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Original Article

Sexual dimorphism of the selected somatic features of students attending physical education course in Kazimierz Wielki University during the years 2006-2017

EKSTEROWICZ JERZY[1], NAPIERAŁA MAREK[2]
[1,2,]Faculty of Physical Education, Health and Tourism, Kazimierz Wielki University, POLAND

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Abstract:
The aim of the below research was the determination of the size of the sexual dimorphism between students attending Physical Education course on Kazimierz Wielki University in Bydgoszcz during the years 2006-2017. 452 men and 378 women were investigated. The somatic measurements were taken using the anthropometric tools manufactured by Swiss company Siber Hegner & Co. Following measurements were conducted: height (B-V) and body mass, TSF triceps skinfold, SCSF subscapular skinfold and SISF suprailiac skinfold, the elbow width (cl-cm) and knee width (epl-epm), circumferences of arm, calf, waist and hip. Based on the received results following parameters were calculated: fat mass, Body Mass Index (kg/m^2), Waist to Hip Ratio (WHR index), Arm Muscle Circumference (AMC index) and the body build condition. The study has shown, that:

- during all years of research men were taller than women and those differences were statistically significant ($p<0,01$)
- during all research years the Body Mass Indexes for men were higher than for women and were statistically significant ($p<0,01$ and $p<0,05$)
- investigated women had higher values of fat content than investigated men and those differences were statistically significant ($p<0,01$)
- WHR index during all years of study, for both men and women investigated groups, was found as statistically not significant
- AMC mean values were noted higher for men than for women and those differences were found as statistically significant ($p<0,01$)

Key words: sexual dimorphism, morphological structure, Physical Education students

Introduction

The constitution of the human body should be considered for men and women separately. Generally, there are many fundamental differences between both sexes, which are changing all the time, during every individual development and growth stage. However, human somatic features depend on several factors. First of all, they depend on the genetic transmission. Secondly on the widely understood environmental conditions, including biogeographical and living conditions, on the way of nutrition, physical activity, general health, degree of education etc. Finally, they depend on the healthy habits, considered as individual or whole subpopulation habits. It could be also considered as simply taking care of ourselves, for example about the proper body mass or body composition or, sometimes, completely ignoring those parameters. Briefly, taking care about human well-being (Wallace 2007, Tingstrom, Nagel 2017).

Above factors change over the years, mainly because of the living conditions, which constantly develop. Also, the population awareness and degree of education increase, availability to knowledge is better and finally, selected somatic standards, which are strongly promoted in social media, change. From the one hand some people, particularly young persons, try to keep very slim and fit silhouettes. However, at the same time there exist many destructive processes, which disturb in keeping proper body mass or body composition. Strong influence has for example availability to cheap food, which is full of high-energy fats and simple sugars. These kind of products could be the reason of the excessive energy intake, in contrast to insufficient energy output. This in fact comes from the basal metabolic rate (BMR), but also from the everyday work, recreation activities, sports and so on. In described case, positive energy balance is created, what finally results in accumulating the extra food as fat tissue (Alameda, M., Whitehead J, 2015, Waskiewicz A., Slonska Z., Drygas W 2009).

Other authors [6] were evaluating the selected somatic features and the sexual dimorphism in the group of 1969 students from the first year of Physical Education course, during the years 1995-2010. The following somatic features were measured: height and body mass, the width of the distal femoral epiphysis, the width of the humerus epiphysis, the thickness of the four skinfolds, arm and calf circumferences. Based on the received data, the participations of ectomorphy, mezomorphy and endomorphy were calculated. Obtained results from

Corresponding Author: EKSTEROWICZ JERZY, E-mail: jekster@ukw.edu.pl

this research have shown, that female students had bigger participation of endomorphy than male students, which in turn had bigger participation of mezomorphy and the differences were statistically significant. Additionally, female students had shown bigger participation of ectomorphy and the differences were statistically significant.

The aim of the below study was to determine the sexual dimorphism, based on the selected somatic features, between students attending Physical Education course on Kazimierz Wielki University in Bydgoszcz, during the years 2006-2017.

Materials and methods

The material for that research was collecting during the years 2006-2017. Investigated persons were students attending Physical Education course on Kazimierz Wielki University in Bydgoszcz, Poland. The results showed in that study are the part of the bigger anthropological research conducted by Physical Culture Institute on Kaziemierz Wielki University. During 12 years of this research 452 men and 378 women from first year of Physical Education course were investigated during their summer sport camp. The study participants were in the age of 20-22 years old, where the calculated average age for men was 20,70±0,78 and for women 20,40±0,67.

The measurements were taken using anthropometric tools manufactured by Swiss company Siber Hegner & Co. Ltd (anthropometer, cephalometer, slide caliper, anthropometric tape). All measurements were taken by the same investigator, applying standard anthropometric methods according to the procedure of the International Biological Program. The below measurements were taken: height (B-V) and body mass, TSF triceps skinfold, SCSF subscapular skinfold and SISF suprailiac skinfold, (epl-epm), circumferences of arm, waist and hip. Using Tanita balance, body mass was measured. From the received results it was calculated: body height, body mass, Body Mass Index (kg/m^2) in accordance with formula BMI= body mass[kg]/ body height[m]^2, fat content according to Durnin-Womersley algorithm, waist to hip ratio (WHR index), waist and hip circumferences [cm], arm muscle circumference (AMC index), which was calculated in accordance with formula: arm circumference [cm] – (3,14 * TSF triceps skinfold). There were also introduced the mean values of the selected morphological features for investigated groups of men and women. Using sexual dimorphism index (SDI) dimorphic differences were determined, which occurred during 12 years of study, based on the formula: SDI=$\frac{\bar{x}_1 - \bar{x}_2}{S_2}$, where: $\bar{x}_1$ - sample mean of female, $\bar{x}_2$ - sample mean of men, S_2 - standard deviation of men; t- t- student test size between male and female in each research year.

The differences between obtained results were determined using t-student test for independent groups for $p<0,05$ and $p<0,01$. Also t-student test was used to find the differences between selected features for investigated men and women. In order to determine the significant differences Statistica 13.3 program was used.

Results analysis

In the below tables (1-6) basic values of compered morphological features are presented, for investigated men and women collected during the years 2006-2017.

In the Table 1 body height values for men and women are presented. The index of the sexual dimorphism stands between -1,11 in 2012 and -3,44 in 2011 year. In all research years sexual dimorphis index (SDI) is negative for women, what means higher values of investigated feature (body height) for men. The differences between body height in all years for both groups do not show statistically significant differences, except for the years 2011 and 2012 for men ($p<0,05$) and women ($p<0,01$). In the women group the significant differences occurred also between years 2016 and 2017 ($p<0,05$). Additionally, men were taller than their women peers during all research years ($p<0,01$).

Table 1. Body height values for investigated men and women

Year	N	Body height (cm) ♂			N	Body height (cm) ♀				t ♂/♀
		$\bar{X}$	S	t		$\bar{X}$	S	t	SDI	
2006	41	180,58	6,07		31	169,83	4,80		-1,77	8,39**
2007	37	180,50	7,79	0,05	27	170,00	4,97	0,13	-1,35	6,57**
2008	32	181,00	8,01	0,26	31	170,01	7,02	0,01	-1,37	5,80**
2009	43	180,00	5,00	0,62	33	169,00	6,00	0,62	-2,20	8,69**
2010	26	181,40	6,01	0,99	28	167,40	8,02	0,86	-2,33	7,29**
2011	20	184,00	5,53	1,52	30	165,00	5,00	1,36	-3,44	12,36**
2012	29	179,87	7,11	2,28*	25	171,98	6,40	4,44**	-1,11	4,29**
2013	38	180,80	6,80	0,54	36	170,00	6,00	1,22	-1,59	7,25**
2014	48	180,99	6,90	0,13	38	170,78	7,39	0,49	-1,48	6,55**
2015	45	179,90	5,13	1,08	33	168,44	8,31	1,24	-2,23	7,00**
2016	56	181,43	7,01	1,61	34	165,82	6,52	1,43	-2,22	10,70**
2017	37	181,58	8,02	0,09	32	169,82	7,08	2,38*	-1,47	6,47**
	37,67	181,00	6,28		31,5	169,01	6,46		-1,91	7,77**

* p < 0,05; ** p < 0,01;

Body mass values for investigated men and women are presented in Table 2. The smallest value of sexual dimorphism index was noted in 2008 year (-1,28) and the highest in 2015 year (-2,75). In all compared years sexual dimorphism index showed differences in body mass in favour of men (negative SDI for women in all investigations). The differences noted for body mass in the men group in each year do not show statistically significant differences. For the women group the statistically significant difference occurred between years 2010/2011 and 2015/2016 ($p<0,05$) and 2016/2017 ($p<0,01$).

In all research years higher body mass values were noted for men than for women and the differences were statistically significant ($p<0,01$).

Table 2. Body mass values for investigated men and women

Year	N	Body mass (kg) ♂			N	Body mass (kg) ♀				t ♂/♀
		$\overline{X}$	S	t		$\overline{X}$	S	t	SDI	
2006	41	76,31	8,10		31	63,82	7,40		-1,54	6,81**
2007	37	76,30	8,43	0,01	27	63,70	6,66	0,06	-1,49	6,87**
2008	32	76,70	9,70	0,18	31	64,30	6,36	0,35	-1,28	6,02**
2009	43	77,60	9,60	0,40	33	63,00	7,97	0,72	-1,52	7,24**
2010	26	76,70	7,91	0,42	28	65,72	6,52	1,47	-1,39	5,54**
2011	20	80,10	10,1	1,24	30	61,30	6,75	2,54*	-1,86	7,31**
2012	29	76,48	8,13	1,33	25	63,88	6,22	1,47	-1,55	6,44**
2013	38	76,90	10,90	0,18	36	62,40	6,71	0,88	-1,33	6,93**
2014	48	78,69	8,58	0,83	38	65,03	9,20	1,41	-1,59	7,04**
2015	45	79,83	6,10	0,91	33	63,06	7,01	1,14	-2,75	11,02**
2016	56	77,72	10,89	1,44	34	58,56	7,24	2,58*	-1,76	10,02**
2017	37	79,36	9,89	0,75	32	64,78	5,95	3,82**	-1,47	7,53**
$\overline{X}$	37,67	77,82	8,61		31,5	63,29	6,99			7,75**

* p < 0,05; ** p < 0,01;

The sexual dimorphism index (SDI) for BMI is negative for women in all considered years (Table 3). The highest SDI was in 2006 year (-1,31) and the lowest in 2010 and 2015 years (-0,01). In the men groups the biggest differences in BMI were noted between 2014 and 2015 years and also in 2015 and 2016 years ($p<0,01$). For women the statistically significant differences ($p<0,05$) were noted in years 2010 and 2011 as well as in 2016 and 2017 ($p<0,01$). During each research year BMI values were higher for men than for women and were statistically significant ($p<0,01$** and $p<0,05$*) in the years indicated in the Table 3.

Table 3. BMI values for investigated men and women

Year	N	BMI ♂			N	BMI ♀				t ♂/♀
		$\overline{X}$	S	t		$\overline{X}$	S	t	SDI	
2006	41	23,30	1,51		31	21,32	1,49		-1,31	5,55**
2007	37	23,41	2,11	0,26	27	22,00	1,92	1,49	-0,67	2,78**
2008	32	23,40	1,70	0,02	31	22,30	1,70	0,62	-0,65	2,57*
2009	43	24,00	2,40	1,27	33	22,20	5,40	0,10	-0,75	1,78
2010	26	23,62	1,91	0,76	28	23,61	1,71	1,42	-0,01	0,02
2011	20	23,60	2,40	0,01	30	22,40	2,70	2,05*	-0,50	1,65
2012	29	23,67	2,49	0,09	25	21,46	3,30	1,14	-0,89	2,74**
2013	38	23,50	2,40	0,28	36	21,60	1,70	0,14	-0,79	3,94**
2014	48	24,00	2,05	1,02	38	22,31	2,99	1,25	-0,82	2,27*
2015	45	22,21	2,10	4,15**	33	22,20	1,63	0,04	-0,01	0,02
2016	56	23,60	2,97	2,75**	34	20,46	1,93	0,55	-1,06	6,01**
2017	37	23,80	2,20	0,37	32	22,56	1,68	4,72**	-0,56	2,65**
	37,67	23,51	2,18		31,5	22,03	2,34			2,70**

* p < 0,05; ** p < 0,01;

Table 4 presents fat mass values measured for the investigated students. The lowest sexual dimorphism index (SDI) was in 2017 year (1,47) and the highest in 2010 year (5,57). In all study years, where FM% were measured, SDI for women is positive. In the men group the significant differences were between years: 2007/2008, 2015/2016 ($p<0,1$) and also 2012/2013 ($p<0,05$).

In the women group the differences are statistically significant between all compared years ($p<0,05$) ($p<0,01$), except for the years 2009/2010 and 2015/2016, what is presented in Table 4.

The investigated women had higher content of fat in all research years in comparison to men. The differences between men and women groups are statistically significant ($p<0,01$).

Table 4. Fat mass (FM%) values measured for the investigated men and women

Year	N	Fat mass (%) ♂			N	Fat mass (%) ♀				t ♂/♀
		$\overline{X}$	S	t		$\overline{X}$	S	t	SDI	
2006	41	12,79	3,79		31	29,45	3,44		4,39	19,47**
2007	37	13,70	2,72	1,23	27	25,40	3,50	4,43**	4,30	16,06**
2008	32	15,73	3,14	2,84**	31	28,38	2,80	3,56**	4,03	16,89**
2009	43	16,26	3,13	0,72	33	30,49	1,96	3,47**	4,55	24,25**
2010	26	14,74	2,60	2,17	28	29,23	3,08	1,87	5,57	18,73**
2011	20	15,72	2,82	1,18	30	26,20	4,27	2,71**	3,72	10,45**
2012	29	14,45	2,95	1,52	25	22,78	5,24	2,41*	2,82	7,04**
2013	38	12,45	3,77	2,43*	36	19,68	3,56	2,57*	1,91	6,89**
2014	48	12,34	2,70	0,15	38	22,94	4,38	3,27**	3,93	13,09**
2015	45	12,23	2,65	0,19	33	19,53	6,82	2,46*	2,75	5,83**
2016	56	10,15	3,29	3,21**	34	19,56	2,30	0,02	2,86	13,13**
2017	37	15,86	3,88	7,41**	32	21,56	2,77	3,17**	1,47	7,09**
	37,67	13,87	3,12		31,5	24,6	3,67			12,96**

* p < 0,05; ** p < 0,01;

In the Table 5 waist to hip ratio (WHR) values for investigated groups are presented. The mean values of the fat content are higher in all research years for women. The lowest sexual dimorphism index (SDI) was in 2009 year (-1,00) and the highest in 2016 year (-3,67). WHR values for men between each study year were noted as statistically significant, except for the years 2006/2007, 2009/2010, 2012/2013 and 2016/2017. For women group no significant differences between each year were noted.

WHR index between compared male and female groups was observed as insignificant during all research years.

Table 5. WHR values for investigated men and women

Year	N	WHR ♂			N	WHR ♀				t ♂/♀
		$\overline{X}$	S	t		$\overline{X}$	S	t	SDI	
2006	41	0,85	0,03		31	0,76	0,06		-2,67	0,06
2007	37	0,84	0,04	1,23	27	0,78	0,05	0,02	-1,50	0,03
2008	32	0,82	0,04	2,11*	31	0,74	0,03	0,01	-2,00	0,04
2009	43	0,86	0,05	3,84**	33	0,81	0,05	0,04	-1,00	0,02
2010	26	0,84	0,04	1,83	28	0,78	0,05	0,01	-1,50	0,02
2011	20	0,81	0,04	2,52*	30	0,74	0,05	0,01	-1,75	0,02
2012	29	0,86	0,04	4,31**	25	0,79	0,06	0,02	-1,75	0,03
2013	38	0,85	0,05	0,91	36	0,78	0,04	0,72	-1,40	0,03
2014	48	0,92	0,04	7,07**	38	0,83	0,05	0,02	-2,25	0,05
2015	45	0,96	0,05	4,25**	33	0,85	0,03	0,01	-2,20	0,05
2016	56	0,89	0,03	8,23**	34	0,78	0,03	0,04	-3,67	0,09
2017	37	0,90	0,03	1,58	32	0,83	0,04	0,03	-2,33	0,05
	37,67	0,87	0,04		31,5	0,79	0,04			0,04

* p < 0,05; ** p < 0,01;

Values presented in the Table 6 indicate, that the dimorphism index for protein nutrition showed differences in its values in favour of men in all research years. The highest sexual dimorphism index (SDI) was noted in 2016 year (-2,89) and the lowest was in 2012 year (-0,90). In the men investigated groups the significant differences occurred between the years 2009/2010 and also 2014/2015 (p<0,01). In turn, in the women investigated groups, the statistically significant differences were observed between most of the research years, both with (p<0,01) and (p<0,05). Significant differences did not occur only between the years 2008/2009 and 2012/2013. The calculated mean values of the Arm Muscle Circumference (AMC) were noted higher for the men group than for the women group in all investigation years and differences were statistically significant (p<0,01). Detailed collected data are presented in the Table 6.

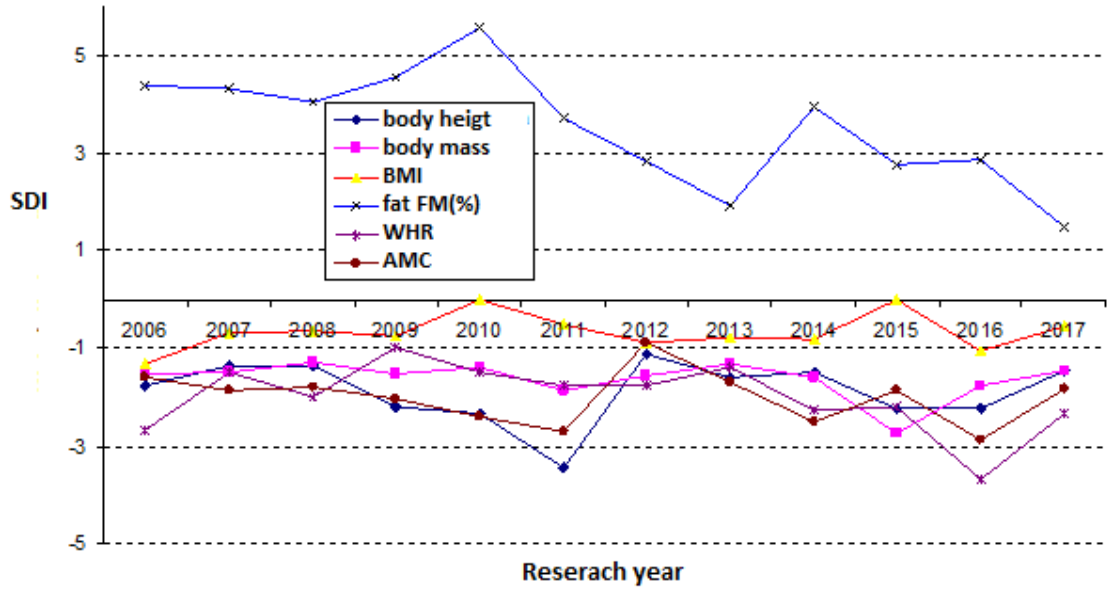
Table 6. AMC values for investigated men and women

Year	N	AMC ♂			N	AMC ♀				t ♂/♀
		$\overline{X}$	S	t		$\overline{X}$	S	t	SDI	
2006	41	27,20	2,68		31	22,90	1,20		-1,60	9,13**
2007	37	27,50	3,21	0,45	27	21,50	2,04	3,12**	-1,87	9,12**
2008	32	27,11	2,42	0,57	31	22,81	1,30	2,87**	-1,78	8,82**
2009	43	26,61	2,54	0,87	33	21,45	1,79	1,74	-2,03	10,38**
2010	26	29,46	1,67	5,67**	28	25,43	1,57	9,25**	-2,41	9,12**
2011	20	28,51	2,19	1,61	30	22,61	1,50	6,98**	-2,69	10,52**
2012	29	27,41	3,54	1,34	25	24,21	3,30	2,24*	-0,90	3,44**
2013	38	27,16	2,56	0,32	36	22,85	1,76	1,88	-1,68	8,48**
2014	48	27,58	2,32	0,78	38	21,75	2,09	2,45*	-2,51	12,24**
2015	45	29,27	3,20	3,53**	33	23,36	2,14	3,19**	-1,85	9,76**
2016	56	28,23	2,40	1,81	34	21,30	2,24	3,85**	-2,89	13,78**
2017	37	28,53	2,77	0,54	32	23,46	1,03	5,08**	-1,83	10,34**
	37,67	27,88	2,63		31,5	22,80	1,83			9,44**

* p < 0,05; ** p < 0,01;

BMI – Body Mass Index
WHR- Waist to Hip Ratio
AMC – Arm Muscle Circumference
FM% – FAT mass

Figure 1 presents SDI for the investigated morphological features. From that graph it can be seen, that all values are higher for the men groups, except for the FM(%), which is higher for women in all research years. The biggest difference in the level of FM(%) was noted in 2010 year (5,57).



Discussion

Human somatic features were investigated many times in the science literature. Some authors [12] strictly focused on the features of teenagers who trained water sports (173 male and female participants), specially rowing, canoeing and swimming. In the cited position, the investigated group consisted of boys and girls in the age of 15 and 16 years old. During the research, the authors estimated the differences between sexual dimorphism for investigated features using Mollison's index and t-student test for the independent groups. The obtained results directly showed, that doing a sport do not cause any dysfunction or disorders in the development of morphological features.

The research of the other authors [5] was focused on the anthropological assessment, based on the sexual dimorphism index (SDI). The study was carried out for the group of 7478 children in the age of 3-18 years old, from Rzeszów in Poland and was conducted during the years 1978-2004. The authors had a final conclusion, that the metrical parameters of the head and body are subject to two-directional intersexual differentiation.

Next deep science research was carried out during the years 1996 and 1997 [11]. The study investigated the dimorphism for different morphological features, which were determined for the group of students who applied for the Physical Education course on WSP in Częstochowa, in Poland. The obtained results allowed to make a conclusion, that investigated somatic features for students attending Pedagogic with Physical Education course on WSP in Częstochowa are not much different than the features measured for students attending Physical Education course on different University- AWF in Katowice, in Poland.

The aim of the next noteworthy literature position [3] was to find the correlation between selected anthropometric indexes and indirect indices of insulin resistance (IR) or insulin sensitivity. The investigated group consisted of adolescents (12,5-17,5 years of age) from 10 European cities, which participated the HELENA research. The following measurements were conducted: body mass, body height, waist circumference (WC), hip circumference, skinfolds thickness, fat mass (FM), body mass index (BMI), waist to hip ratio (WHR). Moreover measured the levels of: fasting plasma glucose and serum insulin. Additionally, homeostatis model assessment (HOMA-IR), which is an insulin resistance indicator, was calculated. The obtained results have shown, that HOMA-IR was statistically significantly correlated with BMI, WC, skinfolds sum, WHR and FM. On the other hand it was also stated, that WC was stronger related to HOMA-IR when compare with other anthropometric indices, among the persons with obesity/ overweight. Based on the collected results, it can be suggested, that WC and WHR indices could be used as alternative sources of identification the adolescent with obesity/ overweight at risk for developing insulin resistance (IR).

Other authors [2] conducted the research, where body mass index (BMI) with several anthropometric indexes related to abdominal obesity were compared. The study was carried out for a group of Brazilian teenagers who attended public schools, during the years 2003-2008. The whole research was divided into two cross-sectional studies, one in 2003 year (N.503) and the second in 2008 year (N.498). Body mass index (BMI), waist and hip circumference (WC and HC), waist to hip ratio (WHR), waist to height ratio (WHtR) were measured. The calculated mean values were compared between both studies using line regression and percentile values using quantile regression. For statistical significance $p<0,05$ was agreed. The obtained results showed, that WC mean values decreased for boys and that BMI mean values increased for girls. Among the investigated boys, the percentiles of WC, HC, and WHtR were lower, however the percentile of WHR were higher in 2008 year, than in 2003 year. In turn, among investigated girls, the values of all measurements were higher in 2008 year, except for WHR. The stated conclusion from that research was, that the anthropometric factors for boys tended to decreasing, while for girls tended to increasing from 2003 to 2008 year. This conclusion indicates an important sexual influence, but also higher risk of morbidity related to excess of fat content for girls.

The next interesting study [4] was conducted in order to verify the argument, that the following indices: BMI, WC, WHR and WHtR determined for active and sedentary students, give misleading results concerning body fat content. 272 students participated this research. 177 of them (90 men and 87 women) were defined as "active" (physical activity 7-9 hour/ week) and 95 of them (49 men and 46 women) were defined as having "sedentary lifestyle" (physical activity 1,5 hour/ week). Body mass, body height, waist and hip circumferences were measured and BMI, WHR, WHtR and BAI (Body Adiposity Index) were calculated. The fat mass (%) was assessed used four measurements of skinfolds. The obtained results, allowed to assume, that BMI overestimates the obesity for slim persons (active man and women and also sedentary lifestyle men), but at the same time minimizes the fat mass for persons with obesity (sedentary lifestyle women). In all investigated groups BMI, WHR, WHtR and BAI were significantly correlated with fat mass content (except for WHR and waist circumference respectively for active women and sedentary lifestyle women). Those conclusions may show, that independently from any physical activities and sex, none of calculated indices can effectively determine the real fat mass for adolescent. This in fact can leads to misshapen picture of the body condition and afterwards to unhealthy eating habits for young people.

Other authors [10] in their study tried to determine the correlation between the abdominal obesity with depression. Their research participated 5000 persons registered in Gutenberg Health Study (GHS). In order to find this correlation, the line regression models were calculated, where anthropometric measurements: BMI, WC, WHR and WHtR were determined as dependent variables and lifestyle factors, cardiovascular risk and psychotropic drugs, were determined as potential factors jamming obesity/depression. It has been shown, that somatic/ affective depression symptoms have higher relation to anthropometric measurements, than cognitive/affective symptoms. This argument refers also to young people with obesity, starting from 35 years old.

Conclusions

1. The obtained mean values calculated for considered somatic features for men and women are similar (go almost in parallel in all study years).
2. All sexual dimorphism indexes indicate that almost all analysed somatic features are higher in men groups, apart from FM (%).
3. Considering sexual dimorphism index (SDI) it can be said, that negative SDI values indicate the advantage of investigated feature in favour of men, however the positive values- in favour of women. The higher absolute value of SDI, the bigger advantage of the one feature. The absolute value of SDI reflects the sexual degree of differentiation and this correlation is directly proportional. The obtained results show, that all SDI values are higher in favour of men, apart from FM(%), which is higher in all research years in favour of women and the differences are statistically significant ($p<0,01$). The highest SDI was noted for FM(%), in 2009 year (5,57)
4. Using the t-student test when comparing somatic features for men and women it was observed, that during all research years there were significant differences in body height, body mass, FM(%) and AMC. Those differences were statistically significant ($p<0,01$). Additionally, no statistical differences were noted for WHR.
5. In all study years men had higher body height and mass results, than women. Those differences were found as statistically significant ($p<0,01$).
6. BMI values differ during all research years, however they are higher for men than for women during all study duration.

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