The Effects of Short-Term Preseason Skill-Based Conditioning on Physiological Characteristics in Elite Female Volleyball Players [original scientific article]

SportLogia, dec. 2022, 18 (1),.
E-ISSN: 1986-6119
doi:

Received: 23.08.2022.
Approved: 20.10.2022.
Udc: 796.325.012.132

EFEKTI KRATKOTRAJNOG KOMBINOVANOG KONDICIONOG TRENINGA NA FIZIOLOŠKE KARAKTERISTIKE VRHUNSKIH ODBOJKAŠICA

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ABSTRACT

This study aimed to investigate the benefits of short-term preseason skill-based conditioning on the physiological characteristics of female volleyball players from the first-division volleyball league over four weeks of training. Twelve female volleyball players (18.33±3.47 years; 177.25±5.28 cm; 65.38±5.93 kg) completed four weeks of game-related drills combined with physical conditioning. Physiological characteristics were measured using a 20-m shuttle run test: average heart rate (HR_{avg}), maximum heart rate (HR_{max}), the maximum number of breaths (BR_{max}), maximum oxygen consumption (VO_{2max}), maximum excess post-exercise oxygen consumption ($EPOC_{max}$) and maximum of metabolic equivalent (MET_{max}). Data collection and extraction were administrated using heart rate monitors and Firstbeat Sports software. After an initial evaluation (T_0), the players were tested after the fourth week of the training cycle (T_1). Heart rate average (HR_{avg}) decreased (-1.9%; p=0.046), maximum metabolic equivalent (MET_{max}) (14.2%; p<0.001) and maximum oxygen consumption (VO_{2max}) (14.1%; p<0.001) increased respectively. The results suggest that the volleyball players continued improving their physiological characteristics during the study. Finally, as a major application, these data provide normative standards of physiological characteristics in the preseason for female volleyball players.

Keywords: *skill-based conditioning, effects, physiological characteristics, female, volleyball*

Stojanović, N., Stojanović, D., Zadražnik, M., Bešić, Đ., & Stojanović, T. (2022).The effects of short-term preseason skill-based conditioning on physiological characteristics in elite female volleyball players. *Sportlogia.* Advance online publication. https://www.sportlogia.com/

INTRODUCTION

A preseason's main goal is to increase players' performances in competitions. The most significant fitness improvement occurs in the preseason and is typically maintained or slightly decreased during the in-season period (Hartmann et al., 2015). Physiological characteristics (PC) assessment is a valuable tool that can help coaches and sports scientists assess and monitor the effects of training programs (Drinkwater et al., 2008). However, estimates of the training effects on PC are diverse, partly because different assessment techniques of varying accuracy and precision are used to quantify exercise-related changes in PC (Malina, 2007). PC such as average and maximum heart rate frequency (HR_{avg}; HR_{max}), the maximum number of breaths per minute (BR_{max}), and the maximum oxygen consumption during exercise (VO_{2max}) are essential parameters for the evaluation of the fitness of volleyball players in both aerobic and anaerobic capacity. A metabolic equivalent (MET) and Excess Post-exercise Oxygen Consumption (EPOC) are also important indicators of training programs' effects on players' PC. MET is defined as the quantity of oxygen consumed by the body from inhaled air under resting conditions, and 1 MET is approximately 3.5 $mL \cdot kg^{-1} \cdot min^{-1}$ or 1 $kcal \cdot kg^{-1} \cdot h^{-1}$ (Ainsworth et al., 2011). According to Kenney et al., (2015), all physical activity can be categorized by intensity according to their requirements for oxygen. Therefore, through MET-s calculations, it is possible to categorize the intensity of different physical exercises. During a volleyball match, players could produce up to 8 METs, described as heavy physical activity, on a physical activity scale spectrum (Jetté et al., 1990).

Moreover, physical activities increase total energy expenditure both acutely and chronically. The first condition refers to the energy expenditure during the exercise performance and the recovery, while the second refers to the alteration of the resting metabolic rate (Hill et al., 1995). Concerning the acute effect, it is well established that the post-exercise O_2 consumption does not immediately return to the resting indices. Excess Post-exercise Oxygen Consumption refers to the need for oxygen during the recovery phase following exercise (EPOC) (Gaesser & Brooks, 1984). Volleyball is an intermittent game where a low-intensity aerobic activity follows a period of intense physical effort, so it can be assumed that aerobic capacity is of great importance (Lidor & Ziv, 2010). To improve their volleyball performance, players must incorporate volleyball-specific resistance, plyometrics, sprint, and agility training (Scates et al., 2003). During elite volleyball competition, besides technical and tactical skills, agility, muscular strength, and power, both anaerobic and aerobic fitness are important factors (Marques et al., 2008; Sheppard & Young, 2006). It is hypothesized that the energy requirements for volleyball are provided by phosphagen breakdown and partially by anaerobic glycolysis; however, it is still not apparent which physiological requirements are essential (Lidor & Ziv, 2010).

Furthermore, it is not uncommon that coaches must deal with shortened preseason periods, so it is questionable whether the athletes can be trained at high intensities and yet properly rest and recover between training sessions (Trajkovic et al., 2012). High volumes of instructional training (IT) without increasing the intensity have been proven to have a minimal effect on physical fitness (Gabbett, 2008) and could limit other beneficial training stimuli. Moreover, as volleyball players rely on various skills, technical training can hardly replicate the actual sport-specific demands. However, it should be noted that IT training must also be employed in order to refine technical efficiency (Gabbett, 2008; Trajković et al., 2017). Therefore, applying adequate strategies to plan the training process and implement skill-based conditioning without decay in technique was necessary. The skill-based training approach proved beneficial for increasing vertical jump, sprint, agility, and physiological indicators of physical fitness in female volleyball players (Gabbett, 2008). This approach could be very time-efficient and related to the sport-specific demands (Gabbett, 2008; Gjinovci et al., 2017).

Moreover, skill-based conditioning training could be performed in a HIIT manner, both short and long. HIIT involves brief repeated bouts of high-intensity drills with intermittent rest periods, and it is designed to elicit exercise intensity to approximately VO_{2max} values (Herda & Cramer, 2016). The benefits of HIIT training are the product of simultaneous motor unit recruitment and maximal cardiac output and provide a stimulus for oxidative adaptation of muscles, which can significantly affect the increase in fitness (Altenburg et al., 2007). However, to induce a sufficient stimulus to increase fitness, it is necessary to apply loads that will initiate the process of positive adaptation to the training stimulus. It is crucial to emphasize the importance of an individual approach when planning the training process due to certain factors that could affect the athlete's adaptation, such as preparedness, biological maturity, chronological age, rate of recovery, and work capacity (Nikolaidis et al., 2012). For example, two different athletes could have the same level of performance but not the same work capacity.

In order to achieve the optimal training stimulus, it is necessary to find a balance between training intensity and training load and rest periods between training sessions to prevent overreaching and to overtrain (Lidor & Ziv, 2010).

It is important to note that some skills in volleyball sessions are more fatiguing than others (Marques Junior, 2014, 2017). Marques Junior (2014) determined the intensity of each volleyball skill according to heart rate frequencies. Jump serve, spike, jump set, block, and sprint on defense are moderate to high, set and defense are moderate, and overhead serve and reception are low, which is a fundamental guideline for planning the training process; training loads should follow the skill-prescribed intensity. The importance of this approach can be valorized in conditions when the coach does not have sophisticated diagnostics to monitor athletes.

Moreover, Herman et al. (2006) recommended Fosters scale for session rating of perceived exertion. Using this method, a coach can evaluate the training intensity for each athlete and employ sound strategies to increase the preparedness of the athletes. This approach could maximize training effects and speed up recovery.

To our knowledge, no previous study examined the effect of preseason skill-based conditioning training programs applied in female competitive volleyball players on PC. In addition, it is unclear whether training sessions offer an adequate training stimulus to improve the PC of female volleyball players in the preseason. Considering that season is very long, and there is limited time for preparation, skill-based conditioning training could provide a sport-specific mode of volleyball training and advantages in terms of time efficiency, motivation, and training compliance (Gamble, 2006, 2007).

Therefore, this study aimed to determine the changes in physiological characteristics following a four-week preseason skill-based conditioning program in female competitive volleyball players.

METHODS

Participants

Twelve elite female volleyball players (mean±SD; age: 18.33±3.47 years; height: 177.25±5.28 cm; body mass: 65.38±5.93 kg) from University Volleyball Club "Bihać-Preminger, "one of the top 10 teams in Bosnia and Herzegovina Premier League (I division) participated in this study. All the players had at least three years of professional and elite training experience. Furthermore, no athletes had a history of serious injury, nor were they taking medication during the study. All experimental procedures, possible risks, and benefits were explained to each player. Recommendations designed for clinical research from the Declaration of Helsinki (2013) of the World Medical Association were applied. This study was also approved and reviewed by the Ethics Committee of the Faculty of Physical Education and Sport, University of Banja Luka.

Procedures

The participants were tested at the start of preseason (T_0 – pretest in the last week of August) and immediately after four weeks of the training program before the regular competitive season (T_1 – post-test in the first week of October).

Before conducting the testing procedure, each volleyball player's anthropometric measurement (body height and body weight) took place. Afterward, the players were subjected to a standardized warm-up protocol for 10 minutes of low-intensity running ABCs and dynamic stretching. After a three-minute recovery, the respondents started testing according to a predetermined schedule. The T_0 and T_1 were performed in an indoor stadium at 22 - 24 ° C. Both measurements were performed from 11 to 12 AM to avoid diurnal changes, which could affect the measurement result. Forty-eight hours before the test, the players were not subjected to intensive training and were advised to avoid any additional physical activity and great emotional strain. Moreover, the players were advised not to change their dietary habits before each test and not to consume alcohol, cigarettes, or any stimulants. Both tests were performed on Monday, after a weekend rest.

The 20-m progressive shuttle run test was applied to assess maximal aerobic power in female volleyball players. The test was chosen because of its simplicity and excellent reproducibility according to the protocol proposed by Leger et al. (1988). The test-retest reliability coefficient was 0.90 for female volleyball players (Gabbett, 2008).

For measurement purposes, the players were assigned heart rate monitor Suunto Movesense (Suunto Oy, Finland). The device is placed around the chest, at the heart level. The electrodes were coated with gel before the start of the test for more efficient signal reading. Each device is wirelessly connected using dedicated software Firstbeat Sports (Firstbeat Technologies Oy., Finland). Firstbeat Sports software was able to extract the average heart rate (HR_{avg}), maximum heart rate (HR_{max}), the maximum number of breaths (BR_{max}), maximum oxygen consumption (VO_{2max}), and maximum excess post-exercise oxygen consumption ($EPOC_{max}$). A maximum metabolic equivalent (MET_{max}) was calculated by dividing the value of VO_{2max} with 3.5 $mL \cdot kg^{-1} \cdot min^{-1}$ (Ainsworth et al., 2011).

Preseason Conditioning Program

Generally, throughout the four weeks of preparation, players had 11 sessions per week (5 sessions in the fourth week) and played three friendly and two tournament matches (see Table 1). During weeks 1–4, the emphasis was on instructional training (IT) and skill-based conditioning. Apart from IT training, the goal of the preseason conditioning was to increase the intensity of sport-specific training, with the emphasis on high-intensity skill-based conditioning games (SCG) (small-sided and full-court games), and high-intensity skill-based conditioning drills (SCD) (spiking, blocking, jump serving, jump setting, sprinting on defense). SCD was performed at the beginning of the week, emphasizing power production with short bouts of high-intensity volleyball drills. Conversely, SCG was performed at the end of the week, emphasizing prolonged high-intensity intervals. The training frequency was lower in the first (adaptation) and the last week (preseason matches).

SCG was performed as long HIIT (>3 minutes) and SCD as short HIIT intervals (<20 sec), respectively. The work-rest ratio was 1: 2 to 1:3 for SCD and 1: 1 for SCG. In SCD, four sets of 2-4 intervals were performed with passive rest periods between 1st and 2nd, thi^{rd,} and fourth set (3 minutes) and active rest between 2nd and third (15 minutes of setting, reception, overhead serve). The number of intervals in SCG ranged from 3-5.

Due to the high training frequency, it was necessary to apply adequate strategies when determining the training load. For monitoring of training load, we used the session rating of perceived exertion scale (season RPE) (Herman et al., 2006), and for monitoring of daily variations in athlete preparedness, we used the acute: chronic workload ratio (ACWR index) method (Murray et al., 2017; Williams et al., 2017). According to the recommendation, the ACWR index should be 1.0-1.49. The morning sessions included 11.1-33.3% of specific warm-ups, 44.4-78.8% of low-intensity IT training, and 11.1-33.3% of low-intensity recovery-based drills and dynamic stretching. The afternoon included 14.3-33.3% of warm-up, 46.2-64.3% of SCG or SCD, and 11.1-33.3% of low-intensity recovery-based drills and dynamic stretching.

Table 1. *Four-week preseason skill-based conditioning program*

	1 week		2 week		3 week		4 week	
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
Mon	IT	SCD	IT	SCD	IT	SCD	Match	SCD
Tue	IT	IT	IT	SCD	IT	SCD	IT	Match
Wed	IT	IT	IT	IT	IT	IT	RB	/
Thu	IT	SCG	IT	SCG	IT	SCG	IT	Match
Fri	IT	SCG	IT	SCG	IT	SCG	RB	/
Sat	IT	/	IT	/	IT	/	Tournament	
Sun	/	/	/	/	/	/	Tournament	

Note. IT: Low-intensity instructional training; SCD: Skill-based conditioning drills; SCG: Skill-based conditioning games; RB: Recovery-based training.

Statistical analysis

The descriptive results are expressed as Means, Standard Deviation (Std.Dev.), Minimal (Min.), Maximal (Max.), and Kolmogorov-Smirnov (K-S) values. Differences from T_0 to T_1 for all physiological characteristics were evaluated with a repeated-measures ANOVA. Effect sizes within subjects were calculated using partial eta squared (η^2_p) according to Keppel (1991). Since this metric is likely to inflate effect sizes, results were interpreted following the likelihood of overestimation as no effect if $0 \leq \eta^2_p < 0.05$; a small effect if $0.05 \leq \eta^2_p < 0.26$; a moderate effect if $0.26 \leq \eta^2_p < 0.64$; and a large effect if $\eta^2_p \geq 0.64$ (Ferguson, 2016). The percentage change (%Δ) from T_0 to T_1 in outcome variables was calculated with the following formula: $[(T_1–T_0)/T_0] \times 100$. STATISTICA 8.0 for Windows (StatSoft, Inc., Tulsa, OK, USA) was used for analysis, and significance was set at $p<0.05$.

RESULTS

Tables 2 and 3 show the descriptive parameters of physiological characteristics on the pre-and post-test. All physiological characteristics measures are normally disturbed, which can be observed based on the Kolmogorov-Smirnov test results.

Table 2. *Descriptive parameters of physiological characteristics – Pretest.*

Variable	N	Mean	SD	Min.	Max.	(K-S) d
HR_{avg} (b/min)	12	178.42	4.89	169.00	184.00	0.133
HR_{max} (b/min)	12	197.92	5.20	189.00	206.00	0.156
BR_{max} (b/min)	12	33.75	3.55	28.00	40.00	0.154
MET_{max}	12	8.67	1.00	7.50	10.10	0.215
VO_{2max} (ml/kg/min)	12	30.36	3.53	26.10	35.40	0.211
$EPOC_{max}$ (ml/kg/min)	12	47.08	10.40	28.00	66.00	0.163

Note. N: number of subjects; Mean: the mean; SD: standard deviation; Min.: minimum results; Max.: maximum results; (K-S) d: Kolmogorov-Smirnov distribution normality test results.

Table 3. *Descriptive parameters of physiological characteristics – Posttest.*

Variable	N	Mean	SD	Min.	Max.	(K-S) d
HR_{avg} (b/min)	12	175.00	5.59	167.00	186.00	0.167
HR_{max} (b/min)	12	196.33	7.11	186.00	204.00	0.197
BR_{max} (b/min)	12	32.75	3.41	28.00	39.00	0.137
MET_{max}	12	9.90	1.11	8.50	11.80	0.153
VO_{2max} (ml/kg/min)	12	34.65	3.88	29.60	41.30	0.153
$EPOC_{max}$ (ml/kg/min)	12	43.92	10.49	33.00	72.00	0.201

Note. N: number of subjects; Mean: the mean; SD: standard deviation; Min.: minimum results; Max.: maximum results; (K-S) d: Kolmogorov-Smirnov distribution normality test results.

The results of repeated measures ANOVA analysis are shown in Table 4.

Based on the difference in pre-and post-test results, it can be noticed that in volleyball players, there was a significant decrease in the HR_{avg} ($p=0.046$) and in the MET_{max} ($p<0.001$) and VO_{2max} ($p<0.001$) a significant increase. Effect size (ES) values for physiological characteristics measures are in the range of moderate effects in HR_{avg}, to large effects in MET_{max} and VO_{2max}, HR_{max}, BR_{max}, and $EPOC_{max}$ remained statistically unchanged during the preseason period but decreased by -0.8%, -3.0%, and -6.7% in the percentage could be important to some degree, however with a small effect.

Table 4. *Difference between Pre- and Post-test of physiological characteristics.*

Variable	T_1-T_0	%Δ	F	p	ES
HR_{avg} (b/min)	-3.42	-1.9	5.05	0.046*	0.31^{ME}
HR_{max} (b/min)	-1.59	-0.8	1.89	0.196	0.15^{SE}
BR_{max} (b/min)	-1.00	-3.0	2.00	0.185	0.15^{SE}
MET_{max}	1.23	14.2	58.60	0.000†	0.84^{LE}
VO_{2max} (ml/kg/min)	4.29	14.1	56.19	0.000†	0.84^{LE}
$EPOC_{max}$ (ml/kg/min)	-3.17	-6.7	3.26	0.098	0.23^{SE}

Note. T_1-T_0: the difference between post and pretest; %Δ: percentage of the difference between post and pretest; *: statistically significant differences at $p<0.05$; †: statistically significant differences at $p<0.01$; ES: effect size; ^{SE}: small effect; ^{ME}: medium effect; ^{LE}: large effect.

DISCUSSION

This study discovered that the influence of skill-based conditioning training loads applied in 4 weeks of preseason affected physiological characteristics. Decrease in HR_{avg} (-1.9%; ES=0.31^{ME}) and increase in MET_{max} (14.2%; ES=0.84^{LE}) and VO_{2max} (14.1 %; ES=0.84^{LE}) in our players were statistically significant. Other results suggest a slight decrease in value for HR_{max} (-0.8%; ES=0.15^{SE}), BR_{max} (-3.0%; ES=0.15^{SE}) and $EPOC_{max}$ (-6.7%; ES=0.23^{SE}).

The aerobic system is the main energy provision during volleyball match-play, and the average values of VO_{2max} for top-level volleyball players tend to be high (Lidor & Ziv, 2010). While differences may influence VO2max values in standards of play, training regimes, and the phase of the season, a team with superior aerobic fitness would have the advantage of being able to play the game at a higher pace and greater agility throughout the game (Nikolaidis et al., 2012).

A higher level of endurance capacity (higher VO_{2max}, lower HR_{max}) could provide elite players with a better base for on-field performance regarding intensity and demands of volleyball match-play. The decrease in the HR_{avg} is statistically significant, while the slight decrease in HR_{max} (-0.8%) is only at the numerical level, but it is evident that it shows a declining trend. A slight decrease in maximum heart rate could be explained by the fact that it tends to remain stable or slightly reduced after the applied conditioning program, even in highly trained individuals (Kenney et al., 2015). However, there is evidence that highly trained athletes in endurance sports have lower values of maximum heart rate. Individuals with lower maximal heart rates experience longer-lasting cardiac diastole, allowing more efficient ventricular filling and increasing stroke volume (Kenney et al., 2015). Therefore, although HR_{max} is an important parameter, it is not crucial for high performance among volleyball players.

Conversely, HR_{avg} could be a better indicator for monitoring performance because it closely replicates the actual sport-specific demands. Gabbett (2008) reported that skill-based conditioning games are similar to a competitive volleyball match and provided justification for implementing such specific conditioning. However, the values of HR_{avg} obtained in our study are higher than the above, 175±5.59 and 160±2, respectively. The explanation is somewhat logical because our values were extracted from a 20 meters shuttle run test, not from an actual sport-specific condition. The significant increase observed in VO_{2max} after the skill-based conditioning program follows those previously reported in trained female volleyball (Gabbett, 2008; Nikolaidis et al., 2012) and indicates a positive effect of the applied training program. However, the values of VO_{2max} in competitive female volleyball players are 40-56mmol/l (Kenney et al., 2015), which are substantially higher than the values obtained in our study. However, we should emphasize that the volleyball season lasts until the end of March, and the next one starts at the beginning of October. In addition, our players signed the contracts a week before the preseason preparation, so it was impossible to track and maintain their fitness level throughout the off-season, which could ultimately explain the significantly higher increases in VO_{2max} values (14.1%) than expected. The long period between two seasons can be very unfavorable because it is most likely that detraining will occur. There is evidence that trained athletes experience greater VO_{2max} reductions and need a more extended period to regain their previous fitness level, even up to 40 days. The higher the initial fitness level, the smaller the real improvements for the same training volume (Kenney et al., 2015). Moreover, in their review, Lidor and Ziv (2010) reported that VO_{2max} is substantially lower during the preseason compared to the competition period in female volleyball players.

Therefore, skill-based conditioning could be a sound training strategy during the last four weeks of the preseason because it replicates actual sport-specific demands (Gabbett, 2008).

The effects of a four-week preseason intensive skill-based conditioning training program in volleyball can also be observed through a significant increase in the maximum metabolic equivalent (MET_{max}), which is in the high-value zone (Jetté et al., 1990). The decrease in excess post-exercise oxygen consumption (EPOC) by -6.7% is not statistically significant, but these values could be significant in training practice and demonstrate the applied program's effectiveness. Because there are no data available on the long-term effects of exercise on EPOC value, but only those related to the effects of a single training session, it was impossible to compare our results, which could be evidence of the positive effects of the applied program since reducing the EPOC also allows a shorter recovery period for athletes after intense exercise (Børsheim & Bahr, 2003). However, Børsheim and Bahr (2003) suggested that high-intensity drills produce a more extended increase in the EPOC than low-intensity drills (when they have equivalent volume) since high-intensity regime cause greater metabolic stress, therefore producing more considerable energy cost in order to return to homeostasis. Based on the obtained VO_{2max} values, it was expected that the EPOC values should be higher. A possible explanation is that EPOC manifests changes in the fitness level, so if the EPOC is lower during the same physical activity and similar workload, fitness is probably improved because the oscillation in homeostasis is lower (Børsheim & Bahr, 2003). Therefore, we assume that the volleyball players accumulated lower EPOC values, most likely due to the multistage nature of the test. We can support this claim by comparing HR_{avg}; therefore, we can notice that the values are significantly lower in the T_1 measurement, which may explain why the overall exercise intensity decreased, which could cause lower EPOC values in the T_1 measurement.

Furthermore, VO_{2max} athletes attain during their sport-specific activity could be higher than the values obtained on another less specific test (Stromme et al., 1977). Therefore, we could suggest that the testing procedure should be more sport-specific to elicit the maximal aerobic power output and EPOC. However, this is only our assumption, and more evidence is needed to support this statement.

High-intensity skill-based conditioning, applied to volleyball players, caused significant improvements in physiological characteristics. An explanation could be found in high-intensity training, where specific anaerobic training can elicit a large percentage of VO_{2max} due to activating many motor units and near-maximal cardiac output. Moreover, high-intensity training can increase the anaerobic threshold and time to exhaustion, stimulating aerobic power and speeding up recovery (Herda & Cramer, 2016). We believe that the last weeks of the preparation period should be sport-specific to transfer the trained abilities to the competition period effectively. Furthermore, we think high-intensity skill-based conditioning can be separated into game-related and skill-specific. The previous statement could be supported by the fact that the efficiency of performing each volleyball skill is related to developing only a few skills at a time. Thus, according to Issurin (2008), combining many skills is not desirable because the positive transfer is smaller. Therefore, individual training sessions should specialize in developing one, possibly two skills, for example, spiking and blocking.

Moreover, it should be emphasized that instructional (IT) training had a specific role in developing tested abilities in our study. However, Gabbett (2008) points out that female volleyball players mostly spend training time at low intensities during IT training. Therefore, the increase in VO_{2max} is relatively insignificant. Furthermore, it was impossible to neglect IT training due to the high technical demands of the I-division volleyball league.

Although positive, the present study's results are limited only to short-term effects on the examined parameters.

Although positive changes are evident, this does not necessarily indicate that the effects could be projected in the long term. Interestingly, the planning of such a program is quite simple, yet it could be intensified and specific enough to replicate the actual conditions of the volleyball game (Gabbett, 2008). However, the question arises as to whether the effects of such training could apply to less technically efficient volleyball players.

It should be noted that volleyball technique is essential because the negative outcome of a volleyball match, at the top level, can be a consequence of only one technical inefficiency.

Due to the higher intensity, it is assumed that the skill-based conditioning approach could disrupt already established skill patterns, especially in less technically efficient volleyball players (Gabbett, 2008).

Conversely, Trajković et al. (2017) found that youth female volleyball players increased their technical proficiency after the 12 weeks of the small-sided games program.

Finally, we recommend that the preseason period be longer, and it is necessary to employ other conditioning modalities, such as strength training and plyometrics.

CONCLUSION

In conclusion, the results of the present study showed that intensive short-therm skill-based conditioning for female volleyball athletes positively affected physiological characteristics during preseason over four weeks. The positive effects of the applied training program on physiological characteristics vastly improved overall athletic performance. However, it remains unclear whether a more extended preparation period would significantly affect the observed variables and sport-specific performance or whether the results of such a program could be generalized to another population (e.g., male players, youth).

Disclosure statement
The investigators in the present study have no conflicts of interest.

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SAŽETAK

Ova studija je imala za cilj da proceni efekte kratkotrajnog kombinovanog kondicioniranja na fiziološke karakteristike odbojkašica Premijer lige u toku 4 nedelje treninga. Dvanaest odbojkašica (18,33±3,47 godina; 177,25±5,28 cm; 65,38±5,93 kg) završilo je četvoronedeljni trening tehničko-taktičkih vežbi u kombinaciji sa fizičkom kondicijom. Fiziološke karakteristike su merene korišćenjem 20-m shuttle run testa: prosečna brzina otkucaja srca (HR_{avg}), maksimalni broj otkucaja srca (HR_{max}), maksimalni broj udisaja (BR_{max}), maksimalna potrošnja kiseonika ($VO2_{max}$), maksimalni kiseonički dug posle vežbanja ($EPOC_{max}$) i maksimalni metabolički ekvivalent (MET_{max}). Prikupljanje podataka i ekstrakcija vršeni su pomoću monitora otkucaja srca i softvera Firstbeat Sport. Nakon inicijalne evaluacije (T_0), odbojkašice su testirane nakon četvrte nedelje treninga (T_1). Prosečni broj otkucaja srca (HR_{avg}) je smanjen (-1,9%; p=0,046), maksimalni metabolički ekvivalent (MET_{max}) (14,2%; p<0,001) i maksimalna potrošnja kiseonika ($VO2_{max}$) (14,1%; p<0,001) značajno su povećani. Rezultati sugerišu da su odbojkašice nastavile da poboljšavaju fiziološke karakteristike tokom studije. Konačno, primena ovih podataka daje normativne standarde fizioloških karakteristika odbojkašica u pripremnom periodu.

Ključne reči: *kombinovani kondicioni trening, efekti, fiziološke karakteristike, žene, odbojka*

Primljeno: 23.08.2022. Odobreno: 20.10.2022.

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