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Changes in body structure of adult football players during one training unit

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Abstract
The aim of this study is to establish the quantitative changes in body structure of 28 professional footballers (Premier League of Bosnia and Herzegovina), caused by a single training session during the preparatory period of the team. Structure of the 90 minute training session consisted of introductory-preparatory, main and final part, being designed to combine game with exercise. The subject of study covered transformational processes of body composition of elite football players of Bosnia and Herzegovina in order to determine the effects of a football training sessions on their physical structure. Partial quantitative changes in body composition, formed during training session, were analyzed by T-test for paired samples. These results indicate that there was a statistically significant difference at the level of significance ($p<.01$) variables for the estimation of body mass (AMAS), body mass index (BMI), basal metabolic rate (BMR), fat free body part (FFM) and amounts of body water (TBW). Statistically significant differences at the level of significance ($p<.05$) occurred at the variables for the assessment of resistance in the body (IMPEDANCE). Variables for estimation of height (AVIS), percentage of fat in the body (FAT %) and of fat in body weight (FATMAS) showed that there was no statistically significant changes. It can be concluded that 90 minute training session organized in this manner can have significant impact on the transformation of body composition.

Key words: **football, body composition, quantitative changes, training**

Sažetak
Cilj ovog istraživanja bio je da se kod dvadeset osam profesionalnih nogometaša (Premijer liga BiH) utvrde parcijalne kvantitativne promjene u tjelesnoj strukturi, prouzrokovane jednom trenažnom jedinicom pripremnog perioda ekipe. Struktura treninga u trajanju od 90 min se sastojala od uvodno-pripremnog, glavnog i završnog dijela, a koncipirana je tako da se igra i vježbe kombinuju. Predmetom istraživanja obuhvaćeni su transformacioni procesi tjelesne kompozicije kod vrhunskih nogometaša Bosne i Hercegovine u cilju utvrđivanja efekata jedne nogometne trenažne jedinice na njihovu tjelesnu strukturu. Parcijalne kvantitativne promjene u kompoziciji tijela, nastale u toku treniga, analizirane su T-testom za zavisne uzorke. Dobiveni rezultati pokazuju da je došlo do statistički značajnih razlika na nivou značajnosti od ($p<.01$) kod varijabli za procjenu mase tijela (AMAS), indexa tjelesne mase (BMI), bazalnog metabolizma (BMR), bezmasnog dijela tijela (FFM) i količine vode u tijelu (TBW). Do statistički značajnih razlika na nivou značajnosti od ($p<.05$) došlo je kod varijable za procjenu otpora u tijelu (IMPEDANCE). Kod varijabli za procjenu visine (AVIS), procentualnog udjela masti u tijelu (FAT %) i udjela masti u masi tijela (FATMAS) nije došlo do statistički značajnih promjena Može se zaključiti da je ovako programirana trenažna jedinica pripremnog perioda nogometaša u trajanju od devedeset minuta statistički značajno utjecala na transformaciju u kompoziciji (sastavu) tijela.

Ključne riječi: **nogometaši, kompozicija tijela, kvantitativne promjene, trening**

Introduction

Determination of the physical structure of the individual is a common method, not only in sports but also in anthropology, pedagogy, medicine. In modern sports, diagnosis and evaluation of the training process is of great importance in providing a physical structure and the amount of fat (lean) components of total body mass, compared with the reference values found in the model values in a particular sport. This especially applies to sports in which adipose tissue makes significant ballast weight and reduces the efficiency and effectiveness of the athlete. Most attention is focused on the determination of fat components, in order to assess health status, direction, training evaluation process or the quality of sports performance and nutrition of athletes. There are also legitimate reasons for establishing the content and amount of other components in the structure of body composition (amount of muscle tissue, bones, body resistance, fluids, etc). To determine the physical structure of the most frequently used methods were those used in the field and laboratory conditions, which were based on the measurement of anthropometric measures (folds, height, weight, volume, etc.) and of inclusion in the regression equation on which the percentage of fat in the body was established. The most commonly used methods Jackson and Pollock (1985), Heath and Carter (1967), on the basis of which is determined the somatotype of athletes and those are the aspired values during the training process. In determining the physical structure of the physically active population anthropometric methods of Ramadan and Byrd (1987), Green (1992), Dowson etc. (1999) are used. This method of measuring the dimensions of the human body and using the appropriate equations easily provides an indirect assessment of the content of fat, muscle and bone tissue of the athletes. As a result of increasing demands in sports, there is an increased interest in new, more sophisticated techniques and methods to determine body composition both among the athletes as well as the rest of the population. The development of advanced technologies at the end of the last century resulted in the emergence of modern software systems for determining physical composition of the individual. Initial applications were made in health and medicine but they are increasingly been used in sport as well. The most popular methods for assessing and determining the composition of the body (Ostojić, 2007; Mišigoj and Duraković 2008) are: hydrostatic measurement (Hydrostatic Weighing); double energy X-ray absorptiometry (DEXA) analysis of bioelectric resistance of the body - Bioelectrical Impedance Analysis (BIA), Near Infrared Interactance (NIR), computed tomography (CT) and nuclear magnetic resonances (NMR). Bioelectrical impedance analysis (BIA) that was used in this study is rapid, noninvasive and relatively inexpensive method for evaluating physical composition. The main advantages of BIA method are that it is not as expensive and it is most comfortable method that does not invade the privacy of the person being measured. BIA is a method that evaluates the structure of the body composition of broadcasting low, safe doses of electrical power of 800 μA and frequency of 50 kHz through

the body. Electricity passes through the body - through the lean tissue without any resistance (muscles, bones, internal organs), while resistance exists when passing through fat tissue. This resistance is called bioelectrical impedance and in order to measure it we use the body fat monitors. Entering data of the chosen individual (altitude, weight, year, status), monitor based on the installed software calculates certain structure of the body composition. For these reasons, BIA has gained the trust and support of medical and sports experts within the last decade. This method is used for planning and evaluating the training process, where particular interest is placed in guiding the training sessions and proper nutrition of athletes, to which certain modifications can be substantially affected. Therefore, determining the fat and lean components of body composition of athletes, with the knowledge of the optimal value for a particular sport, occupies an important place in contemporary practice.
The composition of lean body mass component in the total body mass consists of muscles, bones and internal organs, and fat mass are so called relevant and irrelevant fat. Relevant fat accounts for about 2% - 5% of lean body mass in the form of lipid components of cells, and fat in most unimportant seems subcutaneous adipose tissue. The ratio of fat and nonfat components in athletes varies greatly depending on gender, level trainings, period and age. Significantly higher proportion of fat people are female, and the highest ratio between lean body part and the fat person has when he or she reaches 20 years of age, and then that ratio is reduced with non-athletes. After 20 years of age normal increase in body fat by 1% can be expected in each decade. Upper limit of fat percentage is 25% for men and 30% for women, while the minimum values range from 5% - 10% for men and 5% - 17% for women (Wilmore, 1986; Wilmore and Costill, 2004). The scope of activities at the time of measurement, quality of food and competitive period of the season are the factors that should be taken when evaluating body composition. Method of assessment or measurement of body composition should also be taken into account during the interpretation of the results. In any case, changes in the structure of body composition represent an important indicator of the correlation between training intensity and extensity, nutrition of top players, current status providing unambiguous guidelines for creation of the subsequent training sessions.

Methods

Sample of the examines

Research was conducted on a sample of 28 senior players of average age (mean 24.5 ± 5.7), average height (mean 182.2 ± 6.36) and average weight (mean 79.5 ± 6 , 75), comprising a squad of a single professional football team in the Premier League of Bosnia and Herzegovina, with good health status, among whom other psychophysical aberrations are not identified. In the final processing, only the results of the players who participated in the program (having gone through the previous part of the preparatory period of 15 days, attended the training session and the measurements) were taken into account. The training consisted of three parts: introductory-preparatory, main and final. Keynote - part of the preparatory training (20 min) consisted of a warm-up session of working with the ball and dynamic shaping and stretching exercises. In the main part of the training (55 min) the players were divided into three groups, two of which (8x8) played on the forecourt with four goals and the third group did exercises of continuous running for 8 min. The final part of training (15 min) consisted of loosening up and stretching.

Sample of the variables

In this study, body composition was determined using bioelectrical impedance measurements (Bioelectrical Impedance Analysis) - BIA. For this purpose the Tanita TBF-300 (Tanita Corporation of America Inc.) electric scales were used, which indicate the share of fat (% and kg) compared to lean mass (% and kg) in order to have the optimal value in relation to the age of athletes that are studied. After measuring body height the examinee stands on the scale in a normal upright position until the person performing the measurement gives him a sign to leave the measuring position. Software automatically provides a checklist with data of the examinee for the following variables of body composition:

1 Body height (AVIS)
2 Body mass (AMAS)
3 Body Mass Index (BMI)
4 The value of basal metabolic rate (BMR)
5 Electrical resistance of the body (impedance)
6 Percentage of body fat (% FAT)
7 The share of fat in body mass (FAT MASS)
8 Share-body fat free (FFM)
9 Percentage body water (TBW)

According to the World Health Organization (WHO, 1998) BMI of less than 18.5 is considered to be a lack of weight and could point to presence of malnutrition, irregular feeding or other health problems, whereas BMI greater than 25 indicates that the subject is overweight, while BMI of 30 and over is defined as obesity. TBW (Total Body Water Eng.) is the percentage of water in the body of an athlete and it shows the correct and optimal intake of fluids by athletes. Normal TBW percentage varies among women from 45% - 60%, and among men from 55% - 65%. For athletes, the image is approximately 5% higher than the projected ranges, as they have greater muscle mass, and the bones and muscles contain more water than fat (obese) tissue. BMR (Warner basal Metabolic Rate) is the daily minimum level of energy or calories that are necessary for the effective functioning of the organism in a state of rest. A person with high BMR can burn more calories than a person at rest with lower BMR. BMR is based on the level of muscle mass. Full understanding of the basal metabolism provides the user with an insight into his calorie intake needs as required in accordance with his physique and lifestyle. The more muscle or more general activities an athlete has, the more calories must he take in order to function properly, so that nutrition and training program characteristics may be based on this information.

Data analysis method

Processing of the obtained data was done in the SPSS 12.0 for Windows software package. All the variables are calculated based on central and dispersion parameters of the variables (min, max, mean, std., Variance, skewnis, kurtosis) before and after training. T-test for paired samples was used to determine the partial quantitative differences through two time points at a unified variable level (before and after training).

Results and Discussion

Highest class football players are in average aged between 25 to 27 with a standard deviation of about 2 years (Ekblom, 1994; Shephard, 1999), where in Croatia and Serbia that average is around 23 years ± 3 years (Jerković, Jerković, & Sporiš, 2006; Ostojić 2000). According to the research conducted by Bloomfield and associates (2005) the average height, weight and BMI of European soccer players showed that the Bundesliga players are the highest 1.83 ± 0.06, 77.5 ± 6.4, the heaviest and have the highest BMI of 23.2 ± 1.1 of the four European top leagues. Players in the Spanish La Liga are the smallest (1.80 ± 0.06), and an average Serie A player had the lowest index for body mass 74.3 ± 5.4 BMI 22.8 ± 1.1. High class footballers in Croatia are 178.73 ± 5.81 high and weigh around 78.01 ± 5.73 (Jerković, Jerković, & Sporiš ,2006), Serbia and 181.9 ± 5.7, and weigh 77.4 ± 5, 9 and the percentage of fat 10, 8 ± 2.1. As seen from Tables 1 and 2, players in Bosnia and Herzegovina have approximately the same value as the European top players. Also, most of the variables have normal distribution of results because the skewnisa and kurtosis values are within -1 to +1, with a tendency toward zero.

Table 1. *Descriptive parameters of body composition before training*

Variable	Min	Max	Mean	Std.	Variance	Skew.	Kurt.
AVISI	172,40	197,00	182,2071	6,36460	40,508	,329	-,354
AMASI	66,10	94,30	79,5321	6,75415	45,619	,078	,172
BMII	20,80	26,80	23,9750	1,50791	2,274	-,027	-,378
BMRI	7198,00	9208,00	7985,5000	467,04084	218127,148	,613	,691
IMPEN.I	382,00	555,00	460,1429	37,98607	1442,942	,624	,750
FAT%I	5,00	13,20	9,2929	2,12549	4,518	-,168	-,664
FATMASI	3,70	11,80	7,4286	1,89734	3,600	-,029	-,074
FFMI	59,90	85,30	72,1036	6,00342	36,041	-,023	,347
TBWI	43,90	62,40	52,8036	4,39937	19,354	-,031	,300
YEARS	18,00	39,00	24,50	5,73811	32,926	,944	,350

Table 2. *Descriptive parameters of body composition after training*

Variable	Min	Max	Mean	Std.	Variance	Skew.	Kurt.
AVISF	172,40	197,00	182,2071	6,36460	40,508	,329	-,354
AMASF	65,00	93,40	78,2036	6,76376	45,749	,102	,147
BMIF	20,30	26,20	23,5464	1,47610	2,179	-,022	-,329
BMRF	7134,00	9122,00	7910,4286	469,86574	220773,810	,592	,603
IMPEN.F	384,00	553,00	468,0357	40,63066	1650,851	,482	-,061
FAT%F	4,10	13,20	8,9964	2,23499	4,995	-,254	-,362
FATMASF	3,00	11,30	7,0929	2,06862	4,279	,044	-,327
FFMF	58,90	84,20	71,1250	5,71636	32,677	-,146	,352
TBWF	43,10	61,10	52,0464	4,14116	17,149	-,218	,240

From table 3, which presents comparative values of arithmetic means of variables in the initial and final measurements, it can be seen that for most variables there was a change in the value of both the central and the dispersion parameter. All variables exhibit changes of the arithmetic main value, higher or lower intensity and different directions. Only variables with body height (AVIS) do not show any logical change, because the measurement was conducted at the beginning and at the end of the training session. Therefore, the variations are minimal.

Table 3. *Paired Samples Statistics*

Variable		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	AVISI	182,2071	28	6,36460	1,20280
	AVISF	182,2071	28	6,36460	1,20280
Pair 2	AMASI	79,5321	28	6,75415	1,27641
	AMASF	78,2036	28	6,76376	1,27823
Pair 3	BMII	23,9750	28	1,50791	,28497
	BMIF	23,5464	28	1,47610	,27896
Pair 4	BMRI	7985,5000	28	467,04084	88,26242
	BMRF	7910,4286	28	469,86574	88,79628
Pair 5	IMPENDANCEI	460,1429	28	37,98607	7,17869
	IMPENDANCEF	468,0357	28	40,63066	7,67847
Pair 6	FAT%I	9,2929	28	2,12549	,40168
	FAT%F	8,9964	28	2,23499	,42237
Pair 7	FATMASI	7,4286	28	1,89734	,35856
	FATMASF	7,0929	28	2,06862	,39093
Pair 8	FFMI	72,1036	28	6,00342	1,13454
	FFMF	71,1250	28	5,71636	1,08029
Pair 9	TBWI	52,8036	28	4,39937	,83140
	TBWF	52,0464	28	4,14116	,78261

Table 4 shows the correlation between pairs of variables in the initial and final measurements, where all variable values are extremely high. The main problem of such research methods is determining whether significant changes under the influence of a particular training program (training) have occurred. Partial quantitative changes were analyzed by T-test for paired samples (Table 5). Differences between the two measurements are statistically significant at $p<.01$ for variables used to measure the mass (AMAS), the physical index (BMI), the values of basal metabolic rate (BMR), non-fat substances in the structure (FFM) and the amount of fluid (TBW). These results show that the players lost on average 1.3 kg weight which represents 1.67% of initial weight, which is a good average considering that the top world athletes lose up to 2% of initial weight (Shirreffs, Sawka Stone M. 2006). BMI has decreased as the ratio of a player's weight and height of its products, as well as quantities of other fat free substances (FFM) in the body in average (1 kg). The changes at $p<.05$ occurred only with the electrical resistance body variable (impedance) in the opposite direction, which ibdicates an increase in electrical resistance in the body. This explains the decrease in the composition of body fluids (dehydration on average amounted to 800 g) automatically increasing the resistance, which is the cause of the reduction rate of flow of electricity through the body of players. For variables such as percentage of body fat (% FAT) and fat in body weight in kilograms (FATMASS) during training, declining values appeared, but they are not statistically significant. The percentage of fat among examinees ranging in average of 9.2% in the initial and 8.9% in the final measurement, which corresponds to the model values of elite football player (7-12%) (Shephard, 1999; Wilmore & Costill, 2004). The percentage of fat in the body structure of the composition is also an important indicator of the correlation between intensity of training sessions and nutrition of top players.

Table 4. *Correlations of pairs of variables*

Variable		N	Cor.	Sig.
Pair 2	AMASI & AMASF	28	,998	,000
Pair 3	BMII & BMIF	28	,995	,000
Pair 4	BMRI & BMRF	28	,999	,000
Pair 5	IMPENDANCEI & IMPENDANCEF	28	,909	,000
Pair 6	FAT%I & FAT%F	28	,902	,000
Pair 7	FATMASI & FATMASF	28	,922	,000
Pair 8	FFM & FFMF	28	,993	,000
Pair 9	TBW & TBWF	28	,993	,000

Table 5. *T-test variables of body composition*

Variable		Paired Differences					t	df	Sig.
		Mean	Std. Dev.	Std. Er. Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 2	AMASI- AMASF	1,32857	,40447	,07644	1,17173	1,48541	17,381	27	,000
Pair 3	BMII - BMIF	,42857	,15836	,02993	,36716	,48998	14,320	27	,000
Pair 4	BMRI - BMRF	75,07143	24,03073	4,54138	65,75328	84,38957	16,531	27	,000
Pair 5	IMPEN.I – IMPEN.F	-7,89286	16,98003	3,20892	-14,47703	-1,30869	-2,460	27	,021
Pair 6	FAT%I – FAT%F	,29643	,97163	,18362	-,08033	,67319	1,614	27	,118
Pair 7	FATMASI- FATMASF	,33571	,80195	,15155	,02475	,64668	2,215	27	,035
Pair 8	FFMI - FFMF	,97857	,75048	,14183	,68756	1,26958	6,900	27	,000
Pair 9	TBWI- TBWF	,75714	,56727	,10720	,53718	,97711	7,063	27	,000

Conclusion

Partial quantitative changes in body composition of senior players, formed under the influence of a training session in the preparatory period, were analyzed on a sample of 28 elite footballers (Premier League of Bosnia and Herzegovina). The sample consisted of 9 variables measured by bioelectrical impedance (Bioelectrical Impedance Analysis) - BIA. For this purpose the Tanita TBF-300 electric scales were used (Tanita Corporation of America Inc.). The results were obtained by measuring the same variable before and after training, respectively, during two time periods. All obtained values were analyzed separately according to the basic descriptive data (central and dispersion parameters), and it can be concluded that the distribution of results is within the normal distribution. This research is designed to determine the levels of partial quantitative changes in body composition under the influence of a preparatory period of the training unit. On the basis of established T-test for paired samples, it was found that between two time points there was a significant difference (change) in most variables. The results obtained at the beginning and at the end of training indicate that the program activities for a period of ninety minutes significantly contributes to changes in body composition and on the level of statistical significance of $p < .01$. It can be concluded that such a structured training sessions of the preliminary period based on the model of situational play and exercise has a positive influence on the transformation of the majority of variables that define the composition of the body of players. Players have lost weight of 1.3 kg in average, as dehydration (800 g) increased electrical resistance in the body (with 460 to 468). There was a reduction of energy resources and the percentage of fat in the body (0.3%). By reducing fluid in body composition an increase of resistance appeared by automatism, which causes reduction of the flow rates of electricity through the body of players. For percentage body fat (% FAT) and fat in body weight in kilograms (FATMASS) variables, no statistically significant change occurred due to training.

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