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CORRELATION BETWEEN ANTHROPOMETRIC INDICATORS OF OBESITY: BODY MASS INDEX (BMI) AND WAIST CIRCUMFERENCE (WC) IN STUDENT POPULATION FROM FROM NORTH MACEDONIA

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The body mass index (BMI) allows for assessing the prevalence of overweight/obesity within a population and determining general obesity. Waist circumference (WC) is a simple and practical anthropometric measure for assessing central adiposity.

This study aims to describe the correlation between BMI and WC and examined their significance as indicators of obesity in students.

In total, 839 university students aged 18-20 (411 male and 428 female) from Skopje, R. North Macedonia were analyzed. The following anthropometric parameters and indices were considered: weight, height, waist circumference and BMI using a standard protocol.

A male had a mean BMI of 24.28 kg/ m^2 and a mean WC of 88.01 cm. Females had a mean BMI of 21.56 kg/m^2 and a mean WC of 74.17 cm. There was a strong positive significant correlation between the BMI and the WC in males ($r = 0.81$), and a positive correlation in females ($r = 0.72$). In the identification of overweight/obesity, WC identified significantly more participants than the BMI (255 *vs* 186).

Both the BMI as well as the WC detect people at risk for weight-related diseases, but these results suggest that WC is a better predictor to detect subjects at high risk for abdominal obesity. The determination of obesity based on anthropometric indicators is still an important method for early prevention of serious consequences of obesity among the student population

Keywords: Body mass index, waist circumference, student population.

Introduction

Planning for obesity prevention is an important global health priority [1].

Traditionally, the body mass index (BMI) is used to describe anthropometric measurements and to assess weight-related health risks [2].

This indicator is a useful measure of overweight and obesity and divides subjects into appropriate categories: underweight, normal weight, overweight, and obese. The higher BMI, the higher risk for certain diseases such as heart disease, high blood pressure, type 2 diabetes, gallstones, breathing problems, and certain cancers. Even though BMI is commonly used for monitoring the occurrence population's obesity, it has numerous limitations. Due to the fact that BMI does not measure body fat directly, it does not provide any information on the distribution of the adipose tissue in the body and it should not be used as a diagnostic tool. Instead, BMI should be used as a measure to track weight status in populations and as a screening tool to identify potential weight problems in individuals [3].

Recent studies indicate that abdominal obesity (assessed based on the waist circumference) is more strongly associated with obesity-related health problems and plays a very important role in the development of metabolic disorders, cardiovascular disease, most cases of type 2 diabetes, and more than 10% of gastrointestinal as well as urogenital cancer [4-6].

Anthropometric indices including body mass index (BMI) and waist circumference (WC) are used most frequently to define different obesity categories among various populations [7].

In accordance with that, it has been suggested that waist circumference (WC) can complement body mass index to assess abdominal obesity [8].

The combination of BMI and WC might be better to evaluate the fat distribution. Current studies also showed that people with normal weight and abdominal obesity had a higher mortality risk and overweight without abdominal obesity had a lower mortality risk, demonstrating the importance of combining body mass index and waist circumference [9,10].

According to the authors, the WC should always be determined, even for individuals with normal BMI.

Consequently, this study aimed to describe the correlation between the selected anthropometric indicators of obesity BMI and WC among university students. Overweight/obesity is determined by the means of anthropometric indices, BMI for general as well as WC for central or abdominal obesity. Furthermore, we also assess their importance in identifying respondents who are at higher risk for weight-related diseases.

Materials and methods

Subjects

The study included a healthy student population of both sexes aged 18-20 years from St Cyril and Methodius University in Skopje, North Macedonia. Approval was obtained from the Ethical Commitie of the Faculty of Medicine, UKIM in Skopje, and the study was design in accordance with Declaration of Helsinki. The informed consents were obtained from all participants before the enrolmentt excluded subjects with systemic and metabolic diseases. The total number of subjects (n=839) was divided into two subgroups by sex: (n=411 male and n=428 female).

For the measurements 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) [11].

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 reading precision of 1 mm; medical decimal scales for measuring of weight with a precision of 0,1 kg; stretch-resistant tape for measuring circumferences with a precision of 1 mm; According to the aim the body mass index were taken into consideration: it is defined as body weight (in kilograms) divided by the square of body height (in metres).

Definitions

Body weight categories were defined according to WHO BMI cut-offs as follows: underweight as (<18.5 kg/m^2) or below; normal weight as 18.5-24.9 kg/m^2; overweight as 25.0-29.9 kg/m^2, and obese as BMI of 30.0 kg/m^2 or greater. The WC was also allocated into three categories with gender-specific cutoffs: normal risk (≤80 cm for women and ≤94 cm for men) or normal values, increased risk, overweight (between 80- 88 cm for women and 94-102 cm for men) and high risk, obese (≥88 cm for women and ≥102 cm for men)[12,13].

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. The significance of differences between variables was examined by applying the Anova analysis and Chi-square test. Differences for $p < 0.05$ and $p < 0.01$ were considered significant. In order to study the correlation between anthropometric indicators BMI, WC, weight and height Pearson's correlation coefficients were calculated for both sexes.

Results

The study included a sample of 839 students aged 18 to 20, with female (n= 428) or 51.01% and male (n=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 and WC, for all subjects and by gender group, as well as their sex-specific differences (ANOVA- test) are presented in Table 1.

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

	Mean±SD		
Indicators	**Total (n=839)**	**Male (n=411)**	**Female (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/m^2)	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

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

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

Percentage distribution of general and central or abdominal obesity based on WHO cutoff-points among participants, university students from North Macedonia are presented in Table 2. Overweight/obesity occurs in 34.31 % of the male and 10.52 % of the female.

In the underweight category a significantly higher percentage were female participant (12.61% vs 2.19%) while in the overweight/obesity category a higher percentage was male participant. Central or abdominal obesity across WC cut-off points (increased and high risk) occurs in the males and 142 (34.5%) and 109 (25.47 %) of the females respectively. It is interesting to note that for WC in the overweight (increased risk) and obese high-risk category there was a higher percentage of females compared to the same groups based on the BMI. Similar results were registered also for the male respondent. In line with those results, we found that WC is a better predictor than BMI in the early detection of subjects at high risk for abdominal obesity.

Table 2. Percentage gender distribution of general and central or abdominal obesity based on WHO cutoff-points among university students from North Macedonia.

	Total n (%)	**Male n (%)**	**Female n (%)**
Body Mass index (in kg/m2)			
Underweight (BMI<18.5)	63 (7.5%)	9 (2.19%)	54 (12.61%)
Normal weight (BMI<25)	590 (70.3%)	261(63.5%)	329(76.87%)
Overweight (25<BMI<30)	152 (18.1%)	113(27.5%)	39(9.11%)
Obesity (BMI≥30)	34 (4.1%)	28 (6.81%)	6 (1.41%)
Waist Circumference (in cm)			
Normal risk (M≤ 94, F≤ 80)	588 (70.08%)	269(64.45%)	319 (74.53%)
Increased risk (M 94-102, F 80-88)	166(19.79%)	91 (22.14%)	75 (17.52%)
High risk (M≥102, F≥88)	85 (10.13%)	51 (12.41%)	34 (7.95%)
BMI = body mass index, WC = waist circumference			

Futhermore, for both indicators, BMI and WC, for the general and abdominal obesity were registered statistical significant differences in favour in male (X^2 = 89.9342, p = < 0.00001; X^2 = 8.853, p = 0.011956) respectively.They are presented in Tables 3 and 4.

Table 3. Sex-specific differences of general obesity across BMI among participants, university students from North Macedonia (N=839).

	BMI				
	Underweight	**Normal weight**	**Overweight**	**Obese**	**Total**
Male	9 (30.86) [15.49]	261 (289.02) [2.72]	113 (74.46) [19.95]	28 (16.66) [7.73]	411
Female	54 (32.14) [14.87]	329 (300.98) [2.61]	39 (77.54) [19.16]	6 (17.34) [7.42]	428
Total	63	590	152	34	839
X^2 = 89.9342		**p = < 0.00001**			

Table 4. Sex-specific differences of abdominal obesity across WC among university students from North Macedonia (N=839).

	WC			
	Normal risk	**Increased risk**	**High risk**	**Total**
Male	269 (288.04) [1.26]	91 (81.32) [1.15]	51 (41.64) [2.10]	411
Female	319 (299.96) [1.21]	75 (84.68) [1.11]	34 (43.36) [2.02]	428
Total	588	166	85	839
X^2 = 8.853		**p = 0.011956**		

Table 5 shows the correlation of BMI, WC, weight and height. There was significant (p<0.01) positive correlation values between BMI, WC and weight, and negative correlation values between BMI and height in female respondents. The correlation of BMI with WC (r = 0.81) and weight (r = 0.89) is high positive and slightly stronger in male than in female (r = 0.72 and +0. 88 respectively) respondents. in addition, for both sex categories, the correlation of BMI with weight (r = 0.88) was slightly more pronounced than the correlation of BMI with WC (r = 0.81).

Table 5. Correlation table for BMI, Waist circumference, weight and height according to gender, university students from North Macedonia.

		WC	**Height**	**BMI**	**Weight**
Male	BMI	0.81*	0.07		0.89*
	WC		0.26	0.81*	0.82
Female	BMI	0.72*	-0.02		0.88*
	WC		0.16*	0.72*	0.73*
Total	BMI	0.81*	0.29		0.88*
	WC		0.5*	0.88*	0.85*

r-Pearson`s correlation coefficient, *- Pearson`s correlation coefficient is significant (p<0.01), BMI=Body Mass Index, WC=Waist Circumference

Discussion

This study examined the correlation between anthropometric indicators of obesity, BMI and WC among students population of both sexes from St Cyril and Methodius University in Skopje, North Macedonia. The study also shows the percentage distribution of general and abdominal obesity among the student population as well as the identification of high-risk categories according to the BMI and WC.

Twenty-seven and a half per cent of the male respondent were overweight and 6.81% was obese across BMI based on the WHO cut-off points. The percentage distribution among females was less: 9.11% for overweight and 1.41% for obesity. Only 65.45% of male and 74.53% of female respondents had a normal WC. The percentage distribution of increased WC with a high risk of abdominal (central) obesity was 12.41% in males and 7.95% in the females respondent.

Comparing the high-risk category for BMI and WC, it is remarkable that only 6 (1.41%) of the female are at high-risk or general obesity according to the BMI, but 34 (7.95%) are at high risk or abdominal obesity according to their WC. Among male respondent, the difference was less striking but still significant: 28 (6.81%) of men are at high-risk or obese according to the BMI, but 51 (12.41%) are at high-risk according to their WC or have abdominal obesity.

The correlation between BMI and WC is reported in this study. It is a significant (P<0.01) correlation between BMI, weight and waist circumference however, this is not the case with BMI and height. The correlation of BMI with weight (r=0.88) is slightly more positive than that of waist circumference (r=0.81). Despite this, there is still a relatively high positive linear correlation between BMI and waist circumference in males (r=0.81) and a positive linear correlation in females (r=0.72).

The observed correlation coefficient is similar to those from the meta-analysis by Vazquez et al,as well as in the study of Flegal et al, Wilmet et al, but considerably lower coefficients presented are in the study in Nigeria [2,14,15].

Many authors support the use of waist circumference as a measurement of overweight and obesity in other to predict health risks in people[1-3,6].

It was argued that waist circumference has been shown to be a good or better predictor of abdominal obesity and metabolic syndrome than BMI. Our results are in line with that but there is now good evidence that central obesity carries more health risks compared to obesity assessed by BMI.

Recent studies suggested the use of anthropometric indicators BMI and Waist circumference and their combination with the ability to provide revealing of latent types of obesity and to identify more people at early weight risk [16,17].

Presently, general obesity classified by BMI and central obesity classified by WC is both confirmed to be associated with incident hypertension in Chinese adults [16].

Studies often investigated general and central obesity separately, however, not all people with obesity have both high BMI and WC. A cohort study of US adults found that increased WC may not be related to the change in BMI and suggested that a combination of BMI and WC may provide a better prediction of obesity-related disease than the sole use of BMI or WC alone. Subsequently, Du T et al. indicated that approximately two-thirds of obese people would be missed if WC were not measured in China [18].

These findings implied the importance and necessity of identifying the specific obesity categories defined by BMI and WC simultaneously for predicting obesity-related hypertension. Oellingrath, et all provide novel information on the distribution of combined body mass index and waist circumference (BMI-WC) disease risk categories, lifestyle and health among Norwegian adults [19].

More than half of the population represented combined categories associated with elevated disease risk. Unfavourable health indicators increased with increasing disease risk, as indicated by the BMI-WC categories.

Cong and all in their study point to the importance of a combined consideration of body mass index and waist circumference in the identification of obesity models associated with stroke risk [20].

The findings highlight the importance of using both BMI categories and WC for a personalised assessment of obesity-related risk and the need for follow-up and are considered relevant to public health.

In our study, more male respondents were classified as the highest risk based on both anthropometric indicators. This might be due to the consciousness of the female to the societal perception which encourages slender-shaped females [21,22].

It also might be due to unhealthy eating habits (junky food) highly associated with this age group. In addition, a sedentary lifestyle has become a huge concern in one's life, in which physical inactivity has become a major health problem. The prevalence of sedentary life is increasing nowadays and it commonly strikes the student population. The sedentary lifestyle which leads to obesity is an important health issue and it is increasing on daily basis around the globe. It affects the whole body and mainly causes cardiovascular problems, MetS etc.

Overweight in young adults may have deleterious effects on their subsequent self-esteem, social and economic characteristics and physical health. It is, therefore necessary to monitor BMI and WC regularly to predict subjects with general or abdominal obesity and its attendant related diseases [23].

However, our results are useful as baseline data for future research, especially focusing on waist circumference as a screening tool for abdominal obesity.

Conclusion

The present study shows a strong positive correlation between anthropometric indicators the BMI and the WC. In the identification of respondents at high risk for obesity, the use of the WC identifies more respondents from both sexes than the BMI. Especially more female respondents are ranked in a higher-risk class with the WC than with the BMI classification.

Both the BMI and WC identify most respondents with an increased relative risk, but more male respondents were classified as overweight/ obese than females. Since waist circumference has been reported as a viable power predictor of major metabolic disorders, it is important to assess not only general but also abdominal obesity which is highly associated with elevation of health risk.

There are few arguments to prefer the use of WC above the BMI to detect subjects at high risk for weight-related disease but also are too arguments for their combination with the ability to provide revealing of latent types of obesity and to identify more people at the early stage of obesity-related disease.

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