# Integrating Ballistic Training

The integration of ballistic exercises and ballistic circuit training has gained popularity in recent years fueled by television infomercials (P90X and Insanity) and performance based group exercise programs like CrossFit®. Oftentimes utilized in the athletic environments, ballistic training can certainly present new challenges to an exercise program and promote additional adaptations beyond traditional strength training, but not without certain risks. As fitness enthusiasts look for new and entertaining stimulus to promote physical fitness, many activities once reserved for conditioned athletes enter mainstream fitness. Personal trainers should have a clear understanding of the risks, benefits, and purposes of these training techniques so they can best implement strategies to promote safe and effective training.

When applied to voluntary muscle contractions the term "ballistic" or "ballistic contractions" suggest the actions of force development occur at a very high rate increasing the "power" of the action. The contractile force produced for rapid action generates an acceleration force beyond the velocity of the resistance. The high level force of ballistic contractions, at a minimum, increases the rate of movement with the potential to accelerate a mass beyond traditional range. For example, throwing a baseball is ballistic. The force generated to move the mass is greater than that needed to move it between the starting point and the point of release. Jumping off the ground is another example of a ballistic movement, as is running up a flight of stairs. Since the quantity of force produced is a factor of neural rate and recruitment dynamics that stimulate the force production to move the body mass faster, the nervous system must elicit a rapid and synchronized response of large muscle fibers.

A traditional approach to ballistic training suggests the use of added movement velocity when performing common biomechanical actions with or without external loading. Ballistic training is often considered synonymous with plyometric exercise but this is not entirely correct. Plyometric exercises are always ballistic but ballistic exercises are not always plyometric. Although interpretations may vary, for an exercise to be classified as a plyometric, the movement should be rapid enough to accelerate the center of mass beyond skeletal ROM such as a tuck jump, but also require an added component of contact time. When the body is lifted upward through jumping forces it accelerates faster than gravitational pull but eventually is slowed as constant gravity catches up, equalizes, and then surpasses the forces produced from the jump. As the body returns to the ground the muscles decelerate the mass during the landing using reaction force and then must concentrically contract to jump again. A plyometric occurs when the concentric contractions reaccelerate the mass upward very rapidly, causing the feet to leave the ground (contact phase) in less than approximately a quarter of a second. The amount of time spent in contact with the ground is called the contact or amortization phase. During this time, eccentric contractions used to decelerate (the mass) are overlapped with concentric contractions used to accelerate it, and the resultant force is greater than its parts. Essentially, potential energy is converted into kinetic energy through what is called the stretch–shortening cycle. When performed at a slower rate the potential energy is lost as heat. For this reason specific jump heights and external loading are recommended for plyometric training compared to ballistic training, which can be performed using higher heights and greater loads than plyometrics in the same exercise.

This being said it is not necessary to perform repeat jumps off the ground in a fraction of a second to access the benefits of ballistic training for a variety of populations. In fact, the neural phenomenon of the stretch-shortening cycle can be utilized at slower rates than those seen in plyometric exercises and without ever leaving the ground. Anytime a counter movement or pre-load action is used for acceleration assistance the stretch-shortening cycle is active. Research indicates that taking advantage of the neural changes associated with ballistic training can present many favorable outcomes for almost every participant. Of particular interest for non-athletes is the use of ballistic exercise for improving power, particularly in the elderly, muscular performance without added mass in weight specific activities, as well as improvements in body composition in those looking to reduce fat mass.

Ballistic exercise and the elderly may sound dangerous but actually power training is highly recommended to prevent sarcopenia and related dysfunction with aging. *The Journal of Aging and Physical Activity* published a study in 2009 that examined 112 healthy older adults between the ages of 65 and 75. Investigators analyzed the effects of explosive resistance training at varied levels of maximal strength twice a week for 8-12 weeks. The results indicated that ballistic resistance training can improve the ability to produce higher power outputs with heavier loads without loss of movement velocity in older adult populations. Additionally, the research supported moderate- to high-intensity training as it induced a greater relative contribution of force to peak power production among the elderly.

Recent studies published in the *Journal of Gerontology and Aging and Physical Activity* attempted to discern whether strength training and power (ballistic) training would be equally effective in enhancing physical function in older adults. Due to the fact that loss of muscle power associated with normal aging has greater functional impact than loss of strength alone it is relevant to identify the optimal prevention plan using physical activity. In the first study (2008) sixty-seven healthy, independent older adults age 65-84 years, participated in either a high-velocity varied resistance program or a traditional resistance training program aimed at improving strength. Both groups trained two times per week using six exercises for a 24 week period. Although the number of exercises was consistent the power training activities used a lower repetition range consistent with velocity based training. Upon completion of the study both groups experienced significant yet similar improvements in strength. Interestingly, peak muscle power also increased in both groups (50.5% and 33.8%) with the greater improvement observed in those who engaged in ballistic activities. The training also improved functional performance tasks in both groups compared to controls with the ballistically trained group reporting overall improved quality of life. Of additional benefit, improvements in the ballistically trained group occurred with less total work performed per training session.

These findings were supported by the second study (2009) which compared lower extremity training using either ballistic power or controlled strength exercises. Forty five adults between 69 and 80 years of age were randomized into three groups, power training, strength training and a control group. The participants in both treatment groups performed the same exercises three times per week. Both groups used equal eccentric speeds but the strength training group performed a 2-3 second concentric phase whereas the ballistic group moved the resistance at their highest controlled velocity. Following 12 weeks of training they were re-evaluated for strength and power. Consistent with the prior study both groups demonstrated significant improvements in 1RM strength compared with the control group. The most notable difference was that power increased approximately two-fold in the adults training with ballistic movements compared with those who were strength training. Researchers suggest that in older adults with compromised function, ballistic training leads to similar increases in strength and larger increases in power when compared to traditional strength training programs.

Ballistic training has also demonstrated improvements in strength and power without consequent gains in muscle mass. When the body is heavily muscled from resistance

*Start in a seated position on the bench with a medicine ball held at the chest height. Initiate the movement with rapid hip flexion. Once the center of mass has proportionately transitioned over the base of support extend the knees, hips, and arms while flexing the shoulders to drive the MB upward and forward. Jump into a squat position.*

training the heart must work harder to satisfy the tissue's oxygen demands. Therefore certain sports and activities require smaller physiques to optimize performance, particularly when performed for longer periods of time such as the endurance sports. This being said endurance sport participants such as runners, rock climbers and cyclists can all benefit from improved power output, as can weight relevant sport participants such as wrestlers, boxers, gymnasts and tennis players. Ballistic training has demonstrated an ability to improve force output without significant morphological changes in the muscle fiber. This is accomplished through neural adjustments rather than an increase in fiber size. A 2008 study published in the *Journal of Strength and Conditioning Research* investigated the effects of ballistic resistance training and strength training on muscle fiber composition, peak force, maximal strength, and peak power. Fourteen college age males with resistance training experience were pre- and post-tested in the 1RM squat and peak power in the jump squat. Peak force and rate of force development were tested during a mid thigh pull. Following eight weeks of loaded jump squat training using a 3 days per week periodized program the ballistic trained group showed significant improvement in peak power, rate of force development and peak velocity without significant improvements in 1RM squat strength or muscle hypertrophy. These findings suggest that using ballistic resistance exercise is an effective method for increasing power and rate force development without changes in muscle fiber type expression.

Similar findings were observed in a related investigation examining untrained males performing either ballistic or conventional strength exercises. Following 12 weeks of training the ballistic group demonstrated significant improvements in vertical jump, maximal power and peak power compared to the strength trained group. Although there were increases in whole muscle cross sectional area by 7%, muscle biopsy demonstrated no significant change in Type IIa or Type I fibers from the power training, whereas the strength training group experienced an increase in both overall cross sectional size as well as cross sectional fiber size in both Type IIa (+49%) and Type I (+39%) fibers. Since both groups were comprised of untrained males it is presumably expected that both groups would experience some hypertrophy from resistance training but the limited changes in the fiber distribution supports the conclusions of prior research that ballistic training limits muscle mass compared to traditional strength and hypertrophy training. In addition to performance related concerns for mass adjustments, ballistic exercises may also be useful for females who avoid resistance exercise for fear of mass changes.

For individuals looking to gain a performance edge, ballistic training has demonstrated sport specific improvements in athletic measures in both trained and untrained individuals. It seems that both strong and weak individuals gain similar improvements from ballistic training. A 2009 article published in the *Journal of Strength and Conditioning Research* compared twenty four men grouped by strength level. Following 10 weeks of ballistic training both groups demonstrated significant improvements in sprint and jump performance as well as peak power outputs. Although both groups improved, the stronger group demonstrated a tendency toward eliciting a more pronounced effect on jump performance.

These finding were supported by a related article published in *Medicine and Science in Sports and Exercise* (2009). Individuals defined as weak in strength demonstrated similar improvements in sprint speed and vertical jump

*Start in a standing position lateral to 3-5 cones. Start by flexing the hip and knee of the lead leg while pushing laterally off the drive leg.*

*Rapidly transition from hip and knee flexion to extension in the frontal plane. Transition rapidly back at the end points.*

## MB swing jumps

*Start in a modified deadlift position with MB between the thighs. Jump upward simultaneously swinging the MB up overhead.*

*Land on the box using a flexed knee/hip position.*

following 10 weeks of either strength or power training. In this study jump squats using between 0-30% of 1RM were compared to back squats using 75-90% 1RM. Whereas both groups improved in athletic measures the strength group demonstrated significant improvements in strength over the ballistically trained group. Researchers cited the mechanisms driving these improvements included changes in the force-velocity relationship, jump mechanics, muscle architecture and neural activation that showed a degree of specificity to the different training stimuli. A consistency in the adaptational process associated with ballistic training is the changes in the nervous system.

The neural enhancement associated with ballistic training is heavily due to improvements in the stretch-shortening cycle and eccentric contraction variables. Although the concentric aspect of the movement is often the measure of the performance, it is actually the adjustments in the eccentric component that enhances the myotatic reflex and force generation. Exposure to force rate changes associated with ballistic contractions using counter and preload movements improves the efficiency of the muscle proprioceptors, consequently enhancing the tonic contraction in response to the stretching force (myotatic reflex). In addition, research has demonstrated that changes in eccentric variables were significantly associated with improvements in concentric performance such as increased negative acceleration and velocity during the countermovement as well as improved musculotendinous stiffness. Improvement in musculotendinous stiffness resulted in an enhanced ability to translate the momentum developed during the eccentric phase into acceleration force; more easily stated as greater concentric force.

When programming ballistic exercises into a comprehensive fitness approach the exercise order becomes an important consideration. The force velocity relationship is a key component not only to recruitment but also demand. Avoid loaded or high impact ballistic exercises that require significant proprioception later in the workout. Neural

*Start in an upright position holding a MB with one leg flexed and foot on the step. Initiate the movement by pushing through the step foot while simultaneously rotating the trunk and flexing the shoulders upward.*

*Jump in the air, raising the center of mass high enough to switch leg positions. Land in a switched leg position with ball at the start point. Use the rebound to reaccelerate back and forth.*