Functional Plyometric Exercises for the Throwing Athlete

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Abstract: *In this article we provide athletic health care professionals with a variety of functional strengthening exercises to use in improving the muscular strength of the throwing athlete's shoulder. Upper extremity functional plyometric exercise in sport-specific patterns can be an important component of a throwing athlete's rehabilitation. We discuss several plyometric exercises, using the Inertial Exercise System, the Plyo-ball, and the Theraband. Proper use of these exercises can facilitate a safe and progressive rehabilitation program for the injured, throwing athlete. After the athlete has successfully completed the functional plyometric exercises, a throwing progression can be initiated.*

Recent literature adequately describes the performance of plyometric and eccentric exercises during functional rehabilitation.[1,6,16,19] Terms such as negative work, shock absorption, and deceleration are synonymous with eccentric loading. Plyometric exercise is defined as powerful muscular contractions after rapid stretching or dynamic loading of the same muscle group.[15] When using eccentric exercises to train an athlete for return to intense competition, it is important to consider the SAID principle (specific adaptation to imposed demands) and the concept of specificity.[1,6,16,19] The importance of specificity of training is evident when examining the cocking, acceleration, and deceleration phases of throwing. These phases exhibit powerful eccentric contractions of the internal and external rotators, respectively.[14,19] The purpose of this article is to provide athletic trainers and other health care professionals with a variety of functional strengthening exercises that improve the dynamic muscular strength of the throwing athlete's shoulder.

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Theoretical Basis

The cocking phase of throwing serves to increase the distance through which force may be applied to the ball.[9,14] At the end of the cocking phase, the glenohumeral joint is in a position of maximum external rotation, the scapula is retracted, the elbow flexed, and the trunk is extended. The subscapularis, pectoralis major, and latissimus dorsi all contract eccentrically to decelerate external rotation and protect the anterior and inferior structures of the glenohumeral joint.[12,14]

The acceleration phase of throwing begins with the shoulder in a position of maximum external rotation.[9,14] This phase of throwing is very explosive. At the beginning of the acceleration phase, the speed of shoulder internal rotation is 0°/s, and, at its termination, speed reaches a maximum of 7,000 to 9,000°/s. This phase of throwing is also very short, typically lasting for less than 1 second. It ends with ball release.[9]

After the ball has been delivered, the deceleration phase should allow for quick but comfortable reduction in speed of the throwing arm. During the deceleration phase, the shoulder rapidly internally rotates and horizontally adducts. The eccentric action of the posterior deltoid, supraspinatus, infraspinatus, and teres minor are most helpful in decelerating the forward momentum of the arm and protecting the posterior structures of the shoulder complex. In addition, eccentric contractions of the middle trapezius, rhomboids, pectoralis major, and latissimus dorsi also actively help to slow the throwing arm.[12,14] The activity in the scapulothoracic muscles helps decelerate the scapula, but also helps provide a stable base for the rotator cuff to act upon.

When a throwing athlete injures his/her shoulder, the initial treatment of choice is rest.[6,13] Rest allows for healing of the involved soft tissues and resolution of the inflammatory process.[6] Rehabilitation during the acute stage also includes modalities to reduce pain and an exercise program to maintain the cardiovascular status and lower extremity strength of the athlete. When the shoulder pain decreases and the injury enters the subacute stage, flexibility and pain-free range-of-motion exercise programs are initiated. The flexibility and range-of-motion exercise programs are individually designed with careful consideration for the injured structures and limitations of motion.[6]

After the athlete achieves normal pain-free motion of the shoulder, you can initiate a strengthening exercise program.[2,6,13] The goal of the strengthening program is to restore normal strength and improved muscular endurance of the rotator cuff, scapulothoracic, bicep, tricep, and pectoralis muscles. The athlete should perform most of the strengthening exercises with no weight or light dumbbells (1 to 3 lb) to isolate individual muscles.[6] Carson and Pappas[6,13] provide many exercises to improve flexibility, range of motion, and isolated muscle strength of the shoulder of the throwing athlete.

Plyometrics

We believe that health care professionals should incorporate a variety of plyometric functional exercises of the anterior and posterior musculature in a sport-specific pattern after traditional shoulder-strengthening exercises and before initiating a full throwing progression. Plyometrics are most frequently used in lower extremity strength and power exercise programs, and are defined as quick powerful movements that involve a prestretch of a muscle just before its contraction. The prestretch is the most important phase of the plyometric activity because it increases the excitability of the neurological receptors, which enhances the reactivity of the neuromuscular system.[19]

Plyometrics are also referred to as stretch-shorten exercises.[3,4,7,19] The stretch stimulates body proprioceptors such as the muscle spindle and the golgi tendon organs (GTO). The muscle spindle is a stretch receptor located within the muscle belly.[5,19] A quick stretch stimulus to the muscle spindle reflexly produces a contraction of extrafusal muscles fibers in the agonist and synergist muscles. This reflex is very rapid, occurring in .3 to .5 milliseconds.[4] The GTO are also sensitive to tension, but are located at the musculotendonious junction at both the origin and insertion of the muscle. Stimulation of the GTO produces inhibition of the agonist extrafusal muscle fibers; therefore, the GTO protect against overcontraction or overstretch of the muscle.[11] During proper performance of plyometric exercises, the excitatory effect of the muscle spindle reflex pathway overrides the inhibition provided by the GTO.[11,19]

Another principle to consider when examining physiology of plyometric exercises is the recoil of elastic tissues.[7] During the stretch phase of a muscle, the load is transferred to the elastic components and is stored as elastic energy. The elastic energy stored during the eccentric muscle contraction can enhance the following concentric contraction. The elastic elements deliver this stored energy during the concentric contraction to increase power output. Time, magnitude of stretch, and velocity of stretch affect this storage of elastic energy. To use the stored energy and to achieve maximum results with plyometric exercises, the concentric contraction must immediately follow the application of the load, and the preceding eccentric contraction (stretch) should be of short range and rapid.[3,7]

Adaptation to Stress

The healthy tendon is a metabolically active structure that demonstrates an increase in tensile strength when subjected to progressive controlled stress. This increase in tensile strength has also been observed in injured tendons.[16] To maximize the tensile strength of the tendon, use the eccentric phase of muscle contraction in the strengthening phase of rehabilitation programs, because of its ability to create greater amounts of tensile stress along the tendon.[6,10,16,17] Also, after injury collagen production within the damaged tendon increases, the collagen begins to form into fibrils which line up in a random pattern. The tensile stress created by muscle contraction along the injured tendon is important in realignment of these collagen fibrils.[8] This is the rationale for using functional plyometric exercises before an athlete returns to throwing.[17]

Inertial Exercise System™

The following exercises functionally strengthen the muscles used during the throwing motion. These exercises improve both concentric and eccentric activity of the muscles in a pattern specific to the throwing motion. The Inertial Exercise System or Impulse System (Engineering Marketing Associates, Newnan, GA), increases eccentric torque,[1] and is an excellent way to begin eccentric muscle training. The unit allows the resistance to move horizontally on rollers along a fixed platform. The Inertial Exercise System allows the performance of many exercises, but we review several exercises specific to the throwing motion that are important for the throwing athlete.

Inertial Exercise I: Internal Rotation With the Inertial Exercise System

The athlete begins this exercise in a position of maximum active shoulder external rotation at 0° of shoulder abduction and progresses to a position of 90° of abduction as tolerated (Fig 1). Many throwing athletes may have an increased amount of external rotation when compared to nonthrowing athletes, but we have found that they have little difficulty performing this exercise. The grip attachment can consist of a Velcro loop, or an implement such as a baseball. The athlete begins at maximum shoulder external rotation and internally rotates the shoulder concentrically, causing the resistance to move along the horizontal platform. When the weight carriage passes the center of the platform, the internal rotators are loaded eccentrically as they decelerate the motion of the weight carriage along the horizontal platform (Fig 2). The internal rotators continue to contract eccentrically as the shoulder externally rotates back to the starting position of maximum external rotation where the sequence is initiated again.

Inertial Exercise II: External Rotation With the Inertial Exercise System

The external rotation exercise is similar to the internal rotation exercise, except that the direction of motion is reversed. Have the athlete turn around so that he/she faces the bar, which changes the pull of the resistance from a posterior direction to an anterior direction. The athlete begins in a position of maximum internal rotation and then externally rotates the shoulder (Fig 3). The muscle actions for the external rotators are the same as for the internal rotators during the internal rotation exercise using the Inertial Exercise System.

Fig 1.—Internal rotation with the Inertial Exercise System (start position).

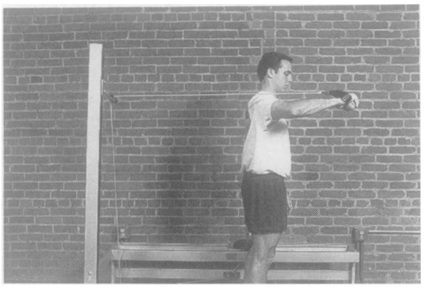

Fig 2.—Internal rotation with the Inertial Exercise System (finish position).

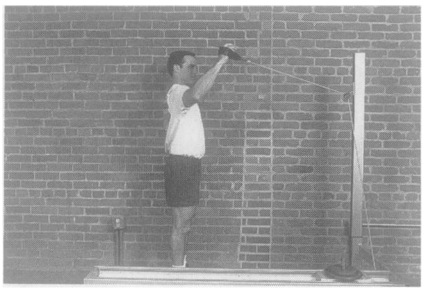

Fig 3.—External rotation with the Inertial Exercise System (start position).

Inertial Exercise III: Shoulder Extension With the Inertial Exercise System

The athlete begins with the shoulder at about 45° of shoulder flexion (Fig 4). He/she then actively moves the arm into a position of full shoulder extension and scapular retraction through concentric contractions of the triceps, posterior shoulder, and scapulothoracic muscles. The movement of the weight carriage on the horizontal platform requires eccentric contraction of the posterior shoulder and scapulothoracic muscles to return to the starting position.

Plyo-Ball™ and Plyoback™ Exercises

The Plyo-Ball and Plyoback, a weighted exercise ball system, (Functionally Integrated Technologies, Watsonville, CA) is an excellent tool to incorporate into the functional shoulder program for the throwing athlete. A trainer supervises and instructs the athlete, who then gradually works alone with the aid of the Plyoback device. The weight of the balls usually ranges from 2 to 12 lb. When the circumference of the heavier balls is too large and more weight is indicated, secure a Velcro cuff weight around the wrist. Start these exercises with the elbow positioned in 90° of flexion and the shoulder in 0° of shoulder abduction. As the athlete progresses and needs to be more challenged, progress these exercises toward 90° of shoulder abduction. The following exercises strengthen and functionally train the shoulder of the throwing athlete.

Plyo-Ball Exercise I: Internal Rotation With the Plyo-Ball

Use a 2-lb Plyo-Ball with the shoulder in 10° of abduction and full external rotation and progress to a position of 90° of shoulder abduction and full external rotation (Fig 5). Throw the Plyo-Ball against the Plyoback device. Catch the ball as it returns off the Plyoback, and allow an eccentric contraction of the internal rotators to slowly decelerate the ball to the starting position (Fig 5). Use a quick concentric contraction of the internal rotators to repeat the sequence.

Plyo-Ball Exercise II: External Rotation With the Plyo-Ball

Execute this exercise in the same manner as the internal rotation exercise with the Plyo-Ball, except that the external rotators of the shoulder are now the muscle group that is eccentrically loaded. The athlete performs this exercise with a trainer's assistance or alone using the Plyoback with practice. The athlete stands facing away from the Plyoback, holding a 2-lb Plyo-Ball. The shoulder is initially placed in 0° of abduction and maximal internal rotation. The elbow is flexed to 90°. As the athlete becomes more skilled with the exercise and has no complaints of pain, he/she can progress to a position of 90° of shoulder abduction and maximum internal rotation. The athlete throws the ball backwards by rapidly externally rotating the shoulder (Fig 6). As the Plyo-Ball bounces off the Plyoback, the athlete catches the ball and eccentrically uses the external rotators of the shoulder to decelerate the ball back to the starting position (Fig 7), where the exercise is repeated.

Plyo-Ball Exercise III: Reverse Throw

The assistance of an athletic trainer is required for this exercise. Position yourself behind the half-kneeling athlete and toss him/her a Plyo-Ball (Fig 8). He/she catches it in a position of 90° of shoulder abduction with maximum external rotation, 90° of elbow flexion and scapular retraction (Fig 9). The athlete slowly decelerates the ball with an eccentric contraction of the posterior shoulder musculature into a position of shoulder adduction, shoulder internal rotation, and elbow extension (Fig 10). This exercise can reproduce the muscle action and motion of the upper extremity during the deceleration phase of throwing, but at a slower speed. The athlete then follows the same path in reverse to quickly return the ball to the trainer. As the athlete improves, accelerate the activity to reach speeds close to actual velocities observed with throwing.

Fig 4.—Shoulder extension with the Inertial Exercise System (start position).

Fig 5.—Internal rotation with the Plyo-Ball (eccentric deceleration phase).

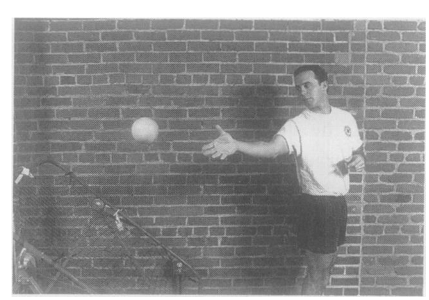

Fig 6.—External rotation with the Plyo-Ball (release phase).

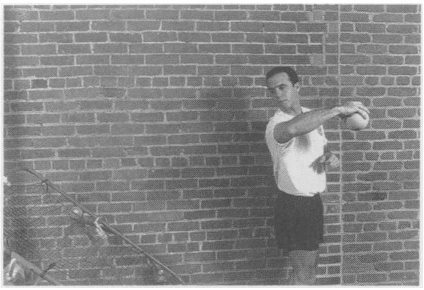

Fig 7.—External rotation with the Plyo-Ball (eccentric deceleration phase).

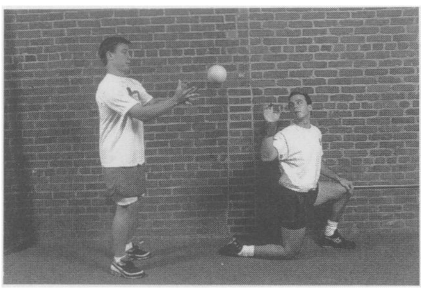

Fig 8.—Reverse throw (start position).

Fig 9.—Reverse throw (catch phase).

Theraband™ Exercises

Theraband (Hygienic Corporation, Akron, OH), a resistive exercise system, provides an inexpensive and easy way to train the muscles of the shoulder concentrically and eccentrically. Theraband is a useful strengthening tool in the clinic as well as an effective component of a home exercise program. The trainer can design Theraband exercise programs to provide resistance to any phase of the throwing motion desired. Theraband exercises are by no means limited to the examples provided in this article.

Theraband Exercise I: Theraband Internal Rotation

The internal rotators of the shoulder can be strengthened in a variety of levels of shoulder abduction. Initially, the athlete will start in 0° of abduction and progress to 90° of abduction, based on reported symptoms and quality of motion (Fig 11). In the starting position, the Theraband should be tight, and positioned to resist the internal rotators of the shoulder. The athlete concentrically contracts the internal rotators of the shoulder until maximum internal rotation is achieved (Fig 12). Eccentric contraction of the internal rotators allows the athlete to return to the starting position.

Theraband Exercise II: Theraband External Rotation

The external rotators of the shoulder can also be strengthened in a variety of levels of shoulder abduction. As with the Theraband internal rotation exercise, this exercise starts in 0° of abduction and slowly progresses to 90° of abduction, based on tolerance and quality of motion. The athlete should start this exercise with the Theraband taut, and positioned to resist the external rotators of the shoulder. Concentric contraction of the external rotators of the shoulder rotate the humerus to the finish position (Fig 13), and eccentric contraction of the external rotators allows the humerus to return to the starting position.

Theraband Exercise III: Theraband Diagonals

Also, diagonal patterns of strengthening with the Theraband can be used to mimic the acceleration and deceleration phases of throwing. The Theraband can provide resistance to the anterior shoulder muscles by attaching the Theraband to a stationary object behind the athlete as he/she throws (Fig 14). This will strengthen the muscles used in the acceleration phase of throwing. The Theraband can also provide resistance to the posterior shoulder muscles by attaching the Theraband to a stationary object in front of the athlete (Fig 15). This exercise will strengthen the muscles that decelerate the arm after release of the ball. To make this exercise more sport-specific, the Theraband can be tied to a ball.

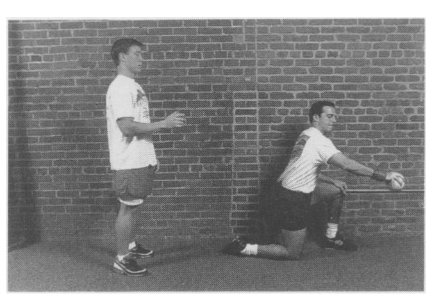

Fig 10.—Reverse throw (eccentric deceleration phase).

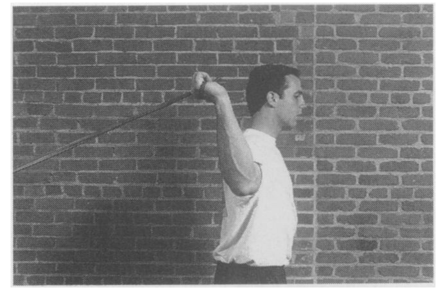

Fig 11.—Theraband internal rotation (start position).

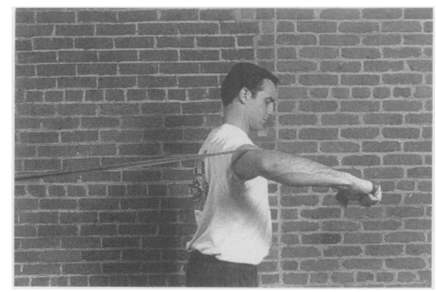

Fig 12.—Theraband internal rotation (finish position).

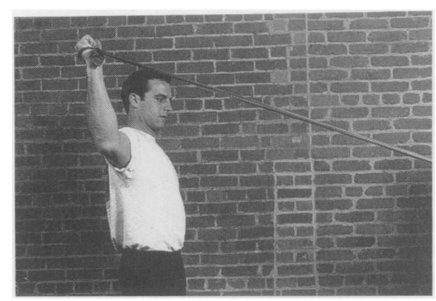

Fig 13.—Theraband external rotation (finish position).

Discussion

The exercises we have provided should help prepare throwing athletes for competition by training the stretch-shorten cycles used during the throwing motion. These exercises should be added one at a time to properly monitor subjective feedback and objective measures (ie, swelling, strength, range of motion). As a general guideline, an athlete can begin by doing three sets of 10 to 30 repetitions and progress to five or more sets of 50 or more repetitions. The athletic trainer

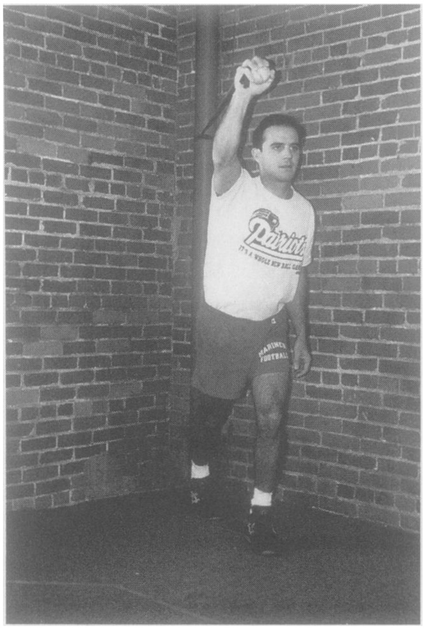

Fig 14.—Theraband diagonal exercise (acceleration).

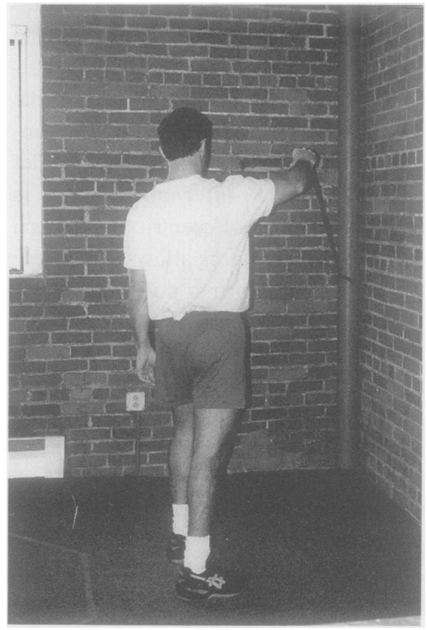

Fig 15.—Theraband diagonal exercise (deceleration).

needs to monitor the athlete closely to detect fatigue and patterns of substitution. After the athlete has successfully completed the functional plyometric exercises, a throwing progression can be initiated.

There are many different throwing progressions available, but the one we use is divided into six phases. The first phase is a warm-up phase which involves tosses at distances of 30 to 40 ft. The athlete will progress to the next phase by increasing his/her throwing distance by 30 ft to a maximum distance of 180 ft. The athlete cannot advance to the next phase of the throwing progression until he/she can complete five or more sets of 50 to 75 repetitions. Velocity of the throw is not considered important. When the athlete can throw the ball 180 ft for three to five sets of 50 to 60 repetitions without pain, the athlete can begin unrestricted throwing.[6] More recently, some authors suggest that unrestricted throwing can begin when the athlete can throw 180 ft for one set of 75 repetitions without pain.[18] Regardless of the progression used, stress proper mechanics during the throwing progression, and if the athlete experiences pain, discontinue the throwing progression until the pain resolves.[6,13,18]

It is important to remember that these exercises address open-chain rehabilitation only and that closed-chain exercises should also be performed. In addition, the entire kinetic chain, including the trunk, elbow, wrist, and lower extremities should be effectively strengthened. The functional phase of the athlete's program is the important link between well-planned rehabilitation and successful return to full competition. The SAID principle (specific adaptation to imposed demands) (SAID) dictates that the late stage of rehabilitation be specifically tailored to meet the individual's needs. The eccentric actions of the rotator cuff and accompanying musculature are critical to the function of the shoulder for the throwing athlete. Used properly, the Inertial Exercise System, Plyo-Ball, and Theraband exercises can successfully achieve sport-specific strength and function of the musculature around the shoulder.

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