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AGE AND SEX DIFFERENCES AND ALLOMETRY IN ANTHROPOMETRIC VARIABLES IN YOUNG ADULTS FROM CENTRAL EUROPE (SLOVAKIA)

ABSTRACT: The subject of study was the anthropometry of an adult population in the period of early adulthood. In this study we evaluated twenty-four anthropometric parameters of Slovak population from three different districts (Bardejov, Zvolen and Považská Bystrica) in Slovakia. Our dataset consisted of 200 probands (108 men and 92 women) of young productive peoples with the age 18 to 35 years old with mean age 22.45 years for men and for women 22.46 years. We measured body mass (V1) and 24 anthropometric parameters (V2–V24). It also included calculation of the body mass index (BMI). The measurements in sexes overlapped, but both the univariate analysis (unpaired t-test) and multivariate analysis (two-way ANOVA) confirmed significant differences between them. The results of BMI values confirmed that both sexes belongs to "about right" weight category, i.e. the values in the range (18.50–24.99 kg/m^2). For males and females were confirmed positive allometry between body mass and body height. Our data confirmed men biased sexual dimorphism with significantly higher dimensions than women and these results are fully consistent with the previous findings from above cited authors. Different allometric patterns obtained for sexes suggests that different changes during growth exist and may be due by different role in reproduction.

KEY WORDS: Variability – Sexes – Two-way ANOVA – OLS regression – Caucasoid

INTRODUCTION

Anthropometry is known as the methodical approach that studies the human body dimensions which are acquire using special devices and techniques whose results are analyzed through statistics (Fredriks *et al.* 2000, Barroso *et al.* 2005, Bláha *et al.* 2007, Bogin, Varela-Silva 2010, Contreras *et al.* 2014). It is also generally regarded as the most readily available, inexpensive and non-invasive method that reflects

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individual's nutritional status (De Onis *et al.* 1996). The ageing process involves modifications in nutritional and physiological status, such as a decrease in body weight and height and (Dey *et al.* 1999, Bonnefoya *et al.* 2002) also a declining in fat-free mass associated with an increase in fat mass. Changes in body composition during aging, occurring differently in sexes, populations and ethnic groups, are affecting anthropometric parameters (Bogin *et al.* 2010). Therefore, the vast majority of anthropometric studies were devoted to the body mass index (BMI) and its importance in obesity, cardiovascular and osteoporosis diseases (Flegal *et al.* 2012). On the other hand, great attention was also paid to metric differences in individual proportions and parts of the body (Farkas *et al.* 1984, 2005, Contreras *et al.* 2014, Gába, Přidalová 2014, Capatan *et al.* 2014, Jervas 2015). In these studies, was also showed importance of anthropometric measurements in ergonomics and them usefulness to inform the design of tools, equipment, workstations and clothes in fashion or in army. Appropriate use of anthropometry in design may improve well-being, health, comfort, and safety.

Das and Roy (2010) noted that anthropometric characteristics provide a better understanding of the growth process by describing changes in the body size and morphology through ages. The authors assumed that these changes in anthropometric characteristics do not reach its peak at the same time and rate or at the same extent with other. These variations may be evident between anthropometric characteristics, between populations, or between sexes. Though, nutritional status are supposed to have a great role in making all types of changes but the variation in the anthropometric and body composition characteristics in the adulthood are primarily due to osteological changes, changes in the fat and muscle tissue. The proportionality of the body is the result of different growth of individual body segments. Allometric growth describes the relationship of an organism's components with change in overall body and is important because variation in a wide variety of morphological, physiological, and life-history traits is highly correlated with variation in organism size (Gustafsson, Lindenfors 2004, Nevill *et al.* 2009, Burton 2010). These relationships generate intuitive hypotheses for understanding trait variation (Voje 2016, Kilmer, Rodríguez 2017). Inter-population variations in proportions and in the shape of the human body are due to differences in lifestyle, genetic predispositions and the environment. Major causes from an eco-geographical point of view include Bergman and Allen's rule. Although climatic changes may affect the anthropometric parameters of the body in a certain measure, nutrition and physical activity are of greater importance. The shape of the body can be affected by the genetic basis and ethnicity (Das, Roy 2010, Bogin *et al.* 2010). Das and Roy (2010) in their study summarized that a large number of studies on age related changes on the elderly population were conducted on different ethnic groups in India. Similarly, several studies concentrated on age changes in anthropometric characteristics during adulthood from Czech Republic (Riegerová *et al.* 2010, Gába, Přidalová 2014, Stříbrná *et al.* 2017) and Slovakia (Sedmák *et al.* 2010, Kramárová *et al.* 2015, Stříbrná *et al.* 2017, Neščáková *et al.* 2017) were also published.

The main aims of our study were as follows: (i) to establish variation and the normal range of anthropometric measurements selected for the study in young adults for majority ethnic group i.e. Slovak population from Central Europe (Slovakia), (ii) to investigate the allometry of anthropometric traits in relation to body height for both sexes. This contribution follows articles published abroad to supplement the unpublished data from Slovak Republic.

MATERIAL AND METHODS

We evaluated twenty-four anthropometric parameters of young adults of majority ethnic group (non-Romany) from three different districts (Bardejov, Zvolen and Považská Bystrica) in Slovakia. Our dataset consisted of 200 probands (108 men and 92 women) of young productive peoples with the age 18 to 35 years old with mean age 22.45 years for men and 22.46 years for women, respectively. We measured body mass (V1) to 0.1 kg and 24 anthropometric parameters (V2–V24), i. e. 3 height dimensions, 7 length dimensions, 2 circumference dimensions and 7 width dimensions to 0.1 cm and 4 skin folds thickness in mm: body height (V2), sitting height (V3), face height (V4), length of upper limb (V5), length of forearm (V6), palm length (V7), length of lower limb (V8), foot length (V9), cranial length (V10), arm span (V11), head circumference (V12), chest circumference (V13), cranial breadth (V14), face width (V15), biacromial shoulder width (V16), bispinal pelvis width (V17), bitrochanteric width (V18), palm width (V19), foot width (V20), biceps skinfold thickness (V21), triceps skinfold thickness (V22), subscapulare skinfold thickness (V23) and supraspinale skinfold thickness (V24).

All parameters were measured according to recommendation of International Standards for Anthropometric Assessment (ISAK LEVEL 1, 1607TSP, 2001; Kopecký *et al.* 2013) and by using classical anthropological instruments (weighing scale, anthropometric tape, anthropometer, skinfold caliper, large slider caliper and wide-spreading caliper). We also calculated body mass index (BMI) as ratio of body height and body weight (kg/m^2), and categorization of the BMI index was determined by (Pastucha *et al.* 2014). The obtained dataset (untransformed data) was evaluated using the following statistical parameters: range value, i.e. mean (M), standard deviation (SD), standard error (SEM), 95% confidence interval (95% CI) and coefficient of variation (V) and by the percentage value of differences (Diff %) among means of the particular variable in men and women (men – women/women*100). The normal distribution was tested by the D'Agostino-Pearson omnibus K^2 test and the Shapiro-Wilk normality test. Before other analysis, measurements were $\log_{10}$-transformed to reduce intra-sample variation and to improve normality.

Morphometric variation was initially examined by means of univariate (unpaired t-test) and multivariate (Principal component analysis – PCA) analysis of variance. Moreover, multiple significance tests with using Bonferroni's correction were performed on correlations among variables so that the critical $p < 0.05$ can be adjusted to $p < 0.001$. The dataset for body measurements PCA excluded body mass, as it changed seasonally and daily. Hotelling's T^2 were used to detect and to validate the statistical significance of variability among quantitative variables for both sexes. We used also a two-way ANOVA with age and sex as factors to test also for their interactions and evaluate the statistical significance of variability. The effects of all traits were evaluated and tested also by using the principal component analysis (PCA) with Pearson's correlation matrix.

We also investigated allometric (log-log) relationships of a human's components with change in overall body size with the ordinary least squares regression (OLS) to determine whether the slopes differed from zero (Voje 2016, Kilmer, Rodríguez 2017).

To compare our data with others populations from twenty-one countries (see Wardle *et al.* 2006) we used mean values of the published data on BMI based on body mass (V1) and body height (V2). Countries (regions) were grouped into three geopolitical/ economic areas: (1) North-Western Europe (Belgium, England, France, Germany, Iceland, Ireland and Netherlands); (2) the former socialist states of Central and Eastern Europe (Bulgaria, Hungary, Poland, Romania and Slovakia) and finally (3) Mediterranean countries (Greece, Italy, Portugal and Spain).

All descriptive analyses and tests (unpaired t-test, two-way ANOVA, the Hotelling T^2 test, OLS regressions, Principal component analysis – PCA) were evaluated by the statistical software OriginPro8.6 (Microral Software Inc., Northampton, USA). The published data obtained from literature, do not allow testing, as raw data are not available.

RESULTS

The descriptive statistics for each measurements considered are reported with samples divided into sexes in *Table 1*. The coefficient of variation (V) was for almost all measures higher than 5.0% indicating a larger variability. The coefficient of variation for body mass of course was high, because this is a cubic measure while all the others are linear. High phenotypic variances were confirmed mainly for measures coupled with different allometric growth pattern and different role by sex selection.

The somatic measurements in both sexes overlapped, but both the univariate analysis (unpaired t-test) and multivariate analysis (two-way ANOVA) confirmed significant differences between them (*Table 1, 3*). The results showed that men were significantly higher almost all measured variable traits, while women were significantly higher mean values in four skinfolds thickness (V21–V24). The Hotelling's T^2-test showed significant sexual size dimorphism in young population ($T^2 = 841.17$, $p < 0.0001$, *Figure 1*).

According to results of mean values of BMI it was confirmed that both sexes belongs to "about right" weight category, i.e. the values in the range (18.50–24.99 kg/m^2). Similarly, we compared our data with data from three geopolitical (economic) areas from Europe and Mediterranean countries in *Table 2*.

The PCA correlation matrix presented herein shows strong inter-correlations of the variables and all of them were still strongly significant ($p < 0.001$) after Bonferroni correction for multiple comparisons. The results of PCA for pooled sample (men and women

TABLE 1: Descriptive statistics of basic anthropometric measurements of Slovak population from Central Europe (Slovakia). Legend: sample size (N); mean (M); standard deviation (SD); standard error of mean (SEM); coefficient of variance (V).

	Male (N = 108)					Female (N = 92)						
Measurements	MEAN	SD	SEM	95% CI Lower-Upper	V (%)	MEAN	SD	SEM	95% CI Lower-Upper	V (%)	p	Diff %
V1	81.08	13.72	1.32	78.46–83.70	16.92	62.82	13.34	1.39	60.05–65.58	21.24	0.0001***	29.07
V2	181.00	6.75	0.65	179.7–182.3	3.73	167.30	6.47	0.67	166.00–168.60	3.87	0.0001***	8.19
V3	90.40	4.36	0.42	89.57–91.23	4.82	87.29	4.00	0.42	86.46–88.12	4.58	0.0001***	3.56
V4	12.81	0.87	0.08	12.64–12.97	6.80	11.93	0.74	0.08	11.78–12.08	6.17	0.0001***	7.38
V5	77.81	4.2	0.39	77.04–78.58	5.16	71.91	3.63	0.38	71.16–72.66	5.50	0.0001***	8.47
V6	26.92	1.74	0.17	26.59–27.25	6.44	24.26	1.53	0.16	23.94–24.58	6.29	0.0001***	10.97
V7	19.48	1.60	0.15	19.17–19.78	8.22	17.57	1.27	0.13	17.30–17.83	7.24	0.0001***	10.08
V8	105.40	5.15	0.50	104.4–106.4	4.88	101.10	5.15	0.54	100.10–102.20	5.90	0.0001***	4.25
V9	26.98	1.44	0.14	26.71–27.26	5.33	24.22	1.46	0.15	23.91–24.52	6.30	0.0001***	11.40
V10	18.56	0.96	0.09	18.38–18.75	5.18	17.86	0.86	0.09	17.69–18.04	4.80	0.0001***	3.92
V11	181.70	7.97	0.77	180.2–183.2	4.39	164.00	7.30	0.73	162.5–165.4	4.29	0.0001***	10.79
V12	56.56	1.61	0.15	56.25–56.87	2.85	55.02	1.87	0.20	54.63–55.41	3.39	0.0001***	2.80
V13	98.14	9.5	0.87	96.42–99.87	9.22	91.19	9.74	1.20	89.17–93.21	10.68	0.0001***	7.62
V14	15.13	0.64	0.06	15.01–15.25	4.24	14.74	0.55	0.06	14.62–14.85	3.75	0.0001***	2.65
V15	11.86	0.99	0.09	11.67–12.04	8.32	11.40	0.70	0.07	11.26–11.55	6.14	0.0003***	4.04
V16	41.16	3.23	0.31	40.55–41.78	7.84	35.78	2.28	0.24	35.31–36.26	6.38	0.0001***	15.04
V17	22.98	2.13	0.21	22.57–23.39	9.29	21.87	2.60	0.27	21.33–22.41	11.88	0.0011**	5.08
V18	34.49	2.78	0.27	33.96–35.02	8.6	33.05	3.14	0.33	32.40–33.70	9.50	0.0007***	4.36
V19	8.90	0.70	0.07	8.76–9.03	7.83	7.65	0.60	0.06	7.53–7.78	7.79	0.0001***	16.34
V20	10.13	0.65	0.06	10.01–10.25	6.42	9.80	0.64	0.07	8.94–9.21	7.70	0.0001***	11.56
V21	13.44	7.1	0.67	12.1–14.77	52.15	17.43	6.12	0.64	16.17–18.70	35.11	0.0001***	-22.90
V22	14.97	6.58	0.63	13.72–16.23	43.96	21.23	6.13	0.64	19.96–22.50	28.85	0.0001***	-29.49
V23	15.90	5.43	0.52	14.86–16.93	34.18	16.58	6.37	0.66	15.26–17.89	38.42	0.4176 ns	-4.10
V24	20.83	12.39	1.19	18.47–23.2	59.45	22.85	11.71	1.22	20.42–25.27	51.26	0.2413 ns	-8.84
BMI	24.72	3.77	0.36	24–25.44	15.27	22.39	4.37	0.46	21.49–23.30	19.51	0.0001***	10.40

TABLE 2: Mean values of two anthropometric measures (V1, V2) and BMI of both genders from sixteen European countries. Note: * own data. ** data taken and modified from Wardle *et al.* (2006).

States	Men			Women		
	V1	V2	BMI	V1	V2	BMI
Slovakia*	81.10	181.00	24.72	62.82	167.30	22.39
Germany**	76.30	181.20	22.80	60.60	169.00	20.90
Poland**	75.00	180.70	22.80	56.60	167.40	20.10
Hungary**	73.00	180.50	22.10	58.00	167.50	20.40
Romania**	70.80	178.10	22.30	54.40	164.30	20.00
France**	69.40	178.20	21.90	56.50	166.10	20.60
Belgium**	72.40	181.60	22.10	58.70	168.30	20.90
England**	72.20	178.80	22.70	56.90	156.20	20.90
Netherlands**	75.40	185.10	21.90	64.30	172.40	21.50
Ireland**	71.50	179.50	22.30	58.20	166.70	21.30
Iceland**	77.30	179.40	23.60	60.10	167.80	22.10
Bulgaria**	74.60	179.10	23.10	55.70	166.90	19.90
Italy**	70.40	178.40	22.20	54.90	165.80	20.00
Portugal**	72.50	177.40	22.90	57.00	164.00	21.10
Spain**	74.00	178.20	23.20	58.40	166.10	21.10
Greece**	77.10	180.80	23.40	58.40	167.30	20.80

together) showed that the first two principal components (PC1–PC2) explain 54.6% of the variation (*Table 4, Figure 2*). The PC1 explained 38.3% of the total variance and was correlated mainly with body height (V2, r = 0.30), head circumference (V11, r = 0.30) and foot length (V9, r = 0.29). The PC2 accounted for 16.3% and was correlated with subscapulare skin fold thickness (V23, r = 0.42), biceps skin fold thickness (V21, r = 0.40) and triceps skin fold thickness (V22, r = 0.39). Finally, the PC3 accounted for 7.1% of the overall variation and was highly associated with face width (V15, r = 0.41).

A summary of the results for our OLS analyses are shown in *Table 5, 6, Figure 3a, b*. The results of regression models showed different patterns for sexes. In general, for men were confirmed mainly negative allometry with exception of relationships between body mass (V1) and body height (V2). For women were also showed positive allometry between body mass and body height. The positive allometric growth were found also between subscapulare (V23) and supraspinale (V24) skinfold thickness with body height. For length of lower limb (V8) was confirmed isometric growth for both sexes (*Table 5*).

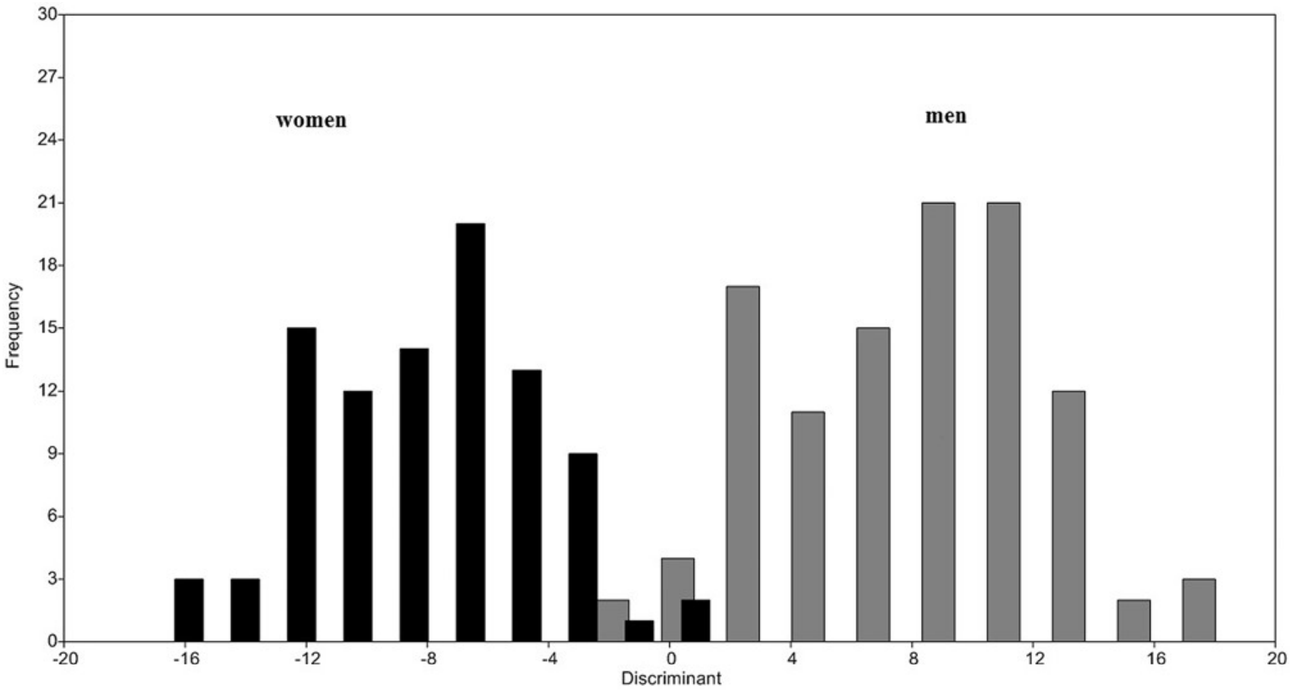

FIGURE 1: Frequency histogram of the scores for the Hotelling T^2-test between both gender of majority Slovak population from Central Europe (Slovakia).

TABLE 3: Results of two-way ANOVA of the twenty-four anthropometric measures and their F-values for three effects (sex. age and sex x age). Legend: df – degree of freedom, SSq – Sum of square, Significant variables are shown with the significant levels: * p <0.05. ** p <0.01. *** p <0.001.

Variables	Effect	df	SSq	F-value	p-value	Variables	Effect	df	SSq	F-value	p-value
V1	sex	1	0.65	105.32	0.000***	V9	sex	1	0.11	184.63	0.000***
	age	3	0.02	1.21	0.30878		age	3	0.00	2.65	0.050
	sex x age	4	0.66	27.14	0.000***		sex x age	4	0.11	48.29	0.000***
V2	sex	1	0.06	218.36	0.000***	V10	sex	1	0.01	28.45	2.65E-07***
	age	3	0.00	2.58	0.05476		age	3	0.00	0.41	0.743
	sex x age	4	0.06	56.81	0.000***		sex x age	4	0.01	7.43	1.37E-05***
V3	sex	1	0.01	27.14	4.78E-07***	V11	sex	1	0.10	277.71	0.000***
	age	3	0.00	2.11	0.09987		age	3	0.00	1.88	0.134
	sex x age	4	0.01	8.47	2.56E-06***		sex x age	4	0.10	71.18	0.000***
V4	sex	1	0.05	56.45	2.03E-12***	V12	sex	1	0.01	39.82	1.83E-09***
	age	3	0.00	0.53	0.66473		age	3	0.00	1.42	0.237
	sex x age	4	0.05	14.52	2.13E-10***		sex x age	4	0.01	11.10	3.91E-08***
V5	sex	1	0.06	115.21	0.000***	V13	sex	1	0.05	30.97	8.58E-08***
	age	3	0.00	0.18	0.91086		age	3	0.01	1.70	0.168
	sex x age	4	0.06	28.97	0.000***		sex x age	4	0.06	8.96	1.15E-06***
V6	sex	1	0.10	131.12	0.000***	V14	sex	1	0.01	20.38	1.10E-05***
	age	3	0.00	0.38	0.76805		age	3	0.00	0.44	0.724
	sex x age	4	0.10	33.09	0.000***		sex x age	4	0.01	5.40	3.79E-04***
V7	sex	1	0.10	87.58	0.000***	V15	sex	1	0.01	12.55	4.95E-04***
	age	3	0.01	1.79	0.15055		age	3	0.00	1.03	0.379
	sex x age	4	0.10	23.22	9.99E-16***		sex x age	4	0.02	3.92	0.004**
V8	sex	1	0.02	34.89	1.53E-08***	V16	sex	1	0.18	180.69	0.000***
	age	3	0.01	4.83	0.00288**		age	3	0.00	0.03	0.992
	sex x age	4	0.02	12.53	4.34E-09***		sex x age	4	0.18	45.22	0.000***
V17	sex	1	0.03	13.70	2.79E-04***	V21	sex	1	1.13	21.59	6.22E-06***
	age	3	0.03	4.91	0.003**		age	3	0.05	0.33	0.804
	sex x age	4	0.05	7.07	2.47E-05***		sex x age	4	1.19	5.69	2.38E-04***
V18	sex	1	0.02	12.40	5.34E-04***	V22	sex	1	1.53	38.69	2.97E-09***
	age	3	0.00	0.34	0.795		age	3	0.08	0.64	0.591
	sex x age	4	0.02	3.33	0.012*		sex x age	4	1.62	10.19	1.64E-07***
V19	sex	1	0.21	190.20	0.000***	V23	sex	1	0.01	0.33	0.565
	age	3	0.01	2.25	0.084		age	3	0.05	0.63	0.595
	sex x age	4	0.22	48.95	0.000***		sex x age	4	0.06	0.56	0.691
V20	sex	1	0.11	131.57	0.000***	V24	sex	1	0.13	2.14	0.145
	age	3	0.00	0.98	0.401		age	3	0.62	3.43	0.018*
	sex x age	4	0.12	33.56	0.000***		sex x age	4	0.76	3.13	0.016*
	sex x age	4	0.06	28.97	0***		sex x age	4	0.05	7.07	2.47E-05***

DISCUSSION

The analyses of anthropometric dimensions on the territory of Europe as well as Turkey, Asia and United States were dealt with by several authors (Barroso *et al.* 2005, Özaslan *et al.* 2006, McDowell *et al.* 2008, Sedmák *et al.* 2010, Flegal *et al.* 2012, Kramárová *et al.* 2015, Neščáková *et al.* 2017, Stříbrná *et al.* 2017). Our data confirmed men biased sexual size dimorphism with significantly higher dimensions than women and

TABLE 4: Loading values of Principal Component Analysis (PCA) for the three main components (PC1–PC3); their eigenvalues, percentage (variability %) and cumulative percentage (cumulative %) expressions.

Measurements	PC1	PC2	PC3
V2	0.30	-0.08	0.02
V3	0.18	-0.06	0.16
V4	0.19	-0.03	-0.01
V5	0.28	-0.08	-0.14
V6	0.27	-0.15	-0.11
V7	0.24	-0.13	-0.31
V8	0.23	-0.12	0.07
V9	0.29	-0.08	0.00
V10	0.19	0.14	0.32
V11	0.30	-0.10	0.07
V12	0.21	0.08	0.22
V13	0.19	0.32	-0.13
V14	0.15	0.12	0.28
V15	0.11	0.20	0.41
V16	0.25	0.08	0.29
V17	0.12	0.21	-0.31
V18	0.18	0.30	-0.12
V19	0.26	0.00	-0.21
V20	0.24	-0.01	-0.10
V21	-0.06	0.40	0.14
V22	-0.08	0.39	0.02
V23	0.06	0.42	-0.11
V24	0.03	0.31	-0.38
Eigenvalue	8.82	3.76	1.63
Percentage (%)	38.3	16.3	7.1
Cumulative (%)	38.3	54.6	61.7

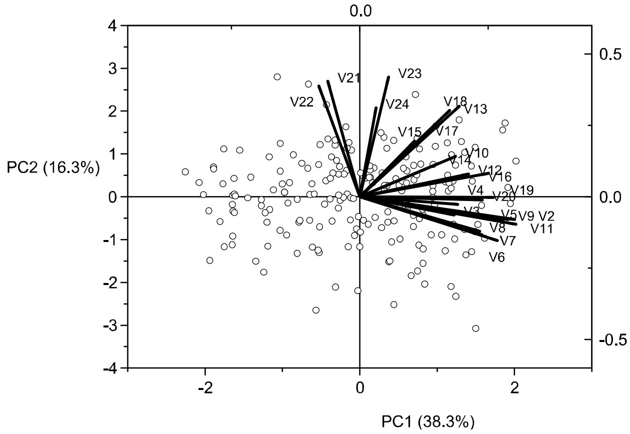

FIGURE 2: Biplot of individual scores in PC1 and PC2 for twenty-three anthropometric measurements of young Slovak population from Central Europe (Slovakia).

these results are fully consistent with the previous findings from above cited authors. The great variability in the measured characteristics was not only between the sexes but also during the research periods. Generally, men have reached higher values in many measured characters, while women reached higher values in the skin folds. This is consistent with the fact that women have in these parts of the body less developed muscle tissue (Riegerová *et al.* 2010). Moreover, we confirmed different pattern of allometric growth for both sexes. It should be emphasized that the vast majority of studies deals with the BMI index (Kikalová *et al.* 2017, Stříbrná *et al.* 2017, Dörnhöferová *et al.* 2017, Svoradová *et al.* 2017, Wardle, Johnson 2002, Wardle *et al.* 2006, Flegal *et al.* 2012), but also with other anthropometric measures (Ingrová *et al.* 2017, Farkas *et al.* 1984, 2005, Fredriks *et al.* 2000, Bogin, Varela-Silva 2010, Gába, Přidalová 2014, Contreras *et al.* 2014, Capatan *et al.* 2014, Fessler *et al.* 2005, Jervas 2015). Nevertheless, the authors point out that the age and ethnicity of the population greatly influence the overall variability of the characters. Wardle *et al.* (2006) summarized the studies of several authors from 22 countries, comparing two anthropometric measurements (body mass and body height) and BMI index. By comparing our data (without statistical testing) with table data from this study, higher body mass values and BMI were confirmed for young adults from Slovakia, but the values fit into the "about right" weight category (Wardle, Johnson 2002, Wardle *et al.* 2006). In contrast, different results was found when comparing our average BMI with BMI values in the American study (Flegal *et al.* 2012), with higher values in American population.

While in men, a positive allometry was found for only one dimension in relation to body height i.e. body mass, in women were recorded also for subscapulare and supraspinale skinfold thickness. It could be interpreted in relation to pregnancy and subsequent maternity. Our results confirmed smaller values in foot and palm for women which are consistent with published data (Jervas 2015, Fessler *et al.* 2004, 2005). Cited authors found controversial results, because given the biomechanical challenges posed by pregnancy, smaller female proportionate foot length is somewhat surprising, as foot length affects dorsoventral stability.

TABLE 5: (MEN). Results of OLS regression slopes, intercepts and 95% confidence intervals (CI), $F_{dfn, dfd}$ and p-values for relationships between traits are shown for adult men (a) and women (b) of the European population from Slovakia. Legend: number (N); coefficient of determination (R^2). All abbreviations and measures are explained in Material and methods. Significant relationships are displayed by significant levels: * p <0.05, ** p <0.01, *** p <0.001.

(a) men

Log Y versus log X variable	N	R^2	OLS slope (95% CI)	Intercept (95% CI)	$F_{1, 106}$	p-values	Allometry
V1 vs V2	108	0.186	1.901 (1.134, 2.667)	-2.387 (-4.118, -0.657)	24.22	p<0.0001***	positive
V3 vs V2	108	0.225	0.617 (0.396, 0.838)	0.563 (0.063, 1.062)	30.68	p<0.0001***	negative
V4 vs V2	108	0.035	0.348 (-0.003, 0.699)	0.321 (-0.471, 1.113)	3.870	0.0518	
V5 vs V2	108	0.341	0.814 (0.596, 1.032)	0.052 (-0.440, 0.545)	54.88	p<0.0001***	negative
V6 vs V2	108	0.220	0.807 (0.514, 1.100)	-0.392 (-1.053, 0.270)	29.84	p<0.0001***	negative
V7 vs V2	108	0.122	0.778 (0.376, 1.180)	-0.468 (-1.375, 0.439)	14.76	0.0002***	negative
V8 vs V2	108	0.629	1.044 (0.889, 1.198)	-0.334 (-0.683, 0.015)	179.7	p<0.0001***	isometry
V9 vs V2	108	0.286	0.773 (0.538, 1.009)	-0.315 (-0.847, 0.214)	42.49	p<0.0001***	negative
V10 vs V2	108	0.055	0.335 (0.068, 0.601)	0.513 (-0.089, 1.115)	6.198	0.0143*	negative
V11 vs V2	108	0.590	0.909 (0.763, 1.056)	0.205 (-0.125, 0.536)	152.2	p<0.0001***	negative
V12 vs V2	108	0.094	0.234 (0.094, 0.375)	1.223 (0.907, 1.540)	11.00	0.0012**	negative
V13 vs V2	108	0.054	0.564 (0.108, 1.020)	0.716 (-0.313, 1.746)	6.031	0.0157*	negative
V14 vs V2	108	0.004	0.076 (-0.148, 0.299)	1.008 (0.503, 1.513)	0.455	0.502	
V15 vs V2	108	0.007	0.183 (-0.252, 0.617)	0.660 (-0.319, 1.640)	0.697	0.406	
V16 vs V2	108	0.087	0.626 (0.236, 1.016)	0.200 (-0.680, 1.080)	10.15	0.0019**	negative
V17 vs V2	108	0.009	0.231 (-0.236, 0.698)	0.838 (-0.215, 1.892)	0.965	0.3281	
V18 vs V2	108	0.075	0.599 (0.193, 1.005)	0.184 (-0.732, 1.100)	8.587	0.0041**	negative
V19 vs V2	108	0.022	0.311 (-0.089, 0.7112)	0.245 (-0.658, 1.148)	2.387	0.1254	
V20 vs V2	108	0.039	0.340 (0.013, 0.667)	0.237 (-0.501, 0.975)	4.267	0.0413*	negative
V21 vs V2	108	0.008	1.508 (-1.679, 4.694)	-2.343 (-9.537, 4.851)	0.882	0.3499	
V22 vs V2	108	0.000	0.239 (-2.425, 2.903)	0.587 (-5.427, 6.600)	0.032	0.859	
V23 vs V2	108	0.006	0.696 (-1.097, 2.490)	-0.396 (-4.444, 3.653)	0.594	0.4427	
V24 vs V2	108	0.008	-1.402 (-4.464, 1.659)	4.412 (-2.499, 3.482)	0.827	0.365	

TABLE 6: (Women). Results of OLS regression slopes, intercepts and 95% confidence intervals (CI), $F_{dfn, dfd}$ and p-values for relationships between traits are shown for adult men (a) and women (b) of the European population from Slovakia. Legend: number (N); coefficient of determination (R^2). All abbreviations and measures are explained in Material and methods. Significant relationships are displayed by significant levels: * p <0.05, ** p <0.01, *** p <0.001.

Log Y versus log X variable	N	R^2	OLS slope (95% CI)	Intercept (95% CI)	$F_{1, 90}$	p-values	Allometry
V1 vs V2	92	0.191	2.239 (1.273, 3.205)	-3.188 (-5.336, -1.041)	21.27	P <0.0001***	positive
V3 vs V2	92	0.539	0.870 (0.702, 1.040)	0.004 (-0.371, 0.379)	105.5	P <0.0001***	negative
V4 vs V2	92	0.022	0.236 (-0.096, 0.570)	0.549 (-0.192, 1.290)	2.001	0.1607	
V5 vs V2	92	0.485	0.916 (0.718, 1.114)	-0.181 (-0.622, 0.259)	84.80	P <0.0001***	negative
V6 vs V2	92	0.295	0.888 (0.601, 1.178)	-0.592 (-1.233, 0.049)	37.65	P <0.0001***	negative
V7 vs V2	92	0.245	0.921 (0.585, 1.255)	-0.803 (-1.547, -0.059)	29.95	P <0.0001***	negative
V8 vs V2	92	0.580	1.015 (0.833, 1.196)	-0.251 (-0.654, 0.151)	124.3	P <0.0001***	isometry
V9 vs V2	92	0.206	0.707 (0.415, 0.998)	-0.188 (-0.836, 0.459)	23.31	P <0.0001***	negative
V10 vs V2	92	0.042	0.252 (0.002, 0.503)	0.691 (0.134, 1.248)	4.013	0.0482*	negative
V11 vs V2	92	0.642	0.891 (0.752, 1.031)	0.233 (-0.077, 0.544)	161.3	P <0.0001***	negative
V12 vs V2	92	0.104	0.281 (0.108, 0.454)	1.116 (0.732, 1.501)	10.41	0.0017**	negative
V13 vs V2	92	0.073	0.702 (0.176, 1.228)	0.397 (-0.773, 1.566)	7.06	0.0093*	negative
V14 vs V2	92	0.021	0.142 (-0.059, 0.344)	0.852 (0.405, 1.298)	1.98	0.1619	
V15 vs V2	92	0.005	-0.115 (-0.447, 0.217)	1.311 (0.573, 2.049)	0.473	0.4936	
V16 vs V2	92	0.102	0.529 (0.199, 0.858)	0.377 (-0.355, 1.109)	10.23	0.0019**	negative
V17 vs V2	92	0.001	0.060 (-0.568, 0.689)	1.203 (-0.193, 2.599)	0.036	0.8492	
V18 vs V2	92	0.078	0.681 (0.191, 1.170)	0.004 (-1.085, 1.093)	7.651	0.0069**	negative
V19 vs V2	92	0.125	0.713 (0.318, 1.108)	-0.703 (-1.582, 0.176)	12.89	0.0005***	negative
V20 vs V2	92	0.069	0.488 (0.112, 0.863)	-0.128 (0.962, 0.707)	6.69	0.0113*	negative
V21 vs V2	92	0.009	-0.949 (-3.052, 1.153)	3.323 (-1.352, 7.998)	0.808	0.3712	
V22 vs V2	92	0.003	0.542 (-1.518, 2.602)	0.099 (-4.482, 4.678)	0.274	0.6020	
V23 vs V2	92	0.052	2.225 (0.243, 4.207)	-3.757 (-8.163, 0.649)	4.991	0.0280*	positive
V24 vs V2	92	0.066	3.719 (0.789, 6.649)	-6.970 (-13.48, -0.456)	6.380	0.0133*	positive

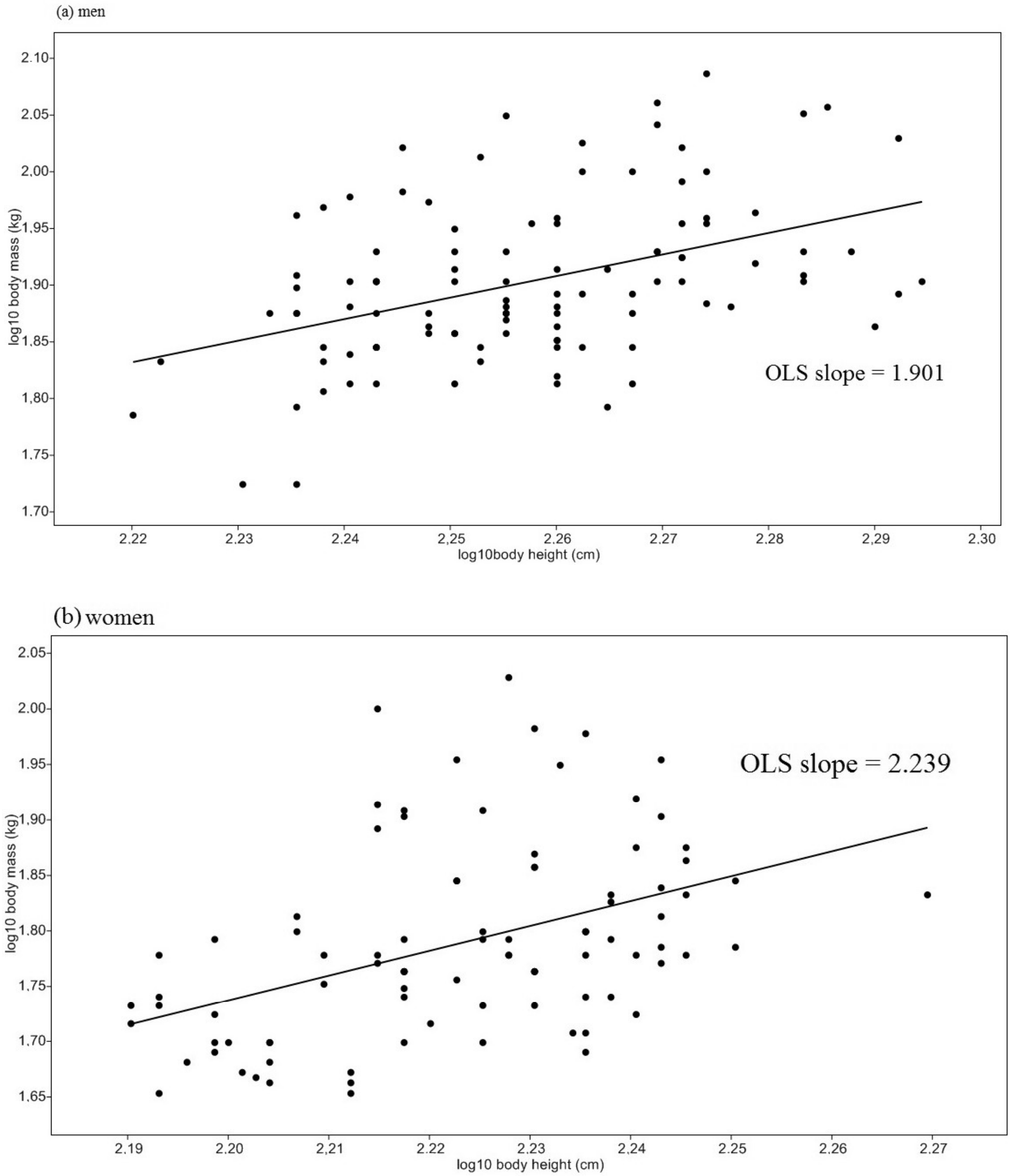

FIGURE 3: Relationships between (a) the body length (V2) in relation to body mass (V1) for men (b) the body length (V2) in relation to body mass (V1) for women in young adults from Central Europe (Slovakia). All variables are $\log_{10}$-transformed. The lines represent the slopes calculated from reduced ordinary least squares regression (OLS).

Authors assume that it is possible that the observed pattern reflects intersexual selection for small female foot size, a cue of youth and nulliparity. It is also in accordance with our data on a positive allometry and a greater influence on reproduction.

CONCLUSION

The subject of study was the anthropometry of a young population in the period of early adulthood. We measured body mass and 24 anthropometric parameters. It also included calculation of the body mass index (BMI). The measurements in sexes overlapped, but analyses confirmed significant differences between them. The results of BMI values also confirmed that both sexes belongs to "about right" weight category i.e. the values in the range. Similarly, for men and women were confirmed positive allometry between body mass and body height. Moreover, for women were also showed positive allometry between subscapulare and supraspinale skinfold thickness with body height. Different results in allometric growth between the genders can therefore be interpreted also on the basis of a different function during reproduction.

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AUTHOR SECTION

The measured values of selected anthropometric parameters (108 men and 92 women) in the age group 18 to 35 years old were obtained with the sole consent of probands, recorded anonyms and were intended for their processing and subsequent publication.

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