Preparing for the Specific Neuromuscular and Biomechanical Demands of the Javelin Throw

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The training for track and field events is highly specific and requires precise technical development. Each event in the sport places unique technical and physical demands on the performer. Knowledge of the demands of any given event is necessary for proper planning and training. This is especially true for the javelin throw. Because the javelin throw is very different from the other throwing events special consideration must be taken when developing a training program to produce maximal performances.

One of the fundamental principals governing training plan design is specificity. In speed-power events like the javelin that have a high technical demand it is important for coaches to understand the biomechanical and neuromuscular demands of the event in order to best provide a training stimulus that prepares the athlete to meet the demands of the event. In light of this, a brief review of the unique biomechanical and neuromuscular demands of the javelin throw will be given followed by a brief selection of exercises and training methods to enhance the physical qualities needed for the event.

Neuromuscular Considerations

Throwing events require high amounts of force production over very short periods of time. Because of the lighter implement, speed of movement (more so than force development) plays a greater role in javelin performance than the other three throws. As would be expected, release velocities in the javelin are considerably higher when compared to the other throws. For elite athletes, the velocity of a javelin release has been measured in excess of 30m/s (Zatsiorsky, 1995; Bartonietz, 2000). The duration of the javelin pull from start to finish has been measured at 0.16-0.18s (Zatsiorsky, 1995). Morriss and Bartlett (1996) showed that in elite athletes as much as 70% of the release velocity of the javelin is developed in the final 0.1 second. This speaks to the importance of rate of force development to success in the event. In other words, athletes should train to produce the greatest amount of force in the shortest amount of time. The only way to do this efficiently is by eliciting the body's natural mechanisms for enhancing performance: the stretch reflex and the stretch-shortening cycle.

The stretch reflex causes a stretched muscle to contract and inhibits the antagonist muscle from contracting. Because this is an involuntary reflex response the rate of contraction is often significantly faster and more powerful than a completely voluntary muscular contraction. In fact, the faster the muscle is stretched eccentrically, the greater the force will be on the following concentric contraction (Komi, 1992).

The stretch-shortening cycle occurs when elastic loading, through an eccentric muscular contraction, is immediately followed by an explosive concentric muscular contraction. The tension developed in the musculo-tendinous junction by the eccentric loading of the muscle causes it to act in similar manner to a rubber band. When this stored energy is released it helps to increase the strength of the following concentric contraction. These neuromuscular considerations have huge ramifications for the preparation of javelin throwers.

Biomechanical Considerations

As with all throwing events, release velocity is far and away the most critical factor for performance. As stated above, javelin release velocities have been measured in excess of 30m/s (Zatsiorsky, 1995; Bartonietz, 2000). Maximizing this parameter gives the athlete the best chance of attaining success in the event (Morriss & Bartlett, 1996). To achieve this objective a proper sequencing of muscle actions must take place. Two movement strategies are critical to success in the javelin and all throwing events in general: proximal-to-distal firing patterns and active acceleration-deceleration of body segments.

Both anecdotal and research evidence suggests that a proximal-to-distal firing pattern is the most effective for increasing the velocity at release. In such a sequencing pattern, the stronger more heavily muscled proximal (close to the torso) joints should become active before the weaker but faster distal joints. This firing pattern has proven the most efficient for several throwing activities in part due to the fact that it takes advantage of each joints' particular impulse-momentum generating characteristics. In accordance with this concept, research evidence (Bartlett et al., 1989; Bartonietz, 2000) suggests that power for overhead throwing athletes is primarily generated with leg extension, hip rotation and trunk flexion. According to Coleman (1998), the actions of these proximal joints account for more than 50% of the forces in a standing overhead throw. This

percentage is likely greater when the throw is preceded by an approach run as is the case when throwing the javelin.

A second characteristic of efficient movement coordination in the javelin is consecutive acceleration and deceleration of the main body segments. This movement strategy becomes very apparent when viewing any highly skilled javelin thrower. Athletes accelerate the athlete-plus-javelin system during the approach run and early moments of the throwing motion and then violently decelerate body segments from the ground up. When done well this permits the athlete to achieve release velocities far greater than they would if they did not use an optimal acceleration-deceleration coordination pattern. The mechanism for this benefit is transfer of momentum. This movement strategy aids in the transfer of momentum from the lower extremity to the upper, and from the upper extremity to the javelin. Several authors (LeBlanc & Dapena, 1996; Morriss & Bartlett, 1996) have identified this transfer of momentum as being critical to performance.

When considering the beneficial effects of the two above mentioned movement patterns it is important to note that much of the benefits from each coordination pattern may in fact be a shared effect of a common point. One of the proposed benefits of a proximal-to-distal coordination pattern is that it generates a whip-like motion (Kearney et al., 1993; Bath & Kearney, 1996). That is because when the upper leg and trunk musculature are the first to contract, greater separation is developed between the shoulders and hips which results in a whip effect as the hips are decelerated and the shoulders accelerate as they uncoil and the implement is released.

The main point to be taken from this discussion is that more so than the three other throwing events, release velocity in the javelin is achieved not by brute force but by putting the body in the best position to take advantage of the above stated neuromuscular and biomechanical considerations.

Development of Physical Qualities important to the Javelin Throw

In light of the above points, the javelin throw has several special considerations that will affect the type of training these athletes should perform. As previously mentioned the muscles closest to the trunk are primarily responsible for accelerating the javelin. As a result, training emphasis should be placed on the quadriceps, hip flexors,

gluteals, and abdominals (Kaufman, 1999). The principal of specificity indicates that to maximize the benefit of a training stimulus the training of these body parts should include elastic loading to produce maximal, explosive, concentric muscular contractions (Wilk, et al., 1993).

In addition to this, the increased speed developed in the approach of the javelin throw places a considerably greater load on the athletes' legs, thus creating an even greater need for leg strength in this event (Zatsiorsky, 1995). Fast-eccentric strength is especially important because it will enable the athlete to better overcome the 300-500% of bodyweight loads that the athlete experiences during the crossovers and allow them to proceed into the throwing motion with greater velocity. Additionally, it is vitally important for javelin throwers to have extreme eccentric strength in the non-throwing side leg to be able to apply the braking forces necessary to rapidly decelerate the body during the final pull (Bartonietz, 2000). Not only does this deceleration help to preserve fair throws but as discussed above, the rapid deceleration of the body by the non-throwing side leg enhances the elastic loading of the throwing-side shoulder musculature due to the whip-like effect that occurs in the throwing arm and thus increases release velocity by means of the neuromuscular and biomechanical consideration discussed above.

Specific Suggestions for Javelin Preparation

Developing event specific physical qualities is important for any sporting event. As with all movements the most direct means of improving performance is by performing the competition movement itself. While competition-specific event training and general physical preparation means should be the foundation of any well-designed training program, alternative training means can stimulate specific adaptations which may further performance. They also provide much needed variance within the training program. The following section of this article provides some exercise examples and training suggestions for developing event-specific capacities for the javelin thrower.

Axe Chop / Sledge Hammer

Purpose: To simultaneously develop strength and flexibility in the shoulder girdle, pectoral and upper back musculature.

Requirements: This exercise requires a sledgehammer or lumber axe, and a stable knee-height hitting surface such as a tractor tire, mound of dirt, or a large log.

Description: The athlete stands in front of a knee-height hitting surface. The axe / hammer is brought over the head and swung violently down on to the hitting surface. The key for this exercise is to let the weight of the axe or hammer pull the arms back so that a stretch is felt through the shoulders and upper back. This will initiate a stretch reflex contraction, while developing strength and flexibility for throwing.

Variations: This exercise can be performed with one hand or two.

Recommendations: Have the athlete initiate the movement with the whole body rather than just the arms; this will create a whip-like effect on the axe or hammer.

Overhead Medicine Ball Throw

Purpose: To develop strength and flexibility simultaneously in the shoulder girdle, pectoral and upper back musculature, as well as the elbow extensors.

Requirements: This exercise requires a medicine ball (preferably a bouncy one) and either a partner or a solid wall.

Description: The athlete stands 10-12 feet away from a partner or 2-3 feet away from a wall. The athletes' bracing or block leg should be placed forward. The medicine ball is thrown from an overhead position. Like the axe / sledgehammer chop, the throw is initiated with the body so that the medicine ball feels as if it is "dragging behind" at the start of the throw. Once this feeling is achieved, the athlete should initiate the throwing action with the arms.

Variations: This exercise can be performed with one hand or two. Also, the athlete may "dribble" the medicine ball on the wall with a short, fast tempo and no "dragging" or stretch.

Recommendations: Throws with a partner are an excellent group warm up. Throws against the wall are a great way to end a workout because many repetitions can be performed in a short period of time, leaving the athlete with a good "pump".

Knockenball or Weighted Ball Throw

Purpose: To develop specific strength in all of the throwing muscles by overloading them with greater than normal resistance.

Requirements: A knockenball or a weighted throwing ball is required for this exercise.

Description: The athlete should prepare to throw as if they were going to throw a javelin. The throwing mechanics should be exactly the same. This exercise can be performed from the power position, with one or more crossovers, or with the whole approach.

Variations: The weights of the implement can be varied depending on the strength of the athlete as well as current phase of the training cycle.

Recommendations: Coaches should closely monitor the athletes' technique when throwing weighted implements. If the weight of the implement compromises the athletes' technique then a lighter implement should be used. Harnes (1990) suggested using light, competition, and heavy weight balls throughout the season with a gradual shift towards competition and light weight balls as the season progresses.

TurboJav™ Throw

Purpose: To develop specific strength in all throwing muscles by overloading them with greater than normal resistance while incorporating the added benefit of forcing the athlete to "throw through the tip."

Requirements: A TurboJav™, and either lead tape, fishing weights, or a weighted sleeve are required for this exercise. Add lead tape, fishing weights secured to the inside, or a weighted sleeve to the implement so that it exceeds the weight of the athletes' regulation javelin.

Description: This exercise is performed as if the athlete were throwing the regulation javelin. . This exercise can be performed from the power position, with one or more crossovers, or with the whole approach.

Variations: The weights of the implement can be varied depending on the strength of the athlete as well as current phase of the training cycle.

Recommendations: Coaches should closely monitor the athletes' technique when throwing weighted implements. If the weight of the implement compromises the athletes' technique then a lighter implement should be used.

Dumbbell Pullovers

Purpose: To develop strength and flexibility simultaneously in the shoulder girdle, pectoral and upper back musculature.

Requirements: This exercise requires a sturdy bench and a dumbbell.

Description: To perform this exercise, the athlete lies flat on a bench and holds a light dumbbell over their chest with arms extended but not locked out. The arms then come back behind the athletes' head with the elbow joint remaining almost completely extended. The dumbbell is brought back until the athlete feels a stretch in the upper back,

shoulders, and rib cage. At this point, the dumbbell is returned to the starting position with the arms remaining just short of being locked out.

Variations: This exercise can be performed with one arm or two.

Recommendations: Athletes should avoid the temptation to "go heavy" on this exercise as this could easily lead to injury.

Glute-Ham Medicine Ball Throw

Purpose: To strengthen the core muscles in a javelin-specific manner.

Requirements: This exercise requires a glute-ham machine or roman chair sit-up machine, a medicine ball, and a partner.

Description: The athlete sets up in the machine as if they were going to perform a roman chair sit-up with the butt resting on the pads and the feet securely placed under the supports. The athlete should begin the exercise in the "up" position and with arms raised overhead. When the athlete is ready, the partner throws the medicine ball to the athlete so that they can catch it with arms extended overhead. At this point, the athlete immediately descends until the trunk and arms become parallel with the floor. The athlete then returns to the starting position, maintaining the extended arms, and throws the medicine ball back to the partner.

Variations: This exercise can be performed with one hand or two. An advanced form of this exercise involves using only one hand and the opposite leg for support. This variation adds an extra element of stabilization and balance to the exercise.

Recommendations: Athletes should focus on throwing with the core muscles rather than the arm.

Pulley-Related Javelin Throw

Purpose: To develop specific strength in all throwing muscles by overloading them with greater than normal resistance.

Requirements: This exercise requires a pulley device. If one is not available a simple pulley system can be built with the grip portion of an old javelin or a 6" piece of piping, and a cord or rope. The cord is run through the piping, pulled taut, and attached to the floor and ceiling at an angle that allows the athlete to perform a throwing motion with the piping moving up the cord in a natural path.

Description: The athlete stands holding the piping as if they were going to perform standing throw and pulls on the piping using leg, hip, and arm strength. The exercise is completed when the piping reaches a point above the athletes' head.

Variations: Resistance can be adjusted by weighting the pipe or by increasing the friction between the cord and the pipe.

Recommendations: Ideally, the javelin grip or piping should have a diameter about 1-2 cm wider than the cord or rope. The optimal release angle for throwing the javelin is about 35± 3 degrees in relation to the horizontal (Bartonietz et al., 1996; Brown et al., 2000; Mero et al., 1994). This should be taken into consideration when setting up the pulley system.

Isometric Javelin Contractions

Purpose: To develop strength in the whole throwing motion by increasing strength at various angles using isometric contractions.

Requirements: This exercise requires either a partner or an immovable object that the athlete can pull on.

Description: The athlete assumes a standing throw position. At this point the athlete grabs the immovable resistance at a given arm angle. An isometric contraction is applied against the resistance. The tension in the muscle should build progressively and reach its peak in 2-3 seconds. Each set should last for 5-6 seconds.

Recommendations: Due to the angle specificity of isometric training, sets should be performed at every 30° to cover the entire range of motion. For the javelin arm mechanics this means the athlete will need to perform sets at five or more locations.

Javelin Box Jump

Purpose: To develop eccentric strength to overcome the lading forces experienced by the approach and penultimate step.

Requirements: This exercise requires a sturdy box with a height ranging 6-24', and a flat landing surface.

Description: The athlete stands on the box with their back throwing leg hanging off the box. The athlete then drops off the box onto the leg that was hanging off the box and immediately proceeds into javelin throw footwork.

Variations: The intensity of this exercise can be varied by changing the height of the box or by adding resistance in the form of a weight vest.

Recommendations: To maximize the benefits of this exercise, the athlete must make a conscious effort to push from the back leg the instant it contacts the ground.

Bungee Hip-Snaps

Purpose: To strengthen the core and develop an explosive hip drive and flexibility through the shoulders and back.

Requirements: A bungee cord or stretch bands are required for this exercise.

Description: The bungee is securely fastened to a fixed object. The athlete holds the free end of the bungee in the throwing hand and assumes a standing throw position. The bungee should be taut at this point. From this position, the athlete performs a partial standing throw, emphasizing good hip and leg drive. The movement is completed when the athlete hits the "Reverse C" position. This position is demonstrated in Fig. Y.

Variations: The resistance on this exercise can be changed by using different bungee cords. This exercise can also be combined with the Javelin Step-Up exercise.

Recommendations: The athlete should not attempt to go beyond the "Reverse C" position. Due to the elastic qualities of the bungee (the farther it is stretched, the greater the tension) a complete throwing motion would place dangerous levels of stress on the shoulder.

Bounding

Purpose: To develop the explosive strength for the approach as well as strength to overcome the loading forces created by the approach and penultimate step.

Requirements: This exercise requires a flat 15-50m surface, preferably grass or a synthetic track.

Description: The athlete bounds 15-50m emphasizing explosiveness by attempting to achieve maximum distance with minimal ground contact.

Variations: This exercise can be performed using straight legs, alternating bounds with short runs (10m run, 15m bound, 10m run, 15m bound), carioca bounds, or crossover bounds.

Recommendations: Bounding drills can be a good way to develop the tempo or acceleration of an approach if the athlete consciously tries to accelerate or increase the tempo over the given distance.

Crossovers up Stairs

Purpose: To overload the muscles used for explosive crossovers.

Requirements: This exercise requires a flight of stairs with consistent and even step heights and widths.

Description: Athletes run up a flight of stairs performing crossovers. The athlete should be perpendicular to the stairs and only one foot contacts each step.

Variations: A weight vest can be used to increase the resistance on this exercise.

Recommendations: Ideally, the steps should have a width of at least 18" and a height of no more than 6".

Resisted Approach Runs

Purpose: To develop strength and explosiveness through the entire approach run.

Requirements: This exercise requires either a weighted vest or a parachute.

Description: The athlete performs the approach as they would in a competition with the added resistance of the weighted vest or chute. The chute may be either strapped to the waist or carried in the throwing hand. This exercise can be performed using the whole approach or broken down into segments.

Variations: Adding weight or using a different chute can modify the resistance of the exercise. Another variation on this exercise would be to hold a weighted ball in the throwing hand while performing the approach against the resistance of the weighted vest or chute. This adds the extra dimension of strengthening the shoulder and core muscles.

Recommendations: This exercise would best be performed under the same circumstances as in a competition. For instance, if the athlete normally wears javelin boots they should be worn for this exercise.

Full Approach Runs

Purpose: To develop speed through the entire approach run and the ability to withstand the increased loads associated with competition speed approach runs.

Requirements: This exercise requires no equipment other than a javelin or weighted ball.

Description: The athlete performs the approach as they would in a competition attempting to achieve maximum controllable velocity in the run.

Variations: Increasing the length and / or speed of the approach run beyond that of competition approach will serve as an overload stimulus.

Recommendations: This exercise would best be performed under the same circumstances as in a competition. For instance, if the athlete normally wears javelin boots they should wear them on this exercise.

Conclusion

As with other events the javelin places specific demands on the athlete which necessitates specific training means. Although this article focuses largely on preparing for the specific demands of the javelin throw, general means of preparation should remain the foundation for any athletic preparation. Foundational fitness levels including high levels of general strength parameters are necessary to maximize the benefits of any specific training stimulus. Nonetheless, it is important to address the specific neuromuscular and biomechanical demands of the event in training. The suggestions in this article are by no means comprehensive. Instead they are intended to spur thought for further training concepts.

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