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REVIEW ARTICLE

Plyometric training effects on explosive power, sprint and direction change speed in basketball: A review

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Abstract. Plyometric training involves the use of exercises in which the actual muscles after eccentric contraction become concentric. The aim of this narrative review was to determine the significance and role of plyometric training in basketball, ie this review aimed to determine the influence of plyometric training on the explosive power, sprint, and the change of direction speed of basketball players. The results of this review indicate that plyometric training is an effective method that has a positive effect on short-term maximum performance in basketball. However, some studies have indicated that the effect may be absent on sprint and change of direction speed in basketball players. The general factors of application of plyometric training are age, warm-up, exercises, performance technique, equipment, and surface. The effects of plyometric training can vary depending on factors such as athlete's level, gender, sports activity, duration, type of plyometric training. Therefore, further original studies are needed, in order to further clarify the effect of plyometric training on short-term maximum performance, especially on sprint and change of direction speed of basketball players.

Keywords. Basketball, motor skills, plyometrics, short-term performance.

Introduction

Basketball is a highly intermittent game that involves repeating transitions between attack and defense and frequent movement changes (McInnes et al., 1995). During a basketball game, periods of high-intensity activity are interrupted by periods of low to moderate-intensity activity. These activities differ in terms of movement structure (e.g., running, jumping, sideways movement), intensity, distance, frequency, and duration. During a match, jumps occur approximately every minute (Abdelkrim et al., 2007; Scanlan et al., 2011), which is more than in other team sports. In addition, basketball players go through numerous sprints and high-intensity lateral movements (Abdelkrim et al., 2007; Scanlan et al., 2011) that emphasize the need to perform maximum effort during the game. Recent studies (Abdelkrim et al., 2007; Scanlan et al., 2012) recorded a higher frequency of movement and intensity with higher intermittent demands than was originally recorded during a basketball match (McInnes et al., 1995). Variations between current studies and those conducted before 2000 can be attributed in part to rule changes. These rule changes include shortening the attack time after gaining possession of the ball (from 30 s to 24 s) and reducing the time to transfer the ball to the opponent's half (from 10 s to 8 s). These changes are important to note when gathering evidence from existing research spanning decades.

One of the most popular workouts in the 20th century is plyometric training. Plyometric training involves the use of exercises in which the actual muscles after eccentric contraction turn into

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concentric (eg through jumps), and just such a pattern of muscle contraction is very present in many sports, including basketball. The mentioned type of contraction is called reversible, and it represents the muscle elongation-contraction cycle – stretch-shortening cycle, SSC (Zatsiorsky & Kraemer, 2009). SSC is an integral part of plyometric exercises because it improves the ability of musculoskeletal units to produce maximum force in the shortest period (Komi, 2008). Higher forces are associated with shorter damping from the eccentric to the concentric phase and with higher energy stored in the elastic component of the muscle. Also, it should be emphasized that jumps are typical plyometric exercises that cause stress on musculoskeletal units (Taube et al., 2012).

There are different forms of plyometric exercises and they are used depending on the goal of the program, and they are all composed of natural movements (de Villarreal et al., 2009). The basic means of plyometric training methods are vertical, horizontal, and deep jumps (Branković et al., 2008). A typical plyometric program includes countermovement jump (CMJ), the drop jump (DJ), and squat jump (SJ) which can be combined or used separately. The combination of these jumps gives better results than their separate use (de Villarreal et al., 2009; Zelenović et al., 2020). In the literature, plyometrics is often equated with depth jumps, although plyometric exercises, which are characterized by a rapid transition from eccentric to concentric muscle contraction, are in practice used for the upper part of the body, for throwing movements. In plyometrics, exercises can be formulated to isolate different parts of the body for training (Radcliffe & Farentinos, 2009).

Plyometric exercises can be performed with or without external load, and both methods have been shown to increase explosive power, sprint abilities, and change of direction speed in basketball players (Arazi & Asadi, 2011; Aksović, 2019). It is often used in sports such as basketball and volleyball to develop vertical jump height, power and coordination (Jamurtas et al., 2000).

The effects of plyometric training can vary depending on different characteristics. The effect of plyometric training on short-term maximum performance (explosive power, sprint, and change of direction speed) may also depend on the characteristics of the subjects, such as the level of an athlete (Stojanović et al., 2017), gender (de Villarreal et al., 2009), an age (Asadi et al., 2016a), sports activity (de Villarreal et al., 2012). Other factors that also determine the effectiveness of plyometric training are duration, type of plyometric training (types of implemented jumps, jumps combined with load training), intensity, and volume (de Villarreal et al., 2009; Stojanović et al., 2017). Thus, the optimal combination of these factors to maximize short-term maximum performance is still unclear to basketball players.

The aim of this narrative review was to determine the significance and role of plyometric training in basketball. Therefore, this review of the current literature aimed to determine the influence of plyometric training on the explosive power, sprint, and the change of direction speed of basketball players.

Theoretical Consideration of the Problem

History of Plyometric Training

This training first appeared in Russian sports literature in 1966 in the work of VM Zaciorski. The success of Russian high jumpers and triple jumpers in the 1960s stimulated interest in the systematic application of plyometrics (Radcliffe & Farentinos, 2009). The name plyometrics is derived from the Greek word "pleythyein", which means to increase. Đinić et al. (2010)emphasize that the name comes from the Latin words "plio" which means more and "metrios" which means measurement, so the whole expression can be translated as "measurable increase".Some trainers also call this method the "shock training method". Verhošanski (1979), the founder of this method, then referred to as the strike method, came up with numerous results that revolutionized training in the development of explosive power. Keohane (1977) showed that skaters who participated in the jump program not only increased the result in the "jump and reach" test, but also achieved an increase of 5.8 cm in height achieved during the current skating jumps. Hajnal (1985) conducted research in which he opposed the so-called specific method (application of specific jumps that are often represented in the basketball game) and "classic" percussion method (rebound), and the results in the manifestation of these specific jumps were in favor of the specific method. It should be mentioned that plyometric training is a partial reason for the unusual progress and success of Russian sprinter Valery Borzov, the winner of the gold medal in

the 100 m (10 s, 14 s) race at the 1972 Olympic Games. Borzov increased the passing time from 13 s, which he achieved from 14 years to 10 s in his twentieth year (Dintiman, 2010). Many other terms are associated with the term plyometrics, such as stress training, jump training, and elastic reactivity (Radcliffe & Farentinos, 2009).

General Factors of Application of Plyometric Training

Since plyometric training includes exercises of higher intensity and the possibility of injury is increased, its application requires special caution. Performing plyometric exercises is simple, does not require special space, and is not expensive (Radcliffe & Farentinos, 2009). Accordingly, attention should be paid to several important general factors, namely: age, warm-up, exercises, performance technique, equipment, and surface.

Age: The earliest research has indicated that the maturity of the skeletal-nervous system greatly influences the effects of plyometric training (Bosco & Komi, 1981). Young athletes who have not yet entered puberty should not perform plyometric exercises, and the reason for that is the continuous growth of the bone and joint system, as well as the cartilage on the epiphyseal bone plates in that period (Radcliffe & Farentinos, 2009).

Warm-up: In order for the plyometric training to be conducted with quality, it is necessary to perform a quality warm-up. It needs to be heated body segments that will be under the influence of the greatest loads - foot, ankle, knee, flexor muscles, extensors, and torso rotators (Branković et al., 2008).

Exercises: The basic means of plyometric training are vertical, horizontal, and deep jumps (Branković et al., 2008). Plyometric exercises can be performed with or without external load, and both methods have been shown to increase power, vertical jump height, and sprint ability (Arazi & Asadi, 2011).

Execution technique: When performing plyometric exercises, especially of maximum intensity, one should focus on the goal of the exercise and the technique of performing it. Jumps should be performed so that contact with the ground lasts as short as possible. In deep jumps, the heel must never hit the ground, ie the center of gravity of the body must be in balance at the time of landing from the aspect of the supporting surface of the foot (Čoh, 2004).

Equipment: Plyometric training can be performed indoors and outdoors. The equipment should provide safety during training and is therefore made of softer materials and without sharp edges (Stefanović et al.,2010).

Surface: The best surface is nurtured grass, then artificial grass, wrestling mats, as well as a sandy surface. Concrete surfaces, hardwood surfaces are not recommended because they do not have good cushioning properties (Čanaki & Birkić, 2009). Arazi & Asadi (2011) recommend that plyometric training be performed in water. Aquatic plyometric training can lead to similar benefits as terrestrial but can reduce the risk of injury (Martel et al., 2005). Water reduces the pressure on the musculoskeletal system because water provides buoyancy that reduces the stress caused by weight on the extremities. Viscosity and resistance to movement within water require additional muscle activation to overcome resistance and produce a similar movement that is easier to produce on land or some other surface (Arazi & Asadi, 2011). Plyometric training in water can help physicians rehabilitate injured athletes (Miller et al., 2006).

Effects of Plyometric Training on Explosive Power

Explosive power, sprint, and change of direction speed as some of the determinants of the success of basketball, they are the subject of current research. In a constant effort to find the most adequate ways to develop maximum short-term performance, researchers seek to develop existing and find new training methods, to develop and raise motor skills to the level necessary to achieve maximum sports results, in sports where they play an important role. In the following chapters that follow, the mentioned motor abilities will be explained in more detail.

Explosive power, an ability to generate maximum muscle strength in the shortest possible time (Santos & Janeira, 2008) is an extremely important motor ability to play basketball (Lehnert et al., 2013; Aksović et al., 2020a; Aksović et al., 2021). Vertical jumps are often used to estimate the explosive power of the lower extremities. Vertical jumps are an important factor in basketball because increasing the reach height of athletes can positively affect the result in sports (Häkkinen, 1993). The American National Basketball

Association (NBA), their fitness and strength training coaches, use plyometric training intensively to improve the explosive power performance of elite professional basketball players (Simenz et al., 2005). The study shows how important jumps, as representatives of explosive power, are for basketball (Okur et al., 2013). The authors determined that the success in the competition was positively related to the result in the vertical jump. In young basketball players of junior and cadet age, plyometric training is recommended as a primary tool in the training process, to increase vertical jumps (Attene et al., 2015; Poomsalood & Pakulanon, 2015; Asadi et al., 2016a; Bouteraa et al., 2020). Young basketball players often use deep jumps (Asadi & Arazi, 2012). Hernández et al. (2018) found in a sample of young basketball players that plyometric training lasting seven weeks has a positive effect on the jump height in young basketball players. Snyder et al. (2018) also indicate that plyometric training has a positive effect on jump height. Similar results were obtained in the studies (Latorre Román et al., 2018; Arede et al., 2018).

Effects of Plyometric Training on Sprint

Basketball, as a physically active sport, depends on numerous motor skills, including short sprints. Short sprint is the ability to increase the speed of movement in minimal time (Bompa & Haff, 2009), and in basketball, it is most often determined by sprinting at 5 m, 10 m, and 20 m (Delextat & Cohen, 2009; Bouteraa et al., 2020).

Plyometric training is widely used to improve generalized short-term maximal performance such as sprinting (Aksović et al., 2020b). As cost-effective easily applicable to adult and young basketball players (Asadi et al., 2016a), it is an effective means of increasing the ability to perform short sprints (Poomsalood & Pakulanon, 2015; Asadi et al., 2016a). Aksović et al. (2020b) obtained results on a sample of young basketball players showing that plyometric training has a positive effect on the sprint (5 m and 20 m), while the effect on the 10 m sprint was absent. However, some studies indicate that plyometric training has proven to be an effective method for improving jump height, while the influence on short sprints is less clear (Bavli, 2011; Bouteraa et al., 2020). A professional basketball player performs short sprints (1 s -2s) 105 ± 52 times on average during a game (Castagna et al., 2009). McInnes et al. (1995) in their study of basketball games of the Australian National League indicate that the longest sprint lasted 5.5s, 5% of sprints lasted longer than 4s, and the largest number of sprints (51%) lasted 1.5 s - 2 s. The average sprint duration was 1.7 s. Also, the high level of the explosive power of the lower extremities of basketball players is positively related to acceleration (Nikolić, 2016).

Effects of Plyometric Training on Change of Direction Speed

The terms change of direction speed and agility are used interchangeably in the sports literature (Sekulic et al., 2013; Delextrat et al., 2015) although they are not consistent in recent literature. Today, agility is defined as rapid changes in speed or direction of motion, in response to a stimulus (Sheppard et al., 2006). The change of direction speed represents the ability to perform a movement in which there is no direct reaction to the stimulus, ie it represents the movement where the change of direction is planned in advance (Sheppard & Young, 2006; Stojanović et al., 2019). While agility movements include movements in response to a stimulus (Sheppard & Young, 2006) the ability to change direction quickly can positively affect agility performance in a variety of sports (Asadi et al., 2016b) and thus in basketball. Thus, the traditional view of agility has since been renamed as the change of direction speed. Therefore, agility and change of direction speed should be observed independently.

Plyometric training is an effective method that leads to improving the change of direction speed of young basketball players (Asadi et al., 2016a; Hernández et al., 2018; Gonzalo-Skoket al., 2019; Aksović, 2019) and basketball player (McCormick et al., 2016). In a doctoral dissertation, Aksović (2019) obtained results that confirm the positive effects of plyometric training lasting 10 weeks on the change of direction speed in young basketball players. Asadi et al. (2016b) also showed that plyometric training improves the rate of change of direction with effects depending on the applied test. Although jumping is a specific activity in basketball, it is possible that the benefit of such training is absent on the sprint and the change of direction speed (Markovic et al., 2007; Bouteraa et al., 2020). Thus, plyometric training can be recommended as an effective form of physical exercise to improve the change of direction speed of basketball players, and the effects can vary depending on a large number of variables, such as training duration, intensity, rest

interval, sample characteristics (sex, age, training). These variables should be considered by experts to design optimal plyometric training to improve the change of direction speed for a particular sport.

Conclusion

The results of this review confirm numerous conclusions that plyometric training is an effective method that positively affects the explosive power, sprint abilities, and change of direction speed of basketball players. However, some studies have indicated that the effect may be absent on the sprint and the change of direction speed. This especially refers to the change of direction speed, because this term has been actively used since 2016. When planning and programming plyometric training, attention should be paid to general factors: age, warm-up, exercises, performance technique, equipment, and surface. The effects of plyometric training can vary depending on factors such as athlete's level, gender, sports activity, duration, type of plyometric training. Therefore, these variables should be taken into account in order to design optimal plyometric training to improve maximum short-term performance in basketball. Thus, further original studies are needed, to further clarify the effect of plyometric training on short-term maximum performance, especially on the sprint and the change of direction speed of basketball players. Certainly, improving plyometric training with the aim of developing maximum short-term performance and achieving optimal physical shape is more than essential for achieving top sports results in basketball.

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