Effect of a 6-Week Strengthening Program on Shoulder and Scapular-Stabilizer Strength and Scapular Kinematics in Division I Collegiate Swimmers

Elizabeth E. Hibberd, Sakiko Oyama, Jeffrey T. Spang, William Prentice, and Joseph B. Myers

Context: Shoulder injuries are common in swimmers because of the demands of the sport. Muscle imbalances frequently exist due to the biomechanics of the sport, which predispose swimmers to injury. To date, an effective shoulder-injury-prevention program for competitive swimmers has not been established. Objective: To assess the effectiveness of a 6-wk strengthening and stretching intervention program on improving glenohumeral and scapular muscle strength and scapular kinematics in collegiate swimmers. Design: Randomized control trial. Setting: University biomechanics research laboratory. Participants: Forty-four Division I collegiate swimmers. Interventions: The intervention program was completed 3 times per week for 6 wk. The program included strengthening exercises completed using resistance tubing—scapular retraction (Ts), scapular retraction with upward rotation (Ys), scapular retraction with downward rotation (Ws), shoulder flexion, low rows, throwing acceleration and deceleration, scapular punches, shoulder internal rotation at 90° abduction, and external rotation at 90° abduction—and 2 stretching exercises: corner stretch and sleeper stretch. Main Outcome Measurements: Scapular kinematics and glenohumeral and scapular muscle strength assessed preintervention and postintervention. Results: There were no significant between-groups differences in strength variables at pre/post tests, although shoulder-extension and internal-rotation strength significantly increased in all subjects regardless of group assignment. Scapular kinematic data revealed increased scapular internal rotation, protraction, and elevation in all subjects at posttesting but no significant effect of group on the individual kinematic variables. Conclusions: The current strengthening and stretching program was not effective in altering strength and scapular kinematic variables but may serve as a framework for future programs. Adding more stretching exercises, eliminating exercises that overlap with weight-room training and swim training, and timing of implementation may yield a more beneficial program for collegiate swimmers.

Keywords: prevention, overuse injuries, swimming

Competitive swimmers train approximately 11,000–15,000 yd/d, 6 or 7 times per week, which correlates to 16,000 shoulder revolutions per week. Significant demand is placed on the shoulder, as the upper extremity supplies 90% of the propulsive force during swimming. Because of this, shoulder pain is commonplace in swimming, accounting for at least 55% of all injuries. Interfering shoulder pain, defined as pain that limits participation in swimming, has been reported in 45% to 87% of swimmers during their careers. The high frequency and intensity of training often leads to “swimmer’s shoulder,” which is the general term for shoulder overuse injuries in swimmers. While the exact cause of swimmer’s shoulder is unknown, potential contributors include swimming technique, practice habits (including yardage, intensity, and training methods), and physical characteristics of the athlete. Of these potential contributors, the physical profile of the athlete is the most easily modifiable. Swimmers have been found to have altered range of motion, strength, and posture that may predispose them to shoulder injuries. On average, swimmers have an increase of 10° in external rotation and 40° in abduction and a decrease of 40° of internal rotation compared with nonswimmers. Since decreased internal-rotation range of motion has been linked to a pattern of scapular kinematics that results in narrowing of the subacromial space, decreased internal-rotation range of motion is implicated in the development of subacromial impingement in overhead athletes. Shoulder adduction and elbow extension are the primary movements required to propel the body forward during swimming. These movements are produced predominantly by the pectoralis major, latissimus dorsi, and triceps brachii. Because of the contribution of the pectoralis major and latissimus dorsi muscles in the stroke, swimmers tend to have increased shoulder internal-rotation and adduction strength.
volume of practice yardage paired with the significant contribution from the pectoralis major and latissimus dorsi causes overdevelopment of the anterior shoulder musculature, leading to a strength imbalance with the posterior shoulder musculature. Strength imbalances of the shoulder musculature and shoulder pain are significantly correlated in swimming athletes. The overdevelopment of the anterior musculature promotes shoulder instability by creating an anterior displacement force on the humeral head and preventing the humeral head from being centered within the glenoid fossa. Shoulder instability can lead to pain, impingement, and decreased functioning in overhead athletes. Establishing a balanced strength profile in swimming athletes may decrease shoulder instability and pain.

Finally, swimmers are notorious for having poor posture. They are characterized as having forward head, rounded shoulders, and increased thoracic kyphosis, which can affect scapular kinematics, muscle strength, and range of motion. The repetitive nature of the sport, biomechanics of the freestyle stroke, and physical profile of swimmers may predispose these athletes to overuse shoulder injuries, which may require them to take time off to allow healing. While rest may be beneficial to treat the injury, significant detraining can occur with as little as 1 week of decreased activity. Because of the detraining that can occur with rest, it is paramount to develop a shoulder-injury-prevention program for swimmers to address the strength deficits and altered pattern of scapular kinematics that have been found to lead to injury and are modifiable characteristics in the current competitive-swimming theory.

Few studies have evaluated a prevention program designed specifically for swimmers that addresses the weaknesses and altered movement pattern of swimmers. Therefore, the purpose of this study was to determine the effects of a 6-week intervention program on shoulder-girdle and scapular strength and scapular kinematics in Division I collegiate swimmers. We hypothesized that after undergoing the training protocol for 6 weeks, swimmers in the intervention group would exhibit greater strength of glenohumeral musculature and scapular stabilizers and more efficient scapular kinematics (increased scapular upward rotation, posterior tipping, external rotation, and retraction) than individuals in the control group.

**Methods**

**Study Design**

A randomized control trial with an intervention and control group was used in this study. The dependent variables were shoulder muscle strength, scapular-stabilizer muscle strength, and scapular kinematics measured preintervention and after 6 weeks of an intervention program. The independent variable was group assignment—control or intervention. After the pretest screenings, the subjects were assigned subject numbers and stratified by sex. The stratified subject numbers were randomized, and then the first half of the randomized subject numbers were assigned to be in the intervention group and the rest were placed in the control group. This method ensured randomization and that an equal number of men and women were in both the control and the intervention groups. Pretest screenings occurred immediately before preseason training, and posttesting was conducted 6 weeks later, before any team competition began. This period was selected because the team was completing the same workouts and practices regardless of stroke specialty or distance group.

**Participants**

Forty-four subjects were pretested for participation in the study. They were recruited from an NCAA Division I swimming team and included in the study if they participated in practice at least 4 d/wk, participated in all weight-lifting sessions, and completed at least 15 of the 18 training sessions. Subjects were excluded from the study if they were diagnosed with a shoulder injury, developed shoulder pain during the intervention period, or were noncompliant with the intervention program. Seven subjects were excluded during the intervention period due to injury or noncompliance. Therefore, 37 subjects were posttested (Table 1). All participants read and signed a consent form approved by the university’s institutional review board.

**Procedures**

All subjects reported for assessment of shoulder-girdle and scapular strength and scapular kinematics. Isometric strength was measured using a handheld dynamometer (Lafayette Inc, Lafayette, IN: Model #01163), which has been shown to be a reliable and valid measure for assessing strength of the shoulder musculature. Interobserver reliability data and minimum detectable differences from pilot testing are presented in Table 2. The strength measurements were taken for shoulder flexion, extension, abduction, adduction, internal and external rotation and scapular retraction, retraction with downward rotation, and retraction with upward rotation. Each position was measured 3 times according to procedures described by Kendall et al.

Scapular kinematic variables were measured using the Motion Star electromagnetic tracking device (Ascension Technologies, Burlington, VT). This device, integrated with Motion Monitor software (Innovative Sports Training Inc, Chicago, IL), was used to acquire the data.

**Table 1 Subject Demographics**

<table>
<thead>
<tr>
<th></th>
<th>Intervention</th>
<th>Control</th>
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<tbody>
<tr>
<td>n</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>Male/Female</td>
<td>10/10</td>
<td>8/9</td>
</tr>
<tr>
<td>Age (y)</td>
<td>19.2 ± 1.2</td>
<td>19.4 ± 1.2</td>
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<tr>
<td>Mass (kg)</td>
<td>73.1 ± 9.9</td>
<td>72.8 ± 12.4</td>
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<tr>
<td>Height (cm)</td>
<td>177.5 ± 9.8</td>
<td>178.1 ± 8.7</td>
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Intervention Program for Competitive Swimmers

through electromagnetic receivers for the calculation of receiver position and orientation relative to the standard range transmitter. The receivers were placed on the spinous process of C7, acromion process, and midshaft of the posterior humerus on the dominant arm, with one attached to the stylus to digitize the anatomical landmarks. Validity of the instrument for the assessment of scapular kinematics has been established previously. Subjects performed 15 elevations at a rate of 4 seconds per repetition in the scapular plane (30° anterior to the frontal plane). Kinematic data were sampled at 100 Hz.

During the 6-week intervention, subjects in the intervention group performed the exercise program 3 times per week after practice, while control subjects were allowed to leave after practice. All training sessions were monitored to track compliance, evaluate technique, and provide feedback if subjects were not performing the exercises correctly or if they had questions. In addition, each subject was given the opportunity to report shoulder pain to the certified athletic trainer and receive a full evaluation during this time. Developed based on recommendations from previous studies (Table 3), the

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Muscles high in EMG activation</th>
<th>EMG studies</th>
<th>Characteristic addressed</th>
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</thead>
<tbody>
<tr>
<td>Shoulder flexion</td>
<td>AD, Rhom, SA, Sub, TM</td>
<td>Moseley et al13, Myers, Pasquale, et al20; Cools et al16</td>
<td>Strengthen scapular stabilizers</td>
</tr>
<tr>
<td>Shoulder extension</td>
<td>Lat, Rhom, Sub, Tri, TM</td>
<td>Myers, Pasquale, et al20; Cools et al16</td>
<td>Strengthen scapular stabilizers</td>
</tr>
<tr>
<td>IR at 90°</td>
<td>LT, Rhom, SA, Sub, TM</td>
<td>Myers, Pasquale, et al20</td>
<td>Strengthen scapular stabilizers</td>
</tr>
<tr>
<td>ER at 90°</td>
<td>LT, Rhom, SA, Sub, Supra, TM</td>
<td>Myers, Pasquale, et al20</td>
<td>Weak ER, strengthen scapular stabilizers</td>
</tr>
<tr>
<td>Throwing acceleration</td>
<td>LT, Rhom, SA, Sub, TM</td>
<td>Myers, Pasquale, et al20</td>
<td>Strengthen scapular stabilizers, proprioception</td>
</tr>
<tr>
<td>Throwing deceleration</td>
<td>LT, Rhom, Sub, Supra, TM, LT, UT</td>
<td>Moseley et al13, Myers, Pasquale, et al20; Cools et al16</td>
<td>Weak ER, improve proprioception</td>
</tr>
<tr>
<td>Low rows</td>
<td>Rhom, Sub, TM</td>
<td>Moseley et al13, Myers, Pasquale, et al20; Cools et al16</td>
<td>Strengthen scapular stabilizers</td>
</tr>
<tr>
<td>Scapular punches</td>
<td>Rhom, SA, Sub TM</td>
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<td>Strengthen SA</td>
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<td>Ys</td>
<td>LT, MT, SA</td>
<td>Ekstrom et al19, Oyama et al12</td>
<td>Strengthen scapular stabilizers, increases scapular up rotation, post tilt, retraction, and ER</td>
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<tr>
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<td>Ekstrom et al19, Oyama et al12</td>
<td>Strengthen scapular stabilizers, increases scapular up rotation, post tilt, retraction, and ER</td>
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<tr>
<td>Ws</td>
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<td>Strengthen scapular stabilizers, increases scapular up rotation, post tilt, retraction, and ER</td>
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<tr>
<td>Sleeper stretch</td>
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<td>McClure et al12</td>
<td>Posterior shoulder tightness</td>
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<tr>
<td>Corner stretch</td>
<td>N/A</td>
<td>Borstad and Ludewig14</td>
<td>Forward shoulder posture</td>
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Abbreviations: AD, anterior deltoid; Rhom, rhomboids; SA, serratus anterior; Sub, subscapularis; TM, teres minor; Lat, latissimus dorsi; Tri, triceps; Supra, supraspinatus; LT, lower trap; UT, upper trapezius; MT, middle trap; Infra, infraspinatus.
intervention program included 2 sets of 15 repetitions of the following strengthening exercises: shoulder flexion, shoulder external and internal rotation at 90° abduction, low rows, D2 pattern acceleration and deceleration, scapular punches, Ts (scapular retraction), Ys (scapular retraction with upward rotation), and Ws (scapular retraction with downward rotation). These exercises have previously been shown to be effective resistance-tubing exercises for activating muscles that are weak in swimmers (Figures 1–11).28–33 Subjects also performed 2 repetitions of 30 seconds each of the corner stretch for the pectoralis minor and the sleeper stretch, which has been shown to be effective in improving internal-rotation range of motion (Figure 12 and Table 3).22,34

Figure 1 — Shoulder flexion.

Figure 2 — Shoulder extension.

Figure 3 — Shoulder external rotation at 90°.

Figure 4 — Shoulder internal rotation at 90°.
Figure 5 — Low rows.

Figure 6 — Throwing acceleration.

Figure 7 — Throwing deceleration.
At the first training session, all subjects were given resistance tubing (Theraband, Hygenic Corp, Akron, OH) and performed 5 repetitions of each exercise with different levels of resistance. Feedback from the subject and observation of proper form were used to determine the appropriate resistance level. Subjects were reevaluated every 2 weeks to determine if they needed to change the resistance level they were using. After the 6-week intervention period, strength and scapular kinematics were reassessed. Researchers performing the strength measurements were blinded to group assignment to prevent assessor bias. These researchers were volunteers who were not affiliated with the swimming team and therefore were not present at any of the training sessions of the intervention program.

Strength data were normalized to body mass and calculated as a 3-trial mean for each strength variable. Raw scapular kinematic data were filtered with a fourth-order zero-lag low-pass Butterworth filter with a cutoff frequency of 10 Hz. Receiver position and orientation data of the thoracic, scapular, and humeral receivers were transformed into a local coordinate system for each of
the respective segments from the International Society of Biomechanics recommendations. Orientation of the scapula was determined as rotation about the y-axis (internal/external rotation), z-axis (upward/downward rotation), and x-axis (anterior/posterior tipping). \( Y'X''Z'' \)-order Euler angles were used to determine the scapular orientation with respect to the thorax, and \( Y'X''Y'' \)-order Euler angles were used to determine the position of the humerus relative to the thorax. The scapular protraction/retraction angle was calculated as the angle formed between the vector extending from the sternoclavicular to the acromioclavicular joint projected onto the transverse plane of the thorax and the frontal plane of the thorax, and the scapular elevation/depression angle was calculated as the angle formed between the vector projected onto the frontal plane of the thorax and the transverse plane of the thorax. Scapular movements in internal rotation, downward rotation, posterior tilt, elevation, and retraction directions were indicated by positive numbers. For ease of interpretation, scapular upward-rotation values were multiplied by \(-1\) to make upward rotation a positive movement. Scapular kinematic variables at 0°, 30°, 60°,
90°, and 120° of humeral elevation were calculated as means of the middle 5 repetitions.

**Statistical Analysis**

Two-way ANOVAs with 1 within factor (session) and 1 between factor (group) were run to determine differences in normalized strengths. Three-way ANOVAs with 2 within factors (session and angle) and 1 between factor (group) were used to examine the interactions and main effects for the scapular kinematic variables. Bonferroni post hoc analyses were conducted to determine if the strength variables changed between pretesting and posttesting in experimental and control groups and to make appropriate comparisons between the scapular kinematic variables when significant interactions were present. Huynh-Feldt correction was used whenever the assumption of sphericity was rejected. An a priori alpha level was set at .05.

**Results**

Strength data are presented in Table 4. There was a significant group-by-session interaction in flexion ($F_{1,35} = 5.972$, $P = .020$) and abduction ($F_{1,35} = 6.635$, $P = .014$) strength, but there were no significant mean differences based on the Bonferroni post hoc analyses using the adjusted alpha level of .0125 (.05/4 comparisons). Subjects in the intervention group gained 2.0% of their body mass in shoulder-flexion strength and 1.7% in shoulder-abduction strength, while subjects in the control group lost 2.3% in flexion and 3.1% in abduction strength (Figures 13 and 14). Minimum detectable differences calculated for flexion and abduction were 1.90 and 1.95, respectively. This suggests that the increase in flexion strength in the intervention group and the decreases in the flexion and abduction strength in the control subjects were beyond error and represent real changes in the muscle strength. Group-by-session interactions were insignificant for the other strength variables. There was a significant main effect of session on extension strength ($F_{1,35} = 8.783$, $P = .005$) and scapular retraction ($F_{1,35} = 55.212$, $P < .005$) when the data were collapsed across groups. On average, subjects increased their shoulder-extension strength by 4.16% and scapular retraction strength by 6.25% between sessions, regardless of group assignment. No other session or group main effects were present.

Scapular kinematic data are presented in Table 5. Angle-by-group-by-session three-way interactions were insignificant for all scapular kinematic variables. There was a significant angle-by-group interaction on internal/external rotation ($F_{4,108} = 5.453$, $P = .018$). Bonferroni post hoc analysis was conducted to compare the scapular kinematics between groups at each of the 5 humeral-elevation angles with an adjusted alpha level of .01 (.05/5). The analysis demonstrated that the scapula was more internally rotated in the treatment group participants than in the control group participants at humeral-elevation angles of 0° ($t_{58} = 2.918$, $P = .005$) and 30° ($t_{60} = 2.840$, $P = .006$) but not at humeral-elevation angles of 60°, 90°, and 120° when the data were collapsed across sessions. There was a significant angle-by-group interaction for scapular-elevation/depression angles ($F_{4,100} = 4.320$, $P = .038$), but post hoc analysis did not reveal between-sessions differences at any humeral-elevation angle. There were no significant angle-by-group interactions in upward/downward rotation, anterior/posterior tilt, or protraction/retraction kinematics. There were no significant angle-by-session or angle-by-group interactions of the scapular kinematic variables. Although subjects were randomly assigned, the intervention group had significantly greater scapular internal rotation than the control group at 0° and 30° of humeral elevation at baseline.

A significant main effect of session was present for internal/external rotation ($F_{1,27} = 25.085$, $P < .0005$), protraction/retraction ($F_{1,25} = 10.88$, $P = .003$), and eleva-

<table>
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<th>Table 4 Shoulder and Scapular-Stabilizer Strength (% Body Mass) Before and After the Intervention and the Change Score, Mean ± SD</th>
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<tbody>
<tr>
<td><strong>Intervention</strong></td>
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<tr>
<td>Flexion</td>
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<tr>
<td>Extension</td>
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<td>External rotation</td>
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<td>Internal rotation</td>
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<td>Retraction with downward rotation</td>
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tion/depression ($F_{1,25} = 4.279, P = .049$). On average, the swimmers’ scapulae were $11.1^\circ \pm 2.21^\circ$ more internally rotated, $8.83^\circ \pm 2.67^\circ$ more protracted, and $2.85^\circ \pm 1.38^\circ$ more elevated at the postintervention session when averaged over groups and angles.

**Discussion**

Shoulder injuries are common in swimmers because of the demands of the sport. Muscle imbalances frequently arise due to the biomechanics of the sport, which predispose swimmers to injury. The objective of this study was to assess the effectiveness of a 6-week intervention program to improve shoulder and scapular-stabilizer strength and scapular kinematics in collegiate swimmers. We hypothesized that the intervention program would significantly improve glenohumeral and scapular-stabilizer strength in intervention group compared with the control group. While the intervention program did not result in statistically significant improvements in glenohumeral-strength variables between groups, there were nonsignificant trends indicating that intervention group subjects may have had stronger flexion and abduction strength than the control group after the intervention. These trends resulted from a modest strength gain in the intervention group and a small strength loss in the control group. These changes in flexion and abduction strength greater than the calculated minimum detectable difference suggest that the strengthening program produced meaningful changes in glenohumeral muscle strength. Our results are similar to findings by Swanik et al., who found no significant isokinetic strength differences between control and intervention groups after a 6-week functional training program that included rubber-tubing, dumb-bell, and body-weight exercises. Their lack of significant changes in strength variables between groups was also partially attributed to the preseason conditioning that was being completed by the team. Swanik et al. found that despite having no strength changes between groups, individuals in the intervention group had fewer reported incidences.
of interfering shoulder pain. They suggest that although the strength variables did not change, the program had a protective effect.

We also hypothesized that subjects in the intervention groups would have improved scapular kinematics compared with those in the control group. Contrary to our hypothesis, no between-groups differences in scapular kinematic variables at any elevation angle between sessions were found. No previous literature has evaluated changes in scapular kinematics in swimmers as a result of a training program. Wang et al.17 found decreased upward rotation and elevation and increased internal rotation after an exercise program in asymptomatic participants with forward shoulder posture. These results may differ from the current study because subjects were being treated for a specific condition and may have had more room for improvement. Unlike the competitive swimmers used in our study, those subjects were not athletes and did not have training demands that may have counteracted any benefits from their intervention program.

The current study found that swimmers’ scapulae became more internally rotated, protracted, and elevated at the postintervention screening than at preintervention regardless of group assignment. The changes in scapular kinematics may be attributed to increased tightness of the posterior shoulder and pectoralis major and minor muscles that developed in response to increasing training intensity. Individuals with posterior shoulder tightness and/or tight pectoralis muscles have been found to have increased anterior tilt, internal rotation, and down-
ward rotation. Therefore, muscle imbalances and tightness that develop due to the increased swim training may be responsible for the increased protraction and internal rotation at the posttesting.

Based on the findings of the current study, the intervention program was not successful in improving the variables as hypothesized and would not be an effective program to implement in competitive swimmers. However, the results of the study do provide a valuable framework for how the intervention program could be modified to benefit competitive swimmers. Modifications to the strengthening and stretching components of the program may yield better results. Strengthening exercises that are adequately completed during swimming, dry-land programs, and weight training should be forgone to prevent excessive fatigue and increase compliance. Shoulder adduction, extension, and internal rotation are the primary movements required to propel the body through the water. These motions are performed with great power during every stroke, and further strengthening the muscles that perform these actions may promote fatigue and not be beneficial to the athletes. Furthermore, it was found that shoulder extension and scapular retraction significantly increased between sessions, regardless of group assignment. This is likely due to a push-up and pull-up program that the entire team performed as a part of the dry-land program or overlap with exercises that are performed in the weight room. Therefore, exercises that target shoulder-extension and scapular-retraction strength could be eliminated to shorten the exercise program, which may improve compliance. Swimming coaches, strength and conditioning coaches, and athletic trainers should coordinate their programs to avoid excessive overlap in exercises that are being performed to prevent overtraining and fatigue.

In addition, the stretching component of the intervention program did not counteract the effects of swimming on muscle-tightness development, as all subjects moved into greater scapular internal rotation, protraction, and elevation. A greater focus on stretching of the pectoralis major, pectoralis minor, and posterior capsule to prevent the increasing scapular internal rotation and protraction, as well as the upper trapezius to reverse the increasing scapular elevation is needed. To better stretch these structures, we propose the addition of the cross-body stretch, pectoralis stretch over the foam roller, and upper trapezius stretch. McClure et al reported that the cross-body stretch is more effective than the sleeper stretch in improving internal-rotation range-of-motion deficits. It could be added to the intervention program to provide additional stretching of the posterior shoulder capsule. An additional stretch for the pectoralis major and minor could be added, as the corner stretch included in this study did not create enough improvements to positively influence the scapular kinematics. A potential stretching exercise to include in future studies is to have the individual lie over a foam roller with a partner pushing his or her shoulders down. This stretch isolates the pectoralis muscles in a safe position, without causing excessive anterior displacement of the humeral head, which promotes anterior instability of the shoulder. Finally, stretching for the upper trapezius muscle may be added to counteract the elevation that was found. Modification and addition of stretches may better meet the needs of competitive swimmers and prevent them from developing a pattern of scapular kinematics that has been linked to shoulder injury.

Finally, the timing and length of the program may be important when introducing an intervention. Fatigue, muscle soreness, and overtraining are all very common in swimmers during preseason training. Any positive effects of the intervention program may have been overshadowed by the physiological changes that occur due to the intense swim training. The intervention program may be able to produce more robust effects if implemented during spring training, when the focus is more on technique than on yardage. The intervention program in the current study was performed for only 6 weeks, while swimmers train over 40 wk/yr. Continuing the intervention program throughout the season may result in greater improvements in strength, as well as long-term effects of establishing normal strength ratios, scapular kinematics, and movement patterns to prevent injury.

There were limitations in the current study. Swimmers have been taught that shoulder pain is normal in the sport, and shoulder pain is often unreported until it is debilitating. It is possible that subjects who were experiencing shoulder pain throughout the intervention period or at posttest were included in the study due to lack of reporting. Previous studies have found that individuals with shoulder pain will exhibit shoulder-strength weakness and altered scapular kinematics, so inclusion of the patients with unreported pain may have influenced the results. Another limitation of this study was that individual effort could not be assessed. Although the exercise program was explained to participants and a biweekly evaluation of tubing resistance was performed, some participants may have chosen resistive tubing that was too easy. Finally, data collection occurred after a 3-week break from swimming, and implementation of the strengthening and stretching program occurred during preseason training, which is the time when swimmers are building their cardiovascular endurance by swimming a significant number of yards at a high intensity, which may have affected the results. Overtraining and the intensity of the swim conditioning may have masked the effects of the intervention program. Strength and scapular kinematics may have been affected by muscle fatigue and muscle adaptations from the high-intensity swim training. However, the study was conducted during preseason training to ensure control of subjects, as yardage differences, tapering, breaks from swimming, different programs based on goals, and individual strengthening programs begin later in the season.

Swimming places a tremendous amount of stress on the shoulders of the athletes. The physical characteristics and sport-specific demands of swimmers are different
from those of any other sport; therefore, a sport-specific dry-land program is needed. Implementation of an evidence-based exercise program tailored for swimmers may decrease the stress on the shoulder and may prevent shoulder pain. In addition, a long-term prospective study assessing the effectiveness of an intervention program in reducing the risk of shoulder injury is needed to truly determine how effective a strengthening and stretching program will be. Finally, research examining shoulder injuries and prevention programs in swimmers of all ages is necessary. Implementing an intervention program in youth swimmers may have a greater impact on the developing muscles and decrease shoulder pain and injuries. In addition, implementing a program in younger individuals may promote physical characteristics that prevent shoulder injuries from developing later in their careers.

Conclusions

The results of the current study did not show significant changes in glenohumeral or scapular-stabilizer strength or scapular kinematics between groups. In addition, we found that all subjects moved into increased scapular internal rotation, protraction, and elevation due to the demands of increased swim conditioning. The results of this study provide some evidence of modifications that may promote physical characteristics that prevent shoulder injuries from developing later in their careers.

References


