SHOULDER STABILITY TRAINING AND SHOULDER AILMENTS IN HIGH SCHOOL SWIMMERS

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The purpose of this study was to explore how specific shoulder stabilizing exercises influenced the shoulder strength balance, incidence of practice time lost due to shoulder ailments and swim performance. Two US high school varsity swim teams participated in the study. The treatment team (N = 59) performed thrice weekly 20-minute dryland activities to improve shoulder and scapular stability, whereas the control team (N = 68) did not explicitly train their athletes in this manner. In addition to the shoulder ailment incidence and lost practice time, we also monitored changes in athletic performance. The results indicate that shoulder-stabilizing exercises reduce the incidence and duration of shoulder ailments in swimmers, without being detrimental to swim performance.

KEYWORDS: competitive swimming, high school athletics, injury risk

INTRODUCTION: Swimming is a sports enjoyed by millions throughout the world, both as an activity to increase fitness and as a competitive endeavor. Though the injury rates in swimming is low (2.2 injuries per 1000 swimming occasions) among all swimmers (McFarland & Wasik, 1996), competitive athletes have a high incidence of shoulder ailments, with over 25% of competitive swimmers stating that shoulder pain has their hindered training and performance (McMaster & Troup, 1993).

The high stroke volume in competitive swimming may be one reason for the elevated incidence of shoulder ailments. Swimmers take approximately 2500 strokes per day (Pink and Tibone, 2000), more than 10 times the repetitions that a typical overhead athlete takes. A second theory identifies muscle imbalance, inflexibility, and asymmetry as the cause of increased shoulder ailments in swimmers (Shapiro, 2001), with Jobe and Pink (1993) stating that musculoskeletal instability is at the core of most shoulder injuries. Musculoskeletal instability can result from an asymmetric strength profile, and research suggests that an increased ratio between external and internal rotational strength ratio (ER:IR) may be indicative of shoulder ailments (e.g. Bak and Magnusson, 1997). Specifically, they noted the functional strength ratio of eccentric external rotation to concentric internal rotation (ER_{ecc}:IR_{conc}) were significantly higher in swimmers with symptomatic shoulders.

As the ER:IR ratio is thought to be indicative of shoulder ailments, a specific shoulder stabilizing program that strengthens the internal and external rotators may decrease the incidence of shoulder injuries. Thus, the objective of this work was to explore how introducing specific stabilizing exercises affected the shoulder ER_{ecc}:IR_{conc} ratio and incidence of shoulder ailments over the course of a high school swim season.

METHODS: Two US high school swim team participated in this study (Table 1). The treatment team (N = 59) engaged in thrice weekly 20-minutes exercises to develop shoulder and scapular stability, whereas the control team (N = 68) did not explicitly include these stability exercises, unless directed by a trainer or physician as part of a rehabilitation or treatment program. Participation in the study included parental consent and subject assent prior to the start of the high school season, as well as participation in all assessments. The study protocol was approved by the University's Institution Review Board.

These teams were chosen because they had a similar number of practices per week (8 practices in 6 days with 1 day off) and swim practice hours (approximately 12 hours weekly). Both teams also incorporated as a part of their program 2 hours dryland activities, which included strength training 2 days per week.

Table 1. Subject demographics. Data reported as mean (SD).

	Treatment Team (N = 59)		Control Team (N = 68)	
	Men	Women	Men	Women
Number of Participants	27	32	33	35
BMI (kg/m^2)	16.2 (1.9)#	21.9 (2.6)#	15.1 (2.3)#	22.3 (2.0)#
Age at Start of Study (years)	16.4 (0.7)	15.9 (1.0)	16.7 (0.9)	16.1 (1.0)
Swimming Experience (years)	6.4 (2.1)	6.7 (1.9)	6.0 (2.3)	7.1 (2.3)
Number of Athletes with Prior Incidence of Shoulder Ailments that Limited Swim Participation (% of team)	8 (25.9%)	11 (34.4%)	8 (24.2%)	10 (28.6%)
Number of Athletes Experience Shoulder Ailments at Start of Season	0	1	0	0

= p< 0.05 between men and women within teams

At the start of the high school swim season, we collected the participants' demographic information (Table 1) and provided a survey to collect their swimming and shoulder injury history. For the shoulder injury history questions, subjects were to explain any non-contact shoulder injuries that limited swim practice (e.g., requiring the subject to refrain from specific swim activities) and to note outcome of the injury (e.g., surgery, rehabilitated, currently still injured, etc.).

On day 2 of the season and 3 weeks prior season's conclusion, participants completed a pre-post swimming assessment of 10x100m on a 2:20 interval. The average 100m swim time was determined for each participant.

The day following the swim assessments, we determined the ER:IR ratios. We followed the protocol by Bak and Magnusson (1997) and used a KinCom dynamometer (Chattecx Corp., Chattanooga Group, Chattanooga, TN, USA). For the testing, we positioned the shoulder at 80° of abduction and 20° of forward flexion and the elbow at 90° of flexion. Subjects had eight warm-up submaximal efforts at 30°/second prior to testing. In the testing, participants underwent maximal efforts of concentric and eccentric internal rotation strength followed by external rotation strength. There was a self-selected rest period of 30-60 seconds between bouts, and testing continued until participants were unable to demonstrate improved strength scores. We normalized the ER:IR ratios by body mass, and the participant's right and left ratios were averaged.

Throughout the season, the coaches of the participating teams emailed the author the injury report provided from the high school, which listed injuries and contraindication for practice. Any contraindications or limitation for practice as a result of shoulder pain were verified by the coach to explain if the athlete refrained from stated activities.

The shoulder exercises (Table 2) addressed the three important areas in shoulder joint's stability, and followed the protocol set by USA Swimming (Rodeo, 2002). The program sought to

Table 2. Treatment team exercises.

Shoulder Stabilizing Exercises		
Rotator Cuff Exercises	**Actions**	**Main Muscles**
External Rotation with Resistance Band	With resistance band in circle, hands are placed in the circle and press the laterally with elbows maintaining close contact with trunk.	Deltoid Infraspinatus Teres Minor
Light Weight Scaption (Straight Arm Lifts)	Using 1-3 lb weights per hand, straight arms lift the weight obliquely at 45° angle.	Supraspinatus
Ball on the Wall	With one arm extended and a tennis ball against the wal, shoulder blades squeeze together and roll the ball in small circles in a counter-clockwise and clockwise motion.	Supraspinatus Infraspinatus Teres Minor Subscapularis
Shoulder Exercises	**Actions**	**Main Muscles**
Resistance Band Low Row	With resistance band connected to stationary object, squeeze shoulder blades together, palms facing upward, bring hands towards body leading with the elbows.	Latissimus Dorsi Rhomboids Posterior Deltoid Trapezius
Prone Reverse Fly	Lying face down on the floor, arms make a 'T' with body, and squeezing shoulder blades together, arms lift off of the ground.	Rhomboids
Push Up Plus	With a regular pushup, at the top of a pushup, continue to push such that shoulders rotate and center of back is farther away from the floor than shoulders.	Pectoral Anterior Deltoid Triceps Latissimus Dorsi Rotator Cuff Muscles
Core Exercises	**Actions**	**Main Muscles**
Dead Bug	Lying supine with a neutral back, hold abdominals tight and light flutter kick, arms can also light alternate overhead.	Rectus Abdominis Transverse Abdominis
Quadraped	On hands and knees, hold a neutral back and slight press one leg behind and the opposite arm forward. Alternate in a slow, controlled motion.	Transverse Abdominis
General Stretches	**Actions**	**Main Muscles**
Hamstrings	Lying supine, with a straight leg, bring leg towards chest.	Hamstrings
Upper Back	With palms together and straight arms at shoulder height, press hands forward, rounding the back,	Trapezius Rhomboids
Neck	With one arm placed behind the back, lightly press the head to the opposite shoulder. Eyes will look forward for one stretch and then eyes will look at a 45° downward for a second stretch.	Trapezius

strengthen the: (1) rotator cuff muscles, (2) scapular stabilizing muscles, and (3) muscles of the low back, abdominal, and pelvis

We used SPSS 15.0 (SPSS Inc, Chicago, IL, USA) for the statistical analysis. The average swim times, shoulder ailments and days of limited swim practice were calculated. ANOVA used to analyze pre-post assessments and ER_{ecc}:IR_{conc}, in addition to incidence and duration of the shoulder ailment.

RESULTS: Throughout the course of the season, the control team men ($p=0.045$) and women ($p=0.048$) experienced significant higher loss of practice due to injury compared to the treatment team men and women (Table 3). These injuries, on average, resulted in significantly more limited swim practices ($p = 0.039$) when compared to the treatment team.

In exploring the changes in swim performance between the two teams, the female treatment group showing significant improved ($p = 0.044$) over the course of the season. This improvement in swim performance is significant, as members of the treatment team reduced their time in the water swimming by one hour to accommodate the shoulder stabilizing exercises during practice.

At the pre-assessment, the functional ER_{ecc}:IR_{conc} strength ratio between team was initial similar between genders and teams.

DISCUSSION: The purpose of this study was to explore how shoulder stability exercises affected the functional ER_{ecc}:IR_{conc} strength ratio and shoulder injury during the course of a high school swim team. There were several significant findings. First, we found that adding shoulder stabilizing exercises does decrease the incidence of shoulder ailments. Second, we noted that shoulder stabilizing exercises can significantly reduced the ER_{ecc}:IR_{conc} strength ratio in both men and women. Finally, we observed that swimmers who routinely performed the shoulder stabilizing exercises experienced a quicker return to practice post-complaint. This data suggest that incorporating shoulder-stabilizing exercises in swim practice may benefit the overall shoulder joint health of the swimmer.

Because of the nature of swimming, swimmers tend to have an increase in internal rotation strength development, and the imbalance between internal and external rotation strength may play a role in higher rate shoulder ailments in swimmers (Bak and Magnusson, 1997). Though the shoulder-stabilizing exercises did not explicitly focus on increasing the shoulder external rotation strength, it does provide a means for emphasizing shoulder health during practice, and it did lower the functional ER_{ecc}:IR_{conc} strength ratio.

From the pre to post-assessment, the treatment teams ER_{ecc}:IR_{conc} was significantly lower for the men and women. The treatment team also had a decrease in shoulder ailments incidence. This could be treatment team's lowered ER_{ecc}:IR_{conc} ration. Moreover, it could be that the swimmers decreased instability through strengthening the smaller supporting

Table 4: Pre-Post assessment results and incidence of injury. All data reported as mean (SD).

	Treatment Team (N = 59)		Control Team (N = 68)	
	Men (N = 27)	Women (N = 32)	Men (N = 33)	Women (N = 35)
Pre-Average Timed 100m Freestyle Repeats (10x100m) (sec)	74.0 (4.9)	80.6 (4.1)†	72.9 (4.5)	79.1 (7.0)
Post-Average Timed 100m Freestyle Repeats (10x100m) (sec)	71.2 (5.1)	74.3 (3.9)†	70.8 (4.4)	74.1 (5.1)
Pre ER_{ecc}:IR_{con} Ratio	1.01 (0.13)†	1.03 (0.13)†	1.01 (0.14)	1.01 (0.13)
Pre ER_{ecc}:IR_{con} Ratio	0.91 (0.09)†*	0.93 (0.10)†	0.99 (0.15)*	1.00 (0.13)
Athletes with shoulder ailments limiting swim participation during season (% of team)	2 (7.4%)	3 (9.4%)	5 (15.2%)	5 (14.3%)
Athletes with shoulder ailments (Number of new ailments / Number of reoccurring previous ailment)	0 / 2	1 / 2	2 / 3	3 / 3
Average number of limited swim participation days per shoulder complaint	2.4 (0.3)*	2.0 (0.3)*	3.1 (0.5)*	3.1 (0.4)*

* $p < 0.05$ between treatment and control teams by gender

† $p < 0.05$ between pre- and post assessment within group

muscles of the rotator cuff (McMaster, 1999). Further research is needed to elucidate the shoulder adaptations to these exercises to understand their effectiveness in limiting shoulder maladies in swimmers.

CONCLUSION: This research suggests that incorporating specific shoulder exercises into a swim program may be one method to decrease the incidence and duration of swimmer's shoulder ailments. There was a significant difference noted between the athletes that experienced shoulder ailments in the two teams. The treatment team with the added shoulder stability exercises had only 1 athlete develop a new shoulder ailment, whereas the control team had 5 new cases. This is an important finding, and we conclude that incorporating shoulder stability exercises early and throughout an athlete's career may decrease the risk of developing shoulder ailments and reduce practice time lost, which may result in increased longevity in swimming.

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Acknowledgement

The author would like to thank the two high school teams, coaches, trainers and administrators for all their work in assisting in collecting data. The author would also like to the undergraduate researchers SS Gutierrez, and CS Criss.