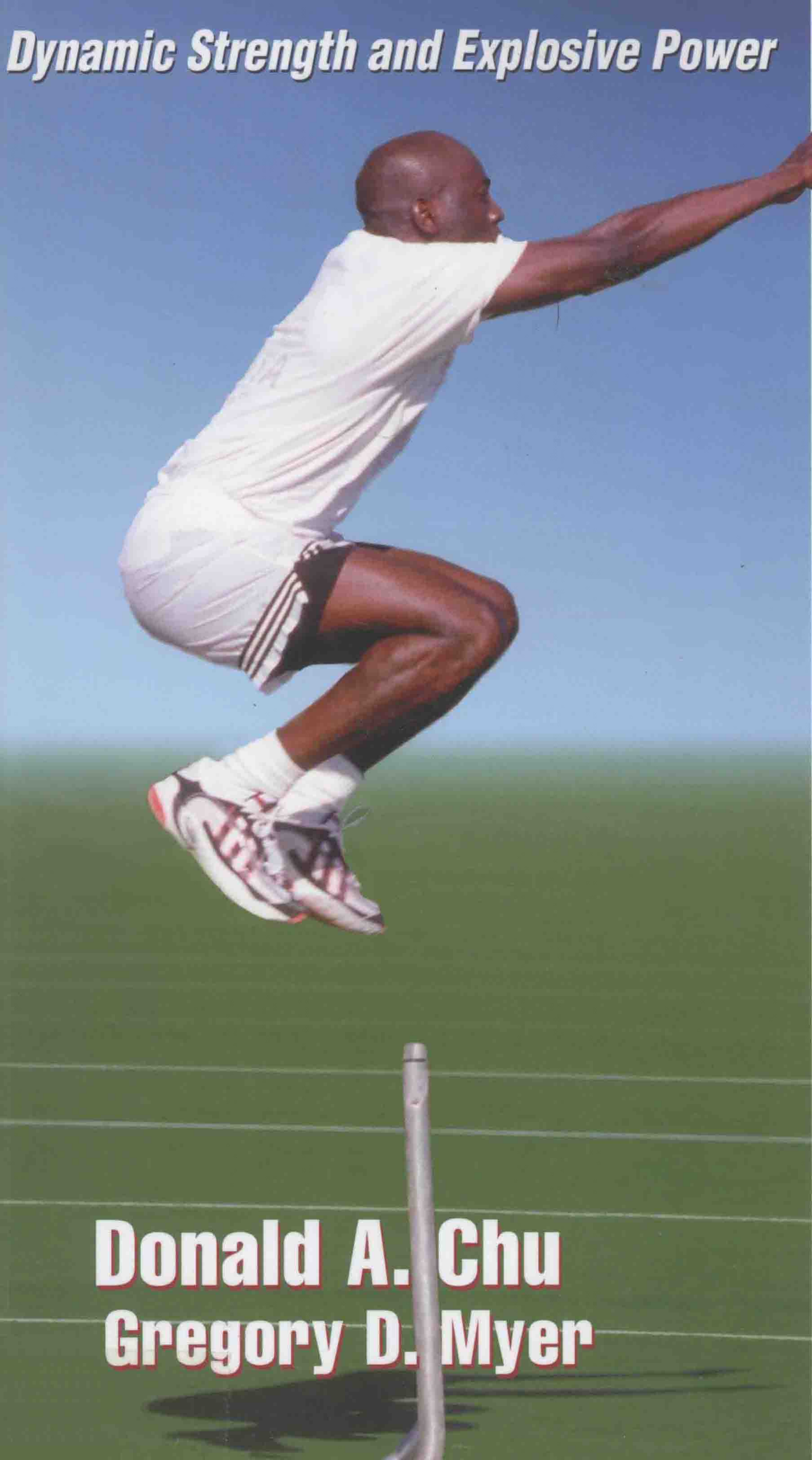
PLYOMETRICS

Dynamic Strength and Explosive Power



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运动力量训练　　Plyometrics

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Human Kinetics

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Preface

The evolution of performance enhancement in today's athletic world is truly amazing. Since *Jumping Into Plyometrics* was first published in 1992, there has been an explosion in the number of trainers and coaches who embrace plyometric training as an integral part of their athletes' development. Originating from track and field, this system of exercise has grown from mysterious to commonplace. The knowledge of these exercises has grown dramatically throughout the sporting world. In sports such as synchronized swimming, once far removed from the concept of power, plyometrics can now be credited for raising the level of performance.

This new book, *Plyometrics,* is an update of knowledge about plyometrics. New and exciting drills to improve footwork and basic movement skills have been included. Drills extend from beginner to more advanced skills. Additional research supporting the inclusion of plyometrics in various sport training programs has also been included. Chapter 11 features programs for new sports, including a sport-specific design for mixed martial arts (one of the fastest growing sports), and for traditional sports such as volleyball, basketball, and football. In addition, you will find chapters focused on the development of plyometric training techniques specific to the fastest growing groups of athletes, including youth (chapter 4) and female athletes (chapter 5). We have also included information regarding the latest research on using plyometric exercise to screen for injury risk (chapter 7), prevent ACL injury in females (chapter 5), and fully rehabilitate athletes in preparation for return to sport (chapter 6). The integration of these concepts into a comprehensive program for complete athletic development is outlined in chapter 10.

In this book, we provide the "nuts and bolts" of how plyometric exercise can be used to merge the physical qualities of speed and strength to produce an athlete capable of running faster, jumping higher, and achieving peak performance. Furthermore, the expansion of plyometrics to cover the multidirectional athlete provides greater variety and even more sport-specific options when designing a training program.

As the body of knowledge concerning the effects of plyometric training on performance enhancement and injury prevention expands, coaches and athletes need to keep their toolbox equipped with the latest and greatest techniques. This book demonstrates and explains the methods that will enable athletes to get the "biggest bang for their buck" in sport training. Not only do plyometrics fit into the complete training program, but a training program is not complete without the inclusion of plyometrics. Plyometric training has undergone a considerable metamorphosis over the past several years. New ideas and innovative techniques will lead athletes into a new generation of plyometric training. The coach or trainer who understands the options and opportunities available through plyometric training will find new ways to train athletes. We wish you well as you undertake the smart way (rather than the hard way) to work and train for athletic development.

Acknowledgments

We all stand on the shoulders of those who came before us and who walked alongside us. Many great European coaches and researchers deserve credit for their work with jump training, the stretch-shortening cycle, and shock training, including Veroshanksy, Boscoe, Komi, Satiskorsky, Medveydev, Javorek, Vittori, Bompa, Crisolan, MacFarlane, Francis, and many others who came before the current generation. We also recognize the many great American coaches who excelled in sport because of their quest for knowledge and adventuresome spirit, including Garhammer, Stone, Tellez, Santos, and Al Vermeil, my colleague, contemporary, and friend, who is probably the singular greatest resource in strength and conditioning the world has ever known.

I wish to thank all the NCAA Division II athletes who allowed me to use their bodies in the grandest of laboratories, the National Championships in Track and Field. I also thank the Santa Clara Aquamaids and coach Chris Carver, who believed they could go to the next level if they could find a training program no others in their sport had dreamed of risking. I am grateful to the professional and elite athletes who have been willing to challenge the odds and perform smart work instead of hard work.

My deep gratitude to my coauthor Greg Myer, who is as prodigious with a pen as any athlete is on the field. He is a key figure in the production of this project, and I am proud to have had him as a student. Now he is mentoring me.

When you want to move forward in the business of performance training, you often have to look back and recognize the roots of this tree of knowledge. It has been a pleasure to watch plyometrics grow from funny exercises used by track and field athletes to everyday, routine drills in most successful training programs. This is dedicated to those who have been and to those who will be. Compete hard and recognize that whoever wins is the best coach—today.

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PART

I

KNOWLEDGE

CHAPTER 1

Muscular Actions, Sport Performance, and Plyometric Training

In this chapter, we discuss the three modes of muscle action—eccentric, isometric, and concentric action—and summarize how each type of muscle action contributes to optimal performance in sport activities. We also outline techniques for plyometric exercise that will help athletes capitalize on the synergistic effects of these muscle actions.

TYPES OF MUSCLE ACTIONS

Eccentric actions, which occur when the muscle lengthens under tension, are used to decelerate the body. Eccentric muscle actions are primarily associated with the loading phase of a plyometric exercise. For example, in a runner's stride, the impact of contacting the ground on a single foot requires the body's center of gravity to drop rapidly. The runner does not collapse at this moment because the leg muscles can respond with eccentric muscle action that slows and controls this lowering motion. Eccentric muscle actions absorb force and decelerate the joint segments in preparation for the transition into isometric and, ultimately, concentric muscle action. Because eccentric muscle action is capable of generating up to 40 percent greater force than the other types of muscle action, the ability to generate eccentric muscle force is critical to successful performance in many sports.

When a runner reaches midstride, the body comes to a complete but very brief halt with no observable movement at a particular joint (e.g., knee joint). This is characteristic of isometric muscle action, or a static position in which there is no muscle lengthening or shortening visible to the observer. In sport activities, this muscle action occurs in the brief instant between the eccentric action and the subsequent concentric action (in which the muscle fibers pull together and shorten). The athlete's timing and execution of the transition through this isometric coupling phase will strongly affect whether the athlete achieves increased power in the plyometric movement. (See chapter 2 for more information about the coupling phase.) To gain benefits from the stretch-shortening cycle, the athlete must be able to generate appropriate force and properly time the coupling phase with the concentric muscle action.

After the isometric coupling phase, the payoff of dynamic movement occurs during the unloading phase of the plyometric activity. In running, this phase of plyometric movement is associated with the concentric action that results in acceleration of the limb segments. Figure 1.1 shows each of the three phases—eccentric (loading), coupling, and concentric (unloading)—for an athlete performing a jump. The synergy of the muscles as they transition through each of these muscle actions (eccentric, isometric, concentric) is ultimately what determines the benefits gained from the stretch-shortening cycle.

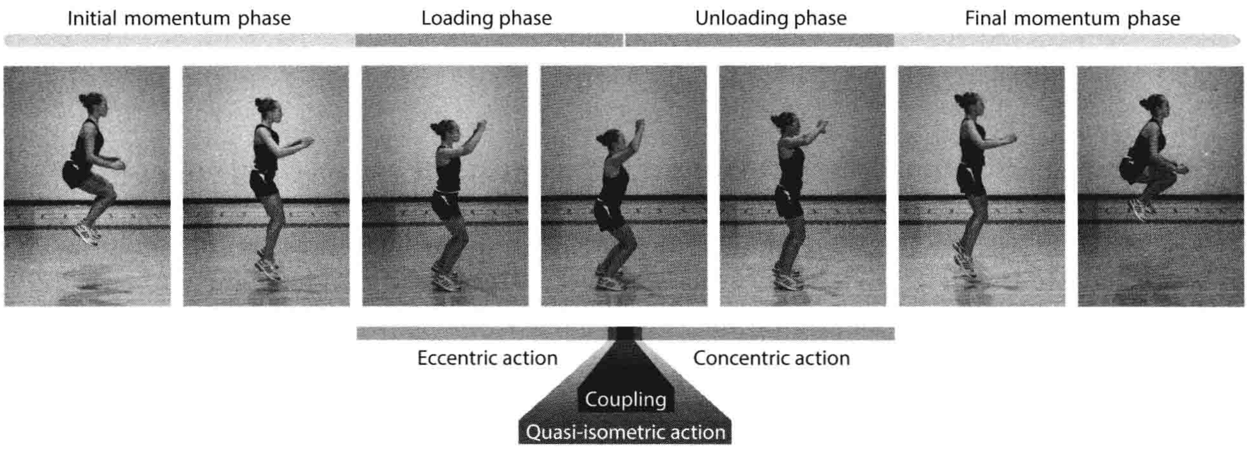

Figure 1.1 Muscle actions associated with each phase of a plyometric exercise.

The upcoming sections detail the relationship between muscular strength and the critical phases of plyometric exercise. These sections also identify techniques that can be used to target each mechanism for improved plyometric performance.

ECCENTRIC STRENGTH

The largest forces that muscles are capable of producing occur when an external force exceeds that produced by the muscle, forcing the muscle to lengthen. This is known as an *eccentric action* or *negative work*. An athlete who is running or jumping depends on eccentric actions of the lower extremities to dampen the forces when the body makes contact with the ground. If not for eccentric actions decelerating the body, the athlete would collapse to the ground every time he made foot contact. Muscles are structured so that they absorb and decelerate the body in a protective manner. In cases of rehabilitation from tendon and muscle injuries, eccentric actions are an integral part of the rehabilitation program; these actions should also be a major focus in the prevention of injuries. In strength training, eccentric-focused movements deserve the same attention to detail as concentric movements, although they may be a smaller component of total volume.

Eccentric muscle actions are the first stage of muscle work and involve the muscles acting as shock absorbers or springs; this is known as the loading phase of the plyometric movement. During the course of normal walking or running, the muscles in the lower extremities are collectively doing nearly equal amounts of eccentric (lengthening) and concentric (shortening) work. This dynamic balance between muscle actions can be seen when examining the stretch-shortening cycle (SSC) and its role in improving performance. (See chapter 2 for more information on the SSC.) The first phase (stretch or loading phase) of the SSC comes as the muscle lengthens in response to an increased load being placed on it. The load might be produced by gravity and the individual's body weight as he makes contact with the ground. As this occurs, elastic energy is produced within the muscle and may be stored for a very short period of time. If the eccentric action immediately precedes a concentric action, the muscles will stop acting as shock absorbers and will perform as if they were springs. However, if the time between the eccentric and concentric actions is too long (i.e., the subsequent shortening of the muscle does not occur immediately), the energy will be dissipated as heat within the muscle.

The storage and recovery of elastic energy within the muscles during an SSC become an important factor in performance; the energy stored can actually increase force and power production in the subsequent shortening cycle. In effect, the muscles are made up of muscle fibers, tendons, and the respective fascial tissues. All of these tissues contribute to the spring properties of the muscle-tendon system that stores and recovers elastic energy during running and jumping.

Eccentric muscle actions are particularly useful in a training program for strength development. Because eccentric actions have the unique ability to develop much greater forces, they provide greater overload to the muscle compared to when the athlete emphasizes only concentric actions. This can have an important role in preventing the muscle wasting that occurs with aging or preventing the atrophy that occurs as a result of recovery from injury or surgery.

When forces are decelerated by a limb or body segment, the entire muscle-tendon system participates. If the forces needed to decelerate the body exceed the strength of the muscle-tendon system, this can result in injury to the muscle, the tendon, or the attachment of the tendon to the bone. Athletes who experience recurring hamstring or adductor strains have been shown to have an eccentric strength deficit as great as twice a normal limb. Eccentric resistance training may prevent injury to the muscle-tendon unit by improving the unit's ability to absorb more energy before failing. Eccentric strength building has also been associated with increased hypertrophy, positive changes at the cellular level that indicate increased strength at the myotendinous (muscle-tendon) junction, and production of increased collagen for reinforcement of the tissue.

Finally, the increase of bone and muscle mass is directly related to the magnitude of muscle forces and other loads (body weight) on bone. Therefore, the strength and density of bone are influenced positively when muscle strength is developed through resistance training and eventually through plyometric training.

Training isolated muscle actions during dynamic tasks is difficult because isolating specific muscle actions can be a challenge. However, certain techniques can be used to focus on a particular muscular action at a joint. These types of exercises are often used in combination with technical instruction to help athletes improve their overall technical performance of plyometric exercise. To focus on eccentric strength in the lower extremities, an athlete could use exercises such as the assisted Russian hamstring curl (figure 1.2). Ultimately, athletes should progress from eccentric-focused exercise to speed-strength movements, but they can still employ specific plyometric movements that focus on the eccentric or loading phase, such as squat jumps (figure 1.3) or single-leg squats.

ASSISTED RUSSIAN HAMSTRING CURL

The trainer anchors the athlete by standing on the athlete's feet and provides lift assistance by using a strap that is attached around the athlete's chest (figure 1.2). The athlete performs the full eccentric (lowering) movement, getting assistance as needed to achieve the proper speed. At the end point of the movement, the athlete begins the concentric (raising) portion of the exercise; the trainer provides assistance in order to ensure the athlete's success with the movement.

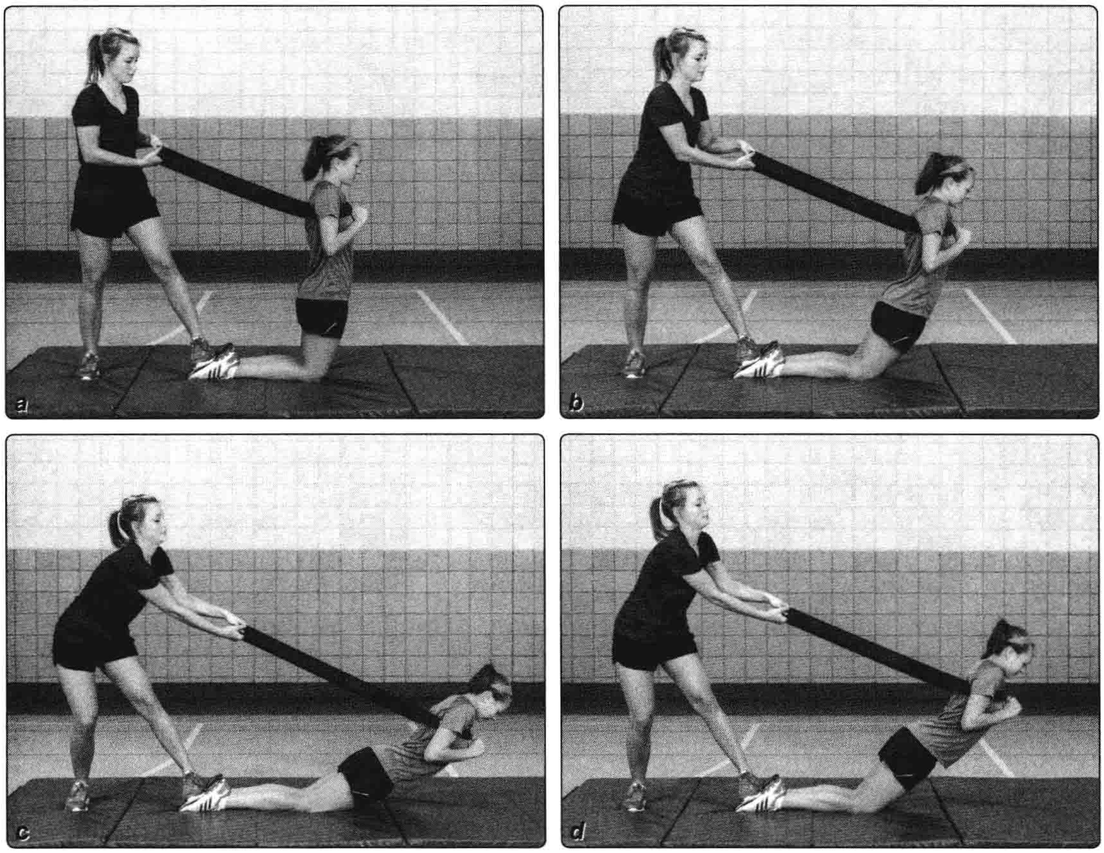

Figure 1.2 Assisted Russian hamstring curl: *(a)* start; *(b)* eccentric lowering; *(c)* bottom position; *(d)* concentric raising with assistance.

SQUAT JUMPS

For a squat jump, the athlete begins in the athletic position with feet flat on the mat and pointing straight ahead (figure 1.3). Focusing on the eccentric muscle action, the athlete drops into deep flexion of the knee, hip, and ankle, touching the floor (or mat) as close to the heels as possible and then takes off into a maximum vertical jump. The athlete jumps straight up vertically and reaches as high as possible. On landing, the athlete immediately returns to the starting position and repeats the jump.

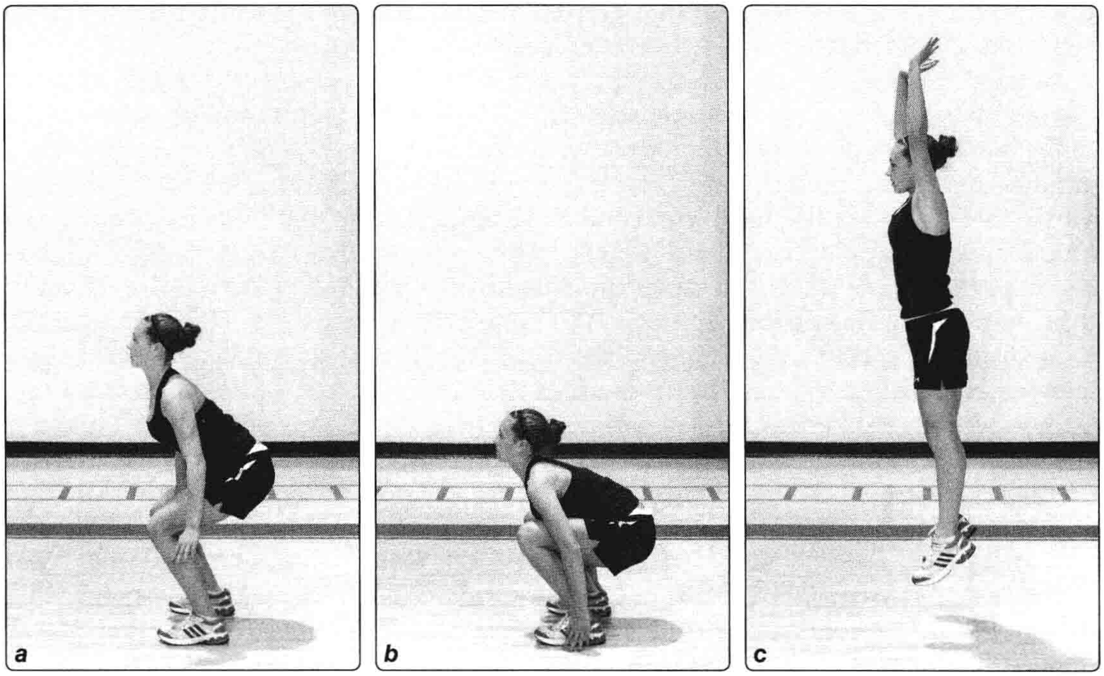

Figure 1.3 Squat jumps: *(a)* starting position; *(b)* deep flexion of the knee, hip, and ankle; *(c)* maximum vertical jump.

SINGLE-LEG SQUAT

The athlete places the heel of one foot on the back edge of a box or platform 12 to 24 inches (30 to 60 cm) tall and holds the other foot off the edge of the box. The athlete descends and slowly lowers his body until the knee on the box is fully flexed and the buttocks come to rest against the calf area of the supporting leg. The athlete then ascends at an accelerated rate until he achieves the standing starting position again. While lowering his body weight, the athlete should be mindful of keeping the knee over and in line with the second toe. The knee should not be allowed to collapse to the inside of the body, nor should it be substantially out in front of the toes. The athlete should be able to achieve 10 repetitions performed at a tempo of 8-2-2 (8-second descent, 2-second pause, and 2-second ascent). Although classified as a body weight exercise, this exercise is a definite challenge and goes a long way in helping an athlete develop eccentric strength within the lower extremity.

ISOMETRIC STRENGTH

Isometric or static muscle actions are defined as those in which no visible movement occurs; this is known as the coupling phase of a plyometric exercise. (Refer to figure 1.1 and see chapter 2 for more information about the coupling phase.) Even though studies indicate that muscle fibrils do move slightly during a static hold, the coupling phase is a point at which little or no observable joint movement occurs; thus, it is more of a quasi-isometric muscle action. In running or jumping, the coupling phase is the point at which the body "stops" for a very brief period. At this point, the joint is at a position that can be measured before the eccentric action is reversed and becomes the concentric or shortening muscle action.

In weightlifting, athletes often experience a "sticking" point within the range of motion that is difficult to overcome and may prevent them from moving the weight to the completion of a repetition. Most weightlifters know that performing isometric actions at a specific point during the exercise movement (most often the position at which the joint has the least mechanical advantage from the bony segments) can help train the muscle to deal with that specific angle or point in the range—and thus increase the lifter's ability to move the weight through that sticking point. In addition, research indicates that isometric strength is developed at specific points in the joint's range of motion; if other positions (mechanically disadvantaged positions) are ignored in training, strength in those areas will be lacking. For plyometric training, athletes can use specific exercise techniques to focus on improving their isometric strength. For example, figure 1.4 shows a single-leg balance exercise performed on an unstable surface. This exercise forces the athlete to focus on knee stabilizers and to primarily use isometric muscle action (along with a combination of eccentric and concentric corrective positioning). When athletes master this type of stabilization exercise, they can progress to more isometric-focused techniques associated with a plyometric movement, such as the single-leg hop and hold. (See the Stability Movement Progression for single-leg exercises in chapter 4.)

The brief period of static hold as the body switches from eccentric to concentric muscle actions is known in plyometric language as the *amortization phase*. This phase is brief indeed, less than .01 second in power-oriented athletes such as jumpers and sprinters. The ability to rapidly switch from an eccentric action to a concentric contracting phase is the hallmark of good athletes. The one thing we know about good athletes in general is that they don't spend a long time on the ground when running or jumping. These relatively brief ground contact times are directly related to the amortization phase of the athlete's movements.

Another way of thinking about the amortization phase is to relate it to its more traditional definition regarding a loan; the shorter the amortization phase (duration of time over which the loan is repaid), the more the borrower likes the loan. Similarly, the shorter the time that athletes spend on the ground, the more effective and faster they will be.

SINGLE-LEG BALANCE

Balance training drills are performed on a balance device that provides an unstable surface and allows the athlete to focus on the isometric hold position. The athlete stands upright on a BOSU (or other unstable device) on one leg and then bends the knee and hip of the supporting leg to achieve a low, athletic position (figure 1.4). The athlete should hold this position briefly before returning to the starting position. To optimize isometric muscle actions during balance training, athletes should focus on maintaining positions as close as possible to the athletic positions used in their sport. In addition, sport-specific actions involving implements—such as soccer kicks or ball tosses and catches to perturb the upper extremity—can be used to supplement balance training exercises.

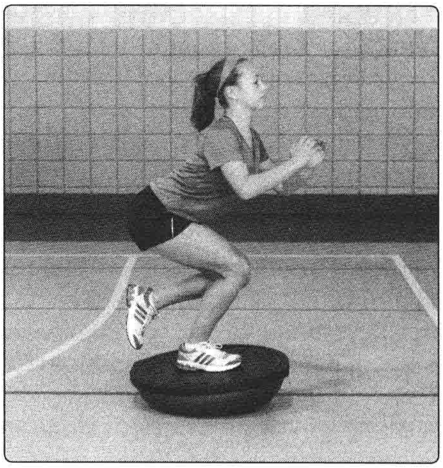

Figure 1.4 Hold position for the single-leg balance drill.

CONCENTRIC STRENGTH

Concentric strength is the "action" portion of the SSC and is the payoff during the unloading phase of a plyometric exercise. This is the result of the muscle fiber shortening after the kinetic energy has been stored by the eccentric loading of the body and after the body has switched from eccentric to concentric modes of muscle action. Now observers see how high or far the athlete jumps, how fast she turns the legs over (stride frequency), how much ground she covers (stride length), or how far she throws the ball. Though these actions are often impressive, keep in mind that all that beautiful flowing motion is the result of the athlete firmly investing in the body's ability to absorb kinetic energy via muscle-lengthening actions under heavy loads. Think of the eccentric and isometric phases as an investment in the bank of physical performance, and think of the concentric action as the return on that investment.

Athletes can train specifically for concentric strength by using a variety of resistance training methods, including medicine ball training (figure 1.5). Ultimately, concentric-focused training should be progressed to link with the other muscle actions so that the athlete learns to capitalize on the payoff portion of plyometric training. However, the use of appropriate plyometric exercises (e.g., wall jumps; figure 1.6) that minimize the loading and coupling phases will allow the athlete to focus on the concentric portions of the movement.

BACKWARD THROW FROM SQUAT

The athlete holds a medicine ball with both hands in front at the waist and stands about 10 feet (3 meters) in front of a partner; both partners are facing the same direction. The athlete drops rapidly into a squat position with the medicine ball between the legs (figure 1.5*a*). After achieving a one-quarter to one-half squat position, the athlete reverses the drop, explodes vertically upward, and uses both hands to direct the medicine ball on a flight path over the head at an angle of about 45 degrees (figure 1.5*b*). The athlete should be careful to bend the knees, bend from the hips, and keep the back straight. Keeping the back straight means the lumbar spine and hips are locked and the torso is slightly inclined, not perfectly vertical to the ground. Locking the spine in slight extension will result in the spine being held straight. This is a maximal effort, and the athlete can be expected to leave the ground slightly at the point at which the medicine ball is released. Thus, the athlete should be prepared to recover to the starting position after the release of the ball. The athlete may also throw the ball against a wall (concrete or cinder block) or may throw it for distance. This exercise has secondary benefits such as improving muscular endurance and body coordination.

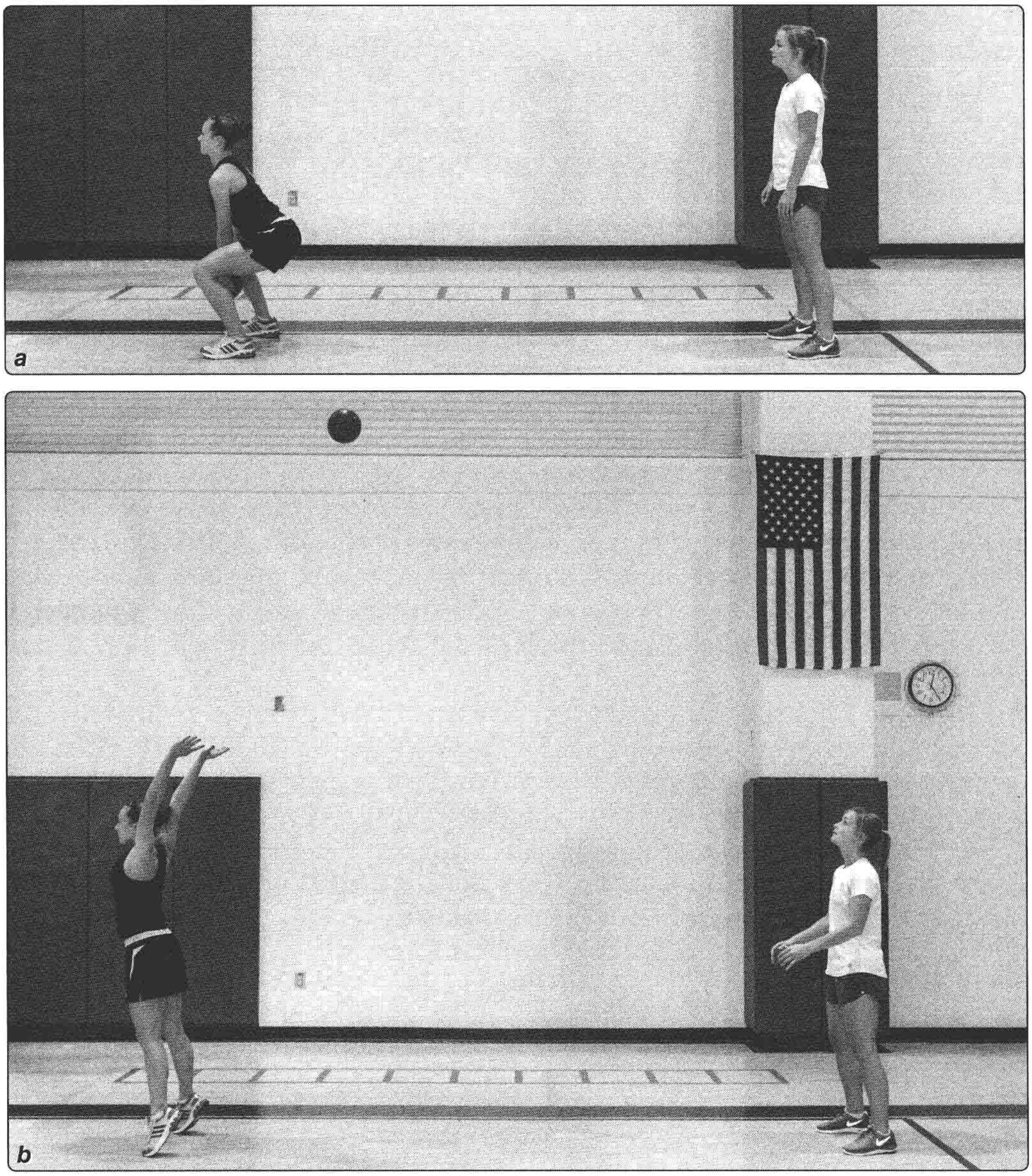

Figure 1.5 Backward throw from squat: *(a)* squat position; *(b)* release.

WALL JUMPS

The athlete stands erect with the arms semi-extended overhead. This vertical jump requires minimal knee flexion. The gastrocnemius muscles should create the vertical height. The arms should extend fully at the top of the jump (figure 1.6). This jump can be used as a warm-up or as a teaching exercise because this relatively low-intensity movement can reveal abnormal knee motion in athletes with poor side-to-side knee control.

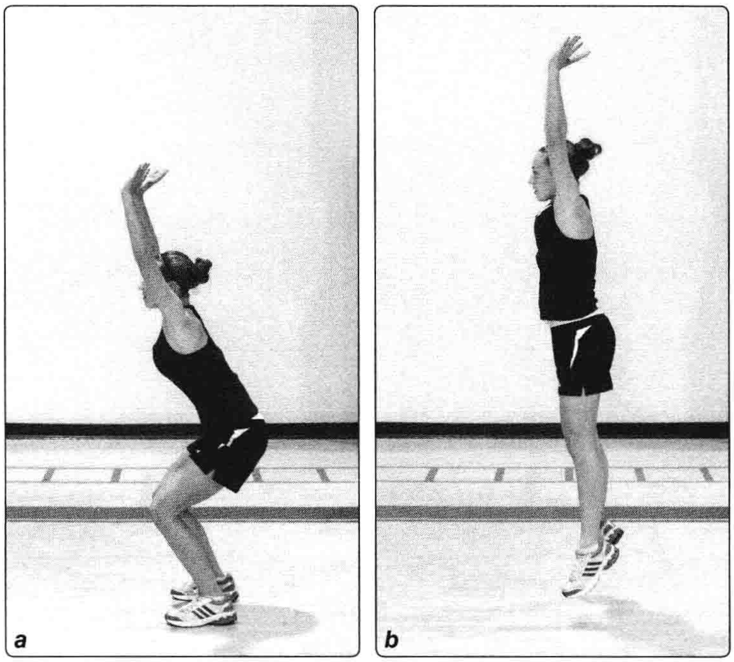

Figure 1.6 Wall jumps: *(a)* start; *(b)* jump.

SUMMARY

- The three types of muscular action are eccentric, isometric, and concentric.
- Eccentric actions, which occur when the muscle lengthens under tension, are used to decelerate the body and are associated with the loading phase of plyometric movements.
- During the coupling phase of a plyometric exercise, the body comes to a complete but brief halt with no observable movement at a particular joint. This is characteristic of isometric muscle action. During this static position, there is no muscle shortening or visible change in the angle of the joint.
- The payoff of plyometric movement occurs during the unloading phase of the plyometric activity. This phase is associated with the concentric muscle action that results in acceleration of the limb segments.
- Training with plyometric exercise can help athletes capitalize on the synergistic effects of each muscle action.