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REVIEW ARTICLE

Development of explosive power in basketball players

Nikola Aksović[1], Bojan Bjelica[2], Filip Milanović[3,4], Ljubica Milanović[2], Nemanja Jovanović[5]

[1] Faculty of Sport and Physical Education, University of Niš, Serbia. [2] Faculty of Physical Education and Sport, University of East Sarajevo, Bosnia and Herzegovina. [3] Faculty of Medicine, University of Belgrade, Serbia. [4] University Children's Hospital, Belgrade, Serbia. [5] Faculty of Medicine, University of Prishtina – Kosovska Mitrovica, Serbia.

Abstract. Basketball is a very active sports game with frequent changes of speed, a large number of jumps and active use of all muscle groups. The aim of this review is to identify, analyze and explain all significant components for the development of explosive power in basketball players. The results showed that despite the high coefficient, which is congenital, explosive power can be developed through well-organized training which should be conducted methodically, rationally and in a well-organized manner. For quality planning and programming of training for the development of explosive power, it is necessary to determine the methods and means of training, training load, as well as their schedule and frequency in the phases of sports preparation. The age of an athlete stands out as the most important factor of individualization. It is necessary to give high attention to the training of explosive power because it is an effective means that contributes to the efficiency of the basketball player.

Keywords. Explosive strength, jumping performance, lower limbs, training.

Introduction

Modern sport puts increasing competitive demands on athletes and coaches, and that imposes the need for training technologies and the process of sports preparation itself to be constantly improved. In accordance with that, it is necessary for all types of sports preparation (technical, tactical, fitness, psychological and theoretical) to be represented in the training, as well as to find their optimal relationship. It is clear that all these types of preparation are interconnected and that a high level of each of them is a prerequisite for entering the state of sports form, however, in today's sport, where it is assumed that top athletes have a high level of technical and tactical training the plan puts conditioning preparation. This has been confirmed by numerous world scientists in the field of sports who have come to the conclusion in their research that in modern sports, especially in the senior category (Hernández et al., 2018; Iacono et al., 2020).

The athlete's condition consists of his bioenergetic potential and biodynamic abilities (coordination and power), and speed as a property describes all these qualities (Stefanović, 2006). One of the biodynamic abilities is, therefore, power, and as one of its forms of manifestation, explosive power stands out (Harry et al., 2020), to which the most attention will be paid in this paper.

Basketball is one of the most important sports today, and therefore great efforts are being made to actively modernize it (Khalil et al., 2020; Hinkle et al., 2020; Lockie et al., 2020; Esteves et al., 2021). The course of the game is such that short high-intensity (maximum and submaximal) activities constantly change with periods of active or passive rest (interruptions in the game), and it occurs within a specific space and time (Karalejić & Jakovljević, 2008). Basketball is a very active sports game with frequent changes of speed, a large number of jumps and active use of all muscle

✉ N. Aksović, e-mail: kokir87np@gmail.com
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groups. For that reason, quality work of coaches is needed in order to achieve the desired results. Explosive power is a very significant ability in many sports (basketball, volleyball, handball, soccer, athletics, etc.). In basketball, the explosive power is manifested through various variants of jumps, starting acceleration, sudden changes in direction of movement, deceleration, abrupt stopping and passing. Knowledge of explosive power in basketball players of different ages is directly related to the effects of training, it facilitates the coach's choice of methods, the process of planning and programming training (Aksović & Berić, 2017). That is why it is very important to pay enough attention to its optimal development in the process of long-term sports training. In the further part of the paper, we will talk about explosive power and its role in basketball, methods and means for its development, training load and the principle of individualization in training. Thus, the aim of this review is to identify, analyze, and explain all significant components for the development of explosive power in basketball players.

Explosive Power in Basketball Players

Explosive power primarily depends on the number of activated motor units, genetic conditioning is 80%, and it is defined as the ability of an athlete to produce the highest possible force in the shortest possible time (Zatsiorsky & Kraemer, 2009).

Numerous examples of research of the explosive power of basketball players of different ages are found around the world (Santos & Janeira, 2008, 2011, 2012; Kocic et al., 2012; Arede et al., 2018; Aksović et al., 2020). In sports such as basketball, explosive power is one of the most important factors for achieving top sports results (McBride et al., 2002; Carlock et al., 2004; Gül et al., 2019; Iacono et al., 2019; Iacono et al., 2020), because today's basketball requires enduring players with well-developed motor abilities. Only one basketball match consists of 46 ± 12 rebounds per player (Mclennes et al., 1995).

Studies aimed at determining the effects of training programs on the explosive power such as jumps, throws, sprints, which lasted four weeks or more (Maffiuletti et al., 2000; Trninic et al., 2001; Santos & Janeira, 2008, 2011, 2012; Khlifa et al., 2010; Tsimahidis et al., 2010; Battaglia et al., 2014; Aksović, 2019) showed that despite the high coefficient, which is congenital, explosive power can be developed through good organized training which should be conducted methodically, rationally and in a well-organized manner. Research also showed a positive correlation between jumps and throws in basketball players of different ages (Santos & Janeira, 2011; Battaglia et al., 2014). A positive correlation between explosive power and short-distance running was found (Stojanovic et al., 2012), while the study (Shalfawi et al., 2011) showed that there are no relations between vertical jumping and short sprint running, which is considered a significant predictor of success in basketball (Latin et al., 1994). The explosive power of the lower extremities of professional basketball players has a positive effect on repeated sprints, and it should be emphasized that it is positively correlated with lean body mass (te Wierike et al., 2014).

Several studies showed significant differences in jumps between basketball players with different levels of performance (Hoare, 2000; Delextrat & Cohen, 2009; Ostojić et al., 2010), indicating that the best players in a team tend to jump more than others. Research showed that a player (if he plays the whole game) runs 6000-7000 meters, performs up to 40 different jumps, about 280 changes of direction, 120 catches of the ball, 80 passes. In one half, the player performed 16-17 rebounds, which would turn out to be about 35 (Narazaki et al., 2009). For this reason, coaches should devote more time to developing explosive power to elite male basketball players, as it has a great impact on competitive success in basketball (Stojanovic et al., 2012).

The basketball players who belong to the category of younger pioneers (10-12 years old), training for the development of explosive power is conducted through various natural forms of movement, through play, resistance is their own body weight, while explosive power of the sprint type is developed by short sprints. Young basketball players (13-14 years old) can have the greatest effect on the development of explosive power, and minimal external loads can be used. In later ages (15-16 years old) gradually increase the possibilities of using outside loads (Aksović & Beerić, 2017; Aksović, 2019).

Training methods for the Development of Explosive Power in Basketball Players

The method of sports training is a deliberate and planned course of training in order to achieve success/results in the competition (Stefanović, 2006).

Strength training methods depend on the available equipment, training space, because otherwise you need to improvise what negatively affects the quality of training (Schelling & Torres-Ronda, 2016). Also, the implementation of strength training, ie the choice of methods depends on the available time, goal (increase, maintenance or rehabilitation), an age of the player and load, training time (preparation, competition or transition period) as well as the total load (tournaments, matches or training). For the subject of this paper, it is important to see how the authors classify explosive power training methods, and to make a selection in accordance with the results of some of the scientific research that confirms or disputes their effectiveness. All strength training methods can be divided into two methods: structural and functional methods (Siff, 2000).

Structural methods are aimed at optimizing the ratio of lean muscle mass and subcutaneous adipose tissue, i.e., optimizing the total amount of muscle mass in relation to the requirements of a particular sport.

Functional methods are aimed primarily at improving intra and intermuscular coordination. Within the functional methods, there are methods of dynamic strain, which are further divided into methods of explosive strain and reactive methods. Explosive strain methods include the high-speed and ballistic method, and reactive methods include the plyometric training method (Zatsiorsky & Kraemer, 2009).

Stefanovic et al. (2010) state the existence of three methods of dynamic strain (for the development of speed and explosive power): speed-powerful, ballistic method and plyometric method. Željaskov (2004) divides the method for the development of speed power and the method for the development of explosive power with an emphasis on impact (plyometric method). Janz et al. (2008) also state the existence of certain combined methods for the development of explosive power, thus distinguishing between the traditional combined method, the mixed method, and the complex (contrast) method.

Based on the results of numerous studies, the speed-powerful, ballistic and plyometric method stand out as the most acceptable for achieving longer-term results in the improvement of explosive power and will be explained in more detail in this paper. Traditional combined and mixed methods have proven to be mainly short-term solutions to improve explosive power, and as no data on their long-term effects are yet available, they can be used in situations where rapid, immediate explosive power improvement is needed, as well as to break training stereotypes. The complex method also showed longer-lasting results, but in direct comparison with the high-speed method, it proved to be less successful (Tricoli et al., 2005). Given these facts, the complex, traditional combined and mixed method will be presented only through the basic characteristics, and the speed-powerful, ballistic and plyometric method will be discussed in more detail in the following chapters.

Complex method, often called and contrasting, involves the alternating use of strength development exercises (Duthie et al., 2002), or a combination of weight training and biomechanically similar plyometric jumps (Freitas et al., 2019). An example of complex training would be performing a series of "back" squats, followed by a series of jumps from a low-load squat, and then alternately performing a series of these types of exercises. Complex training has been shown to be very an effective in improving explosive power in both the short and long term, especially for more advanced athletes with higher levels of strength (Duthie et al., 2002).

Traditional combined method: It consists of strength development exercises followed by force development exercises. While it is certain that strength training alone would lead to improved explosiveness, combined with strength training it leads to much better results in that ability than strength training or force training (Adams et al., 1992). However, although the study (Duthie et al., 2002) have proven that this method has a positive effect on explosive power, these results are only one-time and short-term.

Mixed method involves a combination of plyometric training and strength training. The basic idea is that separating these two workouts by days provides enough time for recovery and thus ensures the least possible neuromuscular fatigue. Compared to complex training, the mixed method has proven to be equally successful in improving explosive power in a short time (Janz et al., 2008).

Speed-Powerful Method

The speed-powerful method implies overcoming medium loads with the maximum possible speed. The most used tools in this training method are Olympic weightlifting exercises and their various variations. Janz et al. (2008) observed that training using

weightlifting techniques has a positive effect on performance in sports such as soccer, basketball, volleyball, and athletics. The authors concluded that it is best for these athletes to train with movements with sudden acceleration, providing resistance to external loads during the entire range of motion, without the intention to slow down or stop. They also concluded that the kinetics and kinematics of the phase of pulling and ejecting weights are quite similar to the kinematics of jumping in various sports, and from a biomechanical point of view, they are also useful in basketball training.

In the study Tricoli et al. (2005) compared weightlifting training (speed-powerful method) with training consisting of squat exercises and plyometric exercises (complex method). The group that trained with the speed-powerful method showed better results in explosive power indicators than the group that used the complex method. The speed-powerful method is based on performing quality repetitions. An athlete must focus on achieving the maximum speed of the weight in each repetition. For the speed of the weight to be maximum, it is necessary to reduce the fatigue factor to a minimum, because in that way it is possible to show great maximum strength in each repetition. Therefore, the duration of the break interval during operation is very important.

Ballistic Method

The ballistic method involves the use of resistances that are significantly less than the maximum force of the muscles, and the movements are performed at the maximum possible speed (James et al., 2018; Zaferanieh et al., 2020). The main difference between the speed-powerful and ballistic methods, except in the applied load, is in the way of completing the concentric part of the movement. Namely, in the ballistic method, the load in the concentric phase is maximally accelerated and thrown into free space (Thibaudeau & Schwartz, 2007; Assist & Hmadragab, 2016). It is usually performed after heating.

Newton et al. (1996) proved in their research that when the "classic" bench press was performed explosively with a lower load (30% of 1RM), there was a significant drop in power which was expressed during 50% of the amplitude of the movement, because the exerciser had to hold a bar that would reach zero speed at the moment of full extension of the arms. The reduction in strength and reduction in acceleration levels was a consequence of reduced agonist activation, ie increased activation of antagonistic muscle groups (upper back muscles produced a pulling force that slowed the bar until reaching zero speed with full extension of the upper extremities).

The application of this method has a smaller effect on the force, and much more on the speed of movement, ie the initial increase in force (starting force). The key factor in the application of the ballistic method is the speed of execution. For that reason, the exercises are performed as long as it is possible to maintain the appropriate speed of movement. Despite the fact that most authors give certain ranges for the number of repetitions, we believe that the quality of repetition performance is crucial for determining the number of repetitions in a series.

Plyometric Method

The plyometric method is the most popular and most applicable in practice, which is not surprising since it involves the use of exercises in which the actual muscles after eccentric contraction become concentric (eg through jumps), and such a pattern of muscle contraction is very present in many sports, and so in basketball (Aksović, 2019). This type of contraction is called reversible and represents a stretch-shortening cycle, SSC (Zatsiorsky & Kraemer, 2009). The application of these and similar exercises enables (helps) the muscles to generate maximum force in the shortest time intervals. The positive effect of plyometric training on explosive power in basketball players has been confirmed in numerous studies (Santos & Janeira, 2011; Hernández et al., 2018; Meszler & Váczi, 2019).

The following phase of movement performance is characteristic (for agonist muscles): preactivation, elongation, and shortening (Stefanović et al., 2010). In eccentric-concentric cycle in the shortening phase, a higher force is realized for four main reasons (Zatsiorsky & Kraemer, 2009). First, at the highest point of the cycle, more precisely at the moment when the elongation stops and the shortening begins, the force develops in isometric conditions. Second, since the force begins to grow in the eccentric phase, the time required for the development of the force is greater. There are two other factors: peripheral elasticity or muscular-tendon elasticity, and central (nervous) or reflex contraction. Muscle and tendon elasticity is also an important factor in athletic achievement. The greater the elasticity of the musculoskeletal complex,

the greater the force will be accumulated and used for the next movement.

After the contact of the feet and the ground during the landing, the height of the muscles and the forces that develop change abruptly. The muscles are forcibly elongated, and at the same time their tension is greatly increased. When a muscle elongates under the action of an external force, the muscle spindles also elongate. Due to the elongation, the muscular spindle is irritated, so alpha motor neurons are activated, and a reflex contraction of the elongated muscle occurs, which helps it to return to its initial length. The minimum time required to activate the myotatic reflex is 35 milliseconds (Čoh, 2004). Since the plyometric method includes exercises of higher intensity and the possibility of injury is increased, its application requires special caution. Accordingly, attention should be paid to several important factors, namely: warm-up, exercises, performance technique, equipment, and surface. When we talk about the components of the load, we primarily mean the intensity, number of series, number of repetitions, duration, and character of the break.

Also, to an influence on explosive power, the positive influence of plyometric training on the sprint in young elite male basketball players has been proven (Aksović et al., 2020).

Training Means for the Development of Explosive Power in Basketball Players

Training resources, in relation to the criterion of similarity according to the sports branch, can be divided into general preparatory, directed, specific and competitive (Stefanović, 2006). It should be noted that there is no quite clear boundary between these means and that there is a possibility of error in classifying training means from one group to another (Cañadas et al., 2018). However, we will try to present general preparatory, directed and specific training means for the development of explosive power in basketball players, and to point out certain movements whose quality of performance could be affected.

Directed training means include motor activities that are the foundation of an athlete's specific movements. They contain such movements that are close to a certain sports activity in terms of the structure of performance, the character of muscle tension and the activity of the functional system.

Specific training means include motor activities that are the foundation for an athlete's competitive activity. They contain such movements that are similar to a certain sports activity in terms of the structure of performance, the character of muscle tension and the activity of the functional system (Stefanović, 2006).

Basic training means in training to develop the explosive power of basketball players are strength exercises. Strength exercises can be divided according to the nature of resistance into (Nićin, 2000):

- Exercises with external resistance (working with weights of objects, usually means working with free weights or medicine ball, the resistance of partners, the resistance of elastic objects, the resistance of an external environment, exercises on trainers, and exercises with self-resistance) (Klusemann et al., 2012),
- Exercises where the load is its weight and include the impact method or plyometric training (Aksović, 2019).

Respect for the Principle of Individualization

When applying training for the development of explosive power and creating a program for a particular athlete, certain individual characteristics of an athlete should be taken into account, as well as the requirements of a particular sport, in this case, basketball.

Individualization can greatly contribute to the effectiveness of the program, but also on other hand reduce the possibility of overtraining and injury. Therefore, it is necessary to determine which individual characteristics of an athlete can influence the mentioned variables for creating the program. The following characteristics were taken into account: 1) Age, 2) Anthropometric characteristics, 3) Level of preparedness, 4) Position in the team.

Perhaps the most sensitive factor in the individualization of training is age. The training of children and young an athlete must not be based on the principles of adult training but must be harmonized with their biological, chronological, psychological, and physical development. It is already known that in the process of growth and development there is a difference in the biological and chronological age of an individual, and, based on that, young athletes are divided into accelerators and retardants. Therefore, we

must be very careful in determining the optimal training stimulus.

In the application of training for the development of explosive power, when choosing the appropriate load, one should also take into account an anthropometric characteristic of an athlete, body height, and body weight (Opstoel et al., 2015). Anthropometric characteristics exert their influence mostly when applying exercises with reversible contraction (plyometric exercises).

Training for the development of explosive power is very demanding and strenuous for the human body. Therefore, athletes must have an appropriate level of preparation, which is reflected, above all, in physical and technical preparation, to start this training. For any exercise (e.g., Olympic weightlifting exercises, various variants of jumps, etc.) to be performed to develop explosive power, it must be technically properly mastered at minimum load and lower performance speeds. Only when this condition is met, of course respecting an age characteristic, can one train with a higher load and at high speeds.

Although explosive power, as an ability, is important for all basketball players, there are still differences in its manifestation concerning the type of movement depending on the position of the players in the team. In basketball, we can distinguish two basic types of players: external and internal players. External players are marked with numbers from 1 to 3, internal players with numbers 4 and 5. Each of the mentioned positions implies different and specific characteristics, abilities, and skills of players concerning their role and tasks in the game (Karalejić & Jakovljević, 2008).

The basic movements in which players in positions 1 and 2 (guards) show explosive power are accelerations, decelerations, fast change of direction in all directions, jumps from bouncing with both legs and from bouncing with one leg with emphasized vertical, and in certain situations horizontal component, of course, in all directions. Players in positions 3 and 4 (forwards) showed explosive power in movements such as changes of direction, acceleration, and deceleration, jumps from movement by bouncing with one and both legs. The main difference between players in positions 3 and 4 in relation to players in positions 1 and 2 is that their explosive power is manifested predominantly in jumping activities. Players in position 5 (centers) move mostly in a straight line, and they realize possible changes of direction in a very small space (te Wierike et al., 2014; Ferioli et al., 2020).

Conclusion

This article despite its limitations contains new information about the explosive power of male basketball players that could be extremely useful for coaches. Despite the inborn coefficient, the development of explosive power can be realized through planned, rational, and well-organized training. Also, these findings suggest that basketball coaches may benefit from talent identification in young basketball players. For quality planning and programming of training for the development of explosive power, it is necessary to determine the methods and means of training, training load, as well as their schedule and frequency in the phases of sports preparation, i.e., periodization of training. The age of an athlete stands out as the most important factor of individualization and requires planned and systematic implementation of training in accordance with the biological, chronological, and psychological development of the young basketball player. Since training for the development of explosive power is very demanding and strenuous for the human body, one should be careful in its application and pay attention to the level of preparedness of an athlete. It is necessary to give high attention to the training of explosive power because it is an effective means that contributes to the efficiency of the basketball player.

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Declaration of Interest

The authors report no conflict of interest in the study.

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