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Descriptive Model and Gender Dimorphism of Body Structure of Physically Active Students of Belgrade University: Pilot Study

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ABSTRACT The purpose of the present study was to analyze descriptive body structure model of physically active students. The sample included 137 male (23.1±2.6 yrs) and 113 female (22.0±2.3 years) students. Body composition was measured with InBody720 where 17 variables were used to define the morphological status. Students had the following characteristics: the body weight was – 82.88 vs. 61.02 kg, water content was 52.85 (63.44%) vs. 33.9 L (48.90%), the amount of proteins was 14.30 (17.22%) vs. 14.8 kg (14.94%), mineral mass was 4.8 (5.8%) vs. 3.2 kg (5.31%), fat weight was 11.3 (13.53%) vs. 14.8 kg (24.28%), and BMI value was 24.5±3.6 and 21.7±3.1 kg/m^2 for males and female, respectively. A clear gender dimorphism was manifested - from 41% to 184%. A large majority of respondents (87-90%) of both genders can be classified in normal ranges of body fat percentage, which can be attributed to a higher level of physical activity.

INTRODUCTION

Morphological characteristics and motor abilities are largely determined by individual characteristics of endogenous and exogenous factors. Inappropriate morphological status generally pointed to insufficiency of certain motor abilities (Malkogeorgos et al. 2010), but at the same time, it is a risk indicator for the occurrence of a various diseases (Ilic et al. 2010; Azizi et al. 2001; Klemenc-Ketis et al. 2011; Ilic et al. 2012).

Longitudinal monitoring of body composition changes can be applied during all ages to monitor growth/development and aging, but also optimization of desirable relationships of different body components (Wardle et al. 2006; Scanlan and Dscombe 2011; Ying-Xiu and Shu-Rong 2011; Uppal 2012; Saygin 2014). Defining standards of body composition is important for planning funds and methods of correction. Changes in eating habits and the level of physical activities (Malkogeorgos et al. 2010; Röthlingshöfer et al. 2011; Koley et al. 2012; Ilic et al. 2012) are most often applied to influence the achievement of favorable body composition.

In recent years bioelectrical impedance analysis (BIA) is a widely used standard method for determining whole body composition and segmental lean mass measurements, because it is fast and non-invasive, relatively inexpensive, and can be performed across a wide range of subjects with regard to age and body shape (Gibson et al. 2008; Völgyi et al. 2008; Sillanpää et al. 2014). Bioelectrical impedance measures body composition by applying a flow of low, safe amount of electric current (800 µamp) through a human body. The obtained results represent a measure of resistance of electric current as it travels through the water that is found in muscle and fat. The Biospace In-Body720 body composition analyzer has previously been shown to have high test-pretest reliability and accuracy (ICC 0.9995) (Gibson et al. 2008). When compared with dual-energy X-ray absorptiometry (DXA) as a golden standard, interclass correlation coefficient with BIA was between 0.96 and 0.99 in normal-weight population (Völgyi et al. 2008; Ling et al. 2011). Having these, this equipment is used extensively in clinics, sports medicine and other health-related fields.

Further, university students are a specific group in the final phase of biological maturing, and, at the same time, these young people are

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finishing their education and preparing themselves for professional obligations (Tarnus and Bourdon 2006; Srdic et al. 2009; Uppal 2012). It has been found that students are exposed to different stressful situations, such as parting from the family, pressure of studies, social issues and financial problems. All these may affect the result of their studies, but the influence on the quality of life and disease occurrence is of special importance (Ilic et al. 2010; Nola et al. 2010; Azizi et al. 2011; Klemenc-Ketis et al. 2011).

University of Belgrade (BU), as the largest University centre in Serbia, attends 84060 students according to the latest data (University of Belgrade 2011). Unfortunately, there is no elementary data about morphological characteristics of this student population, although, the country faced specific geo-spatial, political, and socio-economic changes in the last decade. Further, there are no obligations for practicing physical activities in the system of studies in BU, and, thus, they are left to individual initiative. Specific education of students aiming at acquiring good eating habits and promotion of healthy lifestyle, almost, does not exist.

In this regard, the aim of this study was to determine the initial descriptive model of body structure of the physically active students of the BU, with respect to gender dimorphism. That way, the current status of morphological characteristics of the researched population will be described and, thus, would enable defining basic information and forming a system for continuous monitoring of the researched phenomenon.

METHODOLOGY

Sample of Respondents

The sample of the respondents consisted of 250 students of BU, namely 137 males and 113 females. The average age of male and female students was: 23.1±2.6 and 22.0±2.3 years respectively. Students from 12 Faculties, which accounted for 38.71% of all Faculties of BU, were included in this study. With respect to the total number of students who enrolled 2010/2011 academic year (84060 students), the measured sample represented 0.30% of total student population of BU (http://www.bg.ac.rs/csrp/obrazovanje/pdf/Analiza_trendova_upisa_2010-11.pdf). This study was conducted with the approval of the Ethics Committee of the Faculty of Sport and Physical Education, University of Belgrade. Each subject was well informed about the method and purpose of the study, and all invited agreed to participate.

The average level of physical activity in female students was 3.3±1.4 times or 149.2±141.5 minutes per week, while in male students it was 5.4±2.7 times or 231.6±110.9 minutes per week. Precisely, 55%, 42%, and 3% of female students exercised 2-3 times, 4-5 times and 6 and more times per week. Among male students, 18%, 57%, and 25% exercised 2-3 times, 4-5 times and 6 and more times per week. The values of the minimum and maximum ranges of results of exercising in female students were 77.3 to 786.7 minutes, while in male students it was 121.7 to 759.6 minutes per week.

Measuring Method

Body composition measuring was done by bioelectrical impedance method (bioelectrical impedance analysis – BIA), using a professional instrument of the latest generation – In Body 720 Tetrapolar 8-Point Tactile Electrode System (Biospace, Co., Ltd), which uses DSM-BIA method (Direct Segmental Multi-frequency Bioelectrical Impedance Analysis). All measurements were performed in the period October 2011–April 2012, by applying standardized method (Röthlingshöfer et al. 2011), with respect to the following prerequisites of measuring procedure (ACSM 2005): measurements were realized in the morning hours (between 8:30 and 11:00 am.); the evening before measurement the subjects did not consume any food after 9 p.m., while on the day of measuring they neither had breakfast nor drank anything; 12 hours before measuring the respondents did not have any physical effort; 48 hours before measuring respondents did not consume alcohol; immediately before measuring all of them stood for at least 5 minutes.

Variables

Body composition data included seventeen (17) variables, namely twelve primary (12) and five (5) derived (index) variables.

Primary variables for defining body composition were:

1. BH – body height, expressed in cm,
2. BM – body mass, expressed in kg,
3. ICW, intracellular fluid – expressed in L,

4. ECW, extracellular fluid – expressed in L,
5. TBW, total body water – expressed in L,
6. Proteins – expressed in kg,
7. Osseous, bone mineral contents – expressed in kg,
8. BFM, body fat mass – expressed in kg,
9. VFA, visceral fat area – expressed in cm^2,
10. BCM, body cell mass – expressed in kg,
11. BMR, basal metabolic rate – expressed in kcal,
12. FIS, fitness score calculated according to InBody720 manufacturer software – expressed in points.

    Derived (index) variables for defining body composition were:
13. BMI – body mass index, expressed in kg/m^2,
14. BFM_proc, percent of body fat, calculated as BFM / BM ratio – expressed in %,
15. TBW_proc, percent of body water, calculated as TBW / BM ratio – expressed in %,
16. Index_Prot_Fat, protein fat relation index, calculated as Protein / BFM ratio – expressed in %,
17. Index_Oss_BM, bone mineral content body mass relation index, calculated as Osseous / BM ratio – expressed in %.

Further, the gender dimorphism index was calculated for all variables to define the relationship between individual variables among male students (male gender) and female students (female gender), by applying the following formula:

Gender dimorphism index = (value of the given morphological variable of female students / value of the given morphological variable of male students) • 100.

Thus, the percentage ratio of the value of individual morphological variables was obtained with respect to gender (Dopsaj et al. 2009).

Statistical Data Processing

Basic descriptive statistical parameters were calculated for all results in order to define basic measures of central tendency and dispersion of data (Mean, SD, cV%, Std. Error). Regularity of distribution of individual variables was tested by applying Kolmogorov-Smirnov non-parametric test (K-S Z). After that, using multivariate analysis of variance – MANOVA the difference between respondents in the function of gender was calculated by applying Wilks' lambda criterion. The difference between individual variables was determined by applying Bonferroni test. The level of difference of measurements between individual variables was determined on the probability level of 95%, that is, p value of 0.05 (Hair et al. 1998). Software SPSS Statistics 17.0 was used for all statistical analyses.

RESULTS

Table 1 displays MANOVA results used to determine the existence of statistically significant difference between sets of variables (original and index) in the function of gender on a general level, namely: Wilks' lambda original variables – 0.110, F = 158.46, p = 0.000; Wilks' lambda index variables – 0.225, F = 167.88, p = 0.000. The above results are statistical evidences that morphological structure of samples of male and female students of the BU has statistically significant differences on a general level.

Table 2 presents results of descriptive analysis of all studied variables, F and p values used to determine the level of difference with respect to individual variables, as well as the value of index of gender dimorphism between individual variables (F vs M index).

Figure 1 displays BMI values distribution of the studied sample defined with respect to World Health Organization standards (WHO 2000). Figure 2 displayed distribution of values of adipose tissue percentage (%BF) of the studied sample defined with respect to the accepted standards in sports science (ACSM'S Health-Related Physical Fitness Assessment Manual 2008). Figures

Table 1: MANOVA results – general differences between analyzed sets of variables (original and derived) with respect to gender of respondents

	Multivariate tests[b]					
	Effect	*Value*	*F*	*Hypothesis df*	*Error df*	*Sig.*
Gender–original variables	Wilks' lambda	0.110	158.46	12.00	236.0	0.000
Gender – index variables	Wilks' lambda	0.225	167.88	5.00	244.0	0.000

b. Design: Intercept + Gender

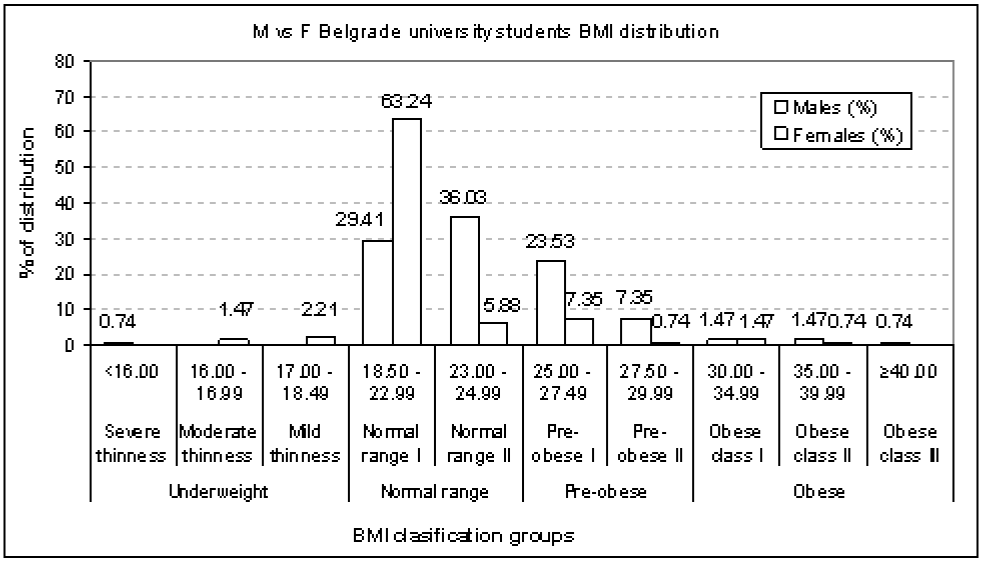

Fig. 1. Distribution of BMI of respondents in accordance with WHO standards

Table 2: Display of basic descriptive statistics with differences and ratio of variables in the function of gender of respondents (gender dimorphism) – of Belgrade University students

	Male students (N = 136)				*Female students (N = 113)*						*F vs M index (%)*
	Mean±	*SD*	*cV%*	*Std. Error*	*Mean±*	*SD*	*cV%*	*Std. error*	*F relation*	*P value*	
BH (cm)	183.58±	6.81	3.71	0.59	167.45±	6.82	4.08	0.64	345.3	0.000	91.16
BM (kg)	82.88±	14.49	17.48	1.08	61.02±	9.97	16.34	1.19	184.6	0.000	73.25
BMI (kg/m^2)	24.54±	3.60	14.68	0.29	21.71±	3.10	14.30	0.32	43.0	0.000	88.20
ICW (L)	33.09±	4.26	12.89	0.32	21.07±	3.01	14.27	0.35	634.9	0.000	63.51
ECW (L)	19.61±	2.75	14.02	0.20	12.78±	1.76	13.75	0.22	520.9	0.000	64.97
TBW (L)	52.85±	7.18	13.58	0.53	33.85±	4.75	14.03	0.58	581.6	0.000	64.05
Proteins (kg)	14.30±	1.85	12.92	0.14	9.12±	1.30	14.26	0.15	630.7	0.000	63.55
Osseous (kg)	4.00±	0.58	14.49	0.04	2.69±	0.38	14.25	0.05	425.4	0.000	66.95
BFM (kg)	11.06±	8.40	75.94	0.65	14.82±	6.30	42.55	0.71	15.4	0.000	131.40
VFA (cm^2)	58.56±	30.56	52.18	2.93	42.95±	24.35	56.69	2.63	19.3	0.000	73.34
BCM (kg)	47.41±	6.12	12.91	0.46	30.18±	4.31	14.26	0.51	634.9	0.000	63.66
BMR (Kcal)	1922.4±	204.9	10.66	15.3	1368.0±	140.3	10.25	16.8	594.9	0.000	71.16
FIS (point)	86.60±	8.01	9.25	0.62	75.97±	6.01	7.92	0.68	135.3	0.000	87.73
BFM_proc (%)	12.91±	6.04	46.77	0.54	23.80±	6.54	27.49	0.59	186.6	0.000	184.31
TBW_proc (%)	63.90±	4.52	7.07	0.40	55.83±	4.83	8.65	0.44	185.8	0.000	87.37
Index_Prot_Fat	1.6898±	0.957	56.64	0.06	0.6935±	0.254	36.67	0.07	115.6	0.000	41.04
Index_Oss_BM	0.0485±	0.037	7.71	0.00	0.0443±	0.037	8.31	0.00	78.5	0.000	91.38

3 and 4 display gender dimorphism of all variables (Fig. 3 – original and Fig. 4 index variables) of the studied morphological area. As noted in Figure 1, approximately 65-70% students are in the category of normal BMI. There are an equal percentage of respondents in the categories of underweight and obese. As noted on the Figure 2, over 70% of male students have a desirable representation of body fat (athletes + fitness), while about 60% of female students are in the same category.

Gender dimorphism is most expressed for the absolute fat content (kg) in a body (BFM = 131.4, which means that female students have 31.4%

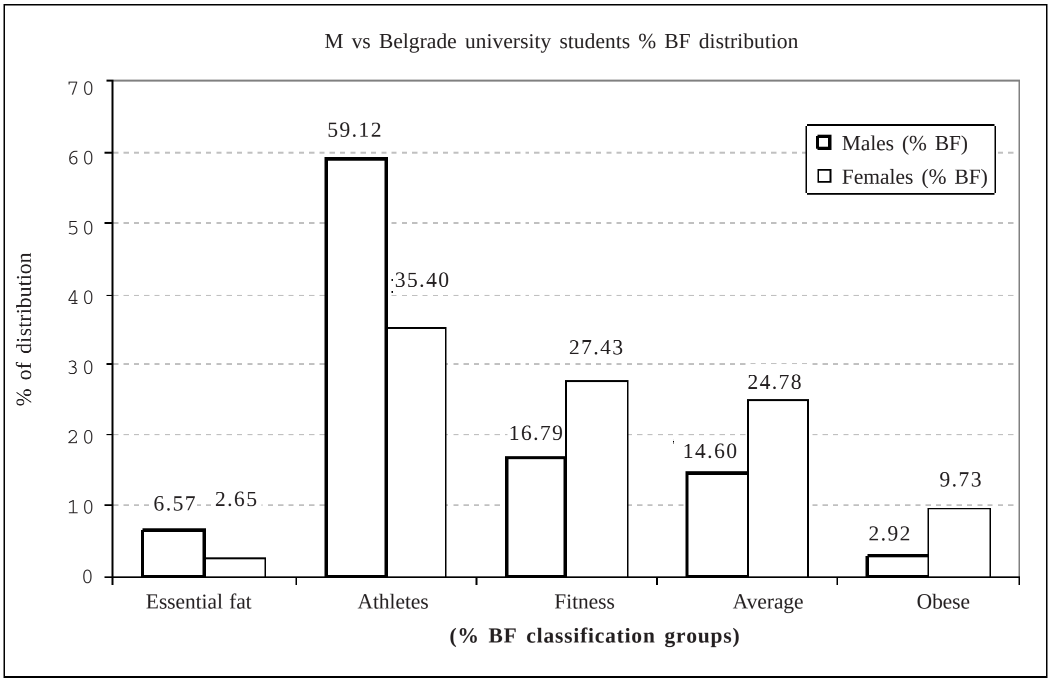

Fig. 2. Distributions of %BF respondents in accordance with ACSM'S standards

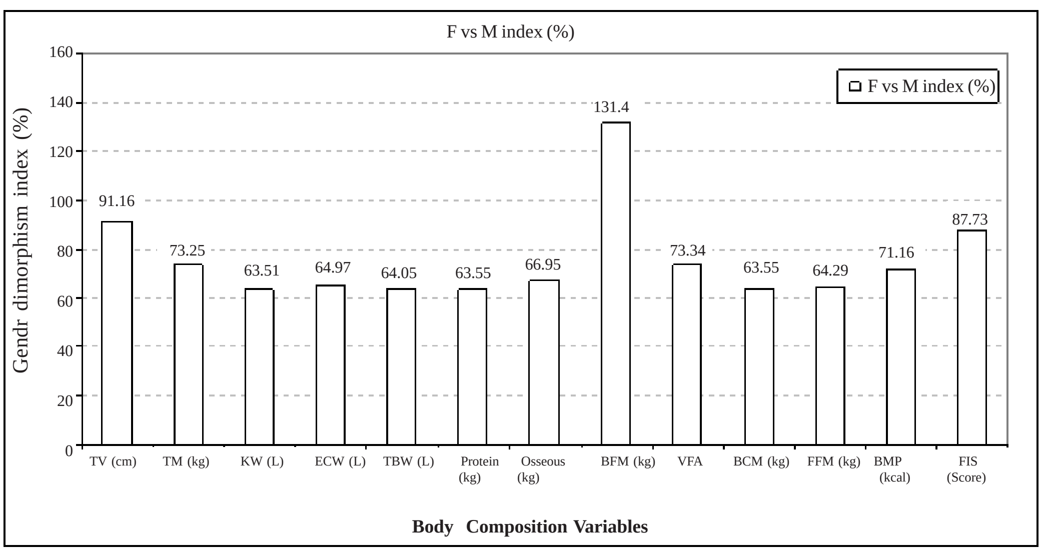

Fig. 3. Gender dimorphism of the studied original variables of morphological characteristics of students

more absolute fat content in body than males), but there are also other high values showing clear differences in body composition of men and women.

Gender dimorphism is most expressed for the percentage of fat content in body composition (BFM_proc % = 184.31, which meant that female students have 84.31% higher percentage of body

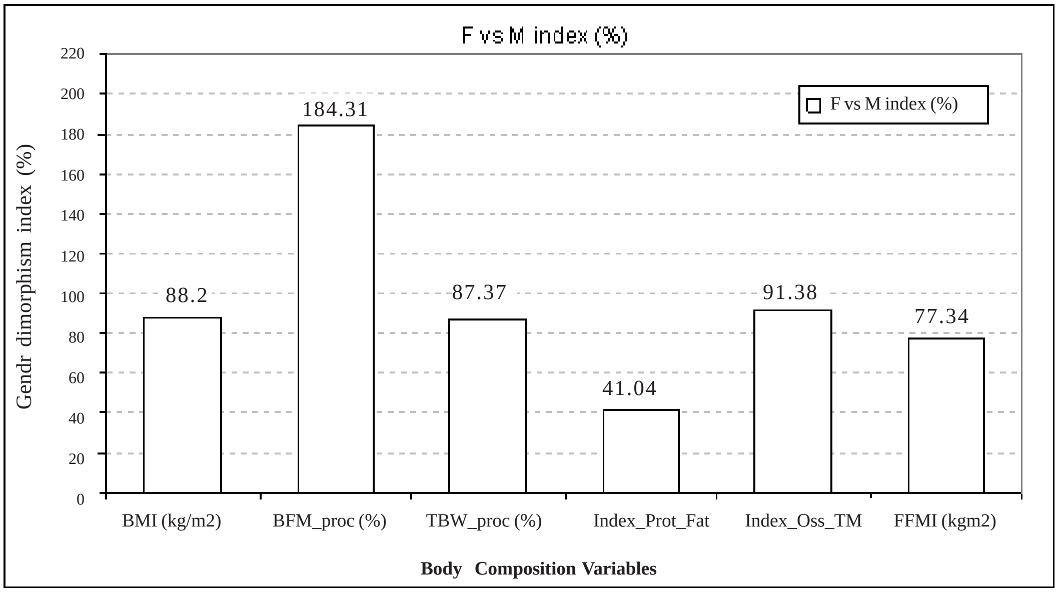

Fig. 4. Gender dimorphism of studied index variables of students' morphological characteristic

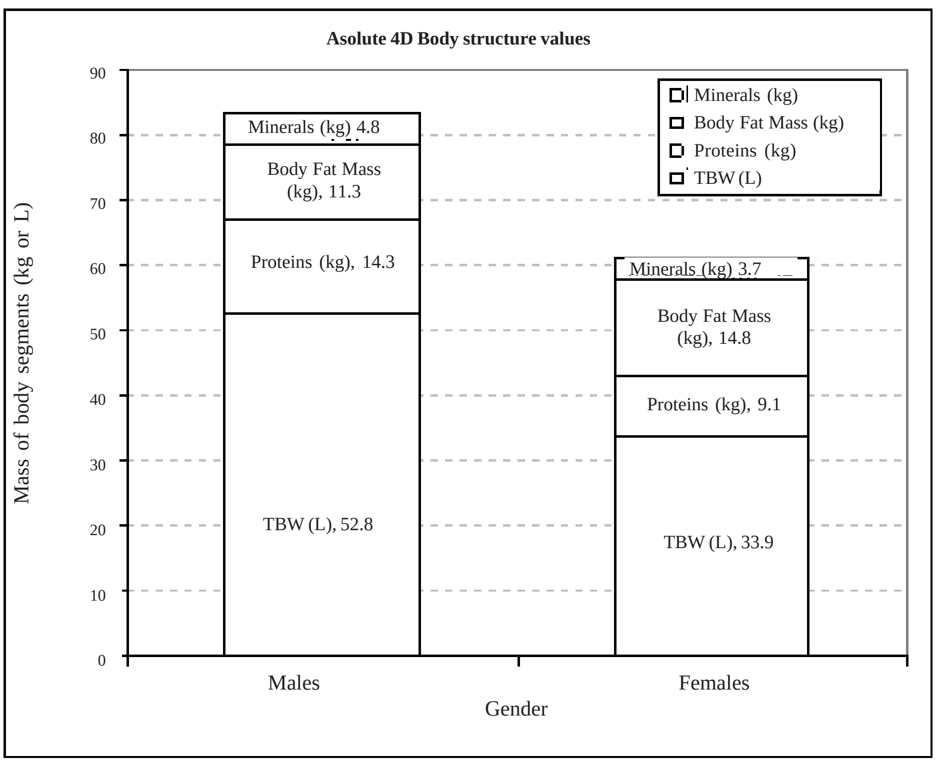

Fig. 5. Absolute 4D models of body structure of respondents (in kg or L)

fat content than males), but there are also other high values showing clear differences in body composition of men and women.

From the Figure 5 of 4D model of body structure of students of both genders, it can be noted that all absolute and relative values are higher in male students, which contributes to higher total BM in boys. The only exception is a higher body fat content in girls (Females 24.28% vs Males 13.35%).

DISCUSSION

The present cross-section study examined the morphological characteristics on the sample of physically active university students. Significant differences were found in male-female body composition for all observed variables.

Sexual dimorphism represented distinct recognition of only two sexes per species, evident at the chromosomal, gonadal, hormonal, somatic and behavioral levels in adults (Krchengast 2010). The data confirm previous studies showing a distinct dimorphism in male-female body composition (Wardle et al. 2006; Krchengast 2010). Multivariate analysis revealed a significant difference for all original and index body composition variables ($p<0.001$) between male and female students (Table 2). The gender dimorphism index for the original variables was ranged from 63.51% to 131.4%, whereas the range of index variables was significantly higher (between 41.04% and 184.31%) (Figs. 3 and 4).

As expected, male students were taller and heavier than female on average. The mean body height and weight of Serbian male and female students was higher than reported in most previous studies conducted on student population (Wardle et al. 2006; Sanilier et al. 2007; Badaruddoza et al. 2008). The reasons for these differences probably lies in the level of physical activity, since it has been shown that exercise training have one of the major influences on the linear growth and muscle mass development (Rogol et al. 2000; Tarnus and Bourdon 2006).

BMI is widely used to assess whether individuals are of normal weight, or overweight or obese person. This is an important parameter that

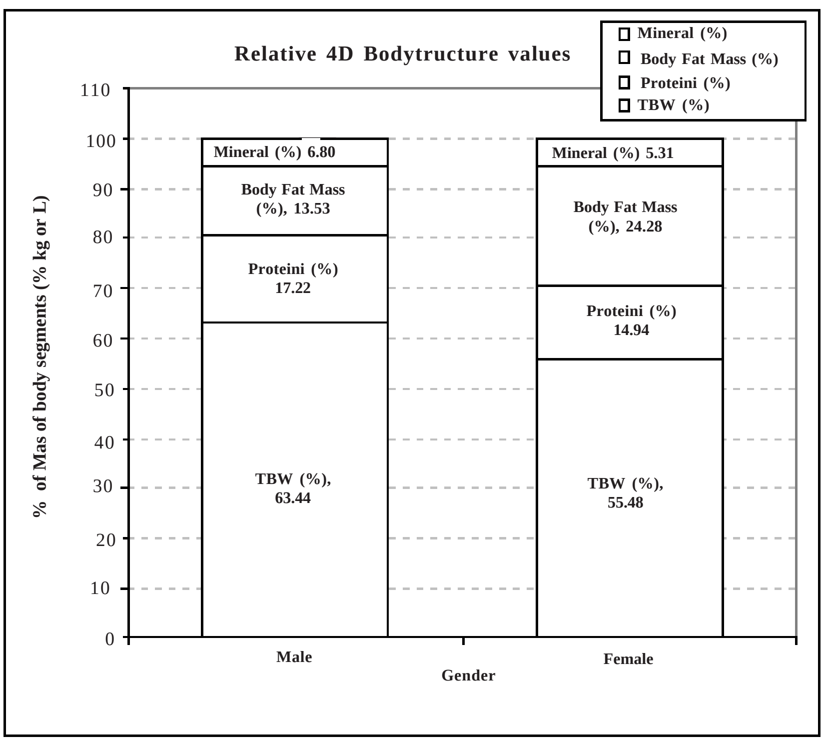

Fig. 6. Relative 4D models of body structure of respondents (in % of kg or L)

highly correlates with coronary disease, metabolic syndrome and diabetes (Mora 2006). According to the BMI value, majority of examined students in the study (65.44% male and 69.12% female) had normal weight (BMI in range of 18.50 and 24.99 kg·m^{-2}). With respect to the structure, 3.68% females were underweight, 69.12% were normal-weight, while 8.09% were overweight. In male students, there was even 69.12% of normal-weight, while 30.88% were overweight (Fig. 1). There were very little students in the category of obese, that is with BMI higher than 30 kg·m^{-2}, only 3.68% for male and 2.21% for female students. Further, the similar results were found for students in Croatia (Nola et al. 2010) and Turkey (Sanilier et al. 2007) where total of 66.3% and 64.2 % had normal values of BMI, respectively. Contrary, a few studies conducted on US college students reported that approximately 27% (Huang et al. 2003) to 35% (Lowry et al. 2005) were overweight or obese. These results are similar to those reported in students of Croatian (Nola 2006) and Canadian University (Perruse-Lachance et al. 2010) where 33.7% and 22.9% respectively respondents had BMI $\geq$ 25 kg·m^{-2}. The data revealed that significantly more men than women had a BMI greater than 25 kg·m^{-2} (32% vs. 9%). However, these results should be interpreted with caution because it is known that the BMI is not sufficiently reliable to assess nutritional status, since overweight among young physically active subjects may be the result of the enlarged muscle mass (Tarnus and Bourdon 2006). As well, BMI alone cannot provide information about the respective contributions of muscle and fat mass to body weight, particularly in the “desirable” BMI range (Kyle et al. 2003; Meeuwsen et al. 2010).

High body fat mass, especially central distribution of body fat mass (visceral fat area – VFA) appears to be associated with functional disability and mortality (Mora 2006). Higher representation of body fat in women should enable adequate synthesis of estrogen and normal reproduction in women. Since sex steroid hormones have a positive influence of quantity and distribution of adipose and muscle tissue (Shen et al. 2009; Meeuwsen et al. 2010), in the study men presented a higher FFM and BCM than the women, who had a higher level of fat mass. The researchers observed the highest gender dimorphism index for BF and BF% (131.40 and 184.31, respectively). Further, BF amount was the only component in the composition of a woman’s body that was greater in regard to males. Using DXA, Coin et al. (2008) recommended reference values for BF% in the age 20–29 years of 13–20% for men and 26.1–34.9% for women. The majority of the subjects had BF% in this range (90.51% male and 87.61% female). Since, over 4/5 of the measured student population had a satisfactory percentage of fat, it can be most probably attributed to higher level of physical activity. Positive effects of continuous exercise were reflected on low values of VFA, which were below the average limit zone of 100 cm^2 (Table 2 – VFA 58.56±30.56 and 42.95±24.35 for males and females, respectively).

One of the algorithmic values calculated by the Inbody 720 original software is fitness score which representing the total body structure with respect to the most ideal one, which value is 100. In male and female students, the recorded values were approximately 87 (86.60±8.01) and 76 (75.96±6.01), respectively (Table 2). In elite wrestlers of Greco-Roman style of the same age, the recorded fitness score was almost 97 but body composition of these athletes had, among the other things, about 8.5% of fat and 53% of muscles, which contributed to almost maximal fitness score (Kasum and Dopsaj 2012).

In the 4D figure of body structure model, which displays 4 basic components, gender dimorphism is clearly observed (Fig. 6). Male students had higher values of BCM, water content, proteins, and minerals, which conditions higher average value of body height, muscle mass representation, as well as total body mass with respect to a woman’s body. In addition to gender determined differences, it seem that larger volume of physical activity of male students compared to female students could influence lower content of body fat. Physical activity of the female respondents was in the line with recommendation of minimal activity of 150 minutes per week, for adult population (WHO 2000). As it may have been expected, male students were more physically active than female. Therefore, two-thirds of men had approximately 180 minutes of physical exercising per week, while a quarter of the studied male students have a high level of physical activity of about 760 minutes per week.

CONCLUSION

In the present study on student population, the researcher set and analyzed the initial descriptive model of body structure measured by the method of multi-channel segmental bioelectrical resistance comprising original and new, derived variables. A clear gender dimorphism was manifested in all variables, especially regarding higher body fat contents in a woman's body. The total of 65-70% of the male and female students had normal BMI, respectively. Large majority of respondents (87-90%) of both genders could be classified in normal ranges of body fat percentage, which can be probably attributed to a higher level of physical activity. With respect to recommendations for minimal physical activity, the respondents were in the category of physically active (149 to 231 min/a week). Differences in body composition of male and female students are clearly observable in the 4D model chart, where a clear gender dimorphism was manifested in range from 41% to 184%, for Index of Protein and Fat until to percent of Body Fat, respectively.

RECOMMENDATIONS

The study provided initial information useful for further study and research of the relationship between nutritional status, physical activity and health at University students. The results of the study showed that the total of 65-70% of students have normal BMI, as well as the 87-90% of both genders can be classified in normal ranges of body fat percentage, which is probably caused and can be attributed to a WHO recommended level of physical activity, because the respondents are in the category of physically active young parsons (149 to 231 min/week). Further, study should be performed on differently physically active students, as well as at more epidemiologically representative populations.

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