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Original article

WAIST CIRCUMFERENCE, WAIST-TO-HIP RATIO CUT-OFF POINTS TO PREDICT OBESITY AND METABOLIC SYNDROME AMONG STUDENT POPULATION IN SKOPJE, NORTH MACEDONIA

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Abstract

Introduction. Abdominal obesity is the most frequently observed component of metabolic syndrome. Any anthropometric measure is only the first step in identifying people at 'early health risk'.

This study aimed to determine a cut-off point of selected anthropometric indicators and to analyze the prevalence of normal weight obesity and abdominal obesity among university students.

Subjects and methods. The study included 839 healthy students aged 18-20 (411 males and 428 females) from the Ss. Cyril and Methodius University in Skopje, R. North Macedonia. The following anthropometric parameters were measured: weight, height, two circumferences (waist WC and hip HC) using a standard protocol. The following indices were taken into consideration: Body Mass Index (BMI), WC and Waist-to-Hip Ratio (WHR).

Results. The prevalence of obesity across BMI cut-off points among Macedonian students was 22.22%. In the underweight group, the number of female students was significantly higher (12.61% *vs* 2.19%), while in the overweight and obesity group a higher percentage of male students was observed (27.5% *vs* 9.11% and 6.81% *vs* 1.41%). Prevalence of abdominal obesity according to WC and WHR cut-off among Macedonian students were: female had the prevalence of abdominal obesity (overweight and obese) of 25.47% WC and WHR 43.23%, respectively. Both cut-off points for the males were 34.55% WC and 52.81% WHR. However, the Macedonian cut-off points for WC and WHR showed a higher prevalence of abdominal obesity among males.

Conclusion. These results and determination of BMI, WC, WHR cut-off values can be used for the prediction of consequences associated with obesity.

Keywords: BMI, WC, WHR, student population

Introduction

An increase in the prevalence of obesity has become a worldwide major health problem in adults, as well as among children and adolescents [1]. Obesity is a significant risk factor for the development of several diseases, such as type 2 diabetes, metabolic syndrome (MetS) cardiovascular diseases, numerous tumors and musculoskeletal disorders as well as a cause of high mortality[2]. The early identification of metabolic disorders allows for early intervention and prevention of serious consequences of diseases. Observed in clinical practice for decades, the MetS is now recognized as having public health importance, most probably due to the growing global prevalence of obesity. The average prevalence of the metabolic syndrome is 31% and is associated with a two-fold increase in the risk of coronary heart disease, cerebrovascular disease, and a 1.5-fold increase in the risk of all-cause mortality. Overweight or obesity (body mass index [BMI] $\geq$25 kg/m^2) characterize 82.5%, 76.4%, and 73.6% of people with type 2 diabetes, hypertension, and dyslipidemia, respectively, and identification of single metabolic disorders that are components of metabolic syndrome (MetS)[3,4].

BMI is commonly used to evaluate obesity. This indicator is simple, easy to calculate, and has clearly defined cut-off points. Because of its low cost, it is used in research worldwide and it enables the comparison of nutritional statuses in different populations[4].

Abdominal obesity is the most frequently observed component of metabolic syndrome. The distribution of adipose tissue has been related to cardiovascular risk factors and biochemical components of the metabolic syndrome[5]. Allowing for very strong correlations with one of the MetS components (i.e., WC) and the inclusion of waist circumference (WC) in the definition of MetS, and index waist-to-hip ratio (WHR) has received attention worldwide because it has found a wide application in the identification of metabolic disorders[6-8].

Any anthropometric measure is only the first step in identifying people at 'early health risk'. The most significant advantages of anthropometric indices include the following: non-invasiveness, low cost, standardized techniques and simplicity of measurements, and the possibility to apply them on a large scale[9-11].

The World Health Organization (WHO) reported sex-specific cut-off values of anthropometric indices to define overweight or obese people[12]. These cut-off values (for WC) are adopted by several medical organizations to define metabolic syndrome. However, these cut-off levels may not necessarily represent the characteristics of the other populations. Therefore, it is recommended that the sex-specific cut-off points should be established for different ethnic groups[13].

Consequently, this study aimed to determine the optimal cut-off points of selected anthropometric indicators to predict the risk of overweight and obesity among university students. Furthermore, our secondary aim was to analyze the prevalence of normal weight obesity and abdominal obesity which provides revealing of latent types of obesity that hold higher risks.

Materials and methods

Subjects

The study included a healthy student population from both sexes aged 18-20 years from the Ss. Cyril and Methodius University in Skopje, R. North Macedonia. Our study was part of the scientific project "Anthropometric and biochemical parameters in detecting obesity as a risk factor for metabolic syndrome in the student population" in which both the Institute of Anatomy and Institute of Medical and Experimental Biochemistry, Faculty of Medicine in Skopje, were involved. Approval was obtained from the Ethics Committee of the Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, and the study was designed following the principles of the Declaration of Helsinki. The informed consents were obtained from all participants before the enrolment. It excluded subject with systemic and metabolic diseases. The total number of subjects (n=839) was divided into two subgroups by sex: 411 males and 428 females.

Anthropometry

Anthropometric indicators were measured using a standard protocol. When the measurements were done, the subjects were wearing light clothes (T-shirts and shorts), they removed their shoes and their anthropometric points and levels were previously marked. The following anthropometric parameters were measured: weight, height, waist circumference (WC) (measure at the end of several consecutive natural breaths, at a level parallel to the floor, a midpoint between the top of the iliac crest and the lower margin of the last palpable rib in the midaxillary line) and the hip circumference (HC) measured at a level parallel to the floor, at the largest circumference of the buttocks[14,15].

The instruments for measuring were standard and were regularly calibrated before measuring; their precision was controlled throughout the entire measurement process. The following standard anthropometric instruments were used: anthropometer by Martin for measuring height with a reading precision of 1 mm; medical decimal scales for measuring weight with a precision of 0.1 kg; stretch-resistant tape for measuring circumferences with a precision of 1 mm. The following indices were taken into consideration: BMI (dividing the weight by the square of the height) and WHR (waist circumference divided by hip circumference).

Definitions

For the aim of categorization of the anthropometric indices' values, the following cut-off points were used: BMI was classified as: underweight (<18.5 kg/m^2), normal or healthy weight (18.5-24.9 kg/m^2), overweight or preobese (25.0-29.9 kg/m^2), and obese (≥30 kg/m^2). Among men, WC was classified as normal values (<94 cm), overweight (94–101 cm), and obese (≥102 cm). The corresponding cut-off values for women were: <80, 80–87 and ≥88 cm, respectively. According to the WHO, a healthy WHR is <0.90 or less for men and ≥0.85 or less for women. According to other authors, WHR was classified among men as normal values (<0.90), overweight (0.90-0.99) or obese (≥1) and the corresponding cut-off values for women were <0.80, 0.80-0.84 and ≥0.85, respectively[6,9,12,13,16-18].

Statistics

The gathered data for the relevant variables were analyzed with descriptive statistics represented by central tendency and its deviation (arithmetic mean ± standard deviation) and percentage. Testing of sex differences was done with the analysis of variance for large, independent samples-ANOVA. Differences for $p < 0.05$ were considered significant.

Results

The study included a sample of 839 students aged 18 to 20, of whom females were 428 or 51.01% and males 411 or 48.99%. The mean age (±sd) was 19.39 (±0.76) years. Descriptive statistics (mean values and standard deviations) of the examined anthropometric indicators: weight, height, BMI, WC, HC and WHR, for all subjects and by sex group, as well as their sex differences (ANOVA- test) are presented in Table 1.

Table 1. Mean and standard deviations and sex-specific differences of examined anthropometric indicators among Macedonian students (n=839)

	Mean±SD		
Indicators	All subjects (n=839)	Males (n=411)	Females (n=428)
Age (year)	19.39±0.76	19.39±0.69	19.38±0.82
Weight (kg)	69.23±14.69	78.73±13.19*	60.11±9.23
Height (cm)	173±9.05	180±6.78*	167±5.81
BMI (kg/m²)	22.89±3.53	24.28±3.54*	21.56±2.97
WC (cm)	80.95±13.29	88.01±13.13*	74.17±9.32
HC (cm)	95.17±10.08	96.69±10.07*	93.7±9.89
WHR	0.85±0.1	0.91±0.09*	0.79±0.08

Values are mean ±SD=Standard deviation, BMI=Body Mass Index, WC=Waist Circumference, HC=Hip Circumference, WHR=Waist-Hip Ratio
*p<0.05 *vs* female (ANOVA)

The average values of the examined indicators for all subjects were: 69.23 kg±14.69 for weight, 173 cm±9.05 for height, 22.89 kg/m^2±3.53 for BMI, 80.95 cm±13.29 for WC, 95.17 cm ±10.08 for HC and 0.85±0.1 for WHR. The results of the comparative examinations of all these parameters showed the existence of sex-specific differences in favor of male subjects.

Prevalence of obesity across BMI based on the WHO cut-off points among Macedonian students are presented in Table 2.

In the present study, the number of participants with underweight, normal weight, overweight and obesity was: 63 (7.5%), 590 (70.3%), 152 (18.1%) and 34 (4.1%), respectively. In the underweight group, a significantly higher percentage were female students (12.61% *vs* 2.19%), while in the overweight and obesity group a higher percentage (27.5% vs 9.11% and 6.81% *vs* 1.41%) was male students.

Table 2. Prevalence of obesity across BMI based on WHO cut-off points among Macedonian students (N=839)

	BMI cutoff points		
BMI class	All subjects n (%)	Male n (%)	Female n (%)
Underweight	63 (7.5 %)	9 (2.19 %)	54 (12.61%)
Normal	590 (70.3 %)	261 (63.5%)	329 (76.87 %)
Overweight	152 (18.1 %)	113 (27.5%)	39 (9.11 %)
Obese	34 (4.1 %)	28 (6.81 %)	6 (1.41 %)

Underweight (<18.5 kg/m^2), Normal (18.5-24.99 kg/m^2), Overweight or preobese (25.0-29.99 kg/m^2), Obese (≥30 kg/m^2), BMI=Body Mass Index

Prevalence of abdominal (central) obesity according to waist circumference and waist-to-hip ratio among Macedonian students are presented in Table 3.

In the examined population of female students, normal values for WC were registered in 74.53% and based on WHR in 56.77%. The female subjects had a prevalence of abdominal obesity (overweight and obese) of 25.47% for WC and 43.23% for WHR.

Both cut-off points for male subjects were: 64.45 and 47.45% had normal values, and the prevalence of abdominal obesity was 34.55 % for WC and 52.81 % for WHR. It is interesting to note that for WHR in the obese risk group there was a higher percentage of female subjects (21.5 *vs* 13.14%) compared to the overweight group (21.73 *vs* 39.41%) where male respondents were in a higher percentage. However, the Macedonian cut-off points for WC and WHR showed a higher prevalence of abdominal obesity among male subjects.

Table 3. Prevalence of abdominal (central) obesity of waist circumference and waist-to-hip ratio among Macedonian students (n=839)

Abdominal obesity cut-off points			
	Normal	Overweight	Obese
WC (cm)*			
Male n (%)	269 (65.45%)	91 (22.14%)	51 (12.41%)
Female n (%)	319 (74.53%)	75 (17.52%)	34 (7.95%)
WHR**			
Male n (%)	195 (47.45%)	162 (39.41%)	54 (13.14%)
Female n (%)	243 (56.77%)	93 (21.73%)	92 (21.5%)

* WC cut-off points for male: normal (<94 cm), overweight (94–101 cm), and obese (≥102 cm); female: normal values (<80 cm), overweight (80–87 cm), and obese (≥88 cm);
**WHR cut-off points for male: normal (<0.90), overweight (0.90-0.99) or obese (≥1) and the corresponding cut-off values for women were normal (<0.80), overweight (0.80-0.84) and ≥0.85, respectively.

Table 4 shows the mean and standard deviations of anthropometric indices (WC and WHR) through BMI categories. According to Table 4, the mean value of WC and WHR was significantly different between the two groups of BMI (<25 and ≥25) in both females and males.

Table 4. Mean and standard deviations of anthropometric indices through BMI categories

	BMI <25 kg/m ^{2}		BMI ≥25 kg/m ^{2}	
	Male	**Female**	**Male**	**Female**
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD
WC	81.25±8.8*	72.54±7.69*	100.88±10.11*	88.02±10.67*
WHR	0.87±0.06*	0.79±0.08*	0.99±0.07*	0.84±0.1*

BMI, body mass index; WC, waist circumference; WHR, waist-to-height ratio, *p>0.05 values between the two groups of BMI in both females and males

Discussion

Obesity is a global epidemic affecting more than one third of the adult population in the world[4]. The occurrence of obesity in early life results in the early development of complications and a significant endangerment to the quality of life since the prevention of obesity in young individuals is a particularly important goal[19,20]. Industrialization and closely related urbanization have led to huge changes in the diet, the so called nutritional transition, as well as an increasingly present regressive tendency, which is reflected in the so-called recreational inactivity of modern people, i.e. sedentary lifestyle, which is also a significant weight factor which contributes to the occurrence of obesity in all groups[19].

The modern obese environment in combination with inadequate high-calorie diet, physical inactivity and stress have serious implications in the increase of numerous risk factors (obesity, increased cholesterol, hyperglycemia and hypertension) which give an increased possibility of metabolic diseases, diabetes, malignant neoplasms, etc. in student population[3,19,20].

As a result, our study conducted among students had the purpose to find out the risk of overweight and obesity in our student population as early as possible. With the BMI as a criterion for defining obesity, we registered 22.22% of students in the risk group (34.31% males and 10.52 females). The frequency of overweight and obesity was higher among male students (for overweight 27.5 *vs* 9.11% in females and for obesity 6.81 *vs* 1.41%.). On the other hand, it is especially important to point out that in the examined population 7.5% were underweight, of whom 12.61% were females and only 2.19% males. Similar results were registered in the student population in Brazil and Spain[18-20].

World Health Organization (WHO) guidelines state that alternative measures that reflect abdominal obesity such as WC, WHR, and waist-to-height ratio (WHtR) are superior to BMI[10,12].

Several studies have suggested that WC can be applied as a screening instrument for determining abdominal obesity and overweight rather than BMI[6,7,9,13,16,21]. A study among the Chinese population demonstrated that while BMI and WC were found to be the important indices of obesity, WC was found to be the best measurement of obesity whereas WHR could be used as an alternative indicator for obesity[6,7,17].

Similarly, WC was also found to be a simple and more accurate predictor of type 2 diabetes mellitus than other indices such as BMI and WHR. WC is an important measure of abdominal obesity compared to WHR[22,23].

In our study, abdominal obesity in females was registered in 25.47% for WC and 43.23% for WHR. Furthermore, in the group of overweight there were 17.52 *vs* 7.95% in the group of obese for WC, while for WHR 21.73 were overweight, and in the group with a higher risk or obese group were 21.5%. In our male students, abdominal obesity was found in 34.55 for WC and 52.81% for WHR. Furthermore, in the overweight group there were 22.14% while in the obese group 12.41% male students for WC, and 39.41 and 13.14% for WHR, respectively. Many studies have presented similar results[21-25]. In another study, WHR managed to identify a larger number of women in the underweight and normal groups as abdominally obese than did WC[7].

The predictive power of these indicators depends on population and varies from race to race. Ethnic and cultural diversity are considered as a reason for the major conflict on the differences in the measurement. WC and WHR are easy and reliable surrogate markers of the visceral adipose tissue mass and a simple index of cardiovascular risk[13, 25]. Visceral obesity, determined by increased WC, is a significant risk of cardiovascular morbidity and mortality and is one of the diagnostic criteria of the metabolic syndrome[26].

However, it is well reported that distinct ethnic groups may have significantly different visceral adipose tissue distributions and different cardiometabolic risk profiles[16, 21-23, 25, 27]. Therefore, the identification of risk by using WC is population-specific and depends on levels of obesity and other risk factors for cardiovascular disease and type 2 diabetes mellitus[28].

The WC and WHR cut-off levels in the present study were appropriate to identify the overweight and obese and had a reasonable power to establish subjects with increased cardiometabolic risk. Some studies have indicated that these indicators can be used alone as a screening tool for overweight and obese identification instead of BMI in weight management and control[27-29].

There is now good evidence that central obesity carries more health risks compared to total obesity assessed by body mass index (BMI). Many authors considered BMI as the simple and most commonly used index for measuring general obesity[30]. It has therefore been suggested that waist circumference (WC and WHR), a proxy for central obesity, should be included with BMI in a 'matrix' to categorize the health risk[10]. Thus, we have also presented values of WC and WHR through BMI categories in order to show the usefulness of their combination and ability to provide revealing of latent types of obesity and to identify more people at early health risk. Similar results have also been presented in many studies[7,9].

Many studies concluded that in the case of type 2 diabetes all anthropometric measures (BMI, waist circumference, waist-hip ratio) performed similarly in predicting the risk[8,31]. BMI indicates general obesity, waist circumference (WC) and waist-to-hip ratio (WHR) as markers for central or abdominal obesity[32].

The presence of obesity among young people requires the comprehensive detailed and timely diagnosis treatment of a disease. Observed in clinical practice for decades, the MetS is now recognized as having public health importance, most probably due to the growing global prevalence of obesity. Identifying metabolic disorders at the earliest phase of their development allows for early intervention and prevention of serious consequences of diseases.

Conclusion

The results obtained have indicated the need and obligation to focus on an accurate and complete diagnosis of obesity. Additionally, anthropometric variables have practical importance for planning certain preventive measures and activities in the field of nutrition in one country. They can also indicate certain misbalance as criteria for the selection of individuals for further clinical research. Moreover, the determination of BMI, WC, WHR optimal cut-off values for the prediction of consequences associated with obesity should be considered in clinical practice.

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