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Research article

PLYOMETRIC TRAINING AND SPRINT ABILITIES OF YOUNG BASKETBALL PLAYERS

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Abstract. *The aim of this research was to determine the effects of plyometric training on sprint abilities. Young basketball players (N=33, Age=15-16) from OKK "Stari Ras" and OKK "Novi Pazar" from Novi Pazar were divided into two groups: an experimental group (EG, n=16; BH=185.45±8.75cm; BM=76.87±11.51kg) with training experience (TE=4.69 ±1.40 years) and a control group (CG; n=17; BH=184.16±6.93cm; BM=76.87±11.51kg) with training experience (TE=5.53±3.18 years). The EG was made up of the players from basketball team OKK "Stari Ras", who in addition to basketball trainings also took part in plyometric training. The CG was made up of the players from basketball team OKK "Novi Pazar", who at that time only took part in basketball trainings. To assess their sprint abilities, three tests were used: Sprint Speed at 5m (S5m), Sprint Speed at 10m (S10m), Sprint Speed at 20m (S20m). The measurement was done with the help of the photocells "Microgate", a parameter which was monitored and the processed time was read in 1/100s. The experimental program lasted for 10 weeks (2x per week). To determine the effect of plyometric training on the sprint abilities of young basketball players, the analysis of covariance ANCOVA was used. The results showed that the EG group achieved significantly greater progress than the CG group on the tests: S5m and S20m. There was no difference between the EG and CG group on the S10m test. Based on these results we concluded that plyometric training has positive effects on the development of sprint abilities in young basketball players.*

Key words: *Plyometrics, Abilities, Basketball, Young Players*

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INTRODUCTION

Plyometric training implies the use of exercises in which the actual muscles after the eccentric contractions transform into a concentric one (for example a series of jumps) and as a form of muscles contraction is very present in many sport branches, and so in basketball. The mentioned type of contraction is called reversible one, and it represents the stretch-shortening cycle (SSC) (Zatsiorsky & Kraemer, 2009). Basketball as a physical active sport which depends on many motor skills, including short sprints, because these days basketball depends much on speed of sprint. Therefore, special attention is required when organizing the training process of basketball players, starting from the youngest age categories to the seniors (Trunić, 2007).

Among young basketball players plyometric training is recommended as a primary means in the training process, with a goal to increase the speed of short sprints (Arede, Vaz, Franceschi, Gonzalo-Skok, & Leite, 2018; Hernández, Ramirez-Campillo, Álvarez, Sanchez-Sanchez, Moran, Pereira, & Loturco, 2018; Asadi, Ramírez-Campillo, Meylan, Yuzo, Nakamura, & Izquierdo, 2016; Asadi & Arazi, 2012; Bavli, 2012; Arazi & Asadi, 2011; Draganović & Marković, 2011; Chu, 1998). Bavli (2012) determined, on a sample of basketball players, that plyometric training is an efficient method which leads to significant improvement of results in the 30m sprint. Similar results were obtained in a study (Hernández et al., 2018), there the authors came to conclusion that seven weeks of plyometric training can lead to an improvement of speed on the 30m sprint. Apart from a positive impact on speed on the 30m sprint Asadi et al. (2016) stresses that plyometric training also has a positive impact on speed on the 60m sprint. Many studies agreed that plyometric training can improve the speed of sprint among young basketball players (Gonzalo-Skok, Sánchez-Sabaté, Izquierdo-Lupón, & Sáez de Villarreal, 2018; Latorre Román, Villar Macias, & García Pinillos, 2018; Prasad & Subramainiam, 2014; Zribi, Zouch, Chaari, Bouajina, Ben, Zaouali, & Tabka, 2014; Komal & Singh, 2013; Asadi, 2013). However, some studies show that plyometric training proved to be an effective method for increasing height jump (Chelly, 2018). Therefore, plyometric training is widely used in improving generalizing short-term maximum performance such as sprinting (Kotzamanidis, 2006).

It should be emphasized that professional basketball players, during one match, make sprints of short duration approximately (1-2sec) 105±52 times (Castagna, Chaouachi, Rampinini, Chamari, & Impellizzeri, 2009). McInnes, Carlson, Jones, & McKenna (1995) in their research of basketball games of the Australian National Ligue reveal that the longest sprint lasted for 5.5 seconds, 5% of sprints lasted longer than 4 seconds, and the largest number of sprints (51%) lasted between 1.5 and 2 seconds. The approximate sprint duration was 1.7 seconds. During one basketball match, a professional player runs between 3500-5000 meters (Janeira & Maia, 1998). Every player performs approximately 1000 activities, most of them are short-term lasting about two seconds, and time analysis of movement shows that these short activities are performed with different frequency according to player position (Abdelkrim, El Fazaa, & El Ati, 2007). Highly developed acceleration ability and speed is very significant not only for external players but also for the internal players (central position). The reason for this is a growing number of trainers who through shortening the duration of attack favor fast transition in the attack but also in defense (Nikolić, 2016). For external players, it is assumed that they run fast and accelerate, and since basketball is a game of high-profile people, the internal players emphasize and they need to pay special attention to speed training (Jakovljević, Karalejić, Pajić, & Mandić, 2011).

The aim of this research was to determine the effects of a 10-week programed plyometric training on the sprint abilities in young basketball players.

METHODS

Sample of participants

The sample of participants in this study consisted of 33 young basketball players from the basketball clubs OKK "Stari Ras" and OKK "Novi Pazar" from Novi Pazar. The participants were divided into two groups: the experimental group (EG, n=16; BH= 185.45±8.75cm; BM=76.87±11.51kg), with training experience (TE=4.69±1.40 years) and the control group (CG; n=17; BH=184.16±6.93cm; BM=73.68±11.70kg) with training experience (TE=5.53±3.18 years). The EG consisted of basketball players of basketball team OKK "Stari Ras" who in addition to the basic technical and tactical training (5x per week) also had plyometric training for a period of 10 weeks (2 times per week). The CG was made up of the basketball players of basketball team OKK "Novi Pazar", who at that time only took part in technical and tactical training (5 times per week).

The measuring instruments

To assess the anthropometric characteristics, the following were used: body height (BH) and body mass (BM). Data on the anthropometric measures were not subjected to statistical analysis and were used to describe the sample of participants. To assess sprint ability, three tests were used: Sprint speed at 5m (S5m), Sprint speed at 10m (S10m) and Sprint speed at 20m (S20m) (Bouteraa et al., 2018; Delextat & Cohen, 2009). The measurement was done with the help of the "MICROGATE" photocells, and the parameter which was monitored and processed was the time read in 1/100s.

The experimental procedure

The experimental group carried out plyometric training (2x per week) for 10 weeks. The pause between the first and second training in a week was at least 48 hours long so the players would have time to adequately rest. The experimental program was realized during the preparatory period and continued through the competition period that began at the end of October 2018. Plyometric training lasted from 45 min at the beginning of the experiment to 70min at the end of the experiment. Each plyometric training consisted of three parts: introductory, main and final.

The main goal of the introductory part was to prepare players for the main part of training. During this part, warm-up activities were carried out (light running, side movements, running backwards, short sprints, straight-line running with tasks-knee lift, heeling, shaping exercises). The duration of this phase was from 7min at the beginning of the experiment, up to 10min at the last session of the experiment. The main part involving the use of plyometric exercises lasted from 30min in the initial weeks of the experiment to

50min in the final. The intensity and extent of the plyometric training was set according to the recommendations (deVillarreal, Kellis, Kraemer, & Izquierdo, 2009).

The first training session in the week consisted of the following exercises: Squat jump, Single leg jump, Countermovement jump, Ankle jumps, Tuck jumps, Lunge jump (Table 1). The other training during the week consisted of the following exercises: Rim jump, Single leg tuck jump, Countermovement jump/Arm Swing, Zigzag tuck jumps, Lateral box jump, Drop jump (Table 2). The goal of the plyometric exercises, which involve vertical jumps on one and both legs, was to strengthen the muscles that play an significant role in explosive activities and activities of quick change of direction during the basketball game. The main goal of the final part was "cooling the body", or stretching the muscles that were forced during main part of the training. Considering the specificity of the plyometric training, great attention is paid to the stretching of the muscles, in order to begin the recovery process that is required after intensive training. The duration of this phase was from 8min at the beginning of the experiment, up to 10min in the last session of the experiment.

Table 1 The program of the first plyometric training during the week

		Squat jump	Single leg jump	Counter movement jump	Ankle jumps	Tuck jumps	Lunge jump
1-3 weeks	NS	2	2	2	2	2	2
	NR	8	8	8	8	8	8
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s
4-5 weeks	NS	2	2	2	2	2	2
	NR	10	10	10	10	10	10
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s
6-7 weeks	NS	3	3	3	3	3	3
	NR	8	8	8	8	8	8
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s
8-10 weeks	NS	3	3	3	3	3	3
	NR	10	10	10	10	10	10
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s

Legend: NS-number of series; NR-number of exercises;
PS-pause between series; PE-pause between exercises

Table 2 The program of the second plyometric training during the week

		Rim jump	Single leg tuck jump	Countermovement jump/Arm Swing	Zigzag tuck jumps	Lateral box jump	Drop jump
1-3 weeks	NS	2	2	2	2	2	2
	NR	8	8	8	8	8	8
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s
4-5 weeks	NS	2	2	2	2	2	2
	NR	10	10	10	10	10	10
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s
6-7 weeks	NS	3	3	3	3	3	3
	NR	8	8	8	8	8	8
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s
8-10 weeks	NS	3	3	3	3	3	3
	NR	10	10	10	10	10	10
	PS	60s	60s	60s	60s	60s	60s
	PE	10s	10s	10s	10s	10s	10s

Legend: NS-number of series; NR-number of exercises;
PS-pause between series; PE-pause between exercises

Data processing

In order to determine the effect of plyometric training on the above-stated abilities of basketball players, the analysis of covariance (ANCOVA method) was used. The results obtained at the initial measurement were used as covariates in the analysis. Before the ANCOVA analysis was accessed, the validity of the assumptions that the analysis of covariance is based on (normality of distribution, homogeneity of variance, measurement of covariates, covariate reliability, homogeneity of regression lean) was tested. Kolmogorov-Smirnov test was used in order to test the normality of distribution of the variables. Data were processed and mistreated by the use of the software SPSS version 12. The statistical significance was set at level $p<.05$.

RESULTS

The results of the Kolmogorov-Smirnov test showed that the variables of the experimental and control groups at the initial and final measurement did not violate the presumption of normal distribution ($p<.05$). Levene's Test of Equality of Error Variances showed that the assumption of equality of the variance was not violated ($p<0.05$). The assumption of homogeneity of regression is not violated for any of the variables ($p<0.05$). Based on this, we can conclude that there is no interaction between the covariate and treatment. After preliminary checks, where we found that the assumptions that the ANCOVA is based on are not violated, we continued with the analysis of covariance and the research into the impact.

Table 3 Univariate analysis of covariance

Test	G	N	SD (In.)	SD (Fin.)	Mean (In.)	Mean (Fin.)	Adj. Mean	F	p	P.Eta Squ.
S5m	EG	16	.034	.066	1.21	1.14	1.16	4.910	**.034**	.141
	CG	17	.084	.121	1.24	1.23	1.22			
S10m	EG	16	.048	.084	2.03	1.95	1.95	1.788	.191	.056
	CG	17	.121	.121	2.04	1.99	1.98			
S20m	EG	16	.149	.169	3.48	3.36	3.36	7.216	**.012**	.194
	CG	17	,257	,234	3,47	3,47	3,47			

Legend: SD (In.) - Standard Deviation of the initial measurement; SD (Fin.) - Standard Deviation of the final measurement; G - group; EG - experimental group; CG - control group; N - number of respondents; Mean (In.) - the mean value of the initial measurement; Mean (Fin.) - the mean value of the final measurement; Adj.Mean - corrected mean values at the final measure from which the influence of covariates is statistically removed; F - the value of F-test to test the significance of differences of arithmetic means; p - coefficient of significance of differences of arithmetic means; P.Eta Squ. (Partial Eta Squared) - size of impact.

After statistically removing the impact of the results obtained on the tests for assessing sprint performance prior to the experimental treatment, it was found that there is a statistically significant difference at the univariate level between the participants of the EG and CG group, after the experimental treatment, on the test **S5m** (F=4.910; p=.034) (Table 3). Based on the revised mean values Adj.Mean (from which the influence of covariates was statistically removed) we can see that the participants of the EG achieved better results (Adj.Mean=1.16) than the participants of CG (Adj.Mean=1.22). Based on the partial eta squared (Partial Eta Squared=.141), we can see that there is a **great impact** (difference). According to Kohen, .01 is - little influence, .06 - medium impact, .14 and more - a great impact (Pallant, 2011). If Partial Eta Squared is multiplied by 100 it can be seen that 14.1% of the variance in the dependent variable is explained by the independent variable. A statistically significant difference at the univariate level between the participants from the EG and CG, after the experimental treatment, is also present on the test **S20m** (F=7.216; p=.012). Based on the revised mean values (Adj.Mean) it can be seen that the participants from the EG group achieved better results (Adj.Mean=3.36) than participants of the CG group (Adj.Mean=3.47). Based on the partial eta square (Partial Eta Squared=.194), we can see that there is a **great impact** (difference). If Partial Eta Squared is multiplied by 100 it can be seen that 19.4% of the variance in the dependent variable is explained by the independent variable. The univariate analysis of covariance, however, shows that there is no statistically significant difference between the participants from the EG and CG group, after the experimental treatment, on the **S10m** test (F=1.788; p=.191).

Discussion

The results show that the EG, which had, besides technical-tactical basketball training, also had plyometric training, achieved statistically significantly higher progress than the CG, on the S5m and S20m test. It means that a 10-week plyometric training (2 times per week) had positive effects on improving the results between two tests on the mentioned sprint abilities tests, while on the S10m test, although there are differences with respect to the initial measurement, in favor of the EG, they are not statistically significant. After the experimental treatment, the results show that the EG made more significant progress than the CG during the S5 test. With the help of partial eta squared (Partial Eta Squared=.141) it can be seen that the effects of plyometric training on improving the results on this test are high. It should be emphasized that no studies have been found in which the effect of the plyometric effect is investigated for the speed of the 5m sprint among young basketball players. There is a study which shows that a 6-week contrast training (a combination of isometrically and plyometric) leads towards significant improvement of results on the 5m sprint among young football players (Alves, Rebelo, Abrantes, & Sampaio, 2010). Bouteraa et al. (2018) obtained different results. Namely, they carried out a designed study with the aim of examining the effects of an 8-week combined plyometric training and training the balance on the physical fitness of young basketball players. After experimental treatment, researchers concluded that the experimental treatment did not contribute to a statistically significant increase in sprint speed on the S5m test (in Nikolić, Berić, Kocić, & Daskalovski, 2017).

The results of research show that there is no statistically difference between the EG and CG after the experimental treatment on the S10m test. It means that plyometric training of 10 weeks (2 times per week) did not have positive effects on improving results between two tests on the already mentioned test. Similar results were found in a study of (Bouteraa et al., 2018). However, Arede et al. (2018) show that 8-week combined plyometric training leads to statistically significant improvement of sprint speed on the S10 test among young basketball players. Slimani, Chamari, Miarka, Del Vecchio, & Chéour (2016) working with a sample of young football players, came to the conclusion that combined plyometric training and strength training lead towards significant improvement of results in sprint speed on 10m. Shalfawi, Sabbah, Kailani, Tønnessen, & Enoksen (2011) show that there is a correlation between the 10m, 20m and 40m sprint, they also show there is a considerable variation between factors that contribute to success at this distances. This could lead towards special training strategies which can improve the speed of sprint at these distances.

The results also show that the EG group achieved statistically significant higher progress from the CG and on the S20m test, which confirms the effectiveness of the experimental treatment conducted for 10 weeks. Based on the partial eta squared (Partial Eta Squared =0.194) we can see that the effects of plyometric training on improving the results on this test are high. The results obtained by the authors (Asadi, 2013; Asadi & Arazi 2012; Draganović & Marković 2011) also indicate a statistically significant improvement in the speed of the sprint on the S20m test in favor of the EG. Draganović & Marković (2011); Asadi & Arazi (2012); and Asadi (2013) found that a 6-week plyometric training (2 times per week) for a basketball, junior and senior age sample leads to a significant improvement in the sprint speed of the S20m. Similar results were achieved (Benis, Rossi, Russo, & La Torre, 2015; Chaudhary & Jhajharia, 2010) for a sample of basketball players, that 8-week plyometric training (2 times per week) led to a significant improvement in 20m sprint results. Also, plyometric training in combination with exercises leads to a significant improvement in the speed of the sprint of young basketball players. Ramateerth & Kannur (2014) found a sample of 21 basketball players (12-13 years old) who showed that the group used the combination of plyometric training and exercise of strength had significantly higher progress than the group that performed only strength training on the S20m.

However, there are studies that show that plyometric training for 8 weeks does not lead towards speed sprint improvement on 20m among young male and female basketball players. Gottlieb, Eliakim, Shalom, Dello-Iacono, & Meckel (2014) on a sample of 19 basketball players (age 16.3±0.5 years old) compared the effect of plyometric training and specific sprint on anaerobic fitness. The research results showed that plyometric training does not lead to a statistically significant improvement in speed of sprint on the 20m test. Bouteraa et al. (2018) also show that combined plyometric training and balance training for eight weeks does not lead to statistically significant improvement in sprint speed on the S20m test.

The results show that sprint speed can also be developed with a combination of plyometric training and strength training, that is, sprint speed can be achieved even when plyometric training is combined with weight-training exercises (Ramateerth & Kannur, 2014). Also, the effect of complex training was confirmed at the speed of the run, that is, at the speed of the sprint at 15m (Nikolić et al., 2017).

Thus, plyometric training represents an effective method that leads to an improvement in the speed of short sprints. It is interesting to compare the size of the impact of the experimental treatment based on the Partial Eta Squared between the S5m and S20m tests. The obtained results indicate that the partial eta squared for S5m (Partial Eta Squared=.141) and S20m (Partial Eta Squared=.194), which means that there is a difference between the mean of the EG and CG on both tests. These values indicate that 10-week plyometric training (2 times per week) had positive effects on improving the sprint speed at 5m and 20m. If we approach the comparison of these values, we note that the higher the value, the greater the effect on the S20m test than on the S5m test.

The technical and tactical trainings conducted by the CG participants also led to some progress on the sprint speed tests. However, in relation to the qualitative changes occurring in the EG after the implemented plyometric program, they were not statistically significant.

CONCLUSION

Based on these results obtained, it can be concluded that plyometric training is absolutely applicable in basketball practice with the aim of developing sprint abilities, which is of great significance for successful basketball.

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PLIOMETRIJSKI TRENING I SPRINT SPOSOBNOSTI MLADIH KOŠARKAŠA

Cilj ovog istraživanja bio je da se utvrde efekti pliometrijskog treninga na sprint sposobnosti mladih košarkaša. Uzorak ispitanika činilo je 33 košarkaša košarkaških klubova OKK "Stari Ras" i OKK "Novi Pazar" iz Novog Pazara. Ispitanici su podeljeni na dve grupe: eksperimentalnu grupu (EG; n=16; TV=185.45±8.75cm; TM=76.87±11.51kg; TI=4.69±1.40 godina) i kontrolnu grupu (KG; n=17; TV=184.16±6.93cm; TM=76.87±11.51kg; TI=5.53±3.18 godina). EG činili su igrači košarkaškog kluba OKK "Stari Ras", koji su pored tehničko-taktičkih treninga imali i pliometrijske treninge. KG činili su igrači košarkaškog kluba OKK "Novi Pazar", koji su u tom periodu imali samo tehničko-taktičke treninge. Za procenu sprint sposobnosti korišćena su tri testa: Sprinterska brzina na 5m (S5m), Sprinterska brzina na 10m (S10m), i Sprinterska brzina na 20m (S20m). Merenje je vršeno uz pomoć foto ćelija "Microgate", a parametar koji je praćen i obrađen je vreme očitavano u 1/100s. Eksperimentalni program trajao je 10 nedelja (2 puta nedeljno). Obrada podataka vršena je programom za statistiku SPSS. Za utvrđivanje efekta pliometrijskog treninga na sprint sposobnosti mladih košarkaša korišćena je analiza kovarijanse ANKOVA. Rezultati su pokazali da je EG ostvarila statistički značajno veći napredak od KG na testovima: S5m i S20m. Nije bilo razlike između EG i KG na testu S10m. Na osnovu ovakvih rezultata zaključili smo da pliometrijski trening ima pozitivne efekte na razvoj sposobnosti sprintanja kod mladih košarkaša

Ključne reči: *pliometrija, sposobnosti, košarka, mladi košarkaši*