

Plyometrics – An Overview

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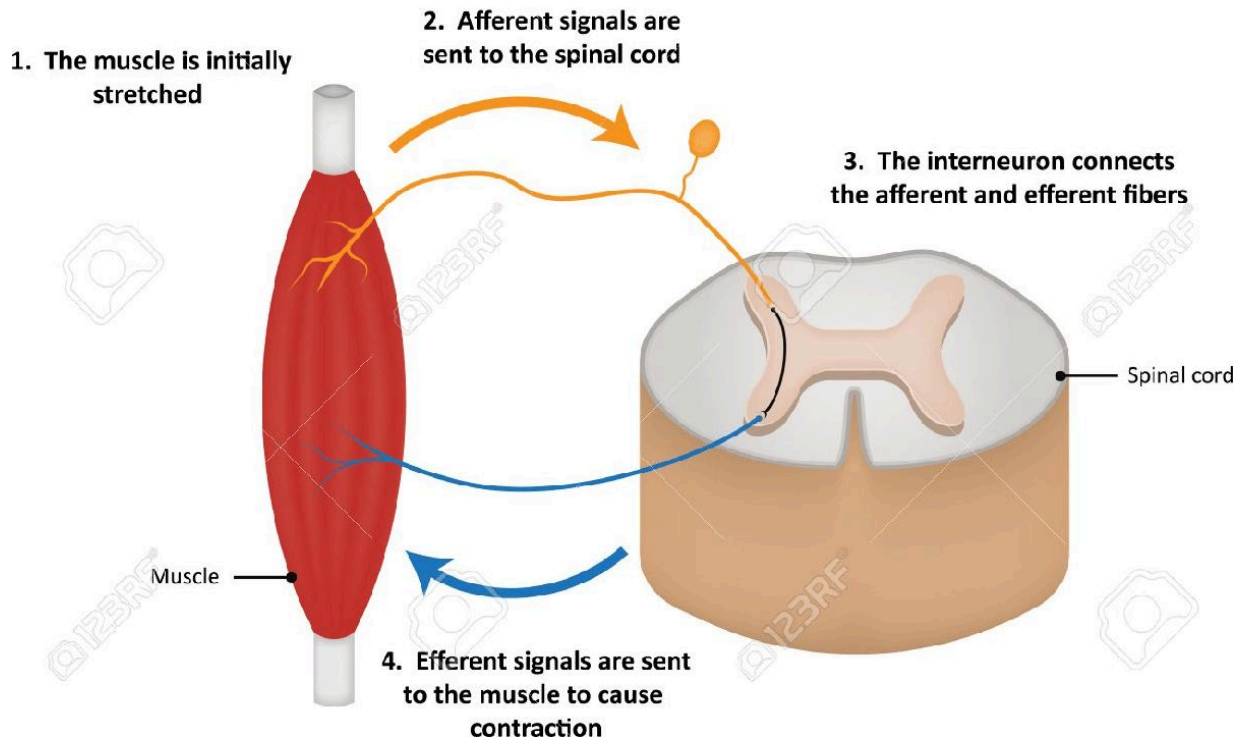


Plyometrics - Introduction

This is another of my older articles that still seems to be quite relevant in today's confusing training environment.

Plyometrics is a popular training technique used by many coaches today. It has been touted as a way to bridge the gap between sheer strength and power. The term plyometrics can be used to describe any exercise that allows the athletes to take advantage of the stretch-shortening cycle to produce an explosive movement. Although plyometric training has been around for many years, there is still debate on its effectiveness and safety. This review seeks to cover relevant information on plyometric training so that its value can be assessed as a training technique.

The Stretch Reflex

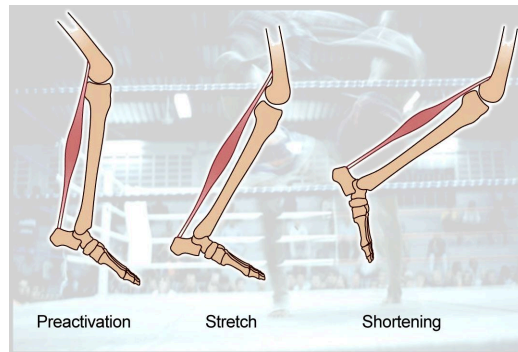


The Stretch Reflex

Knowledge of how the stretch reflex is used is essential to being able to understand how plyometrics work. The stretch reflex causes the muscle to contract when it is stretched and inhibits the antagonist muscle from contracting. It is this reflex which causes the quadriceps muscle to contract when the patellar tendon is hit by a rubber mallet.

The hitting of the tendon causes the quadriceps to stretch which results in activation of the sensory spindle receptors in the muscle. The spindle receptors which lie in the body of the muscle are sensitive not only to the muscle being stretched, but also the speed at which the muscle is stretched. The message that the quadriceps is being lengthened is sent to the spinal cord via a one synaptic junction which causes the motor horn cells in the spinal cord to act on this information. In order to protect the muscle from being over stretched, the motor horn cells react by contracting the muscle that is being stretched (quadriceps) and the inhibiting the contraction of the antagonist (hamstring) muscle (Chu 1983).

Stretch-Shorten Cycle For Sport



The stretch reflex is utilized during many activities because most movements involve two phases of muscular contraction. An eccentric phase which is the muscle lengthening under tension is followed by a concentric phase in which the muscle is shortened. Attaining a pre-stretch of the muscle causes it to be lengthened eccentrically so tension is developed in the muscle like a Rubber band. The tension created in the muscle can be used to help increase the strength of the following concentric contraction. The concentric contraction must take place immediately after being stretched or the tension created dissipates as heat (Wilk 1993). An example would be bending down before jumping which allows the quadriceps to be stretched eccentrically so that the following concentric contraction will be stronger. Taking advantage of the elasticity of the muscle and the stretch reflex is referred to as using the stretch shorten cycle (Bosco et al 1981). It has been shown that the faster the muscle is stretched eccentrically, the greater the force will be on the following concentric contraction (Bosco et al 1980).

History Of The Stretch-Shorten Cycle

During the 1960s, Professor Rodolfo Margaria of Milan was the first to identify the value of the pre-stretch in producing a strong muscular contraction. Margaria's work looked at muscular movement as a whole. Based on this work, a length tension diagram of the working muscle was developed. This allowed for the comparison of the tension in a muscle that had been pre-stretched and one that had not been pre-stretched. Margaria was able to show that the tension a muscle was able to create was based not only on the muscle length, but also on the previous activity of the muscle. Muscles were able to develop more tension if pre-stretched. The amount of tension created by stretching the muscle was dependent on the degree and the speed of the muscles' prestretch. This research was used by NASA to develop the most effective way to walk on the moon (Zanon 1989).

Stretch Reflex To Plyometrics



Margaria's work was not only used by NASA, but also by Soviet researchers who were assigned the task of improving the motor performances in athletes. In 1966, V.M. Zaciorskij used the work done by Margaria as the basis of promoting training programs that involved using the stretch reflex. He referred to this type of training as plyometric which is Greek. It comes from two words meaning greater, longer, wider and to measure, to appraise, to compare. He used this term to describe the greater tension that could be developed in muscles when a quick stretching phase is followed by a fast contraction (Zannon 1989).

There are two types of Plyometric muscle contraction - Short & Long SSC.

Soviet Development Of The Use of Plyometrics



In 1966 Yuri Verkhoshanski a Soviet jumping coach wrote about the importance of finding a new way of bringing about sporting improvements. Previous training methods that included a high volume of jumping exercises combined with weight training were becoming less effective in bringing about improvements in athletes. In looking at triple jumpers, Verkhoshanski observed that those jumpers that spent the least amount of ground contact time (amortisation phase) showed the greatest jumping performance. He reasoned that optimal jumping performance needs muscles to be strong eccentrically so that they can withstand the high mechanical loading in the phase of amortisation. If muscles are strong eccentrically, they will be able to quickly switch from overcoming the eccentric loading to immediately contracting concentrically to accelerate the body in the required direction. This will allow the athlete to take advantage of the tension in the muscle

that is created during the eccentric stretch. Thus improvements can be made in jumping performance by increasing the amount of tension the athlete can generate during the eccentric contraction and by improving the reactive ability of muscles in switching from eccentric to concentric work (Verkhoshanski 1966).

Soviet Way Of Implementing Plyometrics

Verkhoshanski believed the jumping of athletes should be developed in three stages. The first stage consists of general developmental strength and jumping exercises. Lower leg exercises described by Dr. Gunter Fritzsche to develop leg power in young athletes would be applicable for this stage (Jarver 1981). The second stage should involve continued plyometric work with increased resistance training to prepare the athlete for the increased muscle loading. The third stage involves the athlete increasing the reactive ability of the neuromuscular system. This would consist of using more stressful plyometric exercises that would help facilitate an increase in reactive ability (Verkhoshanski 1966).

Depth Jumping



Verkhoshanski developed a plyometric exercise referred to as depth jumping. He wanted an exercise that not only strengthened the muscle, but also developed the reactive ability needed to decrease the amortisation phase. Verkhoshanski explained that resistance training improves strength but slows down the reactive ability of the muscle to switch from eccentric to concentric work during the amortisation phase. To prevent this, he created depth jumping in which an athlete jumps from a predetermined height and upon landing, quickly jumps upwards or forward. This exercise not only demands dynamic strength to withstand the landing, but also develops the reactive ability of muscle to switch from eccentric work to concentric work (Verhoshanski 1966).

Performing Depth Jumps

In 1967 Verkhoshanski wrote an article detailing how depth jumps should be employed in a training program. He stressed that their use should be in developing the reactive ability and dynamic strength in athletes. He suggested that depth jumps should be performed from a height of .75 to 1.15 metres. Depth jumps from .75 metres height allows the athlete to develop his maximal reactive ability, whereas jumping from 1.15 metres develops more dynamic strength in the athlete. He stressed that using a height greater than 1.15 makes depth jumping ineffective. The increased height changes the landing mechanism so neither dynamic strength nor reactive ability is gained. The number of repetitions of depth jump to be performed depends on the preparation and strength of the athlete. He recommends for the prepared athlete, two depth jumping sessions a week, with a maximum of 40 repetitions per session (Verhoshanski 1967). Poole and Maneval (1987) also found

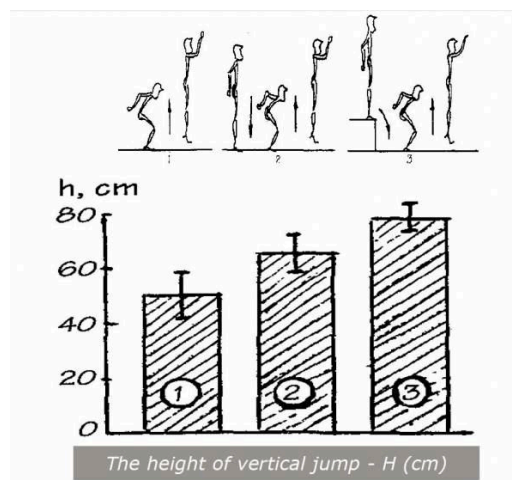
that two sessions per week were more effective than three sessions. Depth jumps should be discontinued ten to fourteen days prior to competition. This is because the after-effects of depth jumping last significantly longer than any other type of strength exercises. Verkhoshanski recommended that the use of depth jumping should be at the end of the strength development period or at the end of the preparatory period of training (Verkhoshanski 1967).

Introduction Of Plyometrics To The USA



Fred Wilt (1975) was the first to write about the use of plyometrics in the United States. He introduced plyometrics as a training technique used by European coaches to bridge the gap between sheer strength and speed. He went on to suggest that the unexpected victory in the 100 and 200 metre sprints by Valery Borozov was due in large part to his plyometric training routine. This article led to the wide spread use of plyometrics in the United States. It also led to a heated debate as to the effectiveness of plyometrics for improving athletic performance.

The Effectiveness of Depth Jumping



There have been several studies looking at the effectiveness at depth jumping in developing lower leg power. These studies have brought about mixed results. The study done by Verkhoshanski and Tatyana (1983) showed that athletes achieved a significant difference in absolute, explosive, and starting muscle strength when they trained using depth jumps. Athletes in the groups that used resistance training and speed strength work did not achieve a significant difference in performance. Blantner and Noble (1979) compared depth jumping and isokinetic training to see if either would have an effect on vertical jump. Both groups showed a significant improvement in vertical jump but neither training method was shown to be more effective than the other. Scoles (1978) found that depth jumping two times a week from a height of .75 metres had no significant difference on his subjects' standing long jump or vertical jump tests. Brown (et al 1986) found that

depth jumping resulted in a significant improvement in male high school basketball players vertical jump. Poole and Maneval (1987) also found that a ten week program of depth jumping significantly improved performance. A major limitation of the above studies, except for Brown (et al 1987), was the athletic ability of the subjects. Most of the subjects were either novices or had limited athletic ability. Most of the studies seem to support that depth jumping does cause improvements. Whether plyometrics is more effective than other forms of training for developing power has not been proven. The wide variety of training designs makes it hard to determine if plyometric training is more effective (Burr and Young 1989).

Safety of Plyometrics

The effectiveness of depth jumping has received much attention because of the stress it places upon the athletes' legs. Matt Brzycki, a strength coach for Rutgers University has been one of the most outspoken critics of plyometric training. He believes that exercises such as depth jumping put too much strain on the lower body and lead to lower extremity injuries. He claims that there is no scientific proof that plyometrics are more useful than other forms of training (Brzycki 1986). Pat Evan MD. and team orthopedist for the Dallas Cowboys says that he sees more medical problems caused from in depth jumping than from any other drill. Dr. Ken Leistner concurs with this view and states "Plyometrics are dangerous in themselves and will also do things to the body that will increase the probability of injuries during future events." Mike Gittleson, the strength and conditioning coach at the University of Michigan, states that his athletes do not use plyometric exercises because of the risk of injuries (Wikgren 1988). There are also numerous athletes such as John Brenner, Lorna Boothe, and Merlene Ottey who blame depth jumping for having a negative impact on their careers. Brenner, a bronze medalist shot putter in the 1987 World Games, detached his quadriceps muscle performing a depth jumps. Boothe and Ottey both blame depth jumping for giving them knee pain (Horrigan and Shaw 1989)

Safe Use of Plyometrics

Peter Tegen, head track coach at the University of Wisconsin, believes that the numerous injuries sustained by athletes in the West from plyometric training is a result of too much too soon. He points out that in Eastern block countries, athletes progress in stages, from small jumping exercises to depth jumps (Horrigan and Shaw 1989). Kim Gross, the strength and conditioning coach for Air Force Academy suggests that many of the injuries from plyometrics occur because athletes and coaches underestimate their intensity. He states that it is important to closely monitor the length and frequency of plyometric workouts. While injuries can occur during plyometric training, there have been no epidemiological studies to suggest that the injury rates associated with using plyometrics is great (Wathen 1993) In fact, plyometrics can be used to prevent pre-season soreness. Borkowski (1990) found that performing plyometrics with weight training helped to reduce the preseason soreness in volleyball players.

Current Views On Implementing Plyometrics



How to introduce plyometrics to athletes was a question that the USA National Strength and Conditioning Association (NSCA) posed to American coaches, who were strong advocates of using plyometrics. The general consensus among the coaches was that plyometric training can be used with prepubescent and pubescent athletes as long as they are performed with low volume and intensity. Jumps should be off of both feet with no added stimulus of weighted vests or boxes. Gambetta suggests plyometric training should progress from simple to complex as the athlete matures. This means going from bouncing movements, standing jumps, short jumps, and then finally progressing to in depth jumps. He stresses that in depth jumping should only be used if technique is sound and adequate strength levels are present. Lundin, Bielik, and Rogers suggest that an athlete needs to be able to back squat 1.5 - 2 times their body weight before participating in advanced plyometric exercises (Bielik et al 1986 A). The NSCA position statement on plyometrics also agrees with this, stating that athletes should be able to back squat 1.5 -2.5 times their body weight (Wathen 1993).

Lowering The Heights Of In Depth Jumps



Research indicates that the height of depth jumps can be lowered, thus reducing the stress to the body if resistance training is used congruently with in depth jumping. Clutch (et al 1983) also found that using three different jump training methods while participating in a resistance weights program resulted in similar improvements for all three groups' vertical jumps. The variation in the three groups training routines were as follows; group 1 used high depth jumps .75 to 1.10 metres, group 2 used low depth jumps .3 metres and group 3 used maximal vertical jumps. Blakey and Southard (1987) attained the same results when they conducted a similar experiment involving using different depth jump heights while undergoing resistance training. Both of these studies indicate that the height of the in depth jumps is not important when it is performed in a training cycle with resistant weight training.

Plyometrics Combined With Resistance Training



The above studies by Clutch (et al 1983), Blakey and Southlard (1987), and Bauer (1990) indicates that plyometric training is effective when combined with resistance training. Studies were done by Verkhoshanski , (1983) and Adams (et al 1992) that focused specifically on the effectiveness of plyometrics by themselves versus using them simultaneously with a resistance program. They both concluded that the best training results came when resistance training was combined with plyometric work. Adams (et al 1992) suggests that this lends support to the idea that plyometrics is a link between strength and power.

Plyometrics To Develop Power

Newton and Kraemer (1994) believe this link between power and plyometrics is caused by the fact that power is based on five critical components. These components are slow velocity strength, high velocity strength, rate of force development, stretch shortening cycle, and inter-muscular coordination and skill. Therefore, combining plyometrics with strength training is the most effective method in maximizing power development, because it allows more components of explosive power to be developed.

Practical Application OF Weights With Plyometrics

Radcliffe offers ideas on how resistance training and plyometrics should be used together in training to develop all the components of power. He gives an example of a resistance training session in which the athletes are not only lifting weights, but are also doing plyometric work such as squat jumps and medicine ball drills in between resistance training exercises (Radcliffe 1994). Lundin also does this, but calls it parallel training. An example of this would be super setting back squats and box jumps together. He states that the speed part of the training is not always true plyometrics, but the objective is to achieve high velocity movements mixed in with the resistance training work. When plyometric work of a specific nature is the aim, Bielik, Lundin, Chu, and Rogers recommend that plyometrics be used before resistance training.

Gambetta believes that resistance training and plyometrics should not be combined. He states that mixed training gives mixed results. All of the experts from the NSCA round table discussion on plyometrics agree that resistance training and plyometrics should be combined in some form, whether it is the same session or on alternate days (Bielik et al 1986 b).

Upper Body Plyometrics



Most of the research on plyometrics has focused on the lower body. Interest is now starting to increase on how upper body plyometrics can take advantage of the stretch-shorten cycle in the same manner as lower body. The most common aid used in performing upper body plyometrics is a medicine ball (Wilk 1993). A lot of the early work done on upper body plyometrics is based on rehabilitation work used on patients after shoulder reconstruction. The medicine ball activities of Chu (1989) such as reverse toss, 90 degree side toss, and behind the back toss allow the athlete to participate in advanced strengthening exercises that are not available through the use of free weights.



Upper Body Plyometrics To Develop Power

These exercises are not only being used for rehabilitation, but are also being used as a way to bridge the gap from traditional strength developed in the weight room to power needed for different sports. Chu (1996) uses an excellent example to illustrate the difference between weight room strength versus functional power. He had two football players that could bench press four hundred pounds and an Olympic javelin thrower who did not bench press. He had the athletes do a sitting chest pass with a medicine ball. The javelin athlete threw the medicine ball 20 feet further than the football players who were accustomed to performing that movement. Obviously the football players were not as effective in converting their strength into power. Using medicine ball drills, which Armstrong (1994) developed that are specific for football, would help these players become more powerful.

General Training Principals When Using Plyometrics

A coach implementing a plyometrics program should keep some general training principals in mind when organizing his program. The plyometric exercises should be specific to the athletes' sport. An upper body plyometric program would be more sports specific for a football player than for a figure skater. The coach should give feedback to the athlete as to how they are performing the exercises. It is important that the athlete understand that ground contact time be as short as possible (Pryor 1994). The coach also needs to be able to evaluate the athletes' performance and make adjustments to training. An example would be if the athlete is spending too much time on the ground, or their form is deteriorating, then the exercise should be stopped (Bielik et al 1986 b).

How Plyometrics Should Be Implemented Into a Training Program

Athletes should progress gradually from simple plyometric exercises to more intense drills. The intensity and volume of the plyometric work should always be comparable to the physiological abilities of the athlete. The emphasis on plyometrics during the training should correspond to the goals of the training cycle. Generally, the preparation phase involves low intensity exercises of longer duration. This helps to give athlete a base as they move into more intense plyometric drills such as depth jumping during the second half of the preparatory phase. During the competition phase, the volume of plyometric exercises are reduced, but the athletes continue to perform a low number of high intensity plyometric exercises. This serves as a maintenance program to keep the strength that has been developed (Bielik et al 1986 b).

Summary

This literature review has looked at the history, effectiveness and safety of plyometrics. Plyometrics were first developed by Soviet coaches to take advantage of the stretch-shorten cycle. Its use was seen as a way to bridge the gap between strength and power. There is still debate on whether plyometrics is more effective in developing power than other forms of exercises. It has been shown that excellent physical improvements can be made when plyometrics are combined with resistance training. Many critics of plyometrics suggest that injuries are caused through its use but there have been no studies to confirm this view. To minimise the chance of injury, it is important that coaches gradually allow their athletes to progress from simple to advanced plyometric exercises. It is also important for coaches to monitor that the athlete is using correct technique while performing plyometric exercises. When plyometric exercises are administered properly in a training program, they can be a valuable asset in the improvement of the athlete.

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