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In-Season Functional Shoulder Training for High School Baseball Pitchers

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summary

The overhead throwing motion is used in numerous sports including track, football, and baseball. Among these sports, the baseball pitch is unique in the demands placed upon the shoulder. The forces created in the shoulder can potentially lead to pathology affecting the athlete's career. To enhance performance and decrease the risk of injury, it is important that the athlete participate in a year-round periodized program. Inappropriate or deficient training combined with the stress that the shoulder experiences during a season can lead to strains, impingement, tendon or labral tears, and instabilities.

The strength and conditioning professional working with the high school athlete faces distinct challenges in developing a periodized program. Many pitchers compete in other sports during the winter season. Fall and winter sports commitments combined with family and school responsibilities leave the high school athlete little time to perform the conditioning preparation vital to a successful and injury-free baseball season. This article will focus on the unique role of the shoulder complex during the pitching motion and will provide a concise and targeted in-season shoulder-training program.

Functional Shoulder Girdle Anatomy

The strength and conditioning professional should possess a thorough understanding of the shoulder's functional anatomy and the biomechanics of the pitching motion before developing a program for this athletic population. Study should include the joints and musculature of the shoulder girdle and the cervical/thoracic spine. Table 1 reviews the muscles of the shoulder girdle and their function related to the overhand pitching motion.

Pitching Biomechanics

Many studies have identified the kinematics and kinetics of the pitching motion (8, 11, 12, 13, 15, 21, 24, 25). An understanding of the range of motion requirements, muscle contraction patterns, and force demands placed upon the shoulder will enable the strength and conditioning professional (or rehabilitation professional in the case of postinjury or postsurgical cases) to prepare an effective and safe training program.

Sports medicine researchers have identified the following phases of the pitcher's throwing motion (7, 8, 14, 16, 24, 28): wind-up, early cocking, late cocking, acceleration, deceleration, and follow-through. Each phase in this biomechanical model has unique characteristics. The application of this model highlights range of motion requirements, muscle firing patterns, and force/load considerations.

Range of Motion

Researchers have identified range of motion patterns specific to the pitcher (5, 8, 24). Maximum external rotation ranges from 170 to 180 degrees (8, 24). During wind-up and early cocking, the shoulder moves toward a posi-

Table 1
Shoulder Musculature and Pitching Function

Muscle	Pitching function
Serratus anterior	Scapula protraction
Trapezius	Scapula elevation
Rhomboids (major and minor)	Scapula retraction
Deltoid	Shoulder abduction
Supraspinatus	Shoulder abduction, eccentric deceleration
Infraspinatus	Shoulder external rotation, eccentric deceleration
Teres minor	Shoulder external rotation, eccentric deceleration
Subscapularis	Shoulder internal rotation
Triceps	Shoulder extension, elbow extension
Latissimus dorsi	Shoulder internal rotation, shoulder extension
Pectoralis major	Shoulder internal rotation, horizontal adduction

tion of 90 degrees of abduction and 15 degrees of horizontal abduction. These two phases place the shoulder in maximal external rotation. During the late cocking phase, the shoulder achieves its terminal range of motion. This is a result of combined scapulohumeral joint interactions and acquired glenohumeral joint laxity (19). During the acceleration phase, the shoulder rotates internally to a position of 90 degrees of external rotation to allow the release of the ball. In deceleration and follow-through, the shoulder continues to internally rotate and moves from an abducted to adducted position (8, 24).

This extreme range of motion is required for success in pitching. However, when combined with intra-articular forces at the shoulder, lack of conditioning, and poor mechanics, it can lead to pathology (19). Injuries can be devastating, resulting in loss of sport participation time, surgery, and rehabilitation (8, 24).

Muscle Firing Patterns and Shoulder Forces

Specific muscle firing patterns occur during each phase. Awareness of the myokinetics will help with exercise design and execution, especially functional training in relation to the rotator cuff.

During the wind-up, the shoulder musculature demonstrates minimal EMG activity (15, 24). In early cocking, the deltoid contracts concentrically to position the shoulder. Concentric rotator cuff activity increases through the cocking phases, especially in the supraspinatus and external rotators. During the late cocking phase, scapular stabilizers contract to provide a stable base for the humerus. The subscapularis begins to fire as the body rotates forward. At the end of the late cocking phase, muscle contraction involves the pectoralis major, latissimus dorsi, and the serratus anterior. Rotation about the torso creates shear forces anteriorly in the shoulder at 400 N, and rotator cuff muscle firing creates 650 N of compressive forces (8, 24).

As the pitching motion proceeds, a transition occurs from a state of potential energy (the cocking phases) toward a kinetic state (ball release). During the acceleration phase, the triceps contract early, and the pectoralis major, latissimus dorsi, and serratus anterior contract late. It is during the deceleration phase that the shoulder experiences the most violent muscle contractions and forces. The rotator cuff muscles fire eccentrically to slow arm rotation (15, 24). Forces created about the shoulder include 400 N of posterior shear forces, 300 N of inferior shear forces, and more than 1,000 N of compressive force (24). In the follow-through phase, muscle contractions return to resting levels.

Musculoskeletal Adaptations

Because of poor habits in posture and training, many high school athletes present to the strength and conditioning professional with poor shoulder flexibility, disproportionate anterior strength, dysfunctional rotator cuff strength, and impaired scapular stability/coordination. These limitations are often interrelated. For example, excessive anterior strength can alter shoulder position, placing the rotator cuff at a mechanical disadvantage. Correcting one deficit without addressing another can delay recovery and cause injury (33). Progression through a periodized program should focus on the disciplined yet gradual correction of these deficits to achieve a dynamically stable shoulder.

Researchers have demonstrated that passive internal rotation on a pitcher's dominant side is significantly less than

their nondominant arm (9). Poor flexibility of the muscles and joint structures will alter shoulder biomechanics (19). Repetitive overhead throwing motions can chronically stress the shoulder, predisposing it to injury (17, 19). One should address the larger muscles involved with internal rotation, such as the pectoralis major and latissimus dorsi, because restrictions of these muscles are common in untrained individuals and novice athletes (18). Another shoulder structure to address is the posterior capsule. A restricted posterior capsule increases humeral head anterior translation and limits the shoulder internal rotation required during deceleration and follow-through (2, 31, 32).

Excessive anterior strength can be a result of popular training habits by unsupervised athletes. Many athletes use the bench press and other pectoralis major strengthening exercises as the cornerstone of their routine, developing powerful internal rotators and protracting the scapula. If exercises for the back are performed, the athlete often focuses on the latissimus dorsi. Although it is located posteriorly, training the latissimus dorsi ultimately adds to the internal rotation strength of the shoulder. The rotator cuff muscles and scapular retractors, such as the rhomboids and trapezius, deserve more attention than is often provided by upper-body training programs (17, 26). Baseball pitchers often demonstrate weakness in their dominant arm's supraspinatus and external rotators when compared with the nondominant side (9, 22).

The extreme mobility of the glenohumeral joint during the pitching motion requires a stable base on which to anchor (17, 26). As capacity develops, scapular coordination should be addressed. The trapezius, serratus anterior, and rhomboid muscles provide scapular stability (9, 17). Proper training of the scapula must encompass all scapular functions. When many athletes train their trapezius, the exercises chosen are dominated by the upper fibers. The ability to activate the lower and middle fibers appropriately provides effective eccentric control of the lower angle of the scapula, maintaining proper scapular-humeral rhythm (17). This places the rotator cuff in the most functional position during the throw and prevents shoulder impingement (6, 17).

Conditioning Considerations and Preparation While Out of Season

Flexibility exercises should be performed to address any observed limitations. Common areas of tightness include the posterior shoulder and the pectorals. The strength and endurance phases are the ideal time to incorporate scapular exercises. EMG analysis has demonstrated that rowing, scaptions, push-up with a plus, and press ups were the best exercises (26). Another recent study identified preferred exercises for each muscle. The shoulder shrug is the best exercise for the upper trapezius, shoulder horizontal extension with combined external rotation for the middle trapezius, overhead arm raise in line with the lower trapezius for both the middle and lower trapezius, and scaptions more than 120 degrees for the serratus anterior (10).

Incorrect performance of these exercises limits their effectiveness in improving scapular strength and stability. As an athlete performs trapezius exercises, such as the seated row, he should focus on scapular retraction with depression. In addition, performing horizontal abduction in external rotation will help with coordination (30). Holding external rotation locks out the rhomboids and upper fibers of the trapezius in a mechanical disadvantage, requiring more activity from the middle and lower fibers of the trapezius (16, 26, 30).

In-Season Training Program

Maintaining power, strength, and endurance while avoiding overtraining should be the focus of an in-season strength-training program. The in-sea-

Table 2
In-Season Program for Baseball Pitchers

Example days					
Tuesday	Seated row (3 × 10 @ 75% 1RM)	Unilateral cable shoulder extension (2 × 25 @ 90% 25RM)	Integrated external shoulder rotation (2 × 25 @ 90% 25RM)	Upper body plyometrics	
Friday	Lunges (2 × 6–8 @ 75% 1RM)	Squats (2x 6–8 @ 75% 1RM)	Quadruped alternate arm-leg raise × 20	Diagonal torso rotation 2 × 12	Bridging × 20
Saturday	Lat pull-down (3 × 10 @ 75% 1RM)	One-arm dumbbell snatch (3 × 5 @ 70% 1RM)	Medicine ball chest throws (3 × 5 @ 70% 1RM)	Integrated external shoulder rotation (2 × 25 @ 90% 25RM)	Integrated internal shoulder rotation (2 × 25 @ 90% 25RM)

RM = repetition maximum.

son phase is marked by higher intensity training at a lower volume for performing specific exercises (3, 29). Maintenance of specific physiological gains from previous conditioning cycles is also necessary in this phase.

The program described for this article assumes the pitcher is throwing up to 10 innings in 2 games each week and involves strength and conditioning training 3 days a week (Table 2). Strength and conditioning training is performed during rest days. Each session is designed to last no longer than 30 minutes. Exercise selection is based upon biomechanical and neuromuscular considerations previously addressed in this article. The emphasis of this article has been upon the shoulder, but functional training for the entire kinetic chain must not be ignored (17).

Speed and power are developed in a kinetic sequence with the transfer of energy from the lower kinetic chain and core up through the pitcher's upper extremity (17). Our in-season lower extremity and trunk exercises consist of both plyometric and isotonic exercises. The plyometric exercises will be discussed in the following paragraphs. The lower-extremity training program consists of lunges and squats. These two exercises are ideal for maintaining strength and power. The lunge is also sport specific to the pitcher's stride. The pitcher should perform 2 sets of 6–8 repetitions at 75% of a 1 repetition maximum (1RM). For the trunk, our pitchers perform 3 exercises, which include the alternate arm and leg raise, bridging, and diagonal torso rotation. The alternate arm and leg raise (aka, "birddog") is performed in the quadruped position. While performing an abdominal bracing maneuver, an alternating arm and leg raise are performed and sustained for 10 seconds. Bridging is performed in the hook lying position (supine with feet flat on the surface and hips and knees slightly flexed). After performing an abdominal bracing maneuver, the hips extend, lifting the buttocks off the surface, but no higher than a neutral spine position. These 2 exercises are performed for 1 set of 20 repetitions. The diagonal torso rotation exercise uses exercise tubing or cables. A weight is chosen in which 12 repetitions can be performed without failure. Both hands clasp a pulley positioned by a hip. A diagonal pattern is performed moving the pulley from a low starting point (hip) to a higher finishing position (opposite shoulder). This exercise is performed bilaterally for 2 sets of 12 repetitions.

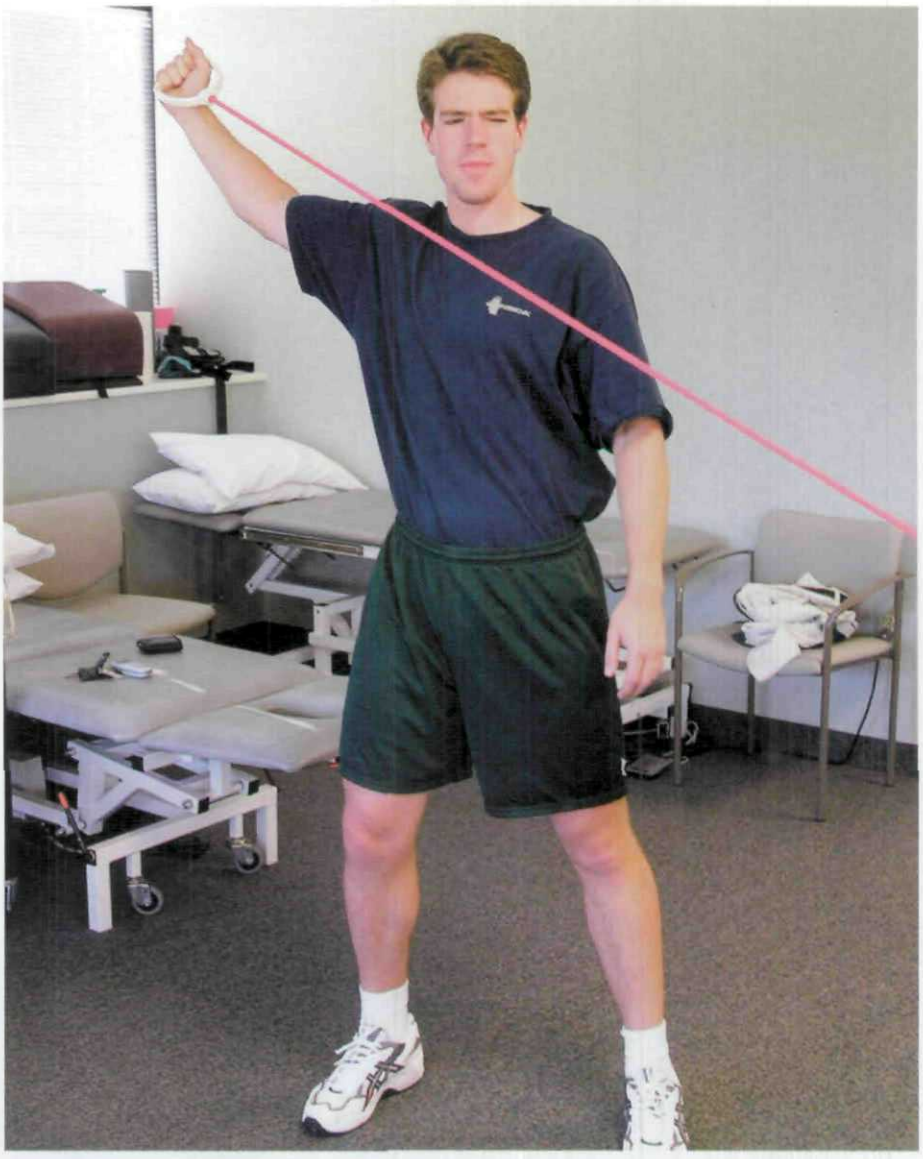

Figure 1. Integrated shoulder external rotation.

Our shoulder program incorporates exercises identified in the sports medicine literature as beneficial for the rotator cuff and scapula (4, 10, 30). We adapt some of these exercises to functionally reproduce sport-specific positions. An example of this is the integrated shoulder external rotation. This exercise is performed in 2 phases. Using elastic tubing, the athlete spins and rotates the body in multiplanar motion with external rotation maximized in the 90-90 position to end phase 1 (Figure 1). In phase 2, the

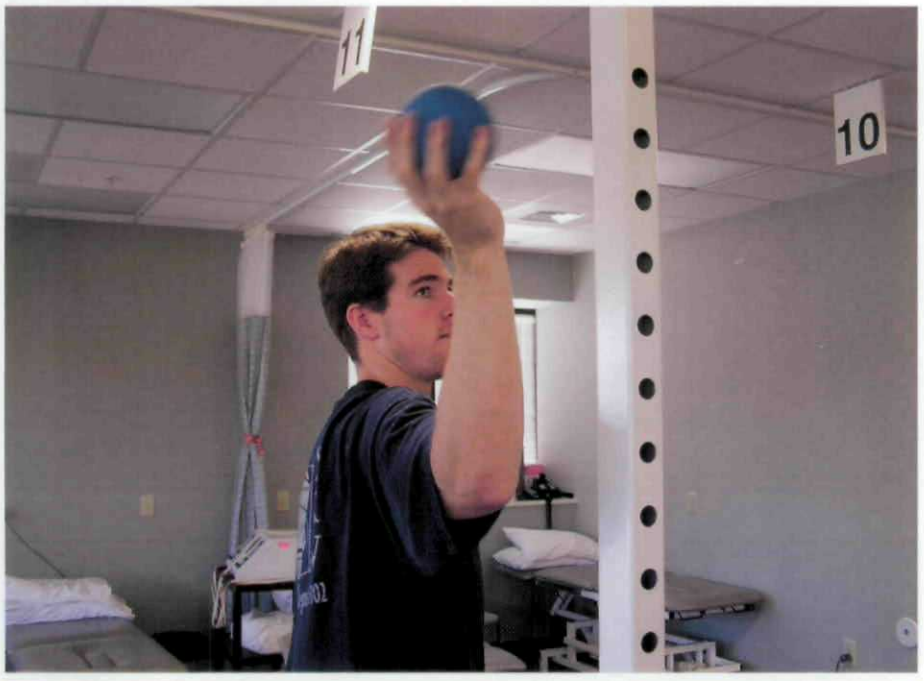

Figure 2. Rapid-fire wall bouncing exercise.

body recoils. The entire kinetic chain decelerates the movement during the recoil (1, 23). The entire movement is reversed for the integrated shoulder internal rotation. Cable units can be an adequate replacement for tubing. The unit should have a 2:1 or, preferably, a 4:1 user-to-machine ratio (mechanical advantage). This allows for smooth movement at higher speed and reduces the kinetic energy that the body is subject to with other ratios. The shoulder rotation and unilateral extension exercises are performed with high repetitions (25–30 repetitions) to maintain endurance. These exercises maintain scapular strength and stability.

Medicine ball throws and one-arm dumbbell snatches were selected as exercises to facilitate explosiveness. At 70% of 1RM, a snatch can be performed with significant power (29). These exercises are designed to improve power output while in sport-specific training postures. The medicine ball throw was chosen over the frequently used bench press. In the throw, the athlete works against inertia rather than gravity. With the release of the ball, there is no need to decelerate a significant load halfway through the explosion.

The seated row and the lat pull-down exercise are performed for 3 sets of 10 repetitions at 75% of 1RM. These exercises were chosen for maintenance of strength, especially for muscles of the scapula.

Exercises for general strengthening or strength maintenance use 6–10 repetitions at 75% of 1RM. Endurance exercises use 25 repetitions per set. Common guidelines used for rest periods are 2–5 minutes between sets for strength and power, whereas endurance activities require a 1:1 ratio (11, 20).

Plyometric exercises are to be performed once a week. Three of the 4 plyometric exercises emphasize the shoulder complex. The fourth integrates the lower extremity and the trunk with upper extremity involvement. During the season, the pitcher should perform 3–5 sets of 5–8 repetitions with each exercise. A work to rest ratio 1:10 with 2- to 3-minute rest periods between exercises should be followed. Each repetition set should be

Figure 3. Backwards catch and throw exercise.

performed rapidly to maximize the stretch-shortening cycle (27). The athlete should be monitored constantly for signs of overtraining or improper exercise technique.

The coronal plane drop-and-catch exercise has the athlete standing in a starting position of shoulder abduction to 90 degrees, shoulder positioned in neutral, and slight flexion at the elbow. The athlete starts by dropping a small, weighted ball and immediately catching it. This sequence is repeated multiple times as the athlete slowly moves the shoulder and arm through horizontal adduction.

The rapid-fire wall bouncing exercise requires the athlete to stand within 2 ft of a wall. The shoulder is abducted and externally rotated to 90 degrees, and the elbow is flexed to 90 degrees. The athlete throws and catches a medicine ball from this position in rapid fashion (Figure 2).

The backwards catch-and-throw exercise positions the athlete on a single knee with the dominant shoulder both abducted and externally rotated to 90 degrees and the elbow flexed to 90 degrees. The strength coach, standing behind the athlete, tosses a weighted ball anterior and medial to the athlete's hand. The catching of the ball requires the athlete to decelerate the momentum of the ball and then explosively reverse directions, throwing the ball back to the coach (Figure 3).

The diagonal throw with twist exercise is performed using a medicine ball and a rebounder. The athlete is positioned at a 90-degree angle, with his nondominant shoulder facing the rebounder. Grasping the ball with both hands, the athlete rotates at his trunk, delivering the ball in a chopping motion.

Conclusion

The high school pitcher should be provided with a safe and effective training program that they can sustain throughout their career. Implementing the exercises and strategies presented in this article should enhance on-field performance and may prevent injuries. ♦

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