

## The Physiology of Plyometrics

Plyometrics refers to exercise that enables a muscle to reach maximum force in the shortest possible time. The muscle is loaded with an eccentric (lengthening) action, followed immediately by a concentric (shortening) action.

This article outlines the physiology behind how and why plyometrics works. It also examines the research that demonstrates why, as a form of power training, plyometric training is very effective.

Practical guidelines for designing a plyometric training program along with animated drills can be found in the main plyometric training section

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### How Plyometric Exercises Work

A muscle that is stretched before a concentric contraction, will contract more forcefully and more rapidly. A classic example is a "dip" just prior to a vertical jump. By lowering the center of gravity quickly, the muscles involved in the jump are momentarily stretched producing a more powerful movement. But why does this occur? Two models have been proposed to explain this phenomenon. The first is the...

#### **Mechanical Model**

In this model, elastic energy is created in the muscles and tendons and stored as a result of a rapid stretch. This stored energy is then released when the stretch is followed **immediately** by a concentric muscle action. According to Hill the effect is like that of stretching a spring, which wants to return to its natural length. The spring in this case is a component of the muscles and tendons called the **series elastic component**. The second model is the...

#### **Neurophysical Model**

When a quick stretch is detected in the muscles, an involuntary, protective response occurs to prevent overstretching and injury. This response is

known as the **stretch reflex**. The stretch reflex increases the activity in the muscles undergoing the stretch or eccentric muscle action, allowing it to act much more forcefully. The result is a powerful braking effect and the potential for a powerful concentric muscle action.

If the concentric muscle action does not occur immediately after the pre-stretch, the potential energy produced by the stretch reflex response is lost. (i.e. if there is a delay between dipping down and then jumping up, the effect of the counter-dip is lost).

It is thought that both the mechanical model (series elastic component) and the neurophysical model (stretch reflex) increase the rate of force production during plyometrics exercises.

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### **The Stretch-Shortening Cycle**

All plyometric movements involve **three** phases. The first phase is the pre-stretch or eccentric muscle action. Here, elastic energy is generated and stored.

The second phase is the time between the end of the pre-stretch and the start of the concentric muscle action. This brief transition period from stretching to contracting is known as the **amortization** phase. The shorter this phase is, the more powerful the subsequent muscle contraction will be.

The third and final phase is the actual muscle contraction. In practice, this is the movement the athlete desires – the powerful jump or throw.

This sequence of three phases is called the **stretch-shortening cycle**. In fact, plyometrics could also be called stretch-shortening cycle exercises.

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## **How to Increase Your Vertical Jump**

One very quick and simple way to demonstrate the effect of the stretch-shortening cycle is to perform two vertical jumps. During the first vertical jump the athlete bends the knees and hips (eccentric muscle action or pre-stretch) and holds the semi-squat position for 3-5 seconds before jumping up vertically (concentric contraction) as high as possible. The 3-5 second delay increases the amortization phase.

On the second jump the athlete bends the knees and hips to the same degree but immediately jumps up without a delay. This keeps the amortization phase to a minimum and makes best use of the stored elastic energy. The second jump will be higher.

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## **Is Plyometric Training Really That Effective?**

By making use of the stretch-shortening cycle, movements can be made more powerful and explosive. Plyometrics is simply a set of drills designed to stimulate the series elastic component over and over again – preferably during movements that mimic those of the athlete's sport. But what long-term effect does practising plyometrics have on the body and performance?

A wide variety of training studies shows that plyometrics can improve performance in vertical jumping, long jumping, sprinting and sprint cycling. It appears also that a relatively small amount of plyometric training is required to improve performance in these tasks. Just one or two types of plyometric exercise completed 1-3 times a week for 6-12 weeks can significantly improve motor performance. Additionally, only a small amount of volume is required to bring about these positive changes i.e. 2-4 sets of 10 repetitions per session or 4 sets of 8 repetitions.

While upper body plyometrics has received less attention, three sessions of plyometric push ups a week has been shown to increase upper body power as measured by medicine ball throws.

Using a variety of plyometric exercises such as depth jumps, counter-movement jumps, leg bounding and hopping etc., can improve motor performance. While the majority of studies have focused on untrained subjects, trained athletes such as soccer and basketball players have improved their performance with plyometrics.

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### **Plyometric Exercise Intensity**

Not all plyometric exercises are equal in intensity. Skipping exercises for example, are relatively light while single leg bounds and depth jumps are the most intense. A program should progress gradually from lower intensity drills to more advanced plyometric exercises – particularly in an individual with less strength training experience.

The number of plyometric exercises is typically kept to a minimum also. A typical session may contain only two or three lower body plyometric exercises interspersed with upper body plyometric drills if they're appropriate for that sport.

Correct exercise selection is **essential!** While there are many plyometric exercises below only a few will be suitable for any one particular sport or event. Again, for all the details on exercise selection, sets, repetitions, rest intervals and so on, see this plyometric training article.

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### **Lower Body Plyometric Exercises (Low Intensity)**

#### **Squat Jumps**

1. Stand with feet shoulder-width apart, trunk flexed forward slightly with back straight in a neutral position.
2. Arms should be in the "ready" position with elbows flexed at approximately 90°.
3. Lower body where thighs are parallel to ground and immediately explode upwards vertically and drive arms up. Do not hold a squat position before

jumping up – keep the time between dipping down and jumping up to a minimum.

4. Land on both feet. Rest for 1-2 seconds and repeat

Prior to takeoff extend the ankles to their maximum range (full plantar flexion) to ensure proper mechanics.

### **Jump to Box**

1. Stand facing box with feet slightly wider than hip-width apart.

2. Lower body into a semi-squat position and immediately jump up onto box. Do not hold a squat position before jumping up – keep the time between dipping down and jumping up to a minimum.

3. Feet should land softly on box. Step back down (not jump back down) and repeat.

### **Lateral Jump to Box**

1. Stand side on to box with feet slightly wider than hip-width apart.

2. Lower body into a semi-squat position and jump up onto box. Do not hold a squat position before jumping up – keep the time between dipping down and jumping up to a minimum.

3. Feet should land softly on box. Step back down (not jump back down) and repeat.

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## **Lower Body Plyometric Exercises (Moderate Intensity)**

### **Split Squat Jumps**

1. Stand with feet hip width apart. Take left leg and step back approximately 2 feet standing on the ball of back foot.

2. Feet should be positioned at a staggered stance with head and back erect and straight in a neutral position.

3. Lower body by bending at right hip and knee until thigh is parallel to floor then immediately explode vertically.

4. Switch feet in the air so that the back foot lands forward and vice versa.

Prior to takeoff extend the ankles to their maximum range (full plantar flexion) ensure proper mechanics.

### **Tuck Jumps**

1. Stand with feet shoulder-width apart, knees slightly bent, with arms at sides.
2. Jump up bringing knees up to chest.
3. Land on balls of feet and repeat immediately.
4. Remember to reduce ground contact time by landing soft on feet and springing into air.

### **Lateral Box Push Offs**

1. Stand to side of box and place the left foot on top of box.
2. Push off the box using the left leg only and explode vertically as high as possible. Drive the arms forward and up for maximum height.
3. Land with right foot on the box and left foot on the ground to the other side of the box.
4. Repeat from this side.

### **Bounding**

1. Jog into the start of the drill for forward momentum.
2. After a few feet, forcefully push off with the left foot and bring the leg forward. At same time drive your right arm forward.
3. Repeat with other leg and arm
4. This exercise is an exaggerated running motion focusing on foot push-off and air time.

### **Bounding with Rings**

1. Jog into the start of the drill for forward momentum.
2. After a few feet, forcefully push off with the left foot and bring the right leg forward. At same time swing left arm forward and land into the first ring,

which is 3-4 feet out and to the left, with the right foot.

3. Continue and repeat with other leg and arm into the second ring, which is now 3-4 feet up and to the right.
4. This exercise is an exaggerated running motion focusing on foot push-off and air time.

### **Box Drill with Rings**

1. Stand with feet slightly wider than hip-width apart with your body facing the first ring.
  2. Hop forward using both feet and land in first ring.
  3. Now hop to the left and land in the ring to the side. Now jump backwards to land in ring behind you. Finish by jumping to your right to land in final ring.
  4. Rest and repeat. Remember to keep ground contact time between bounds to a minimum.
- Hurdle Jumps

### **Lateral Hurdle Jumps**

1. Stand beside object to be cleared.
2. Bring knees up and jump vertically but also laterally off ground and over the barrier.
3. Land on both feet and immediately jump the other direction over barrier.
4. Try not to pause between jumps or sink down into a squat position

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## **Lower Body Plyometric Exercises (High Intensity)**

### **Zigzag Hops**

1. Stand to the left of an agility ladder or similar object approximately 1-2 feet away.
2. Forcefully push off both feet and land the on the other side of the ladder.
3. Repeat and land feet back on the other side, continue repeating and so on down the ladder.
4. Do not "double hop" upon each landing and keep ground contact time to a minimum.

### **Single Leg Tuck Jump**

This is the same as the tuck jump exercise above only one leg is used. Upon landing another jump is performed immediately with minimal ground contact time and with the same leg for the desired number of repetitions. This is repeated for the other leg after a rest period. Single leg plyometric exercises are typically more advanced and require greater strength and balance. They are suitable for sports where a takeoff is completed on one leg.

### **Single Leg Lateral Hops**

1. Start by standing on one leg with your hands on your waist or at your sides.
2. Proceed to hop to the side while maintaining your balance and hop back to the starting position.
3. You can place a rope on the ground or any object on the ground. The object can be small in size and height or large to increase difficulty.
4. Repeat continuously.

### **Depth Jumps**

1. Stand on box with toes close to edge, feet shoulder width apart.
2. Step off (do not jump off) box and land on both feet. Immediately jump up as high as possible and reach up with both hands towards. The jump should be vertical with no horizontal movement.
4. Ground contact time should be short unlike in the diagram. Landing should be soft. **Note:** Start with a box height of 30cm (12in). Intensity can be increased by gradually increasing the box height to a maximum of 107cm (42in) but this is only for experienced athletes with a substantial strength training background.