The effects of short-term preseason combined training on body composition in elite female volleyball players

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Abstract
The present study aimed to evaluate the effects of a short-term preseason combined training programme on the body composition of female volleyball players of the highest Bosnia and Herzegovina division league over 4 weeks of training. Twelve female volleyball players (18.33±3.47 years; 177.25±5.28 cm; 65.38±5.93 kg) completed 4 weeks of volleyball drills and skills combined with physical conditioning. Body composition was measured using aa analysis of bioelectrical-impedance. After the initial evaluation (Pre), the players were tested afterthe fourth week of the training cycle (Post). Total body water increased by 3.3% ($p<0.001$) and fat-free mass by 3.1% ($p<0.001$), also body weight by 2.5% ($p<0.01$) and the body mass index by 2.6% ($p<0.01$), whereas the fat percentage decreased by -1.7% ($p>0.05$). The results suggest that the evaluated volleyball players continued improving their body composition during the study. Finally, as a major application, these data provide normative standards of body composition in the preseason for female volleyball players.

KEYWORDS: combined training, effects, body composition, female, volleyball.

Introduction
For successful participation during elite volleyball competition, in addition to technical and tactical skills, Häkkinen (1993) suggested that anthropometric characteristics and individual physical performances are the most critical factors. Similarly to other team sports, prticular

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attention has been paid to the morphological characteristics of elite players in volleyball (Malousaris et al. 2008). It is well documented that participation in women's team sports may induce changes in body composition (Bayios et al. 2006; Morgan et al. 2016). A comparison among sports has demonstrated distinct body composition dissimilarities in female athletes, which are likely related to sport-specific training practices and body types conducive to sport success (Carbuhn et al. 2010). From the existing data, it appears that the percentage of body fat of elite female volleyball players varies widely among studies, ranging between 13.7% and 23.4% (Mala et al. 2010; Maly et al. 2011; Mielgo-Ayuso et al. 2015; Nikolaidis 2012, 2013; Malousaris et al. 2008; Bayios et al. 2004). Differences are manifested among players of different positions, which are interpreted by their varying roles and demands during a volleyball game (Malousaris et al. 2008).

Body composition (BC) is an essential factor of physical fitness for volleyball teams, and appropriate BC is necessary because of the frequent and intense nature of defensive and offensive jumps, blocks, knockouts, and sprints required in volleyball (Rico-Sanz 1998). Fat-free mass (FFM), in contrast, is indicative of muscle mass (MM) and could increase an individual's production of speed, strength and power (Cormie et al. 2007), and affect injury prevention (Arden & Spector 1997). Specifically, BC is considered to be a significant predictor of muscular force efficiency that directly relates to sports performance (Andreoli et al. 2003; Lidor & Ziv 2010; McManus & Armstrong 2011). However, most athletes have their BC measured only once (Forjasz 2011; Malousaris et al. 2008; Siahkouhian & Hedayatnejad 2010). Rarely is this important tool used to monitor an athlete throughout an entire pre- or competitive season (Reilly 1996).

Therefore, continous monitoring of BC is crucial in athletes participating in high-performance sports (Bandyopadhyay 2007; Tsunawake et al. 2003). One such sport that benefits from these measurements is competitive volleyball. This sport requires the first-rate athletic performance of its players as well as high muscle force production for frequent jumping (Portal et al. 2010).

Coaches have a limited amount of time to work with their athletes during the preseason. Given the short period, it is questionable whether athletes can be trained at high intensities and yet properly rest and recover between training sessions to fully achieve the desired effects (Trajković et al. 2012). Moreover, to our knowledge, no previous study has examined the effect of preseason combined (concurrent) training programme (Gamble, 2006) applied to a sample of female competitive volleyball players. In addition, it is unclear whether training sessions offer an adequate training stimulus to improve the BC of volleyball players in the preseason. Having in mind that the season is very long and there is little time for preparation, combined training offers a sport-specific mode of training for team sports and provide advantages in terms of time-efficiency, motivation, and training compliance (Gamble, 2007).

The main goal of a training season is to increase a player's performance in competitions. The greatest fitness improvement occurs in the preseason, and is normally maintained or may slightly decrease during the in-season period (Hartmann et al. 2015). BC assessment is a valuable tool that can help coaches and sports scientists assess and monitor the success of training programmes (Drinkwater et al. 2008). However, estimates of the effects of training on BC differ, in part because different assessment techniques of varying accuracy and precision are used to quantify exercise-related changes in body composition (Malina 2007).

Therefore, the purpose of this study was to determine the changes in body composition following 4 weeks of a preseason combined training programme in female competitive volleyball players.

Methods

Experimental approach to the problem

This study used a repeated-measures design to follow up the adaptations of body composition in a group of elite female top volleyball players during 4 weeks of preseason in a volleyball team of the highest Bosnia and Herzegovina volleyball division league. To determine whether there were preseason changes in these aspects, the participants were tested at the start of the preseason (T0 - last week of August) and immediately after 4 weeks of the training programme before the regular competitive season (T1 - first week of October). The competitive season in the female volleyball league runs from the start of October to the end of March.

Participants

Twelve elite female volleyball players (18.33±3.47 years; 177.25±5.28 cm; 65.38±5.93 kg), from the University Volleyball Club Bihać-Preminger, one of the top 10 teams in the Bosnia and Herzegovina Premier League, participated in this study. All the players had at least 3 years of professional and elite training experience.

Experimental protocol

Before beginning the study, all of the players underwent a physical examination by the team physician and were cleared of any disease or endocrine disorders which could have limited their ability to effectively participate. Furthermore, no athletes had a history of serious injury nor were any athletes taking medication during the study. All of the experimental procedures and possible risks and benefits were explained to each player. In addition, each player participated voluntarily and signed a written consent form prior to the onset of participation. The study was designed in compliance with the recommendations for clinical research of the Declaration of Helsinki (2013) of the World Medical Association. This study was also reviewed and approved by the Ethics Committee of the Faculty of Physical Education and Sport, University of Banja Luka.

Morphological measures and body composition

Morphological measures and BC assessments included: body height (BH), body weight (BW), body mass index (BMI), fat mass (FM), fat mass percentage (FM%), fat-free mass (FFM) and total body water (TBW). The participants wore single-layer compression shorts and lightweight jog bras during data collection. The participants stood barefoot in an upright position on foot electrodes on the instrument platform and both arms and legs were widely separated from each other. The morphological measures were taken according to the instructions of the IBP at the beginning of the study. Body height was measured to the nearest 0.1 cm. Body composition parameters were assessed using a Tanita Body Composition Analyser (BF-350; Tanita, Tokyo, Japan) with the assistance of GMON Professional Software (Tanita, Tokyo, Japan). The Tanita body fat analyser measures impedance across both legs, arms and the trunk via multiple frequencies of 50 kHz. The system's four electrodes are in the form of footpads and each footpad is divided in half so that the anterior and posterior portions form two separate electrodes. Impedance and body weight (BW) are automatically measured, and the subject's height (BH) and age are manually entered into the system. Body weight (kg) and percentage (%) of fat mass, fat-free mass (kg) and total body water (kg) were measured automatically using the Tanita BF-350, and have been shown on the display. The participants were asked to avoid the following procedures before body composition measurement as described by Rech et al. (2008): performing any physical exercise in the 12 hours prior to testing, eating or drinking anything in the four hours before the evaluation, urinating at least 30 minutes before the evaluation, taking any diuretics in the seven days prior to the test, and consuming alcohol in the 48 hours preceding the test.

Training programme

Preseason conditioning

During the study, periodised preseason training for team sports was utilised. Due to limited training time, the periodised protocol previously used for a competitive female volleyball team was implemented as the combined (concurrent) training programme (Gamble, 2006) in this study. One meso-cycle was analysed in the preseason (season 2012/2013). A short preseason mesocycle (4 weeks) was selected because of the late start of the players' contracts (middle of August) and the early start of the competitions (start of October). The goals of the preseason conditioning were to increase the intensity of sport-specific training, and attention was given to volleyball drills and skills combined with physical conditioning. Thus, the training programme progressed from general conditioning one week before the training programme in order to prevent possible injuries, conducting 11 workouts per week.

In total, over the 4 weeks, players trained for 64 h (27.0% warm up and stretching; 43.2% technical and tactical training, 29.8% physical training) and played 5 matches. A typical training day consisted of 2 daily sessions (Mielgo-Ayuso et al. 2015), one in the morning and one in the afternoon. During weeks 1–3, the training emphasis (60 h and 40 min.) was as follows: 44.4% technical and tactical training consisting of moderate-intensity (26 h and 56 min.), 15.3% aerobic and endurance conditioning consisting of aerobic game-related training of low-intensity continuous drills (9 h and 17 min.), 7.4% anaerobic training consisting of high-intensity plyometric drills and agility-based drills (4 h and 29 min.), and 6.6% resistance training consisting of high-intensity (4 h). In the fourth week, the training emphasis (3 h and 20 min.) was as follows: 30.0% technical and tactical training consisting of moderate-intensity (1 h), 30.0% aerobic and endurance conditioning consisting of aerobic game-related training of low-intensity continuous drills (1 h) and 10.0% anaerobic training consisting of high-intensity pyramid run (20 min.) 5 games were played: three friendlies (Monday-Thursday) and two in the tournament (Saturday-Sunday).

Daily training

In accordance with the periodised programme, the morning sessions included 25 min of a volleyball specific warm-up without and with a ball (20.8%) followed by 95 min of combined training with volleyball practice consisting of technical and tactical drills for 65% of the practice, and aerobic sessions each comprising 30% of the practice. The afternoon session is similar to the morning session, but the volleyball practice is combined with strength, agility-based and plyometric drills. This training programme was executed daily except on match days and the days following a match. On the day after a match, recovery training consisted only of 1 training session of 20 min of jogging and stretching exercises.

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 T0 to T1 for all morphological measures and BC assessments were evaluated with a repeated-measures ANOVA. Effect sizes among the participants were calculated using partial eta squared (η^2_p) according to Keppel (1991). Since this measure is likely to overestimate effect sizes, values were interpreted according to Ferguson (2009) 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 $\eta^2_p \geq 0.64$. The percentage change (%Δ) from T0 to T1 in outcome variables was calculated with the following formula: $[(T1–T0)/T0] \times 100$. STATISTICA 7.0 for Windows (StatSoft, Inc., Tulsa, OK, USA) was used for analysis and significance was set at $p < 0.05$.

Results

Tables 1 and 2 show the descriptive parameters of morphological measures and BC on the pre- and post-test. All morphological and BC measures are normally disturbed, which can be observed on the basis of the Kolmogorov-Smirnov test, whose values for all measures are less than the maximum limit value for a sample of 12 participants (Facchinetti, 2009: 352).

Table 1: Descriptive parameters of morphological measures and BC - Pretest

Variable	N	Mean	Std.Dev.	Min.	Max.	(K-S) d
Body high (cm)	12	177.25	5.28	163.00	183.00	.231
Body weight (kg)	12	65.38	5.93	53.20	73.40	.136
BMI (kg/m²)	12	20.77	1.30	18.60	22.90	.120
Fat mass (kg)	12	15.21	4.41	9.20	22.90	.122
Fat mass (%)	12	23.13	5.85	14.67	32.71	.129
Fat free mass (kg)	12	50.17	5.08	38.90	57.30	.152
Total body water (kg)	12	36.73	3.71	28.50	41.90	.148

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

Table 2: Descriptive parameters of morphological measures and BC– Post-test

Variable	N	Mean	Std.Dev.	Min.	Max.	(K-S) d
Body high (cm)	12	177.25	5.28	163.00	183.00	.231
Body weight (kg)	12	67.02	5.54	55.60	74.20	.182
BMI (kg/m^2)	12	21.31	1.21	19.20	23.40	.182
Fat mass (kg)	12	15.28	3.94	9.00	20.50	.145
Fat mass (%)	12	22.75	5.45	14.47	30.15	.121
Fat free mass (kg)	12	51.74	5.27	40.60	59.20	.116
Total body water (kg)	12	37.92	3.85	29.70	43.30	.113

With the normal distribution of the results of morphological and BC measures, it is possible to apply parametric statistical procedures for determining the differences between the pre- and post-test, and the repeated-measures ANOVA was applied. The results of this analysis are given in Table 3 and shown in Figure 1.

Based on the difference in pre- and post-test results, it can be observed that in volleyball players there was a significant increase in the BM and BMI values, as well as FFM and TBW. ES values for both morphological and BC measures are in the range of moderate effects in BM and BMI, to large effects in FFM and TBW. Unquestionably, FM remained unchanged during the preseason period, but decreased by 1.7% in the percentage (FM%), which is not statistically significant, but it could be relevant to some degree, with a small effect size.

Table 3: Differences between Pre- and Post-test of morphological measures and BC

Variable	T1-T0	%Δ	F	p	ES
Body weight (kg)	1.64	2.5	12.96	0.004*	0.54ME
BMI (kg/m2)	0.54	2.6	13.79	0.003*	0.56ME
Fat mass (kg)	0.07	0.4	0.05	0.824	0.00NE
Fat mass (%)	-0.38	-1.7	1.23	0.292	0.10SE
Fat free mass (kg)	1.57	3.1	20.77	0.001*	0.65LE
Total body water (kg)	1.19	3.3	21.45	0.001*	0.66LE

Legend: T1-T0 - the difference between post and pretest; %Δ – percentage of differences between post and pretest; * - statistically significant differences; ES – effect size; NE – no effect; SE – small effect; ME – medium effect; LE – large effect.

Discussion and conclusion

The results of the morphological measures showed that the average BH (177.25 cm) of the players were similar to the values given by Gualdi-Russo and Zaccagni (2001) regarding Italian national league players (178.4 cm), Malá et al. (2010) regarding Slovak volleyball national team players (179.4 cm) and Malousaris et al. (2008) in players from the Greek A1 division league (179.6 cm). Cardinale and Lim (2003) reported higher average body height in professional players from the Italian national league (183.4 cm), as did Marques et al. (2008) in players from the national first division of Portugal (187.0 cm). Regarding

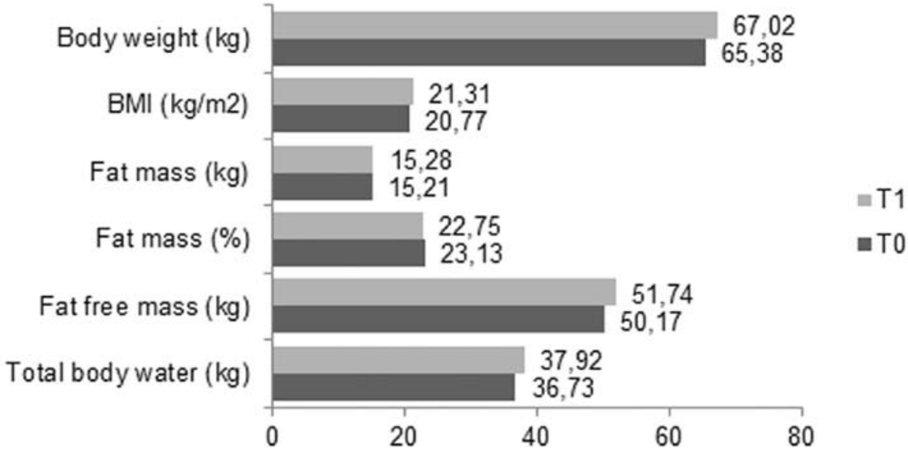

Figure 1: Differences between Pre- and Post-test of morphological measures and BC

BW, the players in the present study showed the lowest weight values (T0=65.38 kg; T1=67.02 kg) compared tothe players' BW in similar studies (67.75–75.10 kg) (Malá et al. 2010; Malousaris et al. 2008; Marques et al. 2008; Cardinale & Lim 2003). Furthermore, taking into consideration the players' BMI value (T0=20.77; T1=21.31), they were in the normal-weight zone. Obviously, this BMI was also the lowest of all in the compared studies (21.69-22.10 kg/m^2) (Nikolaidis et al. 2012; Malousaris et al. 2008; Bayios et al. 2004). Fat mass [(FM%) T0=23.13 % and T1=22.75 %] in our players was similar to the values of high-level volleyball players (22.1 – 23.4 %) given by Nikolaidis (2012, 2013), Malousaris et al. (2008), Bayios et al. (2004), as well as the lower values (13.7 – 17.9 %) found by Mala et al. (2010), Maly et al. (2011) and Mielgo-Ayuso et al. (2015). Finally, the average Fat free mass (FFM) of our players was T0=50.17 kg and T1=51.74 kg. These values were similar to the values (50.8 –52.03) in Parton et al. (2017), Simoes et al. (2009) and Nikolaidis et al. (2012), and lower than the values (53.2 – 54.8 kg) found in high level players by Bayios et al. (2004) and Malousaris et al. (2008).

The present study found that the effect of combined (concurrent) training loads applied in 4 weeks of preseason affected body composition. The increase in BW (2.5 %; ES=0.54^{ME}) and BMI (2.6 %; ES=0.56^{ME}) in our players was significant. Some researchers reported a decrease in BW (-0.15 %) and BMI (-0.71 %) after preseason training loads (Gonzalez-Rave et al. 2001), while in some there was no change (Simoes et al. 2009; Stranganelli et al. 2008). The results from similar studies are contradictory, primarily due to uneven procedures, as well as the different volumes and intensities of the load in the training period. However, the data of the present study indicate otherwise and agree with previously published research showing that BMI may not be a valid measure for assessing or monitoring body composition in athletes (Ode et al. 2007), including female elite athletes (Klungland & Sundgot-Borgen 2012). In this case, an increase in the BW and BMI of volleyball players is caused by an increase in FFM, and not FM. The significant increase observed in FFM (3.1%; ES=0.65[LE]) is in accordance with those previously reported in trained women (1.9 - 3.2%) (Morgan et al. 2016; Gonzalez-Rave et al. 2001; Parton et al. 2017; Simoes et al. 2009), also in TBW (3.3%; ES=0.66[LE]) is in accordance with an increase by 1.5% reported by Silva et al. (2014). Relatively high values of TBW and FFM of our female volleyball players indicate that their good training load is aiding in attaining values characteristic of high-performance sport (Mala et al. 2010).

The significant decrease in FM% in the preseason was observed before (-1.8 to -8.2%) (Gonzalez-Rave et al. 2001; Simoes et al. 2009). The results Theresults of the present study (-1.7 %; ES=0.10[SE]) also agree with the lower FM% (-1.6%) observed in the preseason (Häkkinen 1993), which are not statistically significant, but are important for understanding the relationships between FM%, FFM and BMI.

The increase in BW (1.64 kg) is due to an increase in FFM (1.57 kg), as the absolute value of the FM value slightly increased (0.07 kg). FFM is composed of TBW and extracellular solids (ECS), and since the TBW/FFM ratio is ~ 0.74 (Wang et al. 1999), it can be observed that TBW constitutes a greater part of FFM (Yarasheski et al. 1992). The increase in TBW after the preseason training programme is 1.19 kg, which accounts for 75.8% of the increased FFM. Since 60 percent of TBW is composed of intracellular water (ICW) and represents a compartment of body cell mass (BCM) (Wang et al. 1999), it can be noted that the increase in TBW produced an increase in BCM, whose greater part is muscle mass. This confirms that the effects of a 4-week preseason intensive combined training programme were the largest for the increase in muscle mass of volleyball players and for a slight decrease in FM%, which is consistent with the results of previous research (Morgan et al. 2016; Gonzalez-Rave et al. 2011; Simoes et al. 2009).

In conclusion, the present research showed that a short-term combined training programme for professional volleyball female players positively affected body composition during pre-season over a 4-week period. The positive effects of the training programme on BC, in this study, are largely reflected in volleyball and athletic performance. However, it remains unknown how a longer specific training period would affect the observed variables with volleyball performance, or whether the results of this specific programme could be generalised to another population (e.g., male players, youth).

A limitation of this study could be the small sample size, but also the non-homogeneous composition of the team by age, where the difference between the youngest and the oldest player was 9 years. A study with a larger and more homogeneous sample, could have more significant effects on all components of body composition, including the reduction of fat mass, which was not the case in this study.

Practical applications

During the preseason, in-season and off season, the parameters of the body composition vary, so in the preseason the body mass index, fat free mass and total body water values are increased, while the fat mass values are reduced. In-season values of body mass index and fat mass decreased, and the value of fat free mass and muscle mass increased (Gonzalez-Rave et al. 2011), while in the off season there are no significant changes in any body composition component, regardless of whether a supervised or unsupervised conditioning training programme is applied (Fry et al., 1991).

The primary finding of this study is that the use of sport-specific training during 4 weeks of volleyball drills and skills combined with physical conditioning significantly improves body composition in professional volleyball players. Thus, using a load that maximises intensity output can improve body composition. A feasible model of training described in this article can be used to predict and guide the prescription of future training loads during preseason training phases for a female professional volleyball team. Therefore, both coaches and sport scientists can tailor the combined training more effectively to improve performance. In addition, this study provides normative data for professional female volleyball players, so that coaches can use this information to determine the standards of body composition in the preseason.

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Povzetek

Namen raziskave je bila ocena učinka kratkotrajnega treninga v pripravljalnem obdobju na nekatere dejavnike telesne sestave odbojkaric, ki igrajo v najvišji bosansko-hercegovski ligi. Dvanajst odbojkaric (18,33 ± 3,47 let; 177,25 ± 5,28 cm; 65,38 ± 5,93 kg) je opravilo načrtovan štiritedenski tehnično–taktični trening kombiniran z razvojem telesne priprave. Sestavo telesa smo izmerili z bioelektrično impendančno analizo. Opravili smo meritev inicialnega stanja (Pre) in po štirih tednih še končnega stanja (Post). Dobljeni rezultati so pokazali, da se je količina vode v telesu povečala za 3,3 % ($p <0{,}001$), telesna masa brez deleža maščobe za 3,1 % ($p <0{,}001$), prav tako sta se povečala telesna teža za 2,5 % ($p <0{,}01$) in indeks telesne mase za 2,6 % ($p <0{,}01$), odstotek maščobne mase pa se je zmanjšal za 1,7 % ($p> 0{,}05$). Rezultati kažejo, da se je sestava telesa pri odbojkaricah v času trajanja raziskave izboljšala. In končno, dobljene rezultate lahko uporabimo tudi kot normativne vrednosti kvalitetnih odbojkaric v predtekmovalnem obdobju.

KLJUČNE BESEDE: kombiniran trening, učinek treninga, sestava telesa, odbojkarice

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