RESEARCH ARTICLE

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Effects of A 3-Week Modified Complex Training on Athletic Performance of Women's National Basketball Players

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Abstract: Basketball is one of the popular sports in the world, and physical performance is becoming increasingly important in basketball as the game evolves. The aim of the study was to investigate the effects of a 3-week modified complex training on athletic performance of women's national basketball players. An experimental study involved the participation of 12 highly trained female basketball players (national team of Bosnia and Herzegovina). Observed variables before and after 3-weeks of modified complex training were 300 yards test, 20-yards test, lane agility and beep test. Means and standard deviations for each of the variables were calculated, and differences pre-to-post performance changes were examined using a paired sample t-test. Three weeks of specific complex training sessions show a statistically significant increase in all tested variables, 300 yards ($p \leq .001$); 20 yards ($p \leq .001$); Lane agility ($p \leq .001$) and beep test ($p = .028$). It can be concluded that applied complex training program has significantly improved studied parameters of condition preparation of elite female basketball players.

Keywords: High intensity, Adolescent females, Team sport, Change-of-direction.

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1. Introduction

As one of the most popular sports in the world, basketball requires high levels of preparation from players, including a high level of cardiorespiratory functions [1]. Basketball is classified as a polystructural complex sport due to the need for a variety of movement types. Basketball's primary traits are jumping, running, and direction changes both with and without the ball [2, 3]. As a result, elite basketball players have high levels of power, speed, and agility, while speed and power are the basis of most movement activities in basketball. Speed and power are important in basketball because they determine a player's ability to perform various skills such as dribbling, shooting, and jumping. Speed allows players to move quickly up and down the court, get past defenders, and make fast breaks [4-6]. On the other hand, power gives players the ability to jump high for rebounds and dunks, as well as provide the strength to fight for the ball and body control for quick changes of direction. These abilities are crucial in creating scoring opportunities, playing defense, and controlling the tempo of the game [7].

Complex training is important for female basketball players because it helps to improve multiple aspects of their physical performance [8], including power, speed, agility, and endurance. By combining strength training exercises with plyometric exercises, complex training can enhance the players' ability to jump higher, run faster, and change direction more quickly. Additionally, complex training can also help to reduce the risk of injury and improve overall athletic performance [9]. Furthermore, for female basketball players, who may have different physiological characteristics compared to male players [1], complex training can help to address specific physiological needs and improve their ability to perform at a high level in the sport.

The study's objective was to find if a 3-week modified complicated training program affected the athletes' ability to effectively perform in basketball-specific tests. We hypothesized that a complex basketball-specific training protocol that included movements with and without the ball would improve aerobic performance in top female basketball players.

2. Methods

2.1 Study design and subjects

This study included 12 highly trained female basketball players, average age (25.50±3.92) and average body weight (182.50±5.94) selected for Bosnia and Herzegovina national women's basketball team. According to the average height (182.50±5.94 cm), they are among the shortest national teams in the world. All basketball players have been in the process of systematic basketball training for at least 5 years. Before the test, medical examinations were performed and no health problems were found. All subjects were previously informed in detail about the reasons and procedures of research and they signed a written consent, voluntarily.

2.2 Experimental Approach to the Problem (Experimental Design)

This research evaluated whether a 3-week modified complex training protocol might improve national female basketball players' athletic

performance indicators. A program was devised, which used the dynamic warm-up, jump training, strength training, flexibility, SAQ and plyometric components, along with new exercises and drills to improve speed, agility, overall strength, and aerobic conditioning (Table 1.). A battery of tests was conducted to determine the effectiveness of this training program. The study was conducted in the preparation period for Eurobasket 2021 with two team training sessions per day (morning lasting 1:30h and evening 2:00h) for 3 weeks. Furthermore, no additional strength and conditioning was conducted. All the training sessions were supervised by certified S&C coach of national team.

Table 1. Modified complex basketball training program

I micrcycle		**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Morning training 10:30-12:00	45 min	Initial testing	Energy aerobic training of middle intensity, SAQ	Plyometric training	**FULL DAY REST**	Energy aerobic training of middle intensity, SAQ	**FULL DAY REST**	Energy aerobic training of high intensity, speed endurance
	45 min	Strength and power of lower body part (8 exercises/8-12 repetitions/65-70% 1RM)		Strength and power of upper body part (6 exercises/8-12 repetitions/65-70% 1RM)		Strength and power of lower body part (8 exercises/8-12 repetitions/65-70% 1RM)		Strength and power of upper body part (6 exercises/8-12 repetitions/65-70% 1RM)
Evening training 19:00-21:00		Proprioception , mobility, prevention	Proprioception , mobility, prevention	Proprioception , mobility, prevention	Proprioception mobility, prevention	Proprioception , mobility, prevention	Proprioception , mobility, prevention	Proprioception , mobility, prevention
		Basketball technique	Basketball technique	Basketball technique	Basketball technique	Basketball technique	Basketball technique	Basketball technique
II mycro cycle		**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Morning training 10:30-12:00	45 min	Energy training, increase of capacity of lungs, aerobic low-intensity and anaerobic training of tolerance on lactates	Plypometric training	Warm-up, dynamic stretching and exercises of mobility	Energy training of tolerance on lactates,SAQ	Warm-up, dynamic stretching and exercises of mobility	Interval training of high intensity	Warm-up, dynamic stretching and exercises of mobility
	45 min		Exercises of strength and power of upper body part, circle training, 8 exercises 10x , 4 circles, break 2 min , 30' – 40' (70'%1RM)	Energy training, anaerobic phosphagens, SAQ	Exercises of strength and power of upper body part, circle training, 8 exercises 10x , 4 circles, break 2 min , 30' – 40' (70'%1RM)	Energy training, aerobic training of low intensity		Training of regeneration 60' Aerobic training of low intensity 120 bpm
Evening training 19:00-21:00	20 min	**FULL DAY REST**	Warm-up. Dynamic stretching, and exercises of mobility with a ball 20'	Warm-up. Dynamic stretching, and exercises of mobility with a ball 20'	Warm-up. Dynamic stretching, and exercises of mobility with a ball 20' Proprioception 20'	**FULL DAY REST**	Stative training of strength and power 45', full body, 3 exercises for lower body part /6-8 x/80%1RM	**FULL DAY REST**

	70 min		Basketball technique	Basketball technique	Basketball technique		Basketball technique and tactic 45'	
III micro cycle		**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Morning training 10:30-12:00		Specific condition drills; high-intensity aerobic and glycolyctic lactant anaerobic	Specific condition drills; high-intensity aerobic and glycolyctic lactant anaerobic	Energy training; aerobic low-intensity training	Specific condition drills; high-intensity aerobic and glycolyctic lactant anaerobic	Active rest; walking in the mountain	Final testing	**FULL DAY REST**
Evening training 19:00-21:00		Training of strength and power 40' 3 exercises of upper body part and 3 exercises for lower body part /6-8 x/85%1RM	Training of strength and power 40' 3 exercises of upper body part and 3 exercises for lower body part /6-8 x/85%1RM	Training of strength and power 40' 3 exercises of upper body part and 3 exercises for lower body part /6-8 x/85%1RM	Training of strength and power 40' 3 exercises of upper body part and 3 exercises for lower body part /6-8 x/85%1RM	Basketball technique and tactics 90'	Basketball technique and tactics 90'	**FULL DAY REST**
		Basketball technique and tactics 45'	Basketball technique and tactics 45'	Basketball technique and tactics 45'	Basketball technique and tactics 45'			

2.3 Testing procedures

2.3.1. 300 yards test

The 300-yards (274.32 m) shuttle run is a test of an athlete's anaerobic endurance. Marker cones are placed at the starting line and 25 yards (22.86 m) ahead of the starting line to measure the 300-yards shuttle run. At the start signal, participants sprint 25 yards (22.86 m) 12 times without stopping (300 yards total), and their arrival times are recorded. The trials were recorded by photo cells (Witty Micro Gate photocell, Bolzano, Italy) (Figure 1.).

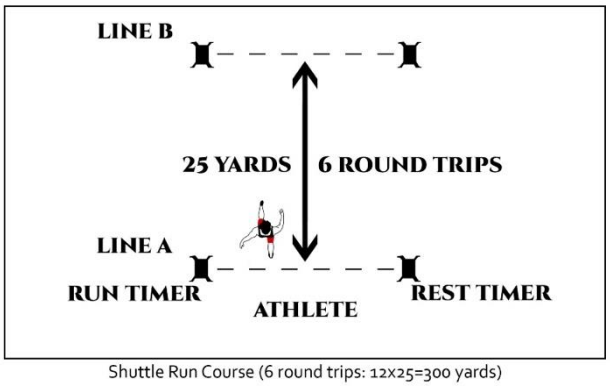

Figure 1. 300 yards test

2.3.2. 20 yards test

Along a line, three marker cones were positioned 4.55 m apart. The players were told to put one hand down in a three-point stance and straddle a marked tape (48 cm) behind the center line, which acted as the start/finish line (where the photoelectric obstacles were situated). The topic began when the signal "ready, steady, go" was given, and the raters began their stopwatches as soon as they passed the starting line. The individual ran 4.55 meters to the right, turning and touching one foot behind the line. The individual then completed the run by racing back through the finish line after moving 9.1 meters to the left and touching one foot behind the other line [10]. The trials were recorded by photo cells (Witty Micro Gate photocell, Bolzano, Italy) (Figure 2.).

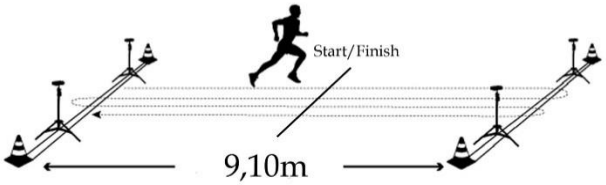

Figure 2. 20 yards test

2.3.3. Lane agility test

Players began at the free-throw line in the upper left corner of the key and ran 5.8 meters to the baseline. Before racing backward to the top right corner of the free-throw line, players side-shuffled 4.9 meters to the right across the baseline. The players then performed a side-shuffle to the left for 4.9 meters, touching the ground at a predetermined position. They then quickly performed the identical circuit in the other way. When players returned to the starting position, the clock stopped [11]. The trials were recorded by photo cells (Witty Micro Gate photocell, Bolzano, Italy). (Figure 3.)

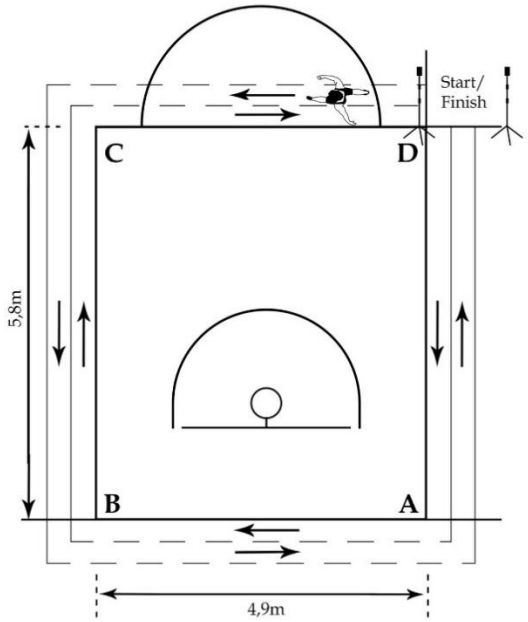

Figure 3. Lane agility test

2.3.4. Beep test

The beep test, also known as the 20-meters shuttle run test, is a type of physical fitness test used to measure aerobic endurance and an individual's ability to repeatedly perform high-intensity aerobic exercise. The test involves running back and forth between two markers 20 meters apart, in time with beep signals that become progressively faster. The test continues until the participant is unable to reach the marker before the beep sounds.

2.4 Statistical analysis

Statistical analyses were carried out using the SPSS 23. program for Windows (SPSS, Inc., IBM Corp). Descriptive statistics were presented as means ± standard deviation (Mean±SD). To evaluate within-group pre-to-post performance changes, paired sample t-tests were applied. The criterion for statistical significance was set at $p < 0.05$. Percentage changes were calculated as ([post-training value - pre-training value]/pre-training value) × 100.

3. Results and Discussion

All players completed at least 90% of the 3 weeks of training sessions. All body composition variables remained unaltered in both groups from pre- to post-testing. Means and standard deviations of the body composition characteristics are presented in Table 2. The pre-test and post-test mean values were presented in Table 3. Three weeks of specific complex training sessions show a statistically significant increase in all tested variables, 300 yards (pre: 54.32 ± 1.44 s, post: 52.65 ± 1.16 s); 20 yards (pre: 5.00 ± 0.23 s, post: 3.68 ± 0.29); Lane agility (pre: 13.27 ± 0.74 s, post: 11.85 ± 0.49 s) and beep test (pre: 11.1 ± 1.7 lvl, post: 11.9 ± 1.1 lvl).

The study's primary findings demonstrated that a 3-weeks modified complex training program improved the performance of female basketball athletes. Results of this study showed positive effects of three-week complex training program on selected key indicators of training of female elite basketball players. Obtained results are statistically significant and their range is from 3.12% for anaerobic capacities (300 yards) to 30.41% for planned agility (20 yards). In general, the biggest progress is achieved in the area of agility (20 yards) and in specific basketball test Lane agility shows positive results of 11.30%. When it comes to tests of agility, it is necessary to emphasize that in the final testing of the average results were 11.85 ± 0.49 in Lane agility test, which is in the range of results recorded in NBA players. Previous studies [12-14] state that average time in this test was between 11.06 and 12.05 s; depending on positions. This indicates that agility of subjects tested in this research after conducted complex of training program is on high level. Obtained results are extremely important for result efficiency in basketball because as Trninić *et al.* [15] state that basketball is a sport of agility, while other skills, abilities and different technical-tactical knowledge are measured by much lower coefficient means. Therefore, agility is part of fast and explosive features, which along with jumping is one of the main links of physical preparations in basketball. Some studies recorded improvement of speed, strength and balance needs to result with improvement of agility [16].

Table 2. Characteristics of participants

Variables	Min	Max	M±SD
Age (year)	19	32	25.50 ± 3.92
Body mas (kg)	61.3	88.4	74.90 ± 8.14
Body height (cm)	174.2	191.2	182.50 ± 5.94
BMI	19.92	25.44	22.44 ± 1.71

Table 3. Characteristics of participants

Variables	Pre-test M±SD	Post-test M±SD	Pre-post Mean Difference	%Δchange	Paired t-test p
300 yards	54.32 ± 1.44	52.65 ± 1.16	1.67	3.12	<0.001
20 yards	5.00 ± 0.23	3.68 ± 0.29	1.32	30.41	<0.001
Lane agility	13.27 ± 0.74	11.85 ± 0.49	1.41	11.30	<0.001
Beep test	11.1 ± 1.7	11.9 ± 1.1	-0.84	6.95	0.028

Kooroshfard *et al.* [17]. compared the results of neuro-muscular training of classical training of strength and combined training, classical training of strength on dynamic balance and sport performances, including strength, sprint and agility in female basketball players. According to results of this study all experimental training programs caused improvements in condition performances, including balance, agility, speed and high jump in professional female players. According to results of this study all experimental training programs caused improvement in conditional performances, including balance, agility, speed and high jump in professional female basketball players in relation to the control group.

Results of this study indicate that statistically significant positive effect on aerobic endurance of 6.95% which are reflected in increase of running distance on Beep test, while effects of anaerobic skills was 3.12% evaluated by test (300 yards). Obtained results are in correspondence to results of earlier studies or a bit smaller. Aschendorf *et al.* [18] reported overall increase of results in Yo-yo test for 26.5% after 5 weeks of specific basketball HIIT training. Also, Zarić, I [19] reported improvement of results of Yo-Yo test of 51.93% in female junior basketball representation of Serbia after 6 weeks of preparations. When comparing these results, differences in tests, where functional skills are measured, need to be taken in consideration, because interval test of endurance, which is closer to HIIT training by its structure, in relation to Beep test, which is continuous. A significant improvement in progress of aerobic and anaerobic endurance of female basketball players is achieved due to selection of operators of strength and metabolic high-intensity training, with properly distributed intervals of work and proper intensity and rest. Since applied complex training program, in the area of functional skills, combined high-intensity trainings (anaerobic alactant and lactant components) with different lengths of intervals of work and rest, which by its structure matches HIIT method of training, it can be assumed that this is the reason for achieved progress in functional skills. As a result, basketball-specific HIIT exercise can be used to improve aerobic efficiency while maintaining essential basketball components.

Although this study hasn't researched physiological mechanisms of adaptation of functional skills on HIIT training, earlier studies stated potential reasons for efficiency of this method of training. However, several studies examined muscle tissue samples after HIIT adoption and discovered possible training-induced changes, including mitochondrial biogenesis, changes in substrate utilization, and changes in muscle buffering capacity [20, 21].

5. Conclusion

Since one of the aims of condition preparation in basketball is adaptation on high intensity in offence and defense during the whole match, it is necessary to

design training programs, which will in short amount of time, achieve desired results. Based on obtained results, it can be concluded that applied complex training program has significantly improved studied parameters of condition preparation of elite female basketball players. The aim of this model of complex training was to connect basic and specific operators in order to develop deficit skills, which have high correlation with the success in basketball match, which is confirmed by results.

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Ethics Approval

The Study was conducted according to the principles of the Helsinki Convention (1974).

Informed Consent

Informed consent was obtained from all subjects involved in the study.

Author's contribution & Statement

Lejla Šebić - Data collection and Manuscript Preparation; Denis Čaušević - Study design, Data collection, Statistical analysis, Manuscript Preparation & Funds Collection, Erol Kovačević - Study design, Statistical analysis, Manuscript Preparation & Funds Collection; Amir Aljiji - Data collection; Mensur Vrcić - Manuscript Preparation, Slobodan Simović- Manuscript Preparation. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The Authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Does this article screened for similarity?

Yes