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Landing Mechanics: What, Why, and When

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Over the years, athletes have learned to jump higher with the help of plyometrics and strength training for the lower body. However, we have fallen behind in teaching the landing portion of the jumping movement. Of course, working on landing technique is not as fun as seeing how high we can jump, but it is just as, if not more, important than the concentric (upward) motion of jumping.

What Exactly Does This Mean?

Basically, we are looking at how effectively an athlete loads and absorbs force as they descend from a jumping movement, while putting themselves in a prime position to re-initiate running and jumping movements. The vast majority of athletes will naturally land stiff legged in a very rigid manner. As a result, all of the impact is absorbed between the hip, knee, and ankle joints. It is much more advantageous for athletes to land softly and transfer their force to the glutes, hamstrings, quads, and calf musculature.

One of the recent points of discussion in strength and conditioning communities is athletes who are quad dominant v. glute dominate. Quad dominant athletes tend to use their quads to shift their weight forward with squatting and jumping movements. This not only transfers a lot of pressure to the front of the knee, but puts a large load on the anterior cruciate ligament (ACL) (4). It is important to realize that the quads are at a mechanical disadvantage when compared to the glutes, making quad dominant athletes less explosive and less likely to succeed in speed and power sports. In figure 1, you will see an athlete who is squatting in a quad dominant pattern. Conversely, figure 2 shows an athlete who is much more glute dominant. Notice the shift posteriorly with the athlete's weight on their heels.

When landing and jumping, we want to utilize this glute dominant position. We know that to maximize jumping, we need the "triple extension" of hip exten-

sion, knee extension, and ankle plantar flexion. That is, with the legs completely straightened and toes pointed. When an athlete uses their quadriceps muscles as a primary source of movement (quad dominant), they have difficulty getting a full hip extension and appear as though they are always sticking their rear out (figure 3). This position robs them of valuable power production as the glutes are the most powerful muscle group of the lower extremity.

Why Are Landing Mechanics Important?

There are two main reasons for focusing on how athletes land: injury prevention and power production. Both are equally important for athletes of all ages, levels, and positions.

All athletes expose themselves to lower body injuries ranging from ankle sprains to low back pain; osteoarthritis to fractures; and probably the most feared, the ACL tear. Recurrent hard landings will lead to premature wear and degeneration of the ankle, knee, and hip joints. These frequent jolts of the lower extremity transfer force up the kinetic chain at a rate much higher than that which the body normally experiences during activity. Learning to land softly, without noise and slowly decelerating the weight of the body will significantly lower the impact forces, decrease the risk of injury, and extend the life of joints.

The other major concern related to poor landing techniques is the ACL tear. The most common position for an athlete tearing the ACL is foot pronation, tibial internal rotation, and a valgus position of the knee (1). In other words, the foot flattens out, and the lower leg rotates inward, while the knee collapses towards the body's midline. For our athletes (especially female) who have weak muscles of the outer hips and poor muscular control of their lower body, this position may be common while attempting to decelerate the body (Figure 4)(2).



FIGURE 1: A quad dominant squatting position



FIGURE 2: A glute dominant squatting position



FIGURE 3: Quad dominant jump without hip extension

This is why most non-contact ACL tears happen while slowing the body down to change direction.

The ACL is unloaded with proper landing mechanics when the athlete loads the glutes upon landing. When you look at the role of the ACL in the knee, its primary role is to prevent the tibia (shin bone) of the lower leg from sliding forward during movement. When we look deeper into the biomechanics of the human body, we see that the hamstrings originate at the lower pelvis, and end on the back of the bones of the lower leg. When they fire (shorten) in conjunction with the glutes upon deceleration of the body, they pull the lower leg back into the knee joint and unload the ACL.

As touched on earlier, landing mechanics are extremely important for power production during sports. If an athlete does not land and decelerate themselves with their weight distributed over their entire foot and their glutes firing, they will be in a poor position to reinitiate explosive jumping or sprinting movements. Many times in sports, athletes are expected to jump multiple times in a row and/or combine jumping with sprinting movements. Athletes must learn to not only initiate the first jumping movement in an advantageous position but also land in the correct position to initiate the next movement.

When Should You Work On Landing Mechanics?

The answer is simple, everyday. Everyday that athletes train in our facilities, we are addressing this issue. Many times we teach it with a simple box jump (Figure 5). Sometimes we work on it specifically with single leg lateral bounds, teaching them to land softly and hold for three seconds before initiating the next movement. We may also choose to combine it with traditional plyometric jumping drills by performing multiple hops for quickness (enhancing the stretch reflex) finished by a soft, glute dominated landing. But, even when we are not specifically teaching the landing mechanics, it should always be in an athlete's mind with every ballistic movement they perform.

The last concern that most people have is whether or not athletes can take this concept into their sport and perform it at game speed. Keep in mind that the neuromuscular system is very active during sporting activities. Research tells us that it takes three to six weeks for athletes to fully learn new movement patterns. During this stage of motor learning, the nervous system is working very hard to perform the activity. Once the movement is successfully mastered, the body creates specific motor programs that become rather permanent fixtures within our

neuromuscular system (3). So, once an athlete has learned the basics of landing, their body will be very likely to apply at least portions of the motor programs whenever possible. Even when an athlete comes down in an awkward position, they will be much more likely to initiate their glutes and land more softly than before.

The key points in teaching landing technique are:

- Land as softly as possible, making no noise when the feet come in contact with the surface (“absorb force with your muscles, not your joints”).
- Land flat footed, keeping weight evenly distributed over the entire foot.
- Shift the glutes back and keep the knees behind the toes (“butt out”).

An athlete should start their basic landing technique training with one to two exercises, two to three times per week. Keep the sets and repetitions fairly basic (two to three sets of six to ten repetitions) as this should be considered an accessory exercise. It should be performed early in the workout, after a quality dynamic warmup and prior to the strength portion of your training.

Jumping and landing training are highly demanding on the nervous system. Thus, the body must be warm enough to perform the ex-



FIGURE 4: Single leg landing in poor positioning



FIGURE 5: Finish position of the Box Jump—Emphasize Landing

ercises efficiently, but not too fatigued to allow for proper motor learning to take place. Once an athlete has mastered the basics of landing, only general daily maintenance (one exercise, two times per week, two sets of six to ten repetitions) is required to keep them injury free and very explosive. ■

¹ Arnheim DD, Prentice WE. Principles of Athletic Training, 8th Edition: 558 – 561. 1993.

² Claiborne TL, Armstrong CW, Gandhi V, Pincivero DM (2006). Relationship between hip and knee strength and knee valgus during a single leg squat. *Journal of Applied Biomechanics*, 22(1):41 – 50. 2006.

³ Hammett JB, Hey WT. Neuromuscular adaptation to short-term (4 weeks) ballistic training in trained high school athletes. *Journal of Strength and Conditioning Research*, 17(3):556 – 560. 2003.

⁴ Wilthrow TJ, Huston LJ, Wojtys EM, Ashton-Miller JA. The relationship between quadriceps muscle force, knee flexion, and anterior cruciate ligament strain in an in vitro simulated jump landing. *American Journal of Sports Medicine*, 34(2):269 – 274. 2005.

Lower Extremity Triple Extensors

Exercise	Primary Movers
Box Jumps-Emphasize Landing	Start with feet flat facing a box. Perform a concentric box jump, landing as softly as possible with full foot flat upon landing on the box. Step down off of the box. Start with 12" box and progress to higher boxes to challenge an athlete's explosiveness.
Jump, Jump, Squat	Perform two jumps consecutively in place. The second jump should finish with a soft landing in a glute dominant squatting position (thus jump, jump, squat) holding for 3 seconds.
Single Leg Lateral Jumps	Start on one leg and bound laterally, landing on the opposing foot. Athlete should land with hip, knee, and ankle in neutral position. Athlete should look for good hang time (not necessarily jumping for distance or height, but hang time).
Broad Jumps-Emphasize	Jump concentrically off of two feet, landing as softly as possible in a good position with feet flat. Walk back to the starting position before repeating.
Single Leg Box Step Offs	Start standing on a box on both feet. Step off of the box with one foot, landing on the ground in a good position, absorbing force. Start with 6" box and progress to a box as the athlete develops eccentric strength and ability to absorb forces.
Stair Step Jumps	Utilize two different sized boxes (i.e. 12" and 36" box). Start on the ground facing the short box with the taller box behind it. Jump concentrically onto the small box. Quickly and explosively jump off of small box spending as little time as possible before landing softly in a good position on the tall box. Applies the concept of the depth jump, but in a safer and less demanding exercise.
Single Leg Box Jumps-Emphasize Landing	Same as the box jumps above, but with a single leg landing. Jump off of two feet, but land on one.
Single Leg Jump, Jump, Squat	Same as the broad Jump-Emphasize landing above, but on a single leg.
Depth Jumps	The classic plyometrics exercise of stepping off of a small box, jumping quickly and explosively off of the floor before landing softly in a good position on a larger box. Should only be performed with athletes who possess a good strength base.
Jumping Course	Combine a variety of jumping over obstacles, with rotation, onto boxes, etc. with landing softly to challenge the athlete and replicate the demands of the sport.

Table 1

Exercise progression of jumping movements (easiest to hardest) to work on proper landing mechanics.