004), who identified that core endurance times between injured and uninjured athletes are similar, and it appears that all athletes, regardless of injury status, are able to maintain postural stability of the trunk.

This study also provided further evidence that the right and left side-bridge are statistically significant. The 1-minute sit-up test was significantly correlated with both the right side-bridge and lateral medicine ball toss, which helps to maintain the 1-minute sit-up test as an established test for measuring abdominal strength and endurance.

The lack of statistical difference indicated by the MANOVA for all core stability data indicates that it is likely there are other muscles which may be responsible for protecting the shoulder joint during competitive swimming. Since this study focused primarily on muscles of the trunk, it is possible that core stability may relate more significantly to overuse shoulder injuries if the rhomboids, latissimus dorsi, and rotator cuff were tested as well as the hip abductors and hip external rotators.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

Shoulder injuries in competitive swimmers are the most common injury sustained, with 40-80% of swimmers receiving injuries (Kammer et al., 1999; Swanik et al., 2002). Although shoulder injuries occur in all overhead athletes, swimmers have the highest incidence of shoulder injury (Wetzler et al., 2002). Many factors may contribute to the high incidence of shoulder injury in swimmers including: the amount of time spent training, the amount of time spent in a freestyle stroke during training, and improper swimming biomechanics due to fatigue and/or weak core and stabilizing muscles (Kammer et al., 1999; Rubin & Kibler, 2002; Wetzler et al., 2002). Women may be more susceptible to shoulder injury due to decreased overall muscular strength and, more specifically, decreased core stability. Thus, female collegiate swimmers were chosen for this study (Baechle & Earle, 2000; Leetun et al., 2004). The results were presented and discussed in chapter four, and this chapter includes a summary of the results, as well as conclusions, and recommendations for future research.

Summary

The purpose of this study was to assess the difference between core stability of female collegiate swimmers with and without overuse shoulder injuries by comparing core stability values and self-reported overuse shoulder injuries. Core stability data were measured using the 1-minute sit-up test, lateral medicine ball toss, and the side-bridge. A MANOVA was used to determine if the uninjured group had stronger core musculature than the injured group.

The participants of the study were 24 women who competed in local Bay Area collegiate swimming teams. To determine demographic and shoulder injury data, all participants completed a questionnaire to evaluate swimming experience, past and present shoulder injuries, previous shoulder surgery, and core stability training experience (see Appendix A). Data for the study were collected during the beginning of the collegiate competitive season, prior to a regularly scheduled weekly practice.

Descriptive statistics were used to analyze the demographic information, a MANOVA was used to compare differences between the core stability of swimmers with and without overuse shoulder injuries, and correlation analyses were used to evaluate if any relationships existed among the core stability and demographic data. SPSS was used for all statistical analyses.

Conclusions

The following conclusions were drawn based on the results.

1. Injury status does not seem to hinder core muscle endurance ability.
2. Lack of statistical difference in core stability for both injured and uninjured groups provides evidence that other variables should be examined.
3. The side-bridge can be tested effectively using only one side due to the significant correlation between the left and right side values found in this study and in previous research.

Recommendations for Future Research

The following recommendations were made based on the results.

1. Examine core stability utilizing other testing procedures which are nearer to the mechanics of swimming. The side-bridge may not be an optimal measure of core stability, since the research indicates that injuries do not hinder a person's ability to perform tests of endurance.
2. Examine other muscles involved in core stabilization which could have a greater effect on the incidence of overuse shoulder injuries, such as the rotator cuff, rhomboids, hip abductor, and hip external rotators.
3. Test a larger number of swimmers: more participants and different levels of competition.
4. Future studies should obtain shoulder injury information from athletic training staff at each prospective institution for greater reliability.
5. Future studies should compare gender differences in core stability and the incidence of shoulder injury in competitive swimming.

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Appendix A

Shoulder Injury Questionnaire

Number: _____

Age: _____

Height (in feet): _____

Weight (in pounds): _____

Years in Competitive Swimming: _____

Year in College: ☐ Freshman ☐ Sophomore ☐ Junior ☐ Senior ☐ Other: Explain _____

Average Hours of Training per Day: _____

Amount of Time Spent Using a Freestyle Stroke in Practice: _____%

Dominant Hand: ☐ Right hand ☐ Left hand ☐ Ambidextrous

1. Do you currently have a shoulder injury? ☐ Yes ☐ No (*If no, skip to question #2*)

If yes, which shoulder? ☐ Right ☐ Left ☐ Both

How long have you been injured? _____ (days, months, years)

What is the diagnosis of your injury? _____

Onset of problem: ☐ Gradual (came on over more than 1 week)
☐ Sudden (in one episode)

How did it occur:
☐ Swimming
☐ Lifting
☐ Falling
☐ Other (*please explain*) _____

What symptoms do you have: (*check all that apply*)

- ☐ Pain
- ☐ Pain w/ swimming
- ☐ Instability
- ☐ Weakness
- ☐ Grinding/popping
- ☐ Catching/locking
- ☐ Swelling

Location of pain: (Check all that apply)

- ☐ Front
- ☐ Back
- ☐ Side
- ☐ Top
- ☐ Deep inside
- ☐ Other (*please explain*) _____

Pain occurs: (*Check all that apply*)

- ☐ Morning
- ☐ Before swimming
- ☐ During swimming
- ☐ After swimming
- ☐ All day
- ☐ Night
- ☐ Interrupts sleep

Do you have:

- ☐ Back pain
- ☐ Radiating pain (*If so, to where?*) _____
- ☐ Numbness (*If so, to where?*) _____

2. Have you had a shoulder injury within the last year?

☐ Yes ☐ No (*If no, skip to question #5*).

If yes, which shoulder?

☐ Right ☐ Left ☐ Both

When was the injury? _____ (Days, months, years)

How long did the injury last? _____ (Days, months, years)

Onset of problem: ☐ Gradual (came on over more than 1 week)

☐ Sudden (in one episode)

How did it occur:

- ☐ Swimming
- ☐ Lifting
- ☐ Falling
- ☐ Other (*please explain*) _____

What symptoms did you have: *(Check all that apply)*

- ☐ Pain
- ☐ Pain w/ swimming
- ☐ Instability
- ☐ Weakness
- ☐ Grinding/popping
- ☐ Catching/locking
- ☐ Swelling

Location of pain: *(Check all that apply)*

- ☐ Front
- ☐ Back
- ☐ Side
- ☐ Top
- ☐ Deep inside
- ☐ Other *(please explain)* _____

Pain occurred: *(Check all that apply)*

- ☐ Morning
- ☐ Before swimming
- ☐ During swimming
- ☐ After swimming
- ☐ All day
- ☐ Night
- ☐ Interrupts sleep

Did you have:

- ☐ Back pain
- ☐ Radiating pain *(If so, to where?)* _____
- ☐ Numbness *(If so, to where?)* _____

3. Have you had a previous shoulder surgery within the last year? __ Yes __ No
If yes, please describe procedure(s):

Approximate date(s): _____

4. If you had a previous shoulder injury, were you performing core strengthening exercises: (*i.e., medicine ball tosses, arm holds, Swiss ball exercises, etc.*)

At the time of the injury? ☐ Yes ☐ No

After the injury (part of rehab)? ☐ Yes ☐ No

5. Have you ever performed core strengthening exercises as part of practice or conditioning? (*i.e. planks, sit-ups, toe touches, side-bridge, medicine ball tosses, etc*)

☐ Yes: How long have you performed core exercises: (Days, months, years)

☐ No

Appendix B

San Jose State University Human Subjects Approval Form

San José State
UNIVERSITY

Office of the Provost
Associate Vice President
Graduate Studies & Research

One Washington Square
San José, CA 95192-0025
Voice: 408-924-2427
Fax: 408-924-2477

E-mail: gradstudies@sjsu.edu
<http://www.sjsu.edu>

To: Rachael Rolle
435 Acalanes Dr. #2
Sunnyvale, CA 94086

From: Pam Stacks, AVP *Pam Stacks*
Graduate Studies & Research

Date: December 15, 2005

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

"Core strength related to shoulder injuries in female collegiate swimmers"

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to all data that may be collected from the subjects. The approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Pam Stacks, Ph.D. immediately. Injury includes but is not limited to bodily harm, psychological trauma, and release of potentially damaging personal information. This approval for the human subjects portion of your project is in effect for one year, and data collection beyond December 15, 2006 requires an extension request.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services that the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2480.

Cc: Leamor Kahanov

The California State University:
Chancellor's Office
Bakersfield, Channel Islands, Chico,
Dominguez Hills, East Bay, Fresno,
Fullerton, Humboldt, Long Beach,
Los Angeles, Maritime Academy,
Monterey Bay, Northridge, Pomona,
Sacramento, San Bernardino, San Diego,
San Francisco, San José, San Luis Obispo,
San Marcos, Sonoma, Stanislaus

Appendix C

Consent Form

**San José State
UNIVERSITY**

**College of Applied
Sciences and Arts**

Department of Kinesiology

One Washington Square
San José, CA 95182-0064
Voice: 408-924-3010
Fax: 408-924-3053

Agreement to Participate in Research

Core strength related to shoulder injuries in female collegiate swimmers

Responsible Investigator: Rachael A. Rolle, ATC

Dear Participant,

You have been asked to participate in a research study investigating the effect of core strength on overuse shoulder injuries in overhead athletes in order to gain important information that could some day influence the types of conditioning that all overhead athletes use to prepare for competition.

If you choose to participate in this study, you will be asked to complete a shoulder injury questionnaire as well as participate in three core tests which should take approximately 30 minutes of your time during a practice. The three tests include: lateral medicine ball toss, side-bridge, and 1-minute sit-up test.

The results of this study could help to benefit all overhead athletes, especially swimmers, by determining whether core strength is associated with a decreased incidence of shoulder injuries.

There is a minimal risk of soft tissue injury, muscular fatigue, and muscular soreness during or after the testing, however, there have been no injuries reported in previous studies that utilized these tests (Allen et al, 2002; Ellenbecker & Roetert, 1998, 2004; Leetun et al, 2004; McGill et al., 1999; Semenic, 1990). Although no injuries have been previously reported, should an injury occur you can seek medical attention from the head researcher, your athletic trainer, team physician, or family physician.

If you have a current overuse shoulder injury and are actively participating in swimming practice, you may participate in this research study. Should you choose to do so, you will not be asked to perform the lateral medicine ball toss. You will only be asked to perform the side-bridge on the uninjured side and the 1-minute sit-up test. If you have an overuse shoulder injury in both shoulders you may choose to perform only the 1-minute sit-up test or opt out of the study all together. You may choose not to participate in any or all of this study. If you are not actively participating in swimming practice due to a shoulder injury, you may not participate in this research due to liability and safety reasons.

The results of this study may be published; however, any information that could result in your identification will not be included. There will be no compensation for participating in this study. Please fill out the enclosed questionnaire prior to the testing date and bring it with you on the day of the testing.

Questions or concerns about this research may be addressed to Rachael Rolle prior to testing or you may contact me at (360)271-6143. Complaints about the research may be presented to Gregory Payne, P.E.D., Department Chair of the Kinesiology Department at San Jose State University (408)924-3010. Questions about research subjects' rights or research-related injury may be presented to Pamela Stacks, Ph.D., Associate Vice President, Graduate Studies and Research, at (408) 924-2480.

The California State University:
Chancellor's Office
Bakersfield, Channel Islands, Chico,
Dominguez Hills, East Bay, Fresno,
Fullerton, Hayward, Long Beach,
Los Angeles, Maritime Academy,
Monterey Bay, Northridge, Pomona,
Sacramento, San Bernardino, San Diego,
San Francisco, San Jose, San Luis Obispo,
San Marcos, Sonoma, Stanislaus

_____ Initial

San José State
UNIVERSITY

**College of Applied
Sciences and Arts**

Department of Kinesiology

One Washington Square
San José, CA 95192-0054
Voice: 408-924-3010
Fax: 408-924-3053

Your consent is being given voluntarily. You may refuse to participate in any part or all of the study. If you decide to participate in the study, you may withdraw at any time without any negative effect on your relations with San Jose State University or any other participating institution or agency. At the time that you sign this consent form, you will receive a copy of it for your records, signed and dated by the investigator.

Sincerely,

Rachael A. Rolle, ATC
San Jose State University

X _____ Date: _____
Participant

X _____ Date: _____
Investigator

The California State University:
Chico State's Office
Sacramento, Chico State, Chico
Dominguez Hills, East Bay, Fresno,
Fullerton, Humboldt, Long Beach,
Los Angeles, Maritime Academy,
Monterey Bay, Northridge, Pomona,
Sacramento, San Bernardino, San Diego,
San Francisco, San Jose, San Luis Obispo,
San Marcos, San Bernardino, Stanislaus