Review Article

PLYOMETRIC TRAINING: A REVIEW ARTICLE

IJCRR

Namrata N. Patel

Lecturer, Sigma Institute of Physiotherapy, Bakrol, Gujarat, India

ABSTRACT

Plyometric Training: This article presents a theoretical basis for plyometric training. It is thought of as missing link between weight training (strength) and athletic performance (power), with particular emphasis on the speed of activity. During this training eccentric contraction is followed by concentric contraction known as stretch shortening cycle. The initial part of paper presents introduction; historical background; neurophysiology and biomechanics; benefits of plyometric training. Final part of paper presents detail about application and progression of plyometric training and evidence for use of plyometric training. The author hopes to encourage physiotherapists to enhance their skills with elements of plyometric training.

Key words: Plyometric training, Stretch shortening drills

INTRODUCTION

Plyometric is a type of exercise which utilizes the stretch-shortening cycle of musculotendinous tissue. Eccentric stretching is followed by concentric shortening of the same muscles. Often involves rebound activities. [1]Plyometric training also called stretch shortening drills or stretch strengthening drills or reactive neuromuscular training. [2, 3]

Plyometric is thought of as missing link between weight training (strength) and athletic performance (power), with particular emphasis on the speed of activity. [4] It is a form of training designed to develop explosive power for athletics. Running, walking and hopping are typical examples in human locomotion of how external forces (e.g. gravity) lengthen the muscle. In this lengthening phase the muscle is acting eccentrically then a concentric (shortening) action follows. The true definition of eccentric action indicates that the muscles must be active during stretch. This combination of eccentric and concentric actions forms a natural type of muscle function called the stretch-shortening cycle (SSC). The period of time between the stretch and shortening cycles is known as the amortization phase. Amortization phase is kept very brief by a rapid reversal of movements to capitalize on the increased tension in the muscle.[5]

HISTORY

The word "plyometrics" has roots in the Greek word "pleythyein" which means to increase or augment. Though eastern countries used plyometric techniques in the 60s, but it came to the attention of the west during the 1970s.4 The leading researcher of plyometric training was a Russian scientist named Yuri Verkhoshansky. Dr. Verkhoshansky developed a system of exercises called "Jump Training" that used repetitive jumping in order to increase the speed and explosiveness of Russian track and field athletes. He published the results of his studies on this new form of training in 1964. Two years later he entered into scientific research. In his research, the use falling weight's kinetic energy to increase the strength effort was adapted further for upper body explosive movements. He named this discovery the "shock method".6 The term plyometric was first used in 1975 by an American track and field coach named Fred Wilt after he performed an extensive study of Dr. Verkoshansky's training methods. Fred derived the word from the Latin words "pilo" and "metrics". Pilo means more and metrics means to measure. By about 1980 had become a valuable tool in major athletic programs. In the early 1990s, George Davies and Kevin wilk introduced plyometrics into rehabilitation. 6

NEUROPHYSIOLOGY AND BIOMECHANICS OF PLYOMETRICS

Plyometrics is also known as reactive neuromuscular training. Loaded eccentric contraction is thought to prepare the contractile element of muscle for a concentric

Corresponding Author:
Namrata N. Patel, 13/152, Netajinagar, Meghaninagar, Ahmedabad, Gujarat, India; Email: patelnamrata27@gmail.com, patelnamrata27@hotmail.com

Received: 09.06.2014 **Revised:** 01.07.2014 **Accepted:** 25.07.2014

contraction by stimulation and activation of monosynaptic stretch reflex. If eccentric contraction occurs more rapidly, more likely it is that the stretch reflex will be activated.[7]

Plyometric training is thought to utilize the serial-elastic properties of soft tissues and stretch reflex of neuromuscular unit. When muscle is stretched; mechanical energy is absorbed by the muscle. This energy can be dissipated as a heat or it can be stored within muscle as elastic energy. This storage of elastic energy in the musculotendinous tissues contributes to the increased force produced in the subsequent concentric contraction phase and increased efficiency of movement. This phenomenon can be visualized as the action of a spring.[8]

Stiffer musculotendinous unit may result in an increased rate of concentric contraction and a more rapid transmission of forces to the working limbs.[9] Increased musculotendinous stiffness is more important than the ability to store more elastic energy in terms of enhancing stretch-shortening cycle SSC performance in activities such as sprinting.[10]

BENEFITS OF PLYOMETRICS

Plyometric training (PT) is a method of choice when aiming to improve vertical jump ability and leg muscle speed-strength and power.[11] Ground reaction time is decreased with plyometric training helps to improved reaction time and agility.[12] Hamstring to quadriceps peak torque strength ratio increases.

After plyometric training, peak landing forces from a volleyball block jump and knee adduction and abduction moments (medially and laterally directed torques) decreases. Multiple regression analysis revealed that knee adduction and abduction moments are significant predictors of peak landing forces. Female athletes demonstrated lower landing forces than male athletes and lower adduction and abduction moments after training. This training may have a significant effect on knee stabilization and prevention of serious knee injury among female athletes.[13,14,15] In season training is more effective than preseason in Anterior cruciate ligament (ACL) injury prevention.[16]

Plyometric activities may facilitate neural adaptations that enhance proprioception, kinesthesia, and muscle performance characteristics.[17] Plyometric jump training continued over a longer period of time during adolescent growth may increase peak bone mass.[18]

APPLICATION AND PROGRESSION OF PLYOMETRICS

1) Equipment

Plyometric can be performed indoors or outdoors. Flooring or playing surface is probably the most important equipment needed for plyometric training. Jumping on concrete or asphalt can lead to knee, ankle, and hip problems; as such these surfaces should be avoided. The landing surface should be able to absorb some of the shock of landing. Gymnastic or wrestling mats are good indoor surfaces as are the sprung wood floors found in many aerobics studios. Outdoors, plyometrics are done on the grass or sand. [19] Footwear should provide good cushion and also sturdy support. A standard cross training shoe is best suited for lower extremity plyometrics for support and shock absorption. Equipments like; Solid boxes 6 to 24 inches or more in height can be used. Plastic cones, hurdles, slide board, plyometric/weighted balls, elastic band, trampoline are very useful for both upper and lower extremity plyometric.[4]

2) Pre training consideration

Plyometrics are a very high intensity form of training, placing substantial stress on the bones, joints, and connective tissue. While plyometrics can enhance an athlete's speed, power, and performance, it also places them at a greater risk of injury than less intense training methods. Prior to starting a program there are several variables to consider so the training sessions are performed in a safe and effective manner.

A person should have an adequate base of muscle strength and endurance as well as flexibility of the muscles to be exercised. Criteria to begin plyometric training usually include an 80% to 85% level of strength and 90% to 95% ROM.[7] Power squat test is a good closed chain exercise to determine whether a patient has an adequate strength base for lower extremity plyometrics. It is performed with 60% of athlete's body weight. Squat repetitions are done in 5seconds, and the depth should be knee flexion close to 90^0 for each repetition. [5] Although static stretching is important in the performance of plyometrics, some ballistic stretching is warranted. An individual must be able to perform a 30 seconds one leg stance with eye open and closed for proprioception and single leg half squat for strength.[20] For shock and high intensity lower extremity plyometrics, it is recommended that healthy athletes have enough leg and hip strength to be able to perform a squat with 1.5 to 2.5 times the athlete's body weight. For high intensity upper extremity plyometrics, it has been suggested that an athlete be able to perform five clap push-ups in row. [5]

Although static stretching is important in the performance of plyometrics, some ballistic stretching is warranted.[4] sufficient warm up is required before engaging to plyometric training.[21]

3) Load

The training with light-load (30% of 1 RM) jump squats results in increased movement velocity, Peak force, peak velocity capabilities than high load (80% of 1 RM).[22] However, no extra benefits were found to be gained from doing plyometrics with added weight.[23]

4) Speed

Drills should be performed rapidly but safely. The rate of stretch of the contracting muscle is more important than the length of the stretch. If a jumping activity is performed, for example, progression of the plyometrics activity should centre on reducing the time on the ground between each jump.[20]

5) Frequency

Plyometrics should not be performed more than two to three times per week unless you are alternating days of upper and lower body plyometric drills. Off-season plyometric routines are performed twice per week. In season, one session per week is appropriate for most sports. Track and field athletes may perform two to three time per week.[4]

6) Intensity

The intensity of plyometric drills is typically classified as low, medium, or high. When high-intensity levels are reached by the athlete, volume should decrease. The intensity of plyometric drills for the lower extremities has been related to foot contacts, direction of jump, speed, jump height and body weight.[4]

7) Classification of plyometric drill

Low intensity	Lower Extremity	Squat jump, Spit squat jump, Ankle bounce ,Lateral hurdle/cone jump
	Upper Extremity	Medicine ball chest pass, Underhand medicine ball throw, Overhead throw
Medium intensity	Lower Extremity	Pick jump, lateral hope, Double and single leg pick jump, Double leg tuck jump, Standing triple jump, Zigzag cone jump, Double leg hop, Alternate leg bounds, Combination bound
	Upper Extremity	Medicine ball push-up, Standing or kneeling side throw, Backward throw
High intensity	Lower Extremity	In depth jumps, Box jumps, Single leg vertical power jump, Single leg tuck jump
	Upper Extremity	Drop push-up, Medicine ball push-up

8) Volume

Plyometric Volume Per Session	
Experience	**Ground Contacts**
Beginner	80 - 100
Intermediate	100 - 120
Advanced	120 - 140

Volume is typically expressed as the number of foot contacts, throws of the medicine ball or distance jumped. Volume of 10 weeks duration and more than 20 sessions using high intensity programs (> 50 jumps per session) seems to maximize the probability of obtaining significantly greater improvements in performance.[23] Adolescent athletes should perform low-impact plyometric training once-weekly to increase lower-body power resulting in increased Vertical Jump and kicking distance.[2]

9) Rest and recovery

The work to rest ratio should be 1:5 to 1:10 to be certain that the intensity and proper execution of movement are preserved. It is suggested that 1 to 5 minutes of rest is needed between plyometric exercises, depending upon the intensity and volume of the workout. Recovery time between sessions is recommended 48-72 hours.[25]

10) Safety consideration

Following points are considered for prevention of knee injuries:

"Stick" the landing, holding the landing for 5 seconds, land softly and quietly, keep the shoulders over knees when landing, and avoid hyper extension during all activities. [4]

11) Progression[4]

Low to high intensity

Two legged jumps to one legged jumps

Raising box jump and heights

Increasing resistance of elastic band

Increase weight of medicine ball

Increasing number of hurdles

DISCUSSION

Philo u. Saunders et al in 2013 performed study on "Effects of knee injury primary prevention programs on anterior cruciate ligament injury rates in female athletes in different sports: A systematic review". They concluded that three training programs in soccer and one in handball led to reduced ACL injury incidence. In basketball no effective training intervention is found. In season training is more effective than preseason in ACL injury prevention. A combination of strength training, plyometrics, balance training, technique monitoring with feedback, produced the most favourable results.[16]

Goran Markovic et al in 2007 had done a meta-analytical review on "Does plyometric training improve vertical jump height?" The result of the study showed that Plyometric training provides both statistically significant and practically relevant improvement in vertical jump height. It also suggest that the effects of PT are likely to be higher in slow stretch-shortening cycle (SSC) vertical jumps (countermovement jumps and countermovement jumps with arm swing) rather than in either concentric (Squat Jump) or fast SSC jumps (drop jumps).[11]

Saunders et al in 2006 performed a study on "Short-term plyometric training improves Running economy in highly trained middle and long distance runners". Short-term plyometric training showed no significant difference in cardio respiratory measures or VO2max in plyometric group. But result showed improvement in Running economy, with likely mechanisms residing in the muscle, or alternatively by improving running mechanics.[26]

Johnson et al had done a Systematic Review on "Plyometric Training Programs for Young Children". The current evidence suggests that a twice a week program for 8-10 weeks beginning at 50-60 jumps a session and increasing exercise load weekly results in the largest changes in running and jumping performance. An alternative program for children who do not have the capability or tolerance for a twice a week program would be a low-intensity program for a longer duration. The research suggests that plyometric training is safe for children when parents provide consent, children agree to participate, and safety guidelines are built into the intervention.[27]

CONCLUSION

Plyometric Training can be safely introduced to improve vertical jump ability, speed-strength and power and reduce chances of sports specific injury.

ACKNOWLEDGEMENT

I acknowledge the immense help received from the scholars whose articles are cited and included in references of this manuscript. I am also grateful to authors / editors / publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed. I want to thank all editorial committee members of IJCRR.

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