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Original research article

BODY COMPOSITION IN A HIGH SCHOOL POPULATION OF ATHLETES AND NON-ATHLETES *

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Abstract. *Body movement produced by muscles requires energy. Thus, there is an interaction between physical activity, body weight, body composition, and energy expenditure. The aims of the current research were to determine the body mass index (BMI), body fat and skeletal muscle mass levels and differences in the high school population of athletes and non-athletes of both genders. Two hundred and forty high school students (120 athletes, 120 non-athletes) aged 16,65±1,14 years (Mean±Std.Dev), with body height 170,62±8,60 cm (Mean±Std.Dev) and body weight 61,11± 10,95 kg (Mean±Std.Dev), a total of 69 males, 171 females, participated in the cross-sectional research. First, Body Height and Body Weight were determined. Then, the bioelectrical impedance analysis (BIA) was used to determine body composition: Body Mass Index - BMI, Body Fat - BF (in %), Skeletal Muscle - MUSCLE (in %) and Resting Metabolism - RM (in kcal). The statistical procedure included descriptive statistics and the t test for independent samples in analyzing the significance of the differences between the sub-sample of athletes and non-athletes, as well as between males and females. The results pointed out that athletes, compared to non-athletes, i.e., males compared to females, do have better body composition (statistically significant differences were determined). Although the majority of the results are within the recommended range, the negative ones, obtained dominantly by the non-athletes and females are most likely a consequence of the continuous lack of adequate physical activity, and an imbalance between energy output and dietary calorie intake, as well as sexual dimorphism.*

Key words: *Body composition, high school students, athletes, non-athletes, gender, differences.*

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INTRODUCTION

Body movement produced by muscles requires energy. Thus, there is an interaction between physical activity, body weight, body composition, and energy expenditure. To move, one uses muscles and energy as stored in body fat. Excess weight in heavier participants usually implicates excess body fat, limiting weight-bearing activities like running. In addition to body weight and body composition, physical activity is a function of predisposition, age, and environment (Westerterp, 2013). Individuals engaged in intense physical activity have a tendency to be slimmer than those who are inactive or lead a sedentary lifestyle (Ching et al., 1996). Changes in body composition are most visible in a healthy sedentary lifestyle-pursuing population and are related to the changing habits in exercise patterns (Pollock et al., 1997). Obesity and body fat distribution largely depend on gender (Freedman et al., 1990), i.e., women have a higher percentage of body fat when compared to men, regardless of age (Borrud et al., 2010, Durnin & Womersley, 1974). The mean value of the percentage of body fat increases from the adolescent period until middle age and shows a decrease in older age (Chumlea et al., 2002). Skeletal muscles represent the largest component of body composition in humans, and play an important role in physiological processes as well as in energy metabolism. The total mass of the skeletal muscles is influenced by factors such as age, gender, race, physical activity, and disease (Forbes, 1987). Engagement in physical activity has a positive effect on human muscle tissue (Solberg et al., 2013). Sports of higher intensity have a greater positive impact on muscle mass in relation to those of lower intensity (Andersen & Aagaard, 2013; Andreoli et al., 2001). In comparison of the muscle mass of untrained men and women, higher values are determined in men. However, the decrease in muscle mass is noted in both genders in relation to the age (Neder et al., 1999). The progression of sarcopienia in the elderly population, particularly in men, may be clinically silent and masked by weight stability resulting from a corresponding increase in total body fat mass (Gallagher et al., 2000).

The aims of the current research were to determine the body mass index (BMI), body fat and skeletal muscle mass levels and differences in high school population of athletes and non-athletes of both genders.

THE METHODS

Two hundred and forty participants (120 athletes, 120 non-athletes) aged 16,65±1,14 years (Mean±Std.Dev), with body height 170,62±8,60 cm (Mean±Std.Dev) and body weight 61,11±10,95 kg (Mean±Std.Dev) participated in a cross-sectional study. The participants were recruited from the high school student population and compared in relation to their sport engagement and gender. Among the athletes, there were 60 males and 60 females, while among the non-athletes there were 9 males and 111 females (in total 69 males, 171 females). The athletes participated in the following sports: volleyball (N=20); martial arts (N=15); soccer (N=13); dance (N=13); basketball (N=12); body building (N=11); handball (N=9); water sports (N=9); aerobic/fitness (N=8); tennis (N=6); athletics (N=2); gymnastics (N=2).

Anthropometric characteristics, i.e., body weight (BODY WEIGHT in kg) and height (BODY HEIGHT in cm) were measured to the nearest 0,1 kg (OMRON BF 511, Kyoto, Japan) and 0,5 cm (Martin's anthropometer), respectively. Following the variables of body composition were measured using the bioelectrical impedance methodology, i.e., OMRON BF 511 device: Body Mass Index - BMI, Body Fat - BF (in %), Skeletal Muscle - MUSCLE (in %) and Resting Metabolism - RM (in kcal). The Bioelectrical impedance analysis (BIA) is a rapid, non-invasive and relatively inexpensive method for the evaluation of body composition in the field and in clinical settings. Electric current passes through the body without resistance of the muscles while there is resistance (bioelectrical impedance) when the current passes through fatty tissue. When it is set for a selected individual (height and weight), the device, based on the installed software, calculates the percentage of fat and skeletal muscle in the structure of body composition (Ostojić, 2005). The research literature supports the use of the BIA devices in the determination of the body composition (Alfonso-Rosa, del Pozo-Cruz, Del Pozo-Cruz, Del Pozo-Cruz, & Sañudo, 2013; Kruisdijk, Hendriksen, Tak, Beekman, & Hopman-Rock, 2012; Wong, Wong, Pang, Azizah, & Dass, 2003). However, according to Dehghan & Merhant (2008), the bioelectrical impedance analysis is a useful tool for clinical studies, but for large epidemiological studies with a diverse population, particularly in developing nations, BIA has limited use unless valuation studies are conducted specifically for the populations under study. If the BIA equation is not appropriately chosen based on age, gender, level of physical activity, level of body fat and ethnicity, the results of the study will not be reliable.

All of the participants avoided excessive exercise prior the measurement which was performed on an empty stomach, i.e. three hours after breakfast.

In relation to BMI, Body Fat and Skeletal Muscle levels, the values proposed by the World Health Organization, Gallagher et al. (2000) and OMRON Health Care (Omron Instruction Manual, n.d.) respectively, are used as referent ones. However, there is no classification given for the skeletal muscle percentage in the participants younger than 18. Therefore, we used a classification for the population aged between 18 and 39.

The statistical procedure included descriptive statistics and the t test for independent samples in analyzing the significance of difference between sub-samples of athletes and non-athletes, as well as between males and females. The significance level was set at $p<0.05$. All the data were screened for normal distribution using SPSS version 11.0 (SPSS, Chicago, IL).

RESULTS

Table 1. Descriptive statistics of the whole sample (N=240).

Variables	N	Minimum	Maximum	Mean	Std. Deviation
BMI	240	14,20	33,20	20,98	2,92
BF (in %)	240	5,20	45,30	23,04	8,88
MUSCLE (in %)	240	15,80	47,40	34,34	6,15
RM (in kcal)	240	1165,00	2173,00	1451,44	206,67

The results presented in table 2 point out on higher incidence of overweight and obese participants among non-athletes (10%, N=12) compared to athletes (5,83%, N=7), i.e., a higher incidence of underweight and normal participants among athletes (94,17%, N=113) compared to non-athletes (90%, N=108). In relation to gender, a higher incidence of overweight and obese participants is noted among the females (8,8%, N=14) compared to males (7,25%, N=5), i.e., a higher incidence of underweight and normal participants among males (92,76%, N=64) compared to females (91,81%, N=157).

Table 2. BMI classification of participants in relation to their sport engagement and gender.

	BMI classification				Total
	Underweight	Normal	Overweight	Obese	
Non-athlete	25 (20,83%)	83 (69,17%)	10 (8,33%)	2 (1,67%)	120
Athlete	15 (12,50%)	98 (81,67%)	7 (5,83%)	0 (0,00%)	120
Total	40 (16,67%)	181 (75,42%)	17 (7,08%)	2 (0,83%)	240
Males	4 (5,80%)	60 (86,96%)	4 (5,80%)	1 (1,45%)	69
Females	36 (21,05%)	121 (70,76%)	13 (7,60%)	1 (0,58%)	171
Total	40 (16,67%)	181 (75,42%)	17 (7,08%)	2 (0,83%)	240

Table 3. Body Fat classification of the participants in relation to their sport engagement and gender.

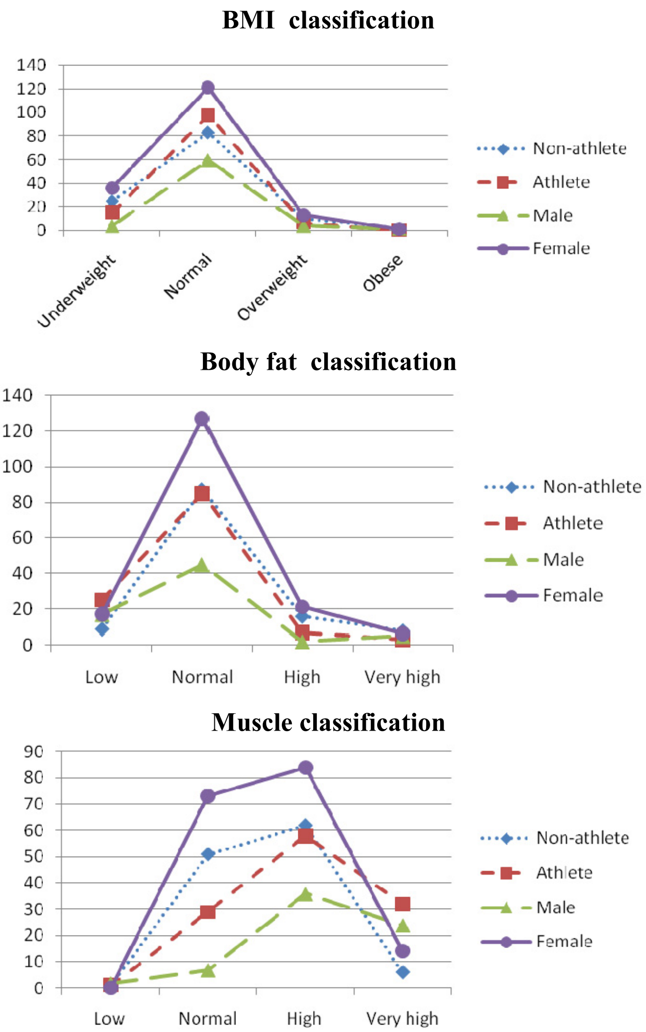
	Body Fat classification				Total
	Low	Normal	High	Very high	
Non-athlete	9 (7,50%)	87 (72,50%)	16 (13,33%)	8 (6,67%)	120
Athlete	25 (20,83%)	85 (70,83%)	7 (5,83%)	3 (2,50%)	120
Total	34 (14,17%)	172 (71,67%)	23 (9,58%)	11 (4,58%)	240
Males	17 (24,64%)	45 (65,22%)	2 (2,90%)	5 (7,25%)	69
Females	17 (9,94%)	127 (74,27%)	21 (12,28%)	6 (3,51%)	171
Total	34 (14,17%)	172 (71,67%)	23 (9,58%)	11 (4,58%)	240

The results presented in table 3 point out a higher incidence of participants with high and very high body fat level among non-athletes (20%, N=24) compared to athletes (8,33%, N=10), i.e., a higher incidence of participants with low and normal body fat level among athletes (91,66%, N=110) compared to non-athletes (78%, N=96). In relation to gender, a higher incidence of participants with a high and very high body fat level is noted among females (15,79%, N=27) compared to males (10,15%, N=7), i.e., a higher incidence of participants with a low and normal body fat level among males (89,86%, N=62) compared to females (85,84%, N=144).

Table 4. Skeletal Muscle classification of the participants in relation to their sport engagement and gender.

	Skeletal Muscle classification				Total
	Low	Normal	High	Very high	
Non-athlete	1 (0,83%)	51 (42,50%)	62 (51,67%)	6 (5,00%)	120
Athlete	1 (0,83%)	29 (24,17%)	58 (48,33%)	32 (26,67%)	120
Total	2 (0,83%)	80 (33,33%)	120 (50,00%)	38 (15,83%)	240
Males	2 (2,90%)	7 (10,14%)	36 (52,17%)	24 (34,78%)	69
Females	0 (0,00%)	73 (42,69%)	84 (49,12%)	14 (8,19%)	171
Total	2 (0,83%)	80 (33,33%)	120 (50,00%)	38 (15,83%)	240

The results presented in table 4 point out a higher incidence of participants with a high and very high skeletal muscle level among athletes (75%, N=90) compared to non-athletes (56,67%, N=68), i.e., a higher incidence of participants with a low and normal skeletal muscle level among non-athletes (43,33%, N=52) compared to athletes (25%, N=30). In relation to gender, a higher incidence of participants with a high and very high skeletal muscle level is noted among males (86,95%, N=70) compared to females (57,31%, N=98), i.e., a higher incidence of participants with low and normal skeletal muscle level among females (42,69%, N=73) compared to males (13,04%, N=9).



Graph 1. BMI, Body Fat and Skeletal Muscle classification of the participants in relation to their sport engagement and gender.

The normality of distribution of the adjusted measurements was tested by the application of the Kolmogorov Smirnov test.

Table 5 Results of the Kolmogorov Smirnov test.

	BODY HEIGHT (in cm)	BODY WEIGHT (in kg)	BMI	BF (in %)	MUSCLE (in %)	RM (in kcal)
Sig. (non-athletes)	,258	,039	,125	,748	,142	,009
Sig. (athletes)	,362	,058	,241	,351	,008	,064

Based on the significance of the Kolmogorov Smirnov test (table 5), normal distribution was determined in most of the analyzed variables (with the exception of BODY WEIGHT and RM in non-athletes and MUSCLE in athletes), which justified the application of the parametric tests in further statistical analyses.

The differences between athletes and non-athletes as well as between genders in each sub-sample were tested by the t-test for independent samples (tables 6 and 7, respectively).

Table 6 Differences between athletes and non-athletes tested by the t-test.

Variables	Sub-sample	N	Mean	Std. Deviation	t value	sig.
BODY HEIGHT (in cm)	Non-athletes	120	166,73	6,24	-7,86	,000
	Athletes	120	174,51	8,89		
BODY WEIGHT (in kg)	Non-athletes	120	58,38	11,39	-3,97	,000
	Athletes	120	63,83	9,80		
BMI	Non-athletes	120	20,93	3,34	-,27	,786
	Athletes	120	21,03	2,44		
BF (in %)	Non-athletes	120	26,73	7,25	7,070	,000
	Athletes	120	19,35	8,84		
MUSCLE (in %)	Non-athletes	120	31,42	3,74	-8,33	,000
	Athletes	120	37,26	6,69		
RM (in kcal)	Non-athletes	120	1368,06	162,96	-6,82	,000
	Athletes	120	1534,83	212,61		

Based on the results presented in table 6, significant differences in the mean values of the analyzed variables between the two studied sub-samples exist for the variables BODY HEIGHT (sig=,000); BODY WEIGHT (sig=,000); MUSCLE (sig=,000) and RM (sig=,000) in favor of athletes, and for variable BF (sig=,000) in favor of non-athletes (in a negative sense).

Table 7 Differences between genders tested by the t test.

Variables	Gender	N	Mean	Std. Dev.	T value	Sig.	N	Mean	Std. Dev.	T value	Sig.
BODY HEIGHT (in cm)	m	9	176,78	5,81	5,64	,000	60	180,63	6,97	10,40	,000
	f	111	165,91	5,54			60	168,39	5,88		
BODY WEIGHT (in kg)	m	9	73,60	17,91	4,49	,000	60	69,02	8,85	6,83	,000
	f	111	57,15	9,83			60	58,63	7,78		
BMI	m	9	23,44	5,04	2,40	,018	60	21,31	2,29	1,25	,215
	f	111	20,72	3,12			60	20,75	2,58		
BF (in %)	m	9	19,40	9,02	-3,28	,001	60	12,72	5,64	-12,41	,000
	f	111	27,32	6,80			60	25,98	6,05		
MUSCLE (in %)	m	9	39,74	4,28	8,97	,000	60	42,64	4,54	14,90	,000
	f	111	30,75	2,77			60	31,87	3,28		
RM (in kcal)	m	9	1751,56	247,69	9,88	,000	60	1716,40	113,26	18,11	,000
	f	111	1336,96	106,10			60	1353,27	106,25		
			Sub-sample of non-athletes					Sub-sample of athletes			

In the sub-sample of non-athletes, the determined gender differences were all statistically significant and in favor of the males (BODY HEIGHT, sig=,000; BODY WEIGHT, sig=,000; BMI, sig=,018; MUSCLE, sig=,000; RM, sig=,000), except for variable BF (sig=,001), where the statistical significance is in favor of the females.

Table 8 Differences between genders (whole sample) tested by the t test.

Variables	Gender	N	Mean	Std. Deviation	T value	Sig.
BODY HEIGHT (in cm)	m	69	180,13	6,91	15,30	,000
	f	171	166,78	5,77		
BODY WEIGHT (in kg)	m	69	69,62	10,40	8,79	,000
	f	171	57,67	9,16		
BMI	m	69	21,58	2,84	2,06	,040
	f	171	20,73	2,93		
BF (in %)	m	69	13,59	6,51	-14,21	,000
	f	171	26,85	6,56		
MUSCLE (in %)	m	69	42,26	4,58	22,14	,000
	f	171	31,14	3,00		
RM (in kcal)	m	69	1720,99	135,98	22,98	,000
	f	171	1342,68	106,13		

In the sub-sample of athletes, the determined gender differences were all statistically significant and in favor of the males (BODY HEIGHT, sig=,000; BODY WEIGHT, sig=,000; BF, sig=,000; MUSCLE, sig=,000; RM, sig=,000), except for variable BMI (sig=,215), where no statistical difference was determined.

Differences between the genders on the whole sample were tested by the t test for independent samples.

Regarding the whole sample, the determined gender differences were all statistically significant and in favour of the males (BODY HEIGHT, sig=,000; BODY WEIGHT, sig=,000; BMI, sig=,040; MUSCLE, sig=,000; RM, sig=,000), except for variable BF (sig=,001), where the statistical significance is in favour of the females.

DISCUSSION

Quantifying body composition is an important assessment parameter for monitoring performance, training and dieting regimes. In recent years, the use of the body mass index (BMI; kg/m^2) and in particular the assessment of body fat to determine optimal body weight for athletes has increased (Torstveit & Sundgot-Borgen, 2012). However, at present there are, from a health perspective, no generally accepted optimum values for body weight or percentage of fat mass in different sports and there is no 'gold standard' method for body composition assessment in athletes (Sundgot-Borgen et al., 2013, Ackland et al., 2012). In addition, the use of the BMI by itself as the tool in body composition assessment, especially in the population of athletes, has been proven as a less accurate index of body fat (Müller, 2009; Nevill, Stewart, Olds, & Holder, 2006; Prentice & Jebb, 2001), because, even though a sedentary person and an athlete (active person) may have the same height and weight, their fat to fat free mass ratios may be very different. When applied to the BMI formula, the active person's additional fat free mass skews the assessment of body composition, resulting in a BMI evaluation that is inaccurate as a predictor of increased risk for chronic diseases (Turocy et al., 2011).

According to Kruschitz et al. (2013) the use of percentage of total body fat and subcutaneous fat patterns may be more effective than BMI in assessing fatness and obesity in physically active individuals and young adults.

Regardless of gender or type of sport involvement, studies have repeatedly shown the extensive cardiovascular, physiological, and psychological benefits associated with exercise at various levels of participation (Kuo, 2012). Improvements in physical fitness derived from sport participation have been associated with decreased mortality, improved psychological outlook and more positive mood states (Goodwin 2003).

Based on BMI values, the actual results show that, as mentioned in the previous chapter, more non-athletes than athletes are classified as overweight and obese (10% vs. 5,83%, respectively), and more athletes than non-athletes are classified as underweight and normal weight (94,17% vs. 90%, respectively), which is in accordance with the findings of Torstveit & Sundgot-Borgen (2012) who compared athletes (N=300) to non-athletes (N=300) of female gender, aged between 13 and 39.

Based on body fat and skeletal muscle values, the actual results are partially comparable to those of Purenović-Ivanović, Popović, Đorđević, & Živković (2013), who investigated body composition in a group of 36 physical education students (males, N=24, females, N=12). The determined incidence of normal and very high values of body fat in female students was 83.33%, and 16.67%, respectively. The determined incidence of normal, high and very high values of body fat in male students was 62.5%, 29.17% and 8.33%, respectively. When it comes to relative skeletal muscle mass, the situation is different: in female students, the majority was determined to have normal values (58.33%), 33.3% was determined to have high values and 8.33% had very high values. In male students, the majority was determined to have normal values (45.83%), 29.17% had high values and as many as 25% had very high values. The authors explained the obtained negative results by the students' sport orientation, level of physical fitness and (mal)nutrition. According to Durnin (1981), adolescence is a difficult period to assess with any great precision as far as the individual basal metabolism rate (BMR) is concerned. There is so much variation in growth rates and in body weights, representing very different states of metabolic stimulus for the individual, that even though the general picture for each gender seems reasonably consistent, there are considerable anomalies. The predicted daily BMR for individuals or groups of individuals of both genders aged 15-18 are ranged between 1570-1655 kcal for males and between 1445-1490 kcal for females. In that sense mean values in the current research for males are slightly above (1751.56 kcal) and for females slightly below (1336.96 kcal) the values presented by Durnin. From the published data, there seems to be a well-established difference in values for males and females (females having a lower rate), which appears after the first few years of life, reaches a maximum of about 10% at around puberty, and then gradually falls to 5% or so from early adult life onwards. The difference may be due to the larger adipose tissue mass in women. However, in the days immediately prior to menstruation, in the female cycle there may be a 2–5% increase in metabolic rate, so that for at least part of the normal menstrual cycle, there will be insignificant differences between men and women Durnin (1981).

The results of the current research are in agreement with those of Lee, Lee, Kim, & Kim (2012) who investigated the differences in body composition, between taekwondo athletes (N=56) and non-athletes (N=70, University students) of both genders. Namely, they found no significant difference in BMI between the athletes and the non-athletes. According to gender, men and women showed statistically significant differences, i.e., there was a significant BMI increase in men compared to women. The fat body mass showed more significant decreases in the taekwondo athletic group than in the non-athletic group. The values of the men group showed significantly greater decreases than those of the women group in both the non-athlete and athlete groups. Finally, the lean body mass showed more significant increases in the athletic group than in the non-athletic group. In terms of gender, the values of the men in both the non-athlete and taekwondo groups showed significantly greater increases than those of the women of both groups.

The current research findings are limited due to the fact that the sample of participants does not represent a random sample of high school students, but rather a sample of healthy adolescents. Namely, we excluded participants with health problems, because actual cross sectional research was performed as a part of longitudinal research dealing with the appliance of plyometrics in adolescence. In that sense, the current findings cannot be considered as representative of the high school population in general, i.e. we are expecting much worse results, related to the incidence of high school students with body composition disruption.

CONCLUSION

Although the majority of the results are within the range of recommended values, the negative ones, obtained predominantly by the non-athletes and females are the most likely consequence of the continuous lack of adequate physical activity, and an imbalance between energy output and dietary calorie intake, as well as sexual dimorphism. The inclusion of appropriate strength training can elevate muscle mass, as well as the basal metabolic rate, and enhance calorie burning in the participants even during rest time.

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TELESNI SASTAV SREDNJOŠKOLACA SPORTISTA I NESPORTISTA

Za kretanje tela pod dejstvom mišića neophodna je energija. Dakle, postoji interakcija između fizičke aktivnosti, telesne težine, sastava tela i potrošnje energije. Ciljevi aktuelnog istraživanja bili su da se utvrde indeks telesne mase (BMI), nivoi telesnih masti i skeletnih mišića, i razlike u srednjoškolskoj populaciji sportista i nesportista oba pola. Dvestačetrdeset srednjoškolaca (120 sportista, 120 nesportista) starosti 16,65±1,14 godina (Mean±Std.Dev), telesne visine 170,62±8,60 cm

(Mean±Std.Dev) i telesne težine 61,11±10,95 kg (Mean±Std.Dev), ukupno 69 muškaraca, 171 devojaka, učestvovalo je u aktuelnom transferzalnom istraživanju. Najpre, utvrđene su telesna visina i telesna težina. Nakon toga, primenjena je analiza bioelektrične impedance (BIA) za utvrđivanje telesnog sastava: indeksa telesne mase-BMI, telesnih masti-BF (u %), skeletnih mišića-MUSCLE (u %) i metabolizma u mirovanju-RM (u kcal). Statistička procedura obuhvatila je deskriptivnu statistiku i t test za nezavisne uzorke u analizi značajnosti razlika između subuzorka sportista i subuzorka nesportista, kao i između muškaraca i devojaka. Rezultati su ukazali da je kod sportista u odnosu na nesportiste, kao i muškaraca u odnosu na devojke utvrđen bolji telesni sastav (utvrđene su statistički značajne razlike). Premda je većina rezultata u okviru preporučenih vrednosti, negativni, utvrđeni dominantno kod nesportista i devojaka, najverovatnije su posledica nedostatka fizičke aktivnosti i neuravnoteženosti između potrošnje energije i dnevnog unosa kalorija, kao i polnog dimorfizma.

Ključne reči: *sastav tela, srednjoškolci, sportisti, nesportisti, pol, razlike.*