UNDERSTANDING THE SIGNIFICANCE OF PLYOMETRIC TRAINING IN ENHANCEMENT OF SPORTS PERFORMANCE: A SYSTEMATIC REVIEW

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ABSTRACT

The purpose of this study is to understand the significance of plyometric training on the enhancement of sports performance. To achieve the purpose, the proliferation of peer-reviewed articles published on plyometric training, including systematic reviews, book chapters, and meta-analysis were taken. In this review, the study of plyometrics and its impact on various parameters of athlete(s) is done. As per literature, plyometric exercises have the potential in improving the huge range of sports performance i.e. sprint, speed, explosiveness, muscular strength, agility, jump height and broadness with the application of systematic and well-designed plyometric training modality. There are many key issues pertaining to plyometric training program are remaining to be resolved unless the significance of plyometrics is well known. The consequences in this review, highlight the significance and issues related to plyometric training modality and allows suggesting the implication of a specific training program as an incredibly effective program and also provides future directions for research.

Keywords: *Plyometric Training, Athlete, Sports, Performance etc.*

1. Introduction

The word training is generally used and understood in different ways in different areas. In sports, the term training refers to performing a set of systematic exercises and adopted methods in order to bring improvement in sports performance. Training includes constructing an activity program to build up a competitor for a specific occasion. This increasing skill and energy capacities need equal consideration of training aspects (Singh, 1991).

Plyometric exercise is the best and popular form of sports training used to improve athletic performance.[1] Plyometric training (PT) is famous among athletes involved in dynamic sports and plyometric exercises such as bounding, skipping and jumping are performed with a goal to increase vibrant muscular performance (Impellizzeri et al., 2008; Wilson et al., 1993; Wilson et al., 1996).Plyometric training is very specific in nature but very broad in applicability. Plyometric training, when utilized in a game with a periodized exercise program, can contribute to enhancements in the vertical jump, speeding up, leg strength, muscular power, expanded joint awareness, and largely proprioception (Wilson et al., 1993). Plyometric drills frequently include discontinuing, starting, and fluctuating directions in a volatile manner. These movements are components that can assist in developing agility (Young et al., 2001). This training emphases on learning how to move from a muscle expansion to compression in a rapid or "volatile" way, such as in specific continued jumping.[1] Plyometrics are essentially utilized by athletes, particularly martial performers, sprinters, and high jumpers,[2] to enhance performance,[3] and are utilized in the fitness field to a much-reduced degree.[4] Plyometric is a process to build muscle elastic strength through explosive movements. It is an incredible method to gain fitness fast.

The consequences in this review, highlight the significance and key issues related to plyometric training and allows suggesting the implication of a sport-specific training program as an incredibly effective program and also provides future directions for the research.

2. Method

2.1 Research Model

The study was a textual analysis of the perspective of plyometrics and its training modality. It was a mixed method research aiming to define typical and existing

plyometric concepts without the intervention of the researcher.

2.2 Historical Roots of Plyometric

Plyometrics were developed in the eastern parts of the world during the 1920s though they weren't widely recognized until the 1960s.The term "plyometrics" was coined by Fred Wilt after observing Soviet athletes get ready for their events in track and field; he stroked this was a key to their success. The plyometric exercise was from Europe. Firstly, it was referred to as 'jump training'. Plyometrics is a recognized form of 'ballistic training', intended to enhance jump performance abilities. The word Plyometric has derived from the Greek word "Pleythyein" which means "to increase" or from the Greek roots "Plio" which further means 'More' and 'Metric' means 'to measure'. Plyometric is some exercises which enable muscles to reach its maximum strength in a very short period of time. Therefore, some people called plyometric exercise as a power training exercise. The majority of plyometric exercises are based on jumping activities and cater primarily to the lower body, although upper body exercises have been developed also (Potach& Chu 2000).

2.3 Why Plyometric Exercises for athletes?

Plyometric training is a very important component of most athletic performances and aided the athletes, coaches, and trainers in various sports discipline. Coaches and athletes have acknowledged the development of potential that plyometrics brought and they have integrated plyometrics into the overall training program which is founded as a significant factor in planning the scope of athletic development. Human motions from altering the direction in rugby to jumping in basketball, and even sprinting in the 100m, it becomes obvious that all of these movements can be deemed as plyometric activities; movements or exercises. Its importance in the sport suddenly becomes transparent. With the growing interest in plyometric training, many researchers have attempted to identify the potency of this training modality for improving performance. Till date, plyometric training has been shown to improve the following qualities in athletes that are strength, speed, power, balance, change of direction speed, jumping, throwing, kicking, and bone density etc. Furthermore, apart from surface plyometrics, aquatic plyometrics have been shown to improve speed, change of direction speed, balance, and jumping.

These exercises additionally support speed and power by engaging the sensory system. At the point when muscles contract, the brain communicates to the muscles by the method of a neuromuscular framework. If this communication occurs more quickly, muscles will be able to move much faster. The result is more speed and power. Apart from that plyometric exercises enhances the ability of the muscle-tendon unit by improving various measures and mechanisms of muscles; strengthens fast-twitch fibers in the muscles; enables muscles to reach maximum strength; minimizes injury by increasing the strength of tendons; boosts the efficiency of the neuromuscular system; produces maximal force in the shortest amount of time; rapid force production; generating explosiveness with high power output; decreases rebound time phase; boosting body movement sequences i.e. jumping, sprinting, changing direction; strengthens the athlete's physical and physiological parameters and helpful in improving athletic performance; helpful in generating thrill, motivation, controlling anxiety, boosting confidence, increasing mental toughness, reducing fear in an athlete for participation in any vigorous activity.

2.4 Additional Consideration for Success with Plyometrics

- **Proper Breaks**

The amount of rest plays a significant role in at a point while doing plyometrics and an athlete want to develop the highest amount of explosiveness at every repetition. To be disciplined and take the full prescribed rest between sets, even if when an athlete feel "easy." And if a set leaves athlete fatigued, adding on 30 seconds more to whatever recommended break is listed in a plyometric training plan. In case, if no break is listed, opting one-minute rest between sets is a good initial idea by allowing muscles for recovery.

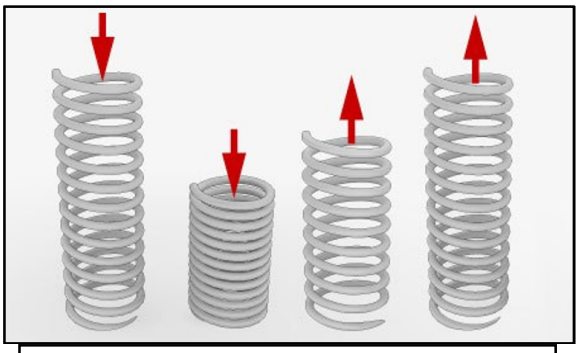
- **Strict About Technique**

By keeping perfect and clean form during each set of a plyometric workout. Appropriate structure guarantees the utmost of every movement and diminishes the danger of injury. Quality is superior to quantity in any case.

2.5 The Mechanism of Plyometrics

The stretch-shortening cycle exists in all practices of human motion. The stretch-shortening cycle (SSC) refers to the 'pre-stretch' action that is generally observed during typical human movements such as jumping or hoping. This pre-stretch enables an athlete to generate more force and move faster. SSC is a combination of the active state and the storage of elastic energy within the tendon.Plyometrics seeks to improve power output arising from the SSC. It includes a stretch of the muscle-tendon unit followed immediately by a shortening of the muscle unit. This process of muscle lengthening and rapid shortening during the stretch-shortening cycle (SSC) is vital to plyometric exercise.[2] The SSC process significantly enhances the ability of the muscle-tendon unit to produce maximal force in the shortest amount of time.[3, 4] Eccentric and concentric muscle actions usually occur simultaneously in combinations of muscle function otherwise known as the stretch-shortening cycle (SSC). The eccentric contraction stretches a muscle's length, and the concentric contraction shortens it. Most movements result from concentric actions preceded by an eccentric counter movement.

The SSC is described as a rapid cyclical muscle action whereby the muscle undergoes an eccentric contraction, followed by a transitional period prior to the concentric contraction. Sometimes, this is referred to as the reverse action of muscles. The action of the SSC is perhaps best described as a spring-like mechanism, whereby compressing the coil causes it to rebound and therefore jump off a surface or in a different direction. Getting higher the speed at which the coil is compacted or how it is hard-pressed down i.e. the volume of power applied will result in bouncing the spring higher or more distant. The process is well-known as the 'rate of loading', and increasing this will often mean the spring will jump higher or more distant. Hence, a jump which joins a "run-up" will regularly enable an athlete to jump higher or cover more distance than a jump from a static position as a result of expansion in the rate of loading.



Spring like Mechanism of the Stretch-Shortening Cycle
https://www.scienceforsport.com/stretch-shortening-cycle/ (retrieved on 12 June 2020)

The majority of plyometric exercises are based on jumping activities and cater primarily for the lower body, although upper body exercises have been developed also (Potach & Chu 2000). Defining the principles of the stretch-shortening cycle will help us understand not only what is occurring within training and performing but also how to apply these principles. This understanding is useful in planning plyometric training.

In analyzing and applying training that uses the stretch-shortening cycle model, remain aware that the performance of human athletic skills is never merely the sum of such factors like strength, velocity, loading, and stretch. Execution of any pattern movement whether it is a plyometric or something is general in nature. It is an integration of all such factors. In developing human power, many mechanisms drive and coordinate the skeletal muscle structure. Enhancing muscular control and reactive power associated with the stretch-shortening cycle exercise relates to changes in complex neuromuscular structure and sensory-motor pathways.

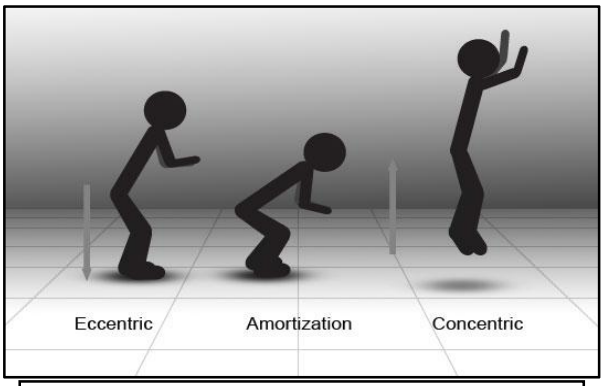
Perhaps the most accurate term to describe the time from the eccentric or stretch portion of the cycle through switching to the concentric or shortened portion is elastic-reactive, a concept that Vern Gambetta described in 1986.Many neurophysiological mechanisms have been

considered to underpin and explain the impact of plyometric training on the stretch-shortening cycle. Most of which includes improved storage capacity and usage of elastic strain energy; increased active muscle working range; enhanced involuntary nervous reflexes; enhanced length-tension characteristics; increased muscular pre-activity; enhanced motor coordination; and increment in the dynamic state because of an increase in the active working range.

Improving these characteristics will probably lead to an increase in leg firmness during contact with the ground, and furthermore, force generation during the concentric contraction. As a result, an increase in these characteristics will likely bring improvements in athletic performance. Plyometric exercises expect athletes to generate elevated amounts of power throughout quick movements. They also demand the athletes to produce this force during very short timeframes. Perhaps the best example of this is sprinting. Maximal speed dashing stresses that the competitor moves their body and extremities at the very peak of their capacity by making it an incredibly faster movement.

2.6 Important Phase in Plyometric

An SSC has three phases; a rapid eccentric lengthening phase, the amortization phase, and finally an explosive concentric phase (Van Ingen Schenau et al., 1997). As a figure shows, when a counter-movement jump is performed, all three phases of the SSC are present. The eccentric phase occurs as the athlete lowers their center of mass towards the ground pre-stretching and loading the muscles and tendons around the hips, knees, and ankles. The amortization phase is the period between the end of the eccentric phase and the beginning of the concentric phase. The concentric phase is the shortening of the muscles which results in the athlete raising their center of mass from the ground. The function of the SSC is to provide enhanced performance in the concentric phase as opposed to when just performing a concentric action without the preceding eccentric action and amortization phase (Komi, 2000).



https://achievingathleticism.files.wordpress.com/2015/01/fig2.jpg (retrieved on 27September 2020)

Amortization is a very short period of inactivity which allows and the body to take rest and rejuvenate. The shorter the amortization phase the more effective and powerful is the plyometric movement because the stored energy is used efficiently in the transition. If the amortization phase is delayed, the stored energy is wasted as heat, the stretch reflex is not activated, and the resultant positive work of the concentric contraction is not as effective.

2.7 Duration of the Ground Contact Time (GCT)

During walking, running, and jumping our feet continuously strike the ground and then leave it again in a reciprocal manner – meaning when one foot leaves the ground, the other is quick to contact it. The timespan in which the foot is in contact with the ground is known as the 'ground contact time'. For instance, during sprinting, the foot-ground contact time can be anyplace between 80-90 milliseconds.Plyometric activities which are equal to the SSC, are categorized either as a 'moderate' or 'fast' plyometric exercise.

- Moderate plyometric exercise = GCT ≥ 251 milliseconds or 0.251 seconds.
- Fast plyometric exercise = GCT ≤ 250 milliseconds or 0.25 seconds.

Some examples of the ground contact time during general movements and their plyometric categorizations is done as follows.

Table No. 1			
GCT of General Exercises			
S.No.	**Activity**	**GCT (milliseconds)**	**SSC Categorization**
1	Race Walking	270-300	Moderate
2	Sprinting	80-90	Fast
3	Countermovement Jump	500	Moderate
4	Depth Jump (20cm-60cm)	130-300	Fast / Moderate
5	Long Jump	140-170	Fast
6	Multiple Hurdle Jumps	150	Fast
7	Basketball Lay-Up Shot	218	Fast
https://www.scienceforsport.com/plyometric-training/ (retrieved on 09 October 2020)			

Additionally, the athletes have been appeared to produce ground reaction forces during each foot contact of 3-4 times bodyweight. Not only that, but they must apply these huge forces in a GCT of just 80-90 milliseconds. Hence while sprinting, athletes are required to move as fast as possible, produce forces of more than 3-4 times bodyweight, and do as such in only 80-90 milliseconds.

2.8 Issues with Plyometric Training Program

However plyometric training is a powerful training modality for improving athletic performance. Though there are several important issues, which practitioners must understand and consider before they attempt to give any form of training recommendation. Plyometrics are highly coordinated and skillful movements. Subsequently, plyometrics are not commonly seen as just activities or drills, yet more as intricate movement skills because of their high-complexity nature. Understanding this is crucial and features how highly organized these movements are, and why they require a lot of consideration and instructing. The intensity of plyometrics is hard to measure. Seemingly, the volume of plyometric training is moderately simple to measure and recommend and is ordinarily done as such by counting the number of ground contacts per session.

For measuring plyometric intensity exactly, the following components must be taken into consideration:

- Speed of movement
- Amplitude of movement
- Points of contact (i.e. unilateral or bilateral)
- Body mass
- Technical competencies
- Strain yielding competencies

Taking body mass as an example, if two athletes perform a drop-jump from a 30cm box, but competitor A is 60 kg and competitor B is 80kg, then competitor B needs to ingest and re-apply more power than competitor A,just due to their weight. This example determines that how the intensity of plyometric exercise is different for each competitor. Professionals ensure about this information when planning and recommending any type of plyometric training.

Majorly, in plyometric research studies the issues pertaining are below mentioned.

1. The status of control group isn't acknowledgedin study whether the group is active or passive which is very important in identifying the result differences.
2. (The size of subjects in comparison to requirement for the study is somewhere not sport specific.
3. (Plyometric training less than 6 weeks appears to be very short for effective improvisation.
4. The expert or a good trainer should demonstrate by executing correct practice of exercises so that the result of the activity be progressive.
5. Lack in accurate training session with their numbers in weeks, involving simple and complex skills or drills.
6. As per available literature there is no study conducted on plyometric training pertaining to para-athletes.

No study is conducted on the psychological parameters of athlete, as the plyometric training enhances the neuro-muscular

coordination, it means the nervous system gets prepared solely and help in boosting confidence, controlling anxiety, helpful in motivation and relieves competition stress up to a great extent.

3. Discussion

The active or passive status of control group ought to be acknowledged in the study to ascertain the performance differences. In research studies, the size of subjects for experimental group and control group in context to the actual requirement need to be sport specific so that the effects could be very significant. The plyometric training program needs to be not less than 6 weeks for efficient and effective results, as it is a thumb rule that the training period (10-12 weeks) is very essential to bring sufficient changes in an athlete. Given that plyometric exercises are very specific in nature but very broad in applicability, the structuration of plyometric training modality for specific sports and individuals is to be well designed. Considering the help of aplyometric training expert to be taken and must demonstrate the exercises in an appropriate manner. There is a huge requirement to produce accurate training session with their numbers in weeks, involving simple and complex skills or drills. Studies on plyometric training pertaining to para-athletes could be conducted. Studies on the psychological parameters of the athlete could also be done, as the plyometric training enhances the neuro-muscular coordination which means the nervous system gets prepared solely in performing rigorous sports activity or training and possibly will help in boosting confidence, controlling anxiety, motivating and relieving competition stress up to a great extent.

Plyometric exercise-induced adaptations which largely dependent on neuro motor pliability of athletes. Fitness components can be improved with age and plyometric training from childhood. Plyometrics is not intended to be a stand-alone exercise program and should be incorporated into an ingenious fitness program.

4. Conclusion

Plyometric training is used by coaches or trainers to enhance human neuromuscular function and improve the performances of both explosive and endurance-builtathletes. It has ordinarily agreed that plyometric training builds up the neural and musculotendinous frameworks of the stretch-shortening cycle to produce maximal power in the shortest measure of time. Given this, plyometrics are regularly utilized as a method of training to connect the division among speed and strength. Indeed, even in spite of the thorough scientific examination, plyometric training keeps on proving itself as a powerful method of training for upgrading athletic performance. Well-trained athletes appear to possess better SSC capacities than less or non-trained individuals, and thus highlights the necessity to optimize this property to enhance athleticism.

Ideally, the athlete utilizing plyometrics training will progressively diminish the time between the eccentric movements (primary stage) and the concentric movements (finalstage). If an athlete is properly trained through the preparation phase, then an athlete requires less and less downtime between rapid movements. The outcome is a faster and robust athlete.

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6. Conflict of Interest

The authors declare no conflict of interest.

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