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Tomasz Boraczyński (A, B, C, D, E, F), Jerzy Urniaż (B, D, F)

Olsztyńska Szkoła Wyższa im. Józefa Rusieckiego, Olsztyn
Olsztyn Józef Rusiecki University College

THE EFFECT OF PLYOMETRIC TRAINING ON STRENGTH - SPEED ABILITIES OF BASKETBALL PLAYERS

Key words: basketball, plyometric training, strength - speed abilities

Corresponding autor: Tomasz Boraczyński, 10-243 Olsztyn, ul. Bydgoska 33; tel. (0-89) 526 04 00 w. 148, e-mail: boraczynski@osw.olsztyn.pl

ABSTRACT

Introduction. The aim of the study was to assess the effect of plyometric training on the strength - speed abilities of basketball players.

Materials and methods. Fourteen players from a third league team participated in two study sessions, at the beginning of the preparation period and after 8 weeks of training. Between the examinations, the players took part in 84 training sessions, among which there were 25 plyometric training sessions.

Results. Biometric characteristics of the players: age 20.3±1.9 lat, body mass 84.4±8.1 kg (I session) and 83.5±7.7 kg (II session) ($p<0.01$), fat free mass – 73.5±7.3 kg (I) and 73.3± 7.1 kg (II), fat mass 11.0±1.9 kg (I) and 10.1±1.6 kg (II) ($p<0.01$). The strength - speed abilities were assessed with a test on a force plate, consisting of 10 vertical jumps (CMJ), separated by a 6 second break. The results show a statistically significant increase of the basic mechanical parameters: the height of rise of body mass centre (H_{max}) – 0.425±0.054 m (I) and 0.464±0.047 m (II) ($p<0.01$), maximum jump velocity (V_{max}) – 2.829±0.185 m/s (I) and 2.979±0.160 m/s (II) ($p<0.01$), maximum force – 1336.9±266.1 N (I) and 1437.5±213.8 N (II) ($p<0.01$), impulse of force (PF) – 251.1±31.4 N·s (I) and 268.3±22.7 N·s (II) ($p<0.01$), maximum power – 2814.4±615.4 W (I) and 2957.8±579.8 W (II) ($p<0.01$), maximum relative power – 32.6±5.4 W/kg (I) and 34.9±5.1 W/kg (II) ($p<0.01$), average power – 1499.6±356.9 W (I) and 1624.4±329.5 W/kg (II) ($p<0.01$), relative average power – 17.4±3.2 W/kg (I) and

19.2±3.0 W/kg (II) ($p<0.01$). No change was observed in the take-off time - T_{to} (s), or countermovement depth – G_{de} (m).

Conclusions: The 8-week basketball training, including the plyometric training, resulted in considerable improvement of the mechanical parameters of the strength - speed abilities of the players.

Optimisation of controlling the training process in professional sport is possible only if it is based on systematic testing of the players' physical fitness and motor abilities [1, 2, 3, 4, 5].

The training of players' physical fitness should focus on developing special abilities to ensure effective competition [6, 5].

Basketball is a discipline dominated by high and maximum intensity efforts, based on anaerobic processes [7, 8]. Such efforts involve fast twitch muscle fibres type IIa and IIx, with a high level of anaerobic metabolism. The type of fibres determine the level of strength, power and jumping ability of players [9].

Jumping ability is one of the major motor abilities of basketball players. It is a complex ability, depending on the strength, speed and coordination [10]. Its high level is a condition of quick take-off, a high speed of players' movements on the court, the jump height and, consequently, high playing efficiency. Systematic testing of the strength - speed abilities is therefore an important element of basketball fitness training.

The diagnostics of the human strength - speed abilities commonly involve a counter movement jump (CMJ), made on a force plate, while the ground reaction force is recorded. It is possible to assess the physical and coordination abilities of a player by analysing the changes in mechanical parameters.

According to common belief, tests using a squat jump and CMJ on a force plate make it possible to assess objectively and precisely the effectiveness of strength - speed training [11, 12, 13, 14].

Study objectives

The aim of the study was to assess the effect of an 8-week basketball training program on the strength-speed abilities of the lower limbs of basketball players.

Materials and methods

Fourteen players of the Trójeczka Olsztyn team took part in the study. During the study season, the team played in league matches and finished on the first place in its group. The biometric parameters of the players are shown in table 1.

Table 1 Selected biometric parameters of the basketball players (n=14)

The examinations were performed twice, at the beginning (30.08.2005) and at the end (25.10.2005) of the preparation period. One of the basic aims of the training cycle, covering the period between the study sessions, was to improve the dynamic strength, power and jumping ability. During the 8-week period, along with the special basketball training, including the improvement of the basic motor abilities, the players received plyometric training. The players had a total of 25 training sessions during which they performed 2-6 series of plyometric exercises, with benches, vaulting boxes, hurdles, weighted belts and medicine balls. Each series consisted of 6-12 repetitions of the exercise. This programme of plyometric training was based on the guidelines drawn up by Radcliffe and Farentinos [15]. The general characteristics of the training in the period under study are shown in Table 2.

Table 2 The general characteristics of the 8-week training period of basketball players (n=14)

In both study sessions, the players performed a series of 10 maximum jumps (CMJ). A PJS-4P (JBA, Poland) was used in the study; it consisted of a force plate and computer software recording the mechanical characteristics of a jump based on the measured value of the vertical component of the platform reaction force. The methodology of calculating particular mechanical parameters has been described in the literature [16].

Comparisons between baseline data (initial) and post-training measures (final) were analyzed using a paired Student's t-test. The level of statistical significance was set at 0.05. The statistical analysis was performed using the Statistica PL ver. 7.1 software package (StatSoft Inc., USA).

Results

The data presented in table 1 indicate that the body mass and fatty tissue content during the period decreased significantly. The body mass loss as a result of a decrease in the fat mass

may be regarded as a positive effect of increased energy expenditure in the training. It was also a positive effect that the fat free mass was maintained. Muscle tissue, which determines the amount of strength in athletes usually accounts for over 50% of the fat free mass.

The mechanical parameters, recorded in the study: maximum force - F_{max}, impulse of force - PF, maximum force - P_{max} and average power - P_{av}, were significantly improved (table 3). A significant increase was also recorded for the maximum jump velocity - V_{max} and the basic index of jumping ability – the body mass centre rise height - H_{max} . It should be emphasised that the latter value increased in all players (Fig. 1).

Table 3. The mean values of the selected mechanical parameters, achieved by the players (n=14) in 10 vertical jumps (CMJ) on a force plate.

Fig. 1 The mean values of the height of rise of body mass centre (H_{max}) achieved by basketball players (n=14) in a series of 10 jumps (CMJ) on a force plate. I test – before the beginning of the preparation period, II test – after 8 weeks of training.

No change was observed in such parameters as: take-off time – T_{to} and countermovement depth – G_{de}; they mainly depend on the size and proportion of body parts as well as the technique of jumping.

Discussion

It is not easy to assess the effectiveness of special training in basketball, as the playing efficiency depends on various physical and mental abilities, skills and the level of technical excellence. The complexity of the problem is shown by the claim about the absence of grounds for any links between the jump height (jumping ability) and the strength of the lower limbs [17]. Other scholars see such links, which seems justified in such disciplines as volleyball and basketball [18]. Many reports have shown a relationship between the body mass centre rise height and the power achieved in the take-off phase of a vertical jump (CMJ). Skrobecki [19] obtained high values of the correlation coefficient between the body mass centre rise height in female and male volleyball players and the sports excellence assessment made by their coaches.

A significant increase in the basic mechanical parameters in basketball players, observed in this study, is proof of the high effectiveness of the implemented training programme. The observed progress was probably determined by the plyometric training, regarded as the most

effective type of power training [15, 20]. The study conducted by Harris et al. [21] did not show any improvement of the jumping ability in vertical jump (CMJ) as a result of the strength training, and significant improvement after "power" training. Diallo et al. [22] observed a significant increase in the power measured in the MCJ jump after a 10-week plyometric training. Similar results were achieved by Staniak et al. [14] in a study conducted on football players. The study quoted above showed a significant increase in the power and the body mass centre rise height as a result of an 11-week period of training, which included "power" training. Boraczyński et al. [23] observed a significant increase in the mechanical parameters which determine the strength-speed abilities of professional volleyball players after a 9-week period of training, which included plyometric exercises.

The absence of any changes in the take-off time and countermovement depth seems natural. Similar results were achieved by other researchers [24, 23, 14]. According to those authors, the body mass centre rise height in CMJ jumps does not depend on the countermovement depth.

Conclusions

1. Studies have shown a statistically significant increase in the basic mechanical parameters which determine basketball players' strength -speed abilities, such as the height of rise of body mass centre, maximum speed, impulse of force, maximum power and average jump power.
2. The improvement of the strength and speed abilities is a proof of the effectiveness of the implemented training programme.
3. The study results justify the application of CMJ jumps in assessment of the effects of training of special strength-speed abilities of basketball players.

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Table 1 Selected biometric parameters of the basketball players (n=14)

Examination		Age (yrs)	BM (kg)	BH (cm)	BF (%)	FM (kg)	FFM (kg)
Initial 30.08.05	**M**	**20,32**	**84,41**	**188,21**	**12,99**	**10,95**	**73,45**
	SD	1,89	8,14	6,92	2,01	1,91	7,34
	Min	18,50	75,10	176,10	8,50	6,61	63,53
	Max	25,60	103,00	199,30	15,40	13,80	89,20
Final 25.10.05	**M**	**20,48**	**83,48**	**188,43**	**12,16**	**10,14**	**73,34**
	SD	1,88	7,70	6,93	1,72	1,59	7,05
	Min	18,60	73,90	176,30	8,20	6,33	63,63
	Max	25,70	100,20	199,50	13,90	12,53	87,68
Differences		0,16	0,93	0,22	0,83	0,81	0,11
T-test		p<0,01	p<0,01	NS	p<0,01	p<0,01	NS

Notes: body mass (BM), body height (BH), body fat (BF), fat mass (FM), fat free mass (FFM)

Table 2 The general characteristics of the 8-week training period of basketball players (n=14)

Week	**Number of trainings**	**Technique and tactics**	**General endurance**	**Specific endurance**	**Global strength**	**Plyometric training**
1	10		4	2	4	
2	12	4	3	2	3	3
3	12	7	3	3	3	4
4	11	8	3	3	3	4
5	12	9	3	3	3	4
6	10	8	2	2	2	4
7	9	7	2	2	2	3
8	8	6	2	2	1	3
Total	**84**	**49**	**22**	**19**	**21**	**25**

Table 3. The mean values of the selected mechanical parameters, achieved by the players (n=14) in 10 vertical jumps (CMJ) on a force plate.

Examination		**H_{max} (m)**	**V_{max} (m/s)**	**T_{to} (s)**	**G_{de} (m)**	**F_{max} (N)**	**PF (N·s)**	**P_{max} (W)**	**P_{max} (W/kg)**	**P_{av} (W)**	**P_{av} (W/kg)**
Initial 30.08.05	**M**	**0,425**	**2,829**	**0,246**	**0,373**	**1336,9**	**251,1**	**2814,4**	**32,6**	**1499,6**	**17,4**
	SD	0,054	0,185	0,044	0,075	266,1	31,4	615,4	5,4	356,9	3,2
	Min	0,347	2,56	0,148	0,224	936	208,2	1759	22,8	892	11,6
	Max	0,494	3,05	0,307	0,502	1832	320,4	4078	40,8	2336	23,0
Final 25.10.05	**M**	**0,464**	**2,979**	**0,243**	**0,376**	**1437,5**	**268,3**	**2957,8**	**34,9**	**1624,4**	**19,2**
	SD	0,047	0,160	0,041	0,063	213,8	22,7	579,8	5,1	329,5	3,0
	Min	0,399	2,63	0,141	0,231	1129	236,2	1935	25,5	1216	16,0
	Max	0,536	3,12	0,289	0,481	1867	326,3	4126	43,0	2411	25,5
Differences		0,039	0,151	-0,004	0,002	100,6	17,1	143,4	2,2	124,8	1,8
T-test		$p < 0,01$	$p < 0,01$	NS	NS	$p < 0,01$	$p < 0,01$	$p < 0,01$	$p < 0,01$	$p < 0,01$	$p < 0,01$

Notes: the height of rise of body mass centre - H_{max} (m), maximum speed - V_{max} (m/s), take-off time - T_{to} (s), countermovement depth - G_{de} (m), maximum force - F_{max} (N), impulse of force – PF (N·s), maximum power – P_{max} (W, W/kg), average power – P_{av} (W, W/kg).

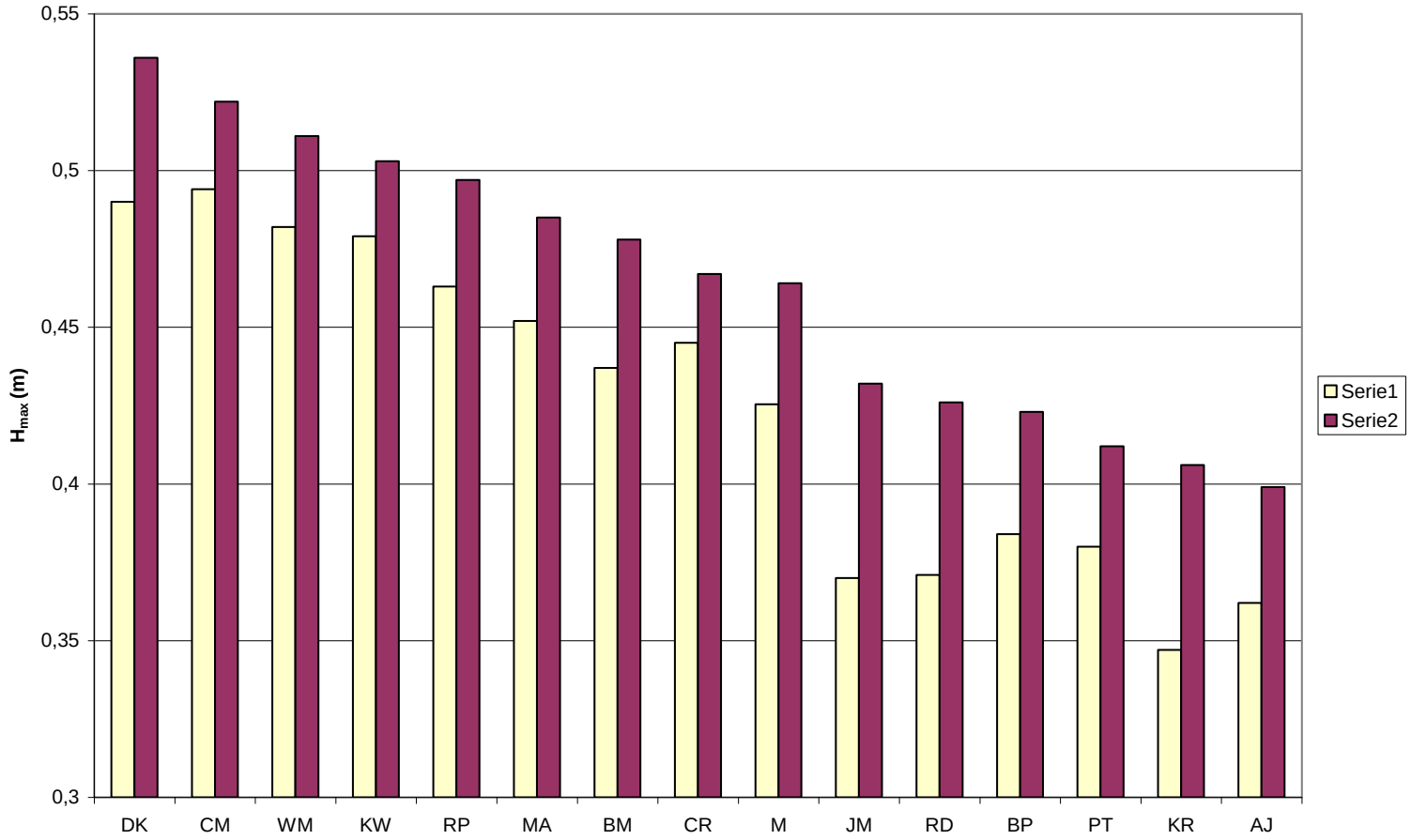

Fig. 1 The mean values of the height of rise of body mass centre (H_{max}) achieved by basketball players (n=14) in a series of 10 jumps (CMJ) on a force plate. I test – before the beginning of the preparation period, II test – after 8 weeks of training.