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ORIGINAL ARTICLE

DIAGNOSIS OF OBESITY AND EVALUATION OF THE RISK OF PREMATURE DEATH (ABSI) BASED ON BODY MASS INDEX AND VISCERAL FAT AREA

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ABSTRACT

Background. Body mass index (BMI) is the most commonly used parameter for identifying obesity. However, it is a tool that can distort the diagnosis as misdiagnose.

Objective. The aim of the study was to evaluate the BMI and visceral fat area (VFA) and to determine the presence of obesity in a group of young people and to assess their suitability for use together with other parameters indicating excessive body fat and increased risk of non-communicable disease and premature death.

Material and Methods. The study group consisted of 339 university students. We used InBody 720 for diagnosis body composition. The following body composition parameters were measured – BMI, waist circumference (WC), fat-free mass (FFM), VFA, percentage of body fat (PBF).

Results. The BMI values by gender indicate overweight in the male group compared to females (25.2 ± 3.1 and 22.2 ± 3.4 kg.m-2, respectively; p<0.001). Women had higher values of VFA than men (70.1 ± 26.4 and 56.2 ± 28.3 cm2, respectively; p<0.001). Although the group of men had an increased average BMI, which allows us to talk about overweight, the risk of premature death was low. In the case of the male group, a high proportion of fat-free mass had a major impact on BMI. Lower values of fat parameters also contributed to the low risk of premature death. We found a nonlinear relationship in the BMI assessment in terms of premature risk of death. Higher values of the premature death risk were found in the subgroups of underweight and obesity. In the case of the VFA and ABSI relationship a linear increase in the curve and the risk of premature death was observed.

Conclusions. In order to evaluate the presence of overweight or obesity it is necessary to use not only BMI but other diagnostic elements for this purpose. The components of the body composition need to be evaluated comprehensively. Evidence of this is the risk of premature death, where optimal BMI values may pose an increased risk and vice versa.

Key words: *body mass index, visceral fat area, obesity, ABSI, premature death*

INTRODUCTION

Lifestyle changes contribute to the increasing incidence of obesity and factors that increase weight include, in particular, a sedentary lifestyle, unhealthy diet and physical inactivity [1]. *Corder* et al. [2] in their meta-analysis showed a decrease in physical activity from the period of adolescence to young adulthood by 13-17%. According to *da Silva* et al. [3] in people who performed physical activity for more than 300 minutes per week, the incidence of obesity was lower compared to the inactive. Those who performed higher intensity activities had a significant protective factor against obesity. *Svozilová* et al. [4] found out the significant associations between adiposity and physical activity and sedentary behaviour patterns even in older women.

Overweight and obesity are complex states of multifactorial origin. Obesity is the result of a violation of energy balance by too many calories consumed and their too low expenditure [5]. Obesity poses a major threat to public health because its prevalence increases very rapidly and has a significant impact on health harm and poor quality of life [6]. It can cause and/or worsen a wide range of concomitant diseases such as cardiovascular disease, type 2 diabetes mellitus, and also increase the risk of developing certain cancers, leading to increased morbidity and mortality [7, 8, 9].

Analysis of body composition is a very important part of the evaluation of the state of nutrition in

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humans and helps to determine the basic nutritional state and diagnose obesity, assess the state of health and the risk of the disease [10]. The composition of the body can be measured in several ways. Anthropometric measurements are an effective and non-invasive method of measuring the composition of the body. Currently, in epidemiology, clinical nutrition and research, body mass index is most often used for the usual characteristics of the state of weight for ease of measurement. However, body mass index is a weak and indirect measure of body composition, because it can be increased due to higher fat mass, but also due to muscle mass [11]. It provides only approximate information on body composition without distinguishing between fat mass and muscle mass. This deficiency can lead to incorrect classification of healthy people [12]. Likewise, body mass index does not distinguish between visceral fat and subcutaneous fat. Individuals with excessive amounts of visceral fat and ectopic fat have a higher cardiometabolic risk [13]. Therefore, central obesity indices could be more reliable indicators of adiposity. Having a larger waist circumference, even within the normal BMI range, is associated with cardiometabolic abnormalities [14] and a higher risk of mortality and morbidity [15, 16]. *Aune* et al. [17] found that abdominal obesity, an increase in waist circumference of 10 cm, led to an increased incidence of heart failure. As a result of these deficiencies, other and newer indicators and variables such as visceral fat or a body shape index for more accurate diagnosis of obesity and mortality estimate are gradually included [18].

The aim of the work was to evaluate the body mass index and visceral fat area and to determine the presence of obesity in a selected group of young people and to assess their suitability for use together with other parameters indicating excessive body fat and increased risk of non-communicable disease and premature death.

MATERIALS AND METHODS

Characteristics of the study group

The study group consisted of 339 university students of the Human Nutrition study program (254 women, age 18-24 years and 85 men, age 18-24 years) with average age 21 ± 2 years. The basic characteristics of the group are given in Table 1. The participant's group consisted of healthy young adults.

Anthropometric measurements

We used InBody 720 (Biospace Co. Ltd., Seoul, Republic of Korea) for diagnosis body composition. Participants were informed about the measurement procedure before the start of the measurement and they were also emphasized information and warnings about the possible risks arising from the measurement if they have an electrical device implanted in their body on the heart or in case of pregnancy. Before the measurement, participants were asked to eliminate and refrain from drinking large amounts of water and all participants signed an informed written consent as well as consent to the processing of personal data. Lookin'Body 3.0 software was used to process the results. The following body composition parameters were measured – body mass index (BMI, $kg.m^{-2}$), waist circumference (WC, cm), fat-free mass (FFM, %), visceral fat area (VFA, cm^2), percentage of body fat (PBF, %). The body height of the participants was measured by using a stadiometer with an accuracy of 0.1 cm. The participant stood upright on a horizontal surface, barefoot, with palms turned inwards and fingers pointing downwards. The head was in horizontal plane. The height was measured from the sole of the feet to the top of the head. Body weight, body mass index, waist circumference, visceral fat area, percentage of body fat and fat-free mass were determined directly by InBody 720. The risk of premature death (ABSI z-score) was calculated according to the methodology of *Krakauer* and *Krakauer* [19]. Participants were assessed as obese if the BMI values were ≥ 30 $kg.m^{-2}$, waist circumference ≥ 88 cm and ≥ 102 cm, for women and men, respectively [20], visceral fat area ≥ 100 cm^2 and body fat percentage values ≥ 28% for women and for men ≥ 20% according to [21].

Statistical analysis

We used Microsoft Office Excel 2016 (Los Angeles, CA, USA) in combination with XLSTAT (Version 2019) to process data and STATISTICA Cz version 13 (TIBCO Software Inc., Palo Alto, California, USA) for statistical analysis. We present the basic statistical characteristics as mean, ± SD (standard deviation), max (maximum) and min (minimum). Levels of statistical significance were determined at $p<0.05$. With a one-factor variance analysis (ANOVA), we tested the differences between anthropometric data and compared using Post Hoc Test.

RESULTS

After a comprehensive evaluation of the study group, we can conclude that in terms of assessing the average BMI and VFA values, the research sample of participants was not included in the category of obesity (Table 1). Based on somatic and biological assumptions and expected differences in terms of gender, we evaluated groups of men and women separately. As expected, differences in key parameters between the genders were significant. The mean BMI values by gender indicate overweight in the male group compared to females (25.2±3.1 and 22.2±3.4

Table 1. Descriptive characteristics of study group (n = 339)

Parameters – all participants (n=339)	Mean	± SD	Max	Min	P – value
Age, years	21	2	24	18	= 0.59
Height, cm	171	8	195	151	< 0.001
Weight, kg	67.2	13.5	116	43	< 0.001
Body mass index, kg.m^{-2}	23.0	3.5	38.8	16.8	< 0.001
Waist circumference, cm	82.0	9.6	119.3	65.6	< 0.001
Fat-free mass, %	75.5	8.2	97.0	50.7	< 0.001
Visceral fat area, cm^2	66.6	27.5	171.1	5.0	< 0.001
Percentage of body fat, %	24.5	8.2	49.3	3.0	< 0.001
ABSI z-score (premature death risk)	0.1032	0.8887	2.3669	-2.7106	< 0.001
Female (n=254)	Mean	± SD	Max	Min	
Age, years	21	2	24	18	
Height, cm	167	6	189	151	
Weight, kg	62.4	10.5	116	43	
Body mass index, kg.m^{-2}	22.2	3.4	38.8	16.8	
Waist circumference, cm	80.4	9.2	119.3	65.6	
Fat-free mass, %	72.8	6.9	88.1	50.7	
Visceral fat area, cm^2	70.1	26.4	171.1	14.3	
Percentage of body fat, %	27.2	6.9	49.3	12.0	
ABSI z-score (premature death risk)	0.3004	0.7360	2.3669	-1.6175	
Male (n=85)	Mean	± SD	Max	Min	
Age, years	21	1	24	18	
Height, cm	180	6	195	168	
Weight, kg	81.6	11	108.7	59.6	
Body mass index, kg.m^{-2}	25.2	3.1	32.8	19.0	
Waist circumference, cm	87.1	9.3	118.1	68.9	
Fat-free mass, %	83.9	5.8	97.0	67.8	
Visceral fat area, cm^2	56.2	28.3	147.9	5.0	
Percentage of body fat, %	16.1	5.8	32.2	3.0	
ABSI z-score (premature death risk)	-0.4846	1.0381	2.3309	-2.7106	

Note. ± SD = standard deviation; Max = maximum value; Min = minimum value

kg.m^{-2}, respectively). We found a significant difference (p<0.001). In the case of a VFA assessment, we found that women had higher values than men (70.1±26.4 and 56.2±28.3 cm^2, respectively, p<0.001). Similarly, we recorded significant differences in other monitored parameters. Although the group of men had an increased average BMI, which allows us to talk about overweight, the risk of premature death was low. There was average risk of premature death for study group but low risk for men and high risk for women. However, in the case of BMI, it is necessary to evaluate the body composition in terms of the proportion of the muscular and fat part. In the case of the male group, a high proportion of fat-free mass had a major impact on BMI values. Lower values of fat parameters such as visceral fat area and percentage of body fat, as well as lower waist circumference values for the male category, also contributed to the low risk of premature death.

Subsequently we focused on the evaluation of the observed parameters in relation to other, equally important components of body composition. Participants were divided into individual subgroups according to average BMI values (Table 2). As expected, the values of other parameters, with the exception of fat-free mass, also increased with increasing BMI values. In the case of FFM, we found a linear but decreasing trend of values. According to *Kutáč* [22] the share of fat-free mass is about 85% for men and 75-80% for women. Of the 68 people who were categorized by BMI into the overweight group, 44.12% of them had FFM 80% or more. The inclusion of these individuals in the category of overweight according to BMI may not be correct, because BMI can be increased due to higher fat-free mass. We did not observe any significant differences in PBF (p = 0.59) between the underweight, normal weight and overweight groups. Significant differences were found between the obese group and all other groups (p < 0.001). There was a linear increase in waist circumference with increasing BMI values in all categories (p < 0.001). Our study confirmed a linear rise in visceral fat area values. The VFA upper reference standard value was exceeded only in the obese group.

Table 2. Body mass index in relation to selected parameters and categorization of the group according to the degree of obesity in terms of BMI

BMI kg.m^{-2}	n	BMI (kg.m^{-2})	WC (cm)	FFM (%)	VFA (cm^2)	PBF (%)	ABSI z-score
< 18,5 / underweight	18	17.87	71.33^a	78.5^a	46.5^a	21.51^a	0.73836^a
18,5-24,9 / normal weight	239	21.67	78.66^b	76.11^a	60.12^a	23.89^a	0.08434^b
25-30 / overweight	68	26.94	91.38^c	75.51^a	80.51^b	24.49^a	-0.1567^b
> 30 / obesity	14	32.56	108.28^d	62.3^b	136.10^c	37.70^b	0.87061^a

Note. n = number of participants; BMI = Body Mass Index; WC = Waist Circumference; FFM = Fat-Free Mass; VFA = Visceral Fat Area; PBF = Percentage of Body Fat; ABSI z-score = risk of premature death; ^{abcd} = different symbols in a line mean significant differences in average intergroup values

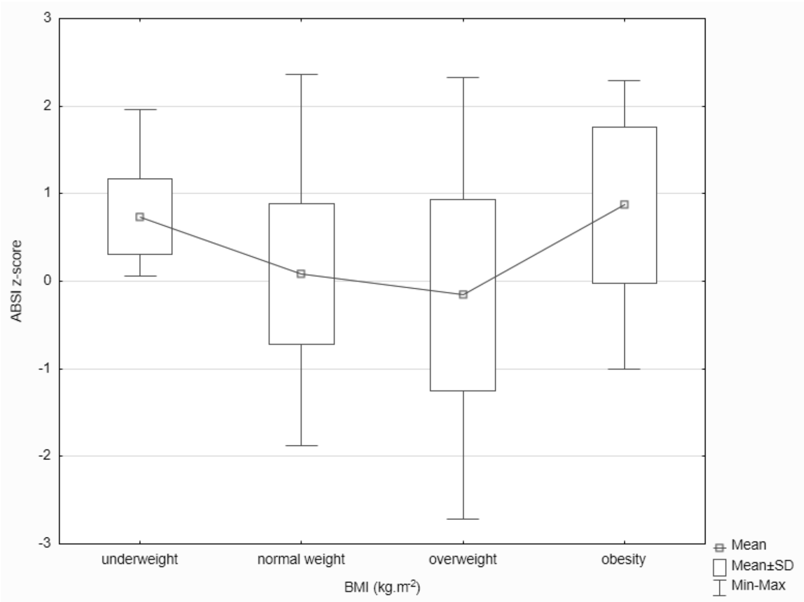

Figure 1. *Box Plot of ABSI z-score grouped by BMI (kg.m^{-2})*

We found a nonlinear relationship in the BMI assessment in terms of premature risk of death (Figure 1). Higher values of the premature death risk were found in the subgroups of underweight and obesity. In terms of the risk of premature death, just as *Krakauer* and *Krakauer* [19] state that at low and high BMI values there was an increase in the risk of mortality compared to medium values.

Visceral fat area is a very important element of body composition. For the health of the individual are not suitable either too low, but also not too high values of this parameter. A majority part of our study group consisted of participants with optimal or limit values of visceral fat area. We found a linear increase in the values of individual parameters with increasing VFA values, except fat-free mass, which had a decreasing curve trend. In most cases, there were significant differences (Table 3).

However, in contrast to the parabolic relationship between BMI and ABSI, we found in the case of the VFA and ABSI relationship a linear increase in the curve and the risk of premature death (Figure 2). From this point of view, the visceral fat area seems to be a very key element in the diagnosis of obesity, but also in the assessment of the health risks associated with it.

DISCUSSION

Body mass index is the most commonly used parameter for identifying obesity. However, it is a tool that, under the influence of several factors, can distort the diagnosis as misdiagnose. In order to evaluate the presence of overweight or obesity in an individual, it is necessary to use other diagnostic elements for this purpose, such as waist circumference, the percentage of fat in the body or the proportion of visceral fat in body weight, but also the proportion of active body mass [23].

The body mass index represents only an approximate assessment of obesity, because it does not capture the proportion of fat and fat-free mass [24, 12, 25, 26]. Based on these findings, we can conclude that the application of BMI is not suitable, for example, in

Table 3. The visceral fat area in relation to selected parameters and categorization of the group according to the degree of obesity in terms of VFA

VFA (cm^2)	n	VFA (cm^2)	WC (cm)	FFM (%)	BMI ($kg.m^{-2}$)	PBF (%)	ABSI z-score
< 40 / low	37	27.65	75.07[a]	87.67[a]	21.24[a]	12.34[a]	-0.7587[a]
40-70 / optimal	175	54.80	77.78[a]	78.29[b]	21.58[a]	21.71[b]	-0.0781[b]
> 70-100 / limit	91	82.81	85.69[b]	70.52[c]	24.08[b]	29.48[c]	0.39217[c]
> 100-130 / high	26	113.30	96.98[c]	63.93[d]	27.38[c]	36.07[d]	1.0911[d]
> 130 / extreme	10	149.08	110.58[d]	58.66[e]	32.50[d]	41.34[e]	1.2675[d]

Note. n = number of participants; VFA = Visceral Fat Area; BMI = Body Mass Index; WC = Waist Circumference; FFM = Fat-Free Mass; PBF = Percentage of Body Fat; ABSI z-score = risk of premature death; [abcde] = different symbols in a line mean significant differences in average intergroup values

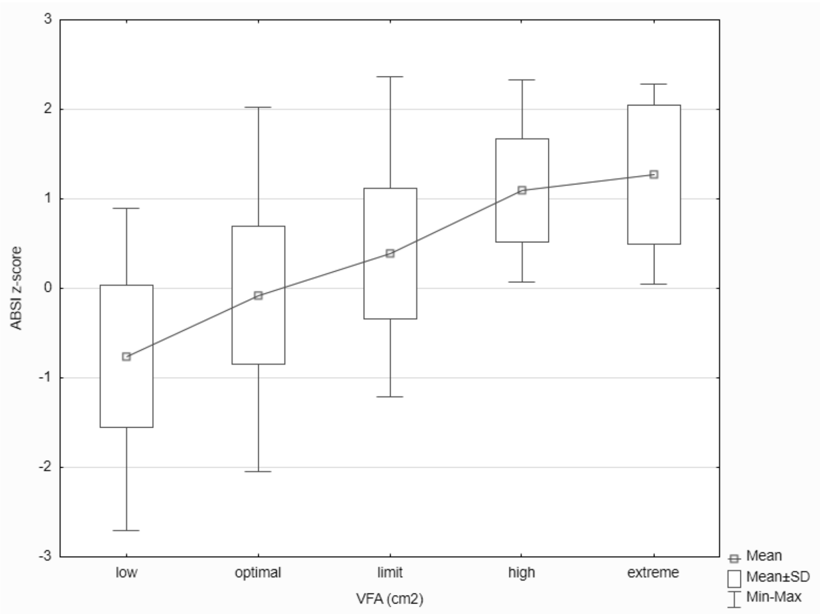

Figure 2. Box Plot of ABSI z-score grouped by VFA (cm2)

athletes or adults who have a high degree of muscle mass [27, 28, 23].

The percentage of body fat could be a more reliable and accurate indicator of general obesity and health risk compared to BMI [29]. The findings of the *Park* et al. [30] suggest that an increase in PBF was associated with a high risk of high blood pressure even in people who did not suffer from obesity.

Gierach et al. [31] found that the waist circumference was significantly correlated with BMI. Similarly, strong correlation between BMI and waist circumference was confirmed by *Sato* et al. [32]. *Aye* and *Sazali* [33] suggest that metabolic risk factors should be detected if waist circumference exceeds 80 cm regardless of gender and regardless of BMI values, as they suggest that waist circumference is a better predictor of risk factors for developing metabolic syndrome compared to BMI. Similarly, *Bouguerra* et al. [34] concluded that waist circumference is a suitable measure of adipose tissue in the abdominal area, which is a risk factor for diabetes and is closely related to other risk factors for cardiovascular disease. In the study by *Jacobs* et al. [35] increased waist circumference value was associated with a higher risk of mortality independently of BMI. The relative risk of death associated with a 10 cm increase in waist circumference ranged from 15% to 25% [35]. The positive association between waist circumference size and mortality in each BMI category is also confirmed by *Cerhan* et al. [36].

Visceral obesity compared to adiposity occurring in another area of the body is associated with higher metabolic morbidity and mortality due to higher levels of inflammatory processes [37]. It follows that, exceeding 100 cm^2 value is no longer very beneficial to health, even if BMI values would be in normal. *Zając-Gawlak* et al. [38] showed a 12 times higher risk of metabolic syndrome in women with VFA >100 cm^2 than in the VFA group < 100 cm^2. In glucose tolerance tests, subjects with VFA >100 cm^2

showed high serum triglycerides, high blood pressure and a high glucose profile [39]. The risk of mortality associated with cardiovascular disease increased at higher VFA values [40]. VFA can be considered as a good index of evaluation not only of accumulation of visceral fat, but also of cardiovascular factors [41]. The waist circumference was in the study by *Janssen* et al. [14] regardless of gender, a stronger correlate of visceral fat compared to BMI. Similarly, we could see this in our group of monitored participants, because the BMI in the group with the boundary visceral fat area was in the range of normal weight and the waist circumference already showed an increased risk for the female gender. Based on the findings of the study by *Gažarová* et al. [42], the size of VFA captures abdominal obesity and may point to an increased risk of associated diseases.

CONCLUSIONS

It is necessary to focus our attention in the routine diagnosis of obesity not only on the evaluation of BMI, but also other anthropometric parameters. Slightly elevated BMI values do not necessarily mean overweight, but it can be a significant effect of lean mass on body weight, which naturally distorts the resulting diagnosis. Attention should be focused, among other things, on visceral fat, which has a significant effect on health and metabolic processes in the body. At the same time, overweight and obesity need to be assessed from a comprehensive perspective in relation to the risk of morbidity and mortality, as well as premature death. As we confirmed in our study, mild overweight in BMI may even be inversely related to the risk of premature death, but this was not confirmed in the case of visceral fat.

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Conflict of interest

There were no conflicts of interest.

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