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Original research article

EXPLOSIVE LEG STRENGTH OF ELITE BASKETBALL PLAYERS

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Abstract. *The study was performed in order to determine changes in the level of explosive leg strength in elite basketball players after a 12-week experimental treatment program. The study included 15 basketball players from the BC Konstantin in Nis. As members of this team, the players also compete in a basketball league in Serbia. The youngest basketball player is 18 and the oldest is 26 years old. The sample of measuring instruments consisted of tests of explosive leg strength: the squat jump, countermovement jump, drop jump and standing long jump. The experimental program lasted for 12 weeks, from January to March 2015 and during this interval there were 36 training sessions, three sessions per week, for the development of explosive leg strength. In addition to taking part in the experimental treatment, the basketball players also participated in regular training sessions throughout the competitive cycle. Statistical analyses included the basic descriptive parameters (mean value - mean and standard deviation – St. Dev) and analysis of variance (MANOVA and ANOVA). Analyses of variance were obtained based on the changes in the final, as compared to the initial measurement. The results showed statistically significant changes in explosive leg strength $p < 0.05$. It can be concluded that the experimental treatment significantly affected the skills.*

Key words: *vertical jumping ability, horizontal jumping ability, excellent basketball.*

INTRODUCTION

Basketball is constantly changing and perfecting throughout history. From initially slow activities involving the ball, it grew extremely dynamic and was defined by the structure of movement activity.... The periods for exercise of technical and tactical tasks are increasingly shortened, and the speed of action in the sports battle, in relation to the

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initial phase, has reached unimaginable proportions. Quick action and dynamism are the main characteristics of the game of basketball today (Stanišić, 2011, 2). Every professional sport demands a superior physical conditioning of players. Basketball is a sport activity with periods of high intensity and short periods of recovery. Players must be at a high level of physical fitness, otherwise, the technique progressively gets worse with the emergence of fatigue and the result is the loss of the match (Foran, 2010).

It is believed that the players with a more pronounced level of explosive leg strength are at an advantage (the peak of basketball goals). Since players are required to be able to move rapidly and have an explosive first step which throws the opponents out of their game, to effectively move along the court with the possibility of abrupt directional changes. For example, cutting, passing, and game jumps for defensive and offensive purposes continuously throughout the game (Foran, 2010).

Explosive power is one of the determinants of success in all the activities that require maximum muscle force performance as quickly as possible (Newton & Kreamer, 1994). The ability to perform an explosive movement is of great importance to sports performance and success. Strength, force, and the pace of development have become more important than the training when performing a particular movement task (Gašić et al., 2011).

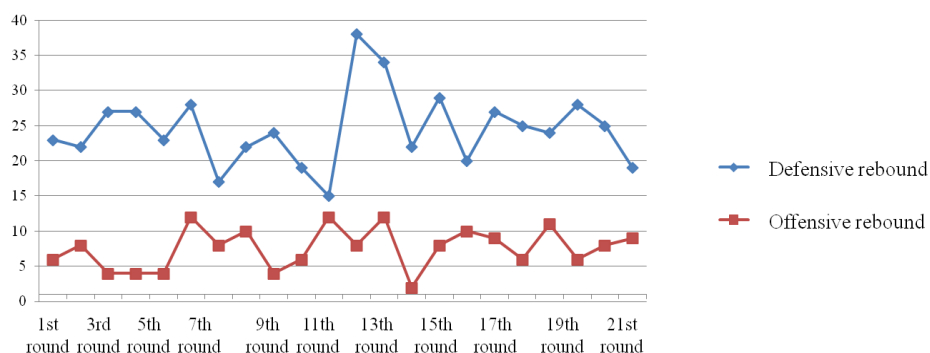
Top results in every sport, as well as in basketball, work as a series of "tiles" stacked in the correct order. Talent or natural talent for each sport is only based on the quality of the results, but the scientific achievements clearly indicate that it is not a fundamental and decisive factor for successful engagement in professional sports. The training process is a term that is often used in scientific research. It is the process in which the athlete goes through phases and stages of learning, training, automation. By developing their skills, athletes affect their characteristics, becoming more efficient and thus increasing their sporting achievements to a new level (Kocić, 2007, 9).

Indicators that determine the level of explosive leg strength

The most important indicator of the level of explosive leg strength in basketball is jumping in attack and defense. When speaking about the attack, the main objective of offensive rebounds is to keep possession of the ball after a missed shot. Although the heights of the players are a possible advantage in rebounds, rebounds are also the key to decisiveness and technique. The statistics of leading jumpers is not just a list of the highest players or players with the highest vertical jump. Most rebounds, even in the highest quality basketball leagues, go under the basket. Positioning and the ability of players to quickly catch the ball (horizontal motion), no jumping ability (high jump), may be the most important ability next to the leap. Jumping requires more than a physical predisposition. It requires significant effort, determination and adequate expression techniques. Perhaps the best testament to the importance of jumping is a high correlation between successful jumps and wins. The rebound, more than any element of attacking techniques, shows the desire and efforts of that attack and win. In addition, the rebound represents a counter-attack and prevention (Berić and Kocić, 2010, 137).

On the defensive half of the field, jumping means obtaining possession of the ball, which is the last stage of defense. You should end with a defense jump whilst in defense. Jumps in defense offer more chances for a counter-attack. The ability of the team to start a counter-attack depends solely on the defense jump and the opponents' turnovers. This is the reason why the proper development of the counter-attack has a well-developed and effective jump in defense. Players usually prefer to counter just because it is easy to motivate them to concentrate on jumps, not on rebounds or counter-attacks. Timing and the ability to jump are two useful attributes for jumping. However, the best chance to jump does not mean anything if the player does not know how to make use of it.

OKK Konstantin-Season 2014/2015



The basic premise for the success of the game is focused on the phase of defense, in other words, preventing attacks that include shooting several times. It is important to emphasize that 60% to 80% of the attacks in transition stem from the defense jump. The defense jump makes up 66% of the total rebounds in the game (Trninić, 1996).

The analysis rebound for the BC Konstantin during the 2014/15 season provided data on the number and frequency of giving a direct projection of the final result of the match. Although the successful leap in basketball is largely dependent on more technical and tactical elements, such as setting up for the jump, construction studs, timeliness, etc., it is also undisputed that the core cause of its problems, is that it is stripped of speed and explosive properties.

METHOD

The study was carried out in order to determine changes in the level of explosive leg strength in elite basketball players after a 12-week experimental program. The study consisted of 15 BC Konstantin basketball players in Nis that competed in the Serbian basketball league in season 2014/15. The youngest basketball player was 18 and the oldest was 26 years old. All the players signed a professional contract with the club. The average basketball internship is 12.7 years.

The following was used to assess explosive leg strength:

- Squat jump – SJ

- Countermovement jump – CJ
- Drop jump – DJ
- Standing long jump – SLJ

Measurement of the first vertical directional jumps were done using the Myotest with an infrared laser system (Bubanj, Bubanj, Stanković and Đorđević, 2010) that represents a wireless accelerometer with the respective software for assessing the intensity of the explosive strength of the muscles, i.e. changes in the values of intensity of the force (in N), power (in watts), speed (in cm/s) and height (in cm) of vertical jumps. On this occasion, the parameter of explosive leg strength was obtained using a Myotest, which was statistically processed for jump height (in cm). The fourth test (the standing long jump), which was represented as the horizontal direction of the vertical jump, was measured by strain gauges.

All of the tests mentioned above used for the evaluation of explosive leg strength can be downloaded from the site TorentSports:

<http://www.topendsports.com/testing/tests/index.htm>. The statistical analysis includes the mean value (mean) and the standard deviation (St. Dev.) as its basic descriptive parameters. To determine the intra group difference from different measurements, both the multivariate analysis of variance (MANOVA), and the differences in each individual measuring instrument, were determined by a univariate analysis of variance (ANOVA).

Experimental procedure

The experimental program lasted for 12 weeks, from January to March 2015 and during this interval, 36 trainings sessions were held, with three sessions per week, for the development of explosive leg strength. The duration of a single training session was 90 min. In addition to training within the experimental treatment, the basketball players had regular training within a competitive cycle. The structure of the training programs (Table 1) consisted of training units that are made up of seven parts, which are implemented according to the established order: dynamic flexibility, sprint drills, agility, accumulation potential, explosive power, expression resources, including stretching, relaxation and massage. The ratio of work to rest within each of the individual parts of the training is designed to a high quality of movements (techniques) through the production of maximum power and speed. There are also pauses in between the parts of the training program, lasting for 2-5 minutes, except between flexibility and sprint exercises, while there were pauses during the disclosure of potential, expansion, relaxation, and massage. Each training session includes a warm-up jog and dynamic stretching exercises. The last part of the training involves jogging and stretching after every 2-5 minutes.

Table 1 The structure of the training program

		Training program							
		Flexibility	Sprint exercises	Agility	Accumulation potential	Explosive power	Expression resources	Including stretching, relaxation and massage	Total
1st	Intensity (%)	50%	80%	80%				30 %	
Week	Volume	20	30	30	0	0	0	10	90
2nd	Intensity (%)	50%	80%	90%	100%			30 %	
Week	Volume	15	25	30	10	0	0	10	90
3rd	Intensity (%)	50%	85%	100%	80%	100%		30 %	
Week	Volume	15	20	20	15	10	0	10	90
4th	Intensity (%)	50%	85%	80%	70%	100%		30 %	
Week	Volume	15	25	20	10	10	0	10	90
5th	Intensity (%)	50%	90%	100%	90%	100%	80%	30 %	
Week	Volume	10	20	20	15	10	5	10	90
6th	Intensity (%)	50%	90%	100%	100%	100%	80%	30 %	
Week	Volume	10	15	20	20	10	5	10	90
7th	Intensity (%)	50%	90%	100%	100%	100%	80%	30 %	
Week	Volume	10	15	15	20	15	5	10	90
8th	Intensity (%)	50%	80%	80%	80%	100%	90%	30 %	
Week	Volume	10	15	10	20	15	10	10	90
9th	Intensity (%)	50%	80%	80%	100%	100%	90%	30 %	
Week	Volume	10	15	10	20	15	10	10	90
10th	Intensity (%)	50%	90%	90%	90%	100%	90%	30 %	
Week	Volume	7	15	10	20	20	10	8	90
11th	Intensity (%)	50%	100%	80%	90%	100%	100%	30 %	
Week	Volume	7	10	10	15	25	15	8	90
12th	Intensity (%)	50%	100%	100%	100%	100%	100%	30 %	
Week	Volume	7	10	10	15	25	15	8	90

RESEARCH RESULTS

Table 2 Basic statistical parameters for the assessment of explosive leg strength

Variable	Initial measurement		Final measurement	
	Mean	St.Dev.	Mean	St.Dev.
SJ	32.07	5.88	38.97	5.63
CJ	39.99	6.81	46.31	6.02
DJ	48.25	7.27	54.49	6.92
SLJ	245.67	16.33	261.27	12.44

In Table 2, we find the arithmetic mean and standard deviation of the initial and final measuring for the BC Konstantin.

Analysis of variance

Table 3 The analysis of variance of explosive leg strength between the initial and final measuring

MANOVA	F-test	P-level
	4.02	.012*
ANOVA	F-test	P-level
SJ	10.78	.003**
CJ	7.24	.012*
DJ	5.79	.023*
SLJ	8.66	.006**

Table 3 presents the results of the test of significance of the differences in arithmetic mean of all the tests between the initial final measuring. There is a statistically significant difference between the participants, given the size of the F-relation (4.02), as shown by the significant difference at the $P = .012$ level. The univariate analysis of variance of explosive power between the initial and final measurement indicates that based on the coefficients of the F-relations and their significance (P-level), statistically significant differences were determined in all tests of explosive strength: the squat jump (SJ .003), countermovement jump (CJ .012), drop jump (DJ .023) and standing long jump (SLJ .006).

DISCUSSION AND CONCLUSION

Modern elite basketball owes its dynamics, among other things, to the high level of development of the physical fitness of each player, regardless of the position in which he plays.

Therefore, great attention is paid to physical preparation, both in the main, technical-tactical training, and on a special training program where work is primarily done on the development of the motor skills (work on the basketball court, workouts in the gym).

Studies on jumping are often based on an examination of the various programs of plyometric training (training dealing with eccentric-concentric muscle contraction – the stretch-shortening cycle).

Morsal et al. (2014), by examining the effect of plyometric training on the development of explosive strength in basketball, have come to the conclusion that after six weeks of treatment, a positive influence on the development of explosive strength in basketball was observed.

Janeiro and Santos (2011), Hoe, Mudah and Hian (2011) and Zhang (2013) showed similar results. Zhang (2013), in addition to investigating explosive power, also investigated the speed of running over short distances, endurance in strength, and noted the positive influence of the explosive force in individual leg strength and endurance in general.

Janeiro and Santos (2011) after 10 weeks of training at full intensity also posted a positive effect of the experimental treatment. This trend was maintained after 16 weeks of training setback.

In the study carried out by Hoe, Mudah and Hian (2011) improvement in the vertical jumping ability was observed after four weeks of plyometric training. Matavulj, Kukolj, Ugarković, Tihanyi & Jarić (2001) examined three different modes: training in order to determine the effect of plyometric training on elite young basketball players and came to

the conclusion that the limited use of plyometric training can improve results in jumping ability, and that the improvement is partly associated with an increase in the maximum force of hip extensors and the levels of development of the forces of the knee extensors.

Janeiro and Santos (2008), working in the field of strength training and plyometrics, focused on the development of explosive strength of young players 14-15 years of age. With the help of the results of the vertical jump: the squat jump, countermovement jump and Abalakov test, they pointed out a reasonable and effective use of complex training programs to improve the level of explosion of the lower extremities in young players.

The conclusion has been made that it is necessary to use more strength training in sports practice, and that this type of training is an effective tool for basketball coaches, very innovative in terms of strength development, contributing to the efficiency of training time. Another longitudinal study using plyometric training was performed by Ramateerth and Kannur (2014) who compared plyometrics with the strength training of basketball players. Their results that indicated the success of plyometric training in relation to strength training in increasing physical performance in basketball.

Researchers who are often engaged in the area of explosive strength are also Janeiro and Santos, who published a number of articles focusing on various experimental treatments and pointed to the positive effects of the development of motor skills. In their work from 2012 (Santos and Janeiro, 2012), they determined the effect of a 10-week endurance training program on the development of the explosive strength of young players.

The results of this study showed that a 10-week endurance training program on a moderate scale and moderate load intensity can improve the results in vertical jumping and throwing a medicine ball from a seated position in young basketball players (adolescence).

It is necessary to know that this type of short endurance training was specially designed for young basketball players, causing an increase in explosive strength, which is very important for the results of the game without any extra burden on the development of skeletal muscles.

At the beginning of the research it was presumed that a statistically significant improvement would be determined for explosive leg strength.

This was also expected based on the sample of participants, all top players of the BC Konstantin, who for several seasons competed in the basketball league of Serbia and represent a united and professional team which consistently recorded good results.

The results this season were more than good, as shown by the team's rank in the league, where during the whole season, the team took one of the first three places.

Indicators of explosive leg strength (jumping in attack and defense), which were analyzed during the whole season, indicate the good physical fitness of the team, so the second place at the end of the session and a place in the Super League of Serbia was expected.

This development in the 2014/15 season, and the safe play of the basketball players of the BC Konstantin has positively influenced the development monitored in this study. The assumption was correct, and the results showed a statistically significant improvement of explosive leg strength ($p > 0.05$).

Finally, it can be noted that this work is one of a series of articles published on this subject, which showed the important place of explosive leg strength in the basketball training process.

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EKSPLOZIVNA SNAGA NOGU VRHUNSKIH KOŠARKAŠA

Istraživanje je izvršeno sa ciljem da se utvrdi promena u nivou eksplozivne snage nogu kod vrhunskih košarkaša nakon 12-nedeljnog eksperimentalnog tretmana. U istraživanju učestvovalo je 15 košarkaša OKK "Konstantin" iz Niša učesnika košarkaške lige Srbije. Najmlađi košarkaš ima 18, a najstariji 26 godina. Uzorak mernih instrumenata sastojao se od testova eksplozivne snage nogu: squat jump, countermovement jump, drop jump i standing long jump. Eksperimentalni program trajao je 12 nedelja i to od januara do marta 2015. godine i u tom intervalu održano je 36 treninga, po tri treninga nedeljno, za razvoj eksplozivne snage nogu. Osim treninga u okviru eksperimentalnog tretmana,

košarkaši su imali i redovne treninge u okviru takmičarskog ciklusa. Statistička obrada podataka obuhvatala je osnovne deskriptivne parametre (srednja vrednost - Mean i standardna devijacija - St.Dev) i analizu varijanse (MANOVA i ANOVA). Analizom varijanse dobijene su promene na finalnom u odnosu na inicijalno merenje. Rezultati su pokazali statistički značajne promene eksplozivne snage nogu $p < 0.05$. Može da se zaključi da je izvedeni eksperimentalni tretman značajno uticao na promenu date sposobnosti.

Ključne reči: *vertikalna skočnost, horizontalna skočnost, vrhunska košarka.*