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CORRELATION OF BODY MASS INDEX, SKELETAL MUSCLE, SUBCUTANEOUS AND VISCERAL ADIPOSE TISSUE IN HEALTHY ADULTS: A CROSS SECTIONAL STUDY

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ABSTRACT. Introduction. Obesity is one of the 21st century major health challenges. Adipose tissue is distributed in different proportions in the human body depending on where it is located in the body. **The purpose of the research.** This study aims to determine the relationship between body mass index, skeletal muscle, subcutaneous and visceral adipose tissue in case of first year students of Partium Christian University from Oradea. **Subjects and methods.** The research included a sample group of 112 students. The analysis of the body composition was performed using the method of bioelectrical impedance. **Results.** The registered data reveal that 23% of the subjects were overweight or obese and 15% had a low percentage of skeletal muscle. **Conclusions.** In case of both genders there is a significant negative correlation between the percentage of skeletal muscle and subcutaneous adipose tissue and a significant negative correlation between the percentage of skeletal muscle and visceral adipose tissue.

Keywords: *body mass index, skeletal muscle, subcutaneous adipose tissue, visceral adipose tissue*

REZUMAT. ***Asocierea dintre indicele de masă corporală, masă musculară, ţesutul adipos subcutanat şi cel visceral la adulţi sănătoşi: studiu transversal.*** **Introducere.** În secolul XXI obezitatea reprezintă una dintre marile provocări medicale ale lumii. Țesutul adipos este distribuit în diferite proporţii în corpul uman în funcție de localizarea sa. **Scopul cercetării.** Scopul acestui studiu constă în determinarea relației dintre indicele de masă corporală, masa musculară, ţesutul adipos subcutanat şi cel visceral la studenţii din anul I ai Universităţii Creştine Partium din Oradea. **Subiecţi şi metode.** Cercetarea a inclus un eşantion de 112 studenţi. Analiza compoziției corporale s-a făcut prin metoda bioimpedanţei electrice. **Rezultate.** Conform datelor înregistrate 23% dintre subiecţi au fost supraponderali sau obezi şi 15% au avut un procent de mușchi scheletici scăzut.

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Concluzii. În cazul ambelor genuri există o corelație negativă semnificativă între procentul de mușchi scheletic și țesutul adipos subcutanat și o corelație negativă semnificativă între procentul de mușchi scheletici și țesutul adipos visceral.

Cuvinte-cheie: *indicele de masă corporală, masă musculară, țesut adipos subcutanat, țesut adipos visceral*

Introduction

Obesity is one of the 21st century major health challenges. Adipose tissue can be categorized into two types, depending on where it is located in the body. Thus, there is a visceral (intraperitoneal) adipose tissue and two types of subcutaneous adipose tissue, distributed in the upper or lower part of the body (Grundy, 2015). Although both types of adipose tissue are important, the world pays more attention to visceral adipose tissue which in some cases is associated with an increased risk of developing certain pathologies.

Adipose tissue is distributed in different proportions in the human body depending on gender (Wu et al., 2001), age (Kyle et al., 2001), genetic inheritance (An et al., 2000), diet (Ramos et al., 2001), physical activity (Kanaley et al., 2001), hormone levels and medication (Evans et al., 2001).

There are two important theories regarding the manner in which the distribution of adipose tissue can influence the appearance and maintenance of metabolic syndrome: a) central or visceral obesity leads to increased mobilization of fatty acids in the portal circulation (Frayn et al., 1996), b) metabolic syndrome originates in the visceral tissue through the accumulation of macrophages, which in turn occurs following adipocyte hypertrophy (Cinti et al., 2005, Trayhurn et al., 2008).

The analysis of body composition using the BIA method is frequently applied in clinical studies and it is considered an accessible, efficient and less expensive method for determining body composition (Mourtzakis et al., 2008 & Kyle et al., 2004).

Subjects and Methods

The research took place between December the 3rd and the 21st, 2018, on a sample group of 112 students aged 18 and 19, in first year at Partium Christian University of Oradea.

The anthropometric method was used to measure the two somatic indicators: height and weight, using a Seca 213 height measure and an Omron BF511 electronic scale. The BMI was calculated according to the reference chart based on age and gender using four categories of nutritional status (Barlow & Committee 2007).

In order to determine the percentage of subcutaneous AT, indicative standard values were used according to the age and gender of the subjects (McCarthy, Cole, Fry, Jebb & Prentice, 2006 and Gallagher, Heymsfield, Moonseong, Jebb, Murgatroyd & Sacamoto, 2000) and it is classified into four levels by Omron Healthcare: a) below the normal limit (BNL) (for girls <21.0%; for boys <8.0%), b) normal values (NV) (for girls 21.0 - 32.9%; for boys 8.0 - 19.9 %) c) excess adipose tissue (EAT) (for girls 33.0 - 38.9%; for boys 20.0 - 24.9%) d) obesity (OBS) (for girls ≥ 39.0%; for boys ≥ 25.0%).

Omron Healthcare's indicative standard values were used to determine the percentage of visceral AT and it is classified into three levels: normal values (1-9), high (10-14), very high (15-30) (Manual de instrucțiuni, 2011).

The interpretation of the result for the percentage of skeletal muscle was calculated according to the indicative values of Omron Healthcare and it is classified into four levels: a) low level (for girls <24.3%, for boys <33.3%; b) normal (for girls 24.3 - 30.3%, for boys 33.3 - 39.3%); c) high (for girls 30.4 - 35.3%, for boys 39.4 - 44.0%); very high (for girls ≥ 35.4%, for boys ≥ 44.1%) (Manual de instrucțiuni, 2011).

To test the significance of the differences between the mean values, we used the non-parametric Mann Whitney-U test, and in cases of a normal distribution of the scores, we used the Independent Sample t test. To see the strength and direction of the relationship between the variables, we used the Pearson correlation coefficient (parametric) and the Spearman rho coefficient (non-parametric).

Results

Following the processing of the collected data, it resulted that 73 women and 39 men participated to the measurements. Using the Kolmogorov-Smirnov test, the normality of the distribution of the obtained data was checked (table 1) resulting in values below the threshold of 95% for the following variables in case of women (weight, BMI, percentage of subcutaneous adipose tissue and visceral adipose tissue). For these variables the data are not normally distributed, thus the non-parametric tests will be used in those cases.

Table 1. Testing the normality of the distribution of the research's variables (N=112)

Variable	Tests of Normality Kolmogorov-Smirnov					
	Women			Men		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Height	0.064	73	0.200*	0.126	39	0.123
Weight	0.155	73	< 0.001	0.119	39	0.177
BMI	0.184	73	< 0.001	0.076	39	0.200*
Percentage of subcutaneous adipose tissue	0.105	73	< 0.05	0.089	39	0.200*
Visceral adipose tissue	0.211	73	< 0.001	0.103	39	0.200*
Percentage of skeletal muscle	0.095	73	0.168	0.134	39	0.076

Note: Df = the degrees of freedom (which is equal to N)

Table 2. Distribution of BMI depending on the gender of the subjects (N=112)

BMI Percentile / Nutritional status	W		M		W+M	
	N	%	N	%	N	%
Underweight BMI percentile < 5	1	2	4	10	5	4
Normal weight BMI percentile 5-85	55	75	26	67	81	73
Overweight and obesity BMI >85	17	23	9	23	26	23
Obesity BMI percentile ≥ 95	8	11	3	8	11	10
Total	73	100	39	100	112	100

Note: W = Women, M = Men

The registered data reveal that 73% of the subjects had a normal weight, 13% were overweight and 10% were obese (Table 2). According to Table 3, 48% had a percentage of AT within normal values (44% in case of girls; 54% in case of boys including BNL), 24% were overweight (25% in case of girls; 23% in case of boys) and 28% were obese (31% of girls; 23% of boys).

Table 3. Distribution of the subcutaneous adipose tissue depending on the gender of the subjects (N=112)

Indicative standard value	W		M		W+M	
	N	%	N	%	N	%
Below normal limit	-	-	1	2	1	1
Normal values	32	44	20	52	52	47
Excess adipose tissue	18	25	9	23	27	24
Obesity	23	31	9	23	32	28
Total	73	100	39	100	112	100

Note: W = Women, M = Men

Out of the total sample group, 97% had a percentage of visceral AT within normal values (108 subjects) and 3% (4 subjects) had high values.

Table 4. Distribution of the percentage of skeletal muscle depending on the gender of the subjects

Nutritional status	W		M		W+M	
	N	%	N	%	N	%
Low	16	21	2	5	18	15
Normal	53	73	10	26	63	57
High	3	4	22	56	25	23
Very high	1	2	5	13	6	5

Note: W = Women, M = Men, (N=112)

According to Table 4, 73% of girls and 26% of boys had a percentage of skeletal muscle within normal values. 6% of girls and 69% of boys had a high and very high percentage of skeletal muscle. According to Table 5, there is a significant negative correlation ($p < 0.001$ in case of women, $p < 0.05$ in case of men) between BMI and skeletal muscle percentage, and a significant positive correlation ($p < 0.001$) between BMI and the percentage of subcutaneous and visceral AT.

Table 5. The correlation between BMI and the SM percentage, subcutaneous AT percentage and visceral AT percentage

Variable	Women N = 73		Men N = 39	
Percentage of SM	$r_{xy} = - 0.73^{**}$	$r_s = - 0.76^{**}$	$r_{xy} = - 0.37^{*}$	-
	$p < 0.001$	$p < 0.001$	$p < 0.05$	-
	$n = 73$	$n = 73$	$n = 39$	-
Percentage of subcutaneous AT	-	$r_s = 0.97^{**}$	$r_{xy} = 0.89^{**}$	-
	-	$p < 0.001$	$p < 0.001$	-
	-	$n = 73$	$n = 39$	-
Percentage of visceral AT	-	$r_s = 0.91^{**}$	$r_{xy} = 0.95^{**}$	-
	-	$p < 0.001$	$p < 0.001$	-
	-	$n = 73$	$n = 39$	-

Note: r_{xy} = Pearson correlation coefficient, r_s = Spearman rho correlation coefficient, SM = skeletal muscle, AT = adipose tissue

Referring to women, there is a significant negative correlation between the percentage of skeletal muscle and subcutaneous adipose tissue ($r_{xy} = - 0.87$, $df = 73$, $p < 0.001$), ($r_s = - 0.88$, $df = 73$, $p < 0.001$). At the same time, there is a significant negative correlation between the percentage of skeletal muscle and visceral adipose tissue ($r_{xy} = - 0.63$, $df = 73$, $p < 0.001$), ($r_s = - 0.72$, $df = 73$, $p < 0.001$).

In case of boys, there is a significant negative correlation between the percentage of skeletal muscle and subcutaneous adipose tissue (r_{xy} = - 0.67, df = 39, p < 0.001). At the same time, there is a significant negative correlation between the percentage of skeletal muscle and visceral adipose tissue (r_{xy} = - 0.61, df = 39, p < 0.001).

Discussions

The adipose organ becomes fully developed at the age of puberty, its development being supported primarily by the proliferation process. However, it has recently been described that, regardless of age or BMI, 10% of fat cells are renewed annually, which demonstrates the existence of a dynamic process of adipocyte turnover in the adult adipose organ (Spalding and others, 2008). BMI is a tool representing the standard in assessing the risks occurred as a result of excess weight. According to the results of BMI values, 13% of the subjects were overweight and 10% were obese, compared to the values of adipose tissue from which it results that 24% were overweight and 28% obese. We notice a difference of 29% of the subjects with weight problems.

According to studies on a sample group of 52 students from Safarik University in Košice, Slovakia, 50% of the subjects were overweight (BMI ≥ 85th %ile) out of which 15% were obese (BMI ≥ 95th %ile) (Brtkova et al., 2014).

Conclusions

In case of girls, there is a significant negative correlation between the percentage of skeletal muscle and subcutaneous adipose tissue (r_{xy} = - 0.87, df = 73, p < 0.001), (r_s = - 0.88, df = 73, p < 0.001) and there is a significant negative correlation between the percentage of skeletal muscle and visceral adipose tissue (r_{xy}= - 0.63, df = 73, p< 0.001), (r_s = - 0.72, df = 73, p < 0.001). In case of boys, there is a significant negative correlation between the percentage of skeletal muscle and subcutaneous adipose tissue (r_{xy} = - 0.67, df = 39, p < 0.001) and there is a significant negative correlation between the percentage of skeletal muscle and visceral adipose tissue (r_{xy} = - 0.61, df = 39, p < 0.001).

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