Volume 26, Number 6, pages 62–66

Keywords: shoulder; rotator cuff; sport-specific; plyometric; interval training

"Ballistic Six" Plyometric Training for the Overhead Throwing Athlete

Ryan Pretz, MPT, CSCS
Southwest Baptist University, Bolivar, Missouri

summary

Peak performance and injury prevention for the overhead throwing athlete often depend on shoulder muscle activity, particularly the rotator cuff. Because of this, strengthening the muscles of the rotator cuff may be advantageous. This article offers recommendations for the implementation of a sport-specific upper extremity plyometric training program for overhead throwing athletes.

Statically, the glenohumeral joint is inherently unstable based solely on its bony configuration, composition, geometry, and somewhat lax ligamentous restraints (18). Glenohumeral joint geometry is composed of a large convex humeral head positioned in a relatively smaller concave glenoid fossa. This affords the shoulder tremendous mobility at the expense of stability. The ligamentous restraints surrounding the joint (i.e., joint capsule and the bands of the anterior glenohumeral ligament) normally provide for a moderate degree of static stability (Figure 1). However, static glenohumeral joint stabilization alone is inadequate for a pitcher. This is because a pitcher repeatedly takes his or her arm through an arc of motion at extreme speeds, placing enormous amounts of stress about its axis of rotation. Werner et al. (17) studied the relationships between throwing mechanics and shoulder distraction in professional baseball pitchers. They found that shoulder rotational velocities can reach as high as 10,000 degrees per second and that distraction forces greater than 947 N occurred across the shoulder joint during the late cocking and deceleration phases of the overhead throwing motion. Baseball pitchers must rely on the muscular components of their shoulder to resist distraction forces and provide dynamic stability (2, 5, 7, 10, 17, 18).

Dynamic stability is produced primarily by the rotator cuff. The rotator cuff (Figure 2) is a group of muscles consisting of the subscapularis, supraspinatus, infraspinatus, and teres minor (15). Besides providing dynamic stability, these muscles, along with the help of other extrinsic shoulder muscles, contract concentrically and eccentrically to produce internal and external rotational torques during pitching (6, 7, 17, 18).

When a pitcher throws a baseball, dynamic stability can be compromised, sometimes resulting in rotator cuff tears, labral tears, and muscle strains (3,

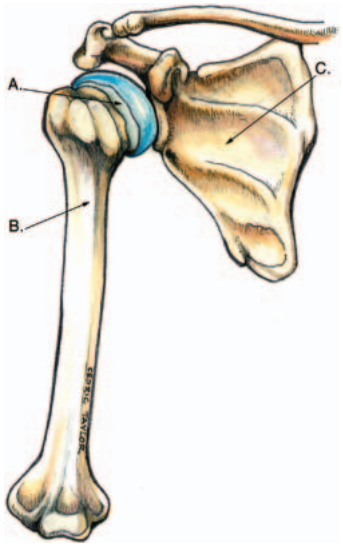

Figure 1. Picture of the osseous shoulder complex and the anterior bands of the glenohumeral ligament (anterior capsule). A = Anterior capsule, B = Humerus; C = Scapula

8, 9). A proper training program incorporating sound strength and conditioning principles like the "Ballistic Six" (Figure 3) is required to increase the dynamic stability of a pitcher's shoulder.

Plyometric training has been shown to be an effective way to increase the strength and performance of the shoulder (4, 6). The Ballistic Six program includes 6 upper extremity plyometric exercises performed with quick, powerful movements requiring a prestretch of the involved shoulder musculature, thereby activating the stretch-shortening cycle. The stretch-shortening cycle is what makes a plyometric exercise unique, and it consists of 3 phases: the eccentric phase, the amortization phase, and the concentric phase.

The eccentric phase is the first phase of a plyometric exercise. It is described as a rapid eccentric contraction that evokes a stretch reflex. The main mechanism of the stretch reflex is the muscle spindle. Muscle spindles are sensory mechanisms located within muscle fibers. They are sensitive to the rate and magnitude of a stretch. When a muscle fiber is quickly stretched eccentrically, the muscle spindle will be activated. The activation of a muscle spindle will result in a more powerful concentric contraction in the opposite direction (1).

The second phase of the stretch-shortening cycle is the amortization phase. This phase is the amount of time between undergoing the yielding eccentric contraction and the initiation of a concentric force. By definition, amortization is the electromechanical delay between the eccentric and concentric contractions, during which the muscle must switch from overcoming work to imparting the necessary amount of acceleration in the required direction. Successful training using the stretch-shortening cycle relies heavily on the rate of stretch rather than the length of the stretch (19). If the amortization phase is slow, elastic energy is wasted, and the stretch reflex is not activated. The more quickly the individual is able to switch from yielding work to overcoming work, the more powerful the response.

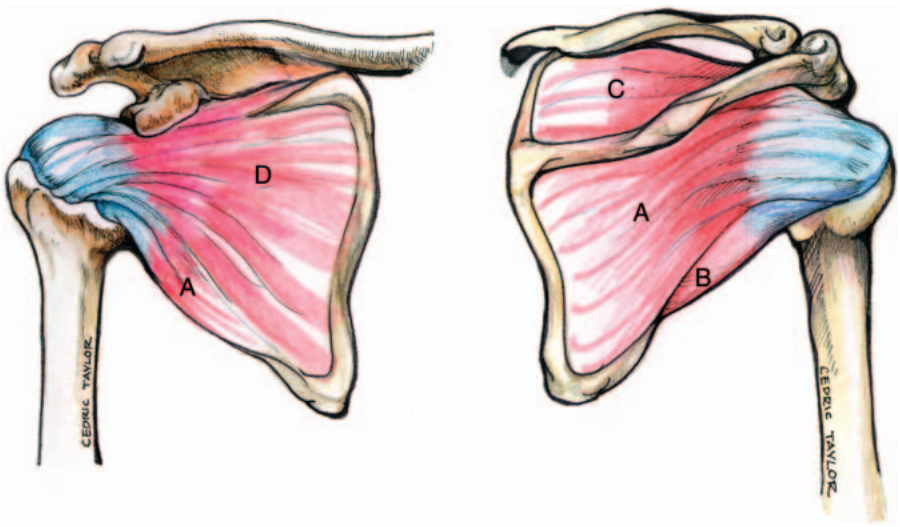

Figure 2. Picture of the rotator cuff: muscles of the shoulder that provide dynamic stability. A = infraspinatus; B = Teres Minor; C = Supraspinatus; D = Subscapularis

The final phase of the stretch-shortening cycle is the concentric phase. During this phase, the athlete concentrates on the effect of the exercise and prepares for initiation of the second repetition. This phase is the summation of the eccentric and amortization phases (1, 6, 19). It is often referred to as the resultant or payoff phase because of the enhanced concentric contraction.

Biomechanical and Physiological Considerations

The Ballistic Six program was created after analyzing biomechanical and physiological research on the pitching motion. The biomechanical analysis of the overhead pitch has been divided into 6 phases (Figure 4). Shoulder musculature is most active during the cocking, deceleration, and follow-through phases (6, 7). Inadequate strength of the rotator cuff during these 3 phases is viewed by many to be the causative factor of most overhead throwing injuries (3, 8, 9, 17). During these phases, the muscles of the rotator cuff act as a steering mechanism, contracting eccentrically to hold the humeral head centered in the glenoid fossa. The subscapularis is most active during the cocking phase to resist excessive external rotation, whereas the supraspinatus, infraspinatus, and teres minor are most active during the deceleration and follow-through phases to resist excessive horizontal adduction and internal rotation (7, 17).

Adenosine triphosphate (ATP) is required to provide the necessary energy to contract the shoulder rotators (14). Low concentrations of ATP are found in skeletal muscle. Because of this, the body relies on 3 chemical energy systems to regenerate ATP: phosphagen system, glycolysis, and oxidative energy system (14). To adequately understand the physiological responses to pitching, a distinction must be made between anaerobic and aerobic metabolism. Aerobic metabolism alludes to a series of chemical reactions that occur in the presence of oxygen. Aerobic activities rely on the oxidative energy system. They are those tasks that are low in intensity but are long in duration, such as marathon running (14). Anaerobic metabolism refers to a series of chemical reactions that occur without the presence

Figure 3. The Ballistic Six.

of oxygen. Anaerobic activities are referred to as short, high-intensity tasks (e.g., weight training and sprinting), and they rely on the phosphagen energy system and glycolysis (14).

Potteiger et al. (13) analyzed the physiological requirements of a pitcher while throwing a simulated 7-inning game of baseball. Pitchers in the study threw 7 innings for a total of 163 pitches, which included warm-up pitches, pitches thrown per inning, and pitches thrown between innings. Physiological analysis revealed that pitching uses the creatine-phosphate energy system and is primarily an anaerobic activity. According to Potteiger et al., maximizing the ability to generate power repeatedly is an extremely important consideration to a pitcher, and training programs should attempt to improve that component (12, 13).

Mullins (11) devised an upper-extremity conditioning program for pitchers. He stated that pitchers can throw approximately 200 pitches in a 9-inning game and, because of this, it is extremely important for them to perform high-repetition shoulder exercises to train the endurance (oxidative energy system) of a pitcher's shoulder. With the above in mind, a physiological sport-specific training program should devote time to train both the anaerobic and aerobic energy systems. To do this effectively, one must consider using interval training. This might be running 100 yd in 15 seconds followed by 45 seconds of rest. This allows an athlete to perform the exercise using the phosphagen (anaerobic) system and use the aerobic system during recovery. In terms of the Ballistic Six program, the baseball pitcher performs the exercises ballistically for 15–20 repetitions and then has a short, but appropriate recovery before performing the exercise again or completing the next exercise.

Strength-Training Principles

The Ballistic Six incorporates several strength and conditioning principles such as specificity, overload, and progression of training.

Specificity

According to the SAID principle (specific adaptation to imposed demands), an effective strength and conditioning program must be sport specific (16). In order for a program to be sport specific,

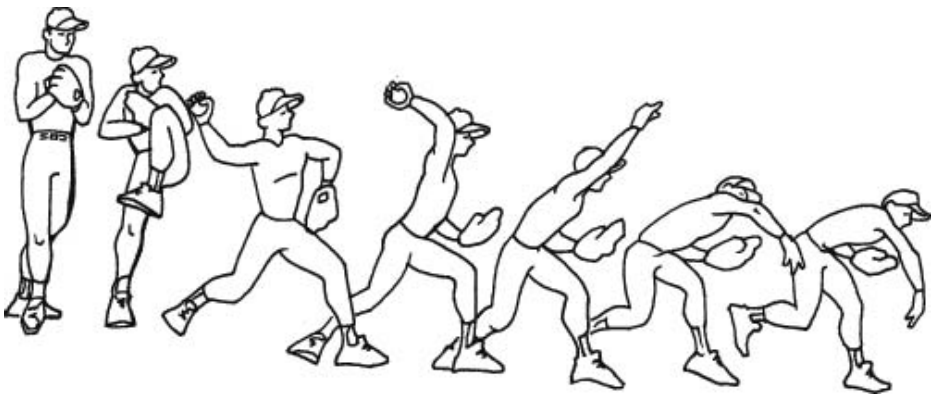

Figure 4 The 6 phases of throwing are wind-up, stride, cocking, acceleration, deceleration, and follow-through

Table 1
Progression of the Ballistic Six

Volume	Intensity
3 sets of 10 reps with 30 s between sets	2-lb ball (1-hand drills) and 6-lb ball (2-hand drills)
3 sets of 15 reps with 30-s rest between sets	2.5-lb ball (1-hand drills) and 8-lb ball (2-hand drills)
3 sets of 20 reps with 30-s rest between sets	2.5-lb ball (1-hand drills) and 10-lb ball (2-hand drills)

Note: A 2.5-lb ball may be too stressful on the athlete's anterior capsule when performing the 1-hand baseball throw. If pain exists in the anterior shoulder, revert back to the 2-lb ball.

it must closely mimic the biomechanical and physiological demands of the sport. The Ballistic Six involves high-intensity plyometric exercises that closely simulate the overhead throwing motion. They are performed in an interval fashion with appropriate rest periods between sets to tax the anaerobic and aerobic energy systems.

Progression

Progression can be described as an approach to resistance training that builds variation in exercise intensity and volume at regular intervals over a specified period of time (1). The Ballistic Six is a form of progressive resistance training and follows the principles of progression. The program requires the athlete to gradually increase the volume and intensity of each exercise at regular intervals throughout the 10-week program (Table 1).

Overload

One goal of a resistance-training program is to develop strength. Whether one is trying to develop muscular strength, power, or endurance, the overload principle must be used to accomplish the desired goals. The overload principle provides a greater stress or load on the body than it is normally accustomed to handling (16). The Ballistic Six program is designed to provide a progressive overload to a pitcher's shoulder. According to the overload principle, pitchers who perform the Ballistic Six program should experience both power and endurance muscular adaptations.

Conclusion

Pitchers who possess poor dynamic stability of their shoulder are prone to injury or poor performance. There are conflicting views on how to appropriately train a pitcher's shoulder. Plyometric training has been shown to be an effective way to increase the strength and performance of the shoulder. However, recommendations for sets, repetitions, and rest periods have not yet been established. The Ballistic Six program is comprised of a group of plyometric exercises performed in an interval fashion with appropriate rest periods in between sets to tax both the anaerobic and aerobic capabilities of the shoulder. The exercises are performed ballistically and closely simulate the overhead throwing motion. Strength and conditioning professionals involved with the training of baseball pitchers may want to use the Ballistic Six interval training program to increase shoulder performance and prevent injury. ♦

References

1. Allerheiligen, W.B. Speed development and plyometric training. In: *Essentials of Strength and Conditioning*. T. Baechle, ed. Champaign, IL: Human Kinetics, 1994. pp. 314–344.
2. Ellenbecker, T.S., and A.J. Mattalino. Concentric isokinetic shoulder internal and external rotation strength in professional baseball pitchers. *J. Orthop. Sports Phys. Ther.* 25(5):323–328. 1997.
3. Fleisig, G.S., J.R. Andrews, C.J. Dillman, and R.F. Escamilla. Kinetics of baseball pitching with implications about injury mechanisms. *Am. J. Sports Med.* 23(2):233–239. 1995.
4. Fortun, C.M., G.J. Davies, and T.W. Kernozek. The effects of plyometric training on the shoulder internal rotators. *Phys. Ther.* 78(5):S87. 1998.
5. Gowan, I.D., F.W. Jobe, J.E. Tibone, J. Perry, and D.R. Moynes. A comparative electromyographic analysis of the shoulder during pitching. *Am. J. Sports Med.* 15(6):586–590. 1987.

6. Heiderscheit, B.C., K.P. McLean, and G.J. Davies. The effects of isokinetic vs. plyometric training on the shoulder internal rotators. *J. Orthop. Sports Phys. Ther*. 23(2):125–133. 1996.
7. Jobe, F.W., J.E. Tibone, J. Perry, and D. Moynes. An EMG analysis of the shoulder in throwing and pitching a preliminary report. *Am. J. Sports Med.* 11(1):3–5. 1983.
8. McCluskey, G.M., and B.A. Getz. Pathophysiology of anterior shoulder instability. *J. Athletic Train*. 35(3):268–272. 2000.
9. Mcleod, W.D., and J.R. Andrews. Mechanisms of shoulder injuries. *Phys. Ther.* 66(12):1901–1904. 1986.
10. Mikesky, A.E., and J.E. Edwards. Eccentric and concentric strength of the shoulder and arm musculature in collegiate baseball pitchers. *Am. J. Sports Med.* 23(5):638–644. 1995.
11. Mullins, J. Upper extremity conditioning program for baseball pitchers. *Natl. Strength Cond. Assoc. J*. 15(4): 46–49. 1993.
12. Potteiger, J.A., and D.G. Wilson. Training the pitcher: A physiological perspective. *Natl. Strength Cond. Assoc. J*. 11(3):24–26. 1989.
13. Potteiger, J.A., D.L. Blessing, and D.G. Wilson. The physiological responses to a single game of baseball pitching. *J. Appl. Sport Sci. Res*. 6(1):11–18. 1992.
14. Stone M., and M. Conley. Bioenergetics. In: *Essentials of Strength Training and Conditioning*. T. Baechle, ed. Champaign, IL: Human Kinetics, 1994. pp. 67–85.
15. Terry, G.C., and T.M. Chopp. Functional anatomy of the shoulder. *J. Athletic Train*. 35(3):248–255. 2000.
16. Wathen D., and F. Roll. Training methods and modes. In: *Essentials of Strength Training and Conditioning*. T. Baechle, ed. Champaign, IL: Human Kinetics, 1994. pp. 314–344.
17. Werner, S.L., T.J. Gill, T.A. Murray, T.D. Cook, and R.J. Hawkins. Relationships between throwing mechanics and shoulder distraction in professional baseball pitchers. *Am. J. Sports Med.* 29(3):354–358. 2001.
18. Wilk, K.E., J.R. Andrews, C.A. Arrigo, M.A. Keirns, and D.J. Erber. The strength characteristics of internal and external rotator muscles in professional baseball pitchers. *Am. J. Sports Med.* 21(1):61–67. 1993.
19. Wilk, K.E., M.L. Voight, M.A. Keirns, V. Gambetta, J.R. Andrews, and C.J. Dillman. Stretch-shortening drills for the upper extremities: Theory and clinical application. *J. Orthop. Sports Phys. Ther*. 17(5):225–239. 1993.

Pretz

Ryan Pretz is currently a physical therapist at Ozark Physical Therapy in Poplar Bluff, Missouri.