POSITION STATEMENT

Literature Review: Explosive/Plyometric Exercises

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Plyometric exercise involves rapid deceleration of a mass followed almost immediately by rapid acceleration of the mass in the opposite direction. The mass can either be an implement or body weight. Lower body plyometric exercises include bounding, hopping and various jumps with one or two legs. Common upper body plyometric exercises include one and two handed catch-tosses, usually with medicine balls, and push-ups in which the hands leave the ground.

Plyometric exercises are very similar to actual movements used by power athletes in sporting activities such as sprinting, jumping, throwing, football, basketball, volleyball, baseball, tennis and handball. Such exercises utilize the stretch-shortening cycle that occurs when a muscle undergoes a rapid eccentric elongation just before a rapid concentric contraction. The muscle is stretched while active, resulting in greater force capability during subsequent concentric contraction than could be generated during a concentric contraction from a static position not preceded by a stretch (1-25, 28-32, 34-45). When the stretch-shortening cycle is practiced and perfected, athletes are better able to accelerate their bodies or sports implements (balls, racquets, javelins, etc.) and generate greater force at high velocities.

Some drills are sport-specific while others are not. For example, athletes requiring sprinting and linear movements (football, baseball) engage in more bounding and hopping drills, while athletes who require vertical movements (basketball and volleyball) utilize more vertical jumping exercises. Athletes engaged in throwing, pushing, stroking (racquet) and heaving activities benefit from upper body plyometric exercises. Plyometric drills were originally developed for track and field athletes (6, 24, 26, 27, 36, 39, 40, 42) and are now used for all types of power sports (2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 18, 21, 22, 23, 28, 29, 37, 44, 45). As the drills were adopted for sports other than track and field, articles criticizing the use of plyometrics (27, 33, 46) contended that the drills did not develop explosive power and, instead, resulted in more injuries than benefits.

Improving Power

Numerous studies have established the effectiveness of plyometric drills in improving power (2, 5, 7, 8, 9, 10, 11, 12, 15, 17, 18, 21, 22, 25, 28, 36, 37, 40). While injuries can and do occur, it must be noted that in no epidemiological studies have relative injury rates been addressed. However, a recent investigation indicated that plyometric exercises performed during the pre-season did not produce injuries but significantly reduced in-season muscle soreness in a group of collegiate volleyball players (13). While forces at various joints are very high in a number of plyometric drills (3, 10, 11, 12, 14, 25, 28, 30, 34, 45), careful application of such exercises and the adherence to proper training procedures can eliminate all but the most unforeseen injuries. Generally, anecdotal evidence indicates that injuries can be traced to violations of training procedures. Due to the high intensity of these drills, it is vitally important that such exercises only be prescribed for physically prepared athletes. Those in poor condition, especially with respect to strength, are not good candidates for plyometrics.

Athletes selected for plyometric training should have completed several weeks or months of both sprinting and resistance training. An estimated minimum strength level of 1 1/2 to 2 1/2 times body weight in the free weight squat has been recommended for safe participation in plyometric drills (6, 20, 24, 39, 42). Another criterion is the performance of five reps of the squat with 60 percent of body weight in five or less seconds. For upper body drills the ability to perform five (5) hand clap push-ups should qualify an individual for beginning upper body plyometric drills. A body weight bench press for larger athletes (over 90 kg) and 1 1/2

Table 1. Recommendations for individual exercise and total workout plyometric training volume, according to intensity of exercise. The limits can be applied separately for the upper and lower body.

Intensity	Individual Exercise sets / repetitions	Total Workout repetitions
Low	10 x 12	400
Moderate	7 x 10	350
High	5 x 8	300
Very High	3 x 6	200

From Stone, M. and H. O'Bryant. Weight Training: A Scientific Approach. Minneapolis, MN: Burgess. 1987. p. 98.

times body weight for smaller athletes (under 90 kg) are reasonable guidelines for moving to more advanced upper body drills.

Athletes with a large body mass (over 100 kg) are not good candidates for some plyometric drills such as depth/drop jumps from heights over 18 inches. The recommended frequency of plyometric drills is one to three days per week. Drills for lower or upper body region should not be conducted on consecutive days. Complete recovery is necessary between sets because fatigue causes decrements in form which can delay improvement and the increased risk of injury. Most authorities do not recommend plyometrics on days of heavy weight training or other intense activity (6, 20, 24, 39, 42).

Footwear and landing surfaces with good shock absorbing qualities are important to prevent stress-related trauma. Proper progression of lead-up drills should be done before complex drills of high intensity are administered. Lower intensity drills should be mastered prior to attempting drills of more complexity and intensity. Not all athletes will benefit from all plyometric drills. The coach/trainer should pick sport-specific drills that the athlete is physically and neurologically capable of performing. The number of foot/hand contacts should be monitored so that athletes perform only the number of repetitions safe for their progression levels (Tables A and B). Most of the anecdotal reports of injuries indicate violation of one of the aforementioned rules. Generally, depth/drop jumps from excessive heights by heavy or physically unprepared athletes account for most problems. Depth/drop jumps are only a part of a multitude of plyometric drills and are utilized by a small percentage of all athletes engaged in plyometric drills. Much like other so called explosive exercises, plyometrics involve controlled practice of powerful motions. They are intended to increase the force that can be exerted at high velocity. In properly controlled, progressively applied training programs these activities can be beneficial and involve minimal risk.

Performing Movements

Explosive stretch-shortening activities constitute the most critical element of many athletic events. Spending a portion of training time performing movements similar to those encountered in a specific sport is necessary for safe adaptation to the physical demands of power-type sporting events. Practicing drills which utilize the stretch-shortening cycle can improve gross motor skills for similar movements. Careful selection of plyometric, exercises along with proper teaching progression and loading, can minimize problems while maximizing performance. An excellent resource is the videotape on plyometric training produced by the National Strength and Conditioning Association, P.O. Box 81410, Lincoln, NE 68501.

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