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Original scientific paper

WAIST-TO-HEIGHT RATIO AS A SCREENING TOOL FOR IDENTIFYING OBESITY IN CHILDREN AND ADOLESCENTS

Veton ADEMI[1], Sadi BEXHETI[2], Alajdin HASANI[3], Muhamed TAIRI[1], Beshra ELEZI[4], Ema BEXHETI[4]

[1]Department of Nursing, Faculty of Medical Sciences, University of Tetova, MK*
[2]Department of Anatomy, Faculty of Medical Sciences, University of Tetova, MK*
[3]Department of Sports Medicine, Faculty of Medical Sciences, University of Tetova, MK*
[4]Tetovo Clinical Hospital, Tetovo, MK*
[*]Corresponding author e-mail:sadi.bexhetii@unite.edu.mk

Abstract

Background: Childhood and adolescence obesity is growing worldwide and raises concerns that overweight or obese children and adolescents are at greater risk of becoming obese than adults. An early diagnosis is very important, and for this purpose, WHtR is a very easy method to use as well as to be interpreted by healthcare workers.
Objective: The main purpose was to investigate the prevalence of childhood and adolescence obesity in the Tetovo region, North Macedonia by analyzing the waist-to-height ratio (WHtR), which has recently attracted attention as a very important anthropometric index for central obesity.
Methods: The character of this research is "Cross-sectional" and was conducted in primary and secondary schools in the region of Tetovo, North Macedonia, during the period April to June 2019 with 625 male and female students aged 12-17 years. The results were processed with statistical programs STATISTICA 10.0 and SPSS 20.0.
Results: The prevalence of overweight and obesity / abdominal obesity was respectively in 8.16% who belonged to the category increased risk/high risk and 0.64% who belonged to the category very high risk. Statistically significant results with $p<0.05$ were found between the mean values of skinfold thickness in relation to the WHtR.
Conclusion: The waist-to-height ratio is much safer than BMI in predicting Obesity and has a stronger association with cardiovascular disease as well as being better at predicting metabolic syndrome and the risks that can come from it.

Keywords: Children, Adolescents, Waist-to-height ratio, Skinfold thickness, Overweight, Obesity.

1. Introduction

Childhood and adolescence obesity is on the rise worldwide and raises concerns that overweight or obese children and adolescents are at greater risk of becoming obese than adults and has become one of the most serious health problems of this century [1,2]. Obesity is a multifactorial disease that is determined by genetic and environmental interactions such as physical activity, way of eating, way of sleeping, time spent using the computer, and time watching TV, and is a very important factor that endangers the individual for the development of some health problems such as metabolic syndrome, cardiovascular diseases hyperlipidemia, insulin resistance, etc. [1,2]. Abdominal obesity is closely related to hypertension, dyslipidemia, and diabetes [3]. Therefore, an early diagnosis is very important and for this purpose, it is recommended to use the waist-to-height ratio (WHtR), which is a very easy method to use as well as to be interpreted by both primary care physicians and other healthcare professionals. [3]. WHtR is a measure of central fat distribution and is very effective for both short and tall people, both children and adults.

What is the waist-to-height ratio and how it is calculated?

WHtR is calculated by dividing the waist circumference by body length. Higher values indicate a higher risk for: obesity, cardiovascular disease, diabetes, hypertension, etc.
The categorization of the waist to length ratio is divided into three categories:

- 'No risk' (<0.50)
- 'Increased risk / High risk' (> 0.50 to <0.60)
- 'Very high risk' (≥0.60)

2. The main goals of this research

The two main goals of this research were:

- to follow the dynamics of growth and development of special characteristics of children and adolescents,
- to investigate the prevalence of obesity in childhood and adolescence in the Tetovo region, analyzing the WHtR.

3. Material and methods

This study is focused on Tetovo and its surroundings, which are in the Polog region, the northwestern part of North Macedonia. There are 184 settlements on this territory, with a total population of 322,605 people [4,5]. It is worth noting that this cross-sectional is the first of its kind in this part of North Macedonia. According to the proposal of the International Biologic Program IBP, No. 9, 1969, the research was conducted in primary and secondary schools in the Tetovo region [4,6] from April to June 2019. In this study, we surveyed children and adolescents aged 12–17 years who were physically capable of performing anthropometric measurements and volunteered to answer the questionnaire.

Sample size determination

Initially, the sample reliability level was set at 95% and P = 0.05. So, from the total number of students aged 12 to 17 who have attended primary and secondary schools in the Tetovo region in the school year 2018/2019 [4], the minimum number required for inclusion in this research that level of 95% reliability is 392 students. In our research, we included 625 male and female students aged 12, 13, 14, 15, 16, and 17 years old, from the primary and secondary schools in the Tetovo region.

Sample selection procedures

The definition of the sampling frame is done in three stages:

- In the first phase: the appropriate sampling frame is defined;
- In the second phase: the sampling method is chosen on the basis of the composition of the population to be surveyed;
- In the third phase: the average sample size was determined as sufficient to represent the surveyed population, where 625 students from the surveyed school classes (groups) were randomly selected.

Cluster sampling was used for sample selection because of the difficulty in researching all individuals (budgetary and time constraints).
The lead author described the objective of this study to selected participants. Written consent from each selected student and permission from the school authorities were obtained. Anthropometric data of 625 students were recorded on the anthropometric card.

Data collection procedure

The intervention protocols were developed according to the Helsinki Declaration [7] and approved by the Regional Bureau for Development of Education in the municipalities where students' anthropometric measurements were taken. Additionally, written consent from each selected participant and permission from the school authorities were obtained. Anthropometric measurements were taken by trained individuals in two-person teams: one conducted the measurements, and the other recorded the measurements in a questionnaire. Based on the culture and customs of the population, in some cases in females, the measurements were performed by trained female collaborators.

Anthropometric measurements were taken early in the morning during physical education class, while the subjects were dressed in light clothing (T-shirts, shorts, and socks), using the techniques of Martin and Saller [8], as well as the amount of water and food consumed in the morning is smaller. An anthropometric card was formed for each student, and the biological age of each student was determined by the date of birth and the date of measurement. GPM Swiss Made anthropological instruments were used for anthropometric measurements. The measurements for height and weight were 1 cm and 0.1 kg, respectively.

Anthropometric measurements

To derive the result of the WHtR it is necessary:

- Measurement of body height;
- Measurement of waist circumference.

Body length is measured with an Anthropometer or Stadiometer, and during the measurement, the person is standing with feet completely flat on the floor, without shoes and socks (barefoot), and the head is kept in Frankfort's horizontal position.

The measurement of the waist circumference is done with the measuring tape. The individual stands up and the measuring tape is placed around the waist slightly higher than the crista iliaca, the strap should be horizontal around the waist and should not be tightened. The WHO protocol suggests that waist circumference should be measured at the end of the expiration.

Inclusion and exclusion criteria from the study

Included:

- students aged 12 to 17 years old,
- physically fit to perform measurements,
- who were able and willing to answer the questionnaire.

Excluded:

- students who refused to take measurements,
- were not of the age involved in the research.

Statistical analysis

Results were processed using the statistical programs STATISTICA 10.0 and SPSS 20.0. The collected data were analyzed using statistical techniques such as attributive statistical series by calculating the coefficients of relationships, proportions, norms, and the statistical significance of detected differences in the difference test. Central tendency and data distribution measures were used to analyze numerical series (mean and standard deviation).

A t-test is used to determine the significance of a difference in a numerical series with a normal distribution, and analysis of variance (ANOVA) was used to determine the statistical significance of the changes). This study used the post hoc Tukey HSD test or multiple comparison tests only after the ANOVA test yielded statistically significant results. Additionally, the Pearson correlation coefficient was used to determine the correlation relationships (r), and Pearson Chi-square was used to calculate the correlation probability between the frequency distributions of the two attribute variables. The Shapiro–Wilk test was also used to examine the normal distribution of variables, and the statistical significance for an error level less than 0.05 was determined using CI (confidence interval ± 95%).

4. Results

The results of this research are presented in the form of tables and figures. In total, 625 male and female students aged 12–17 years were considered as the sample for this study. The number of students in each age group was approximately the same.

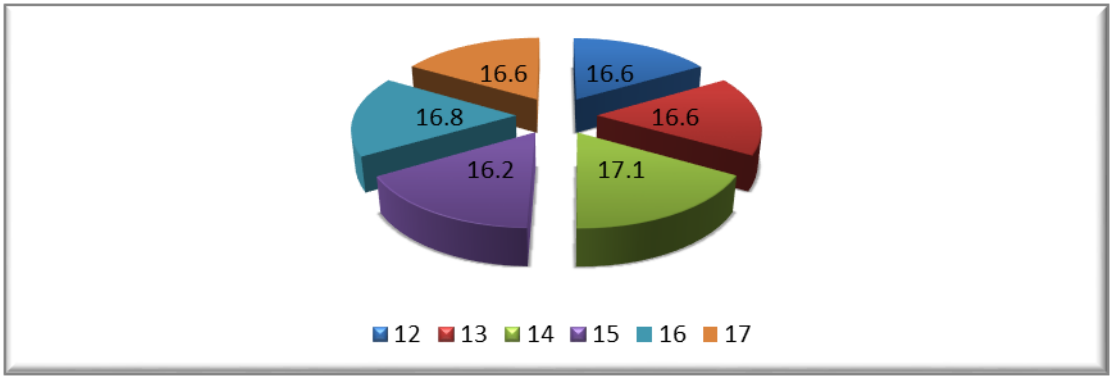

Figure 1. Percentage of students by age

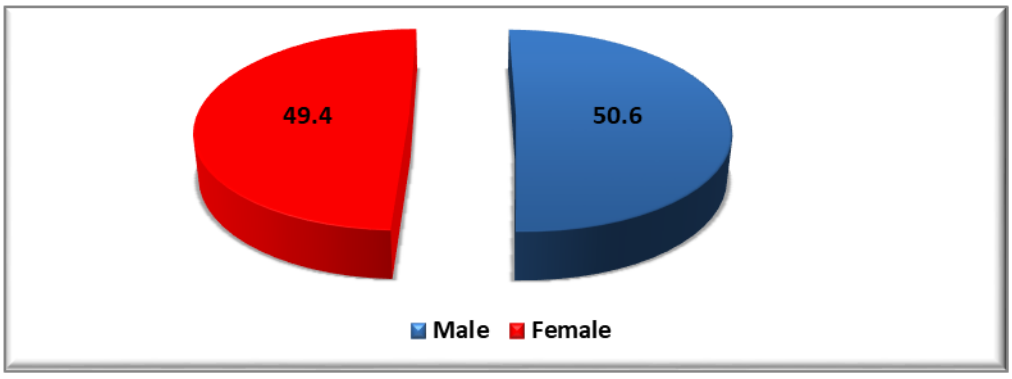

Figure 2. Percentage of students by gender

The results presented in Figure 1 show that, from the anthropometric measurements of 625 students, 104 students or 16.6% are 12 years old and attend the sixth grade in primary school, 104 or 16.6% of the students are 13 years old and attend the seventh grade in primary school, 107 students or 17.1% are aged 14 and attending the eighth grade in primary school, 101 students or 16.2% are aged 15 and attending the ninth grade in primary school, 105 students or 16.8% are aged 16 and attending the first year of high school and 104 students or 16.6% are aged 17 and attend the second year of high school. Of the total number of examinees, Figure 2 shows that 309, or 49.4% were female and 316, or 50.6% were male.

Table 1. Students by place of residence

Residence			Male		Female	
	n	%	n	%	n	%
Rural	455	72,8	245	77,5	210	68.0%
Urban	170	27,2	71	22,5	99	32,0
Total	625	100,0	316	100,0	309	100,0

The results presented in Table 1 show that, from anthropometric measurements of 625 students, 455 or 72.8% of them are living in rural areas, of which 245 men and 210 women while 170 or 27.2% are living in urban areas, of which 71 males and 99 females.

Table 2. The mean values of the WHtR of the students in the age groups from 12 to 17 years old

WHtR	Age	12 y		13 y		14 y		15 y		16 y		17 y	
Gender		M	F	M	F	M	F	M	F	M	F	M	F
n		52	52	50	54	57	50	50	51	55	50	52	52
Mean		.45	.44	.44	.42	.44	.42	.45	.43	.44	.43	.45	.43
Median		.45	.43	.44	.42	.43	.41	.44	.42	.43	.41	.43	.42
Std. Deviation		.04	.03	.03	.04	.04	.04	.04	.04	.05	.04	.04	.05
Range		.15	.18	.20	.24	.23	.19	.27	.21	.24	.20	.20	.29
Minimum		.39	.37	.38	.36	.36	.31	.38	.36	.37	.36	.39	.36
Maximum		.54	.56	.58	.60	.60	.49	.65	.57	.61	.56	.58	.65

Table 2 shows the mean value of the WHtR of the students aged 12 to 17 years. The average WHtR in 12-year-old boys was 0.45, while for girls it was 0.44, in 13-year-old boys, it was 0.44, while for girls it was 0.42, in 14-year-old boys, it was 0.44 while for girls it was 0.41, in 15-year-old boys, it was 0.45, while for girls it was 0.43, in 16-year-old boys, it was 0.44, while for girls it was 0.43, in 17-year-old boys, it was 0.45, while for girls it was 0.43.

Table 3. Students according to the WHtR category

WHtR	**No risk** (normal values)	**Increased risk / High risk**	**Very high risk**	**Total**
Total	570	51	4	625

Table 3 shows the students by category of the WHtR. Out of a total of 625 students, 570 belong to the category No risk, 51 students belong to the category Increased risk / High risk and 4 students belong to the category Very high risk.

Table 4. Relationship between the WHtR and place of residence

WHtR / Place of residence	**No risk** (normal values)	**Increased risk / High risk**	**Very high risk**	**Total**
Rural	418	34	3	455
Urban	152	17	1	170
Total	570	51	4	625

Table 4 shows the correlation between the WHtR with the place of residence. Out of a total of 455 students living in rural areas, 418 belong to the category No risk, 34 belong to the category Increased risk / High risk

and 3 students belong to the category Very high risk, while out of a total of 170 students living in an urban area, 152 belong to the category No risk, 17 belong to the category Increased risk / High risk and 1 student belong to the category Very high risk. In these results, no statistical significance was recorded between the variable WHtR and place of residence with p>0.05 (Pearson Chi-square:.689977, df =2, p =.708229).

Table 5. Average skinfold thickness of the triceps (TST), suprailiac (SIST), and subscapular (SSST) in relation to the WHtR

Skinfold thickness / WHtR	TST (mm)			SIST (mm)			SSST (mm)		
	Mean	n	SD	Mean	n	SD	Mean	n	SD
No risk	11.8	564	4.63	13.2	564	5.23	11.7	564	4.79
Increased risk / High risk	16.6	50	6.02	20.3	50	6.54	19.4	50	5.77
Very high risk	21.7	3	7.02	19.0	3	8.54	18.4	3	11.60

Table 6. Analysis of Variance test of the average TST, SIST, and SSST in relation to the WHtR

Skinfold thickness	SS - Effect	df - Effect	MS - Effect	SS - Error	df - Error	MS - Error	F	p
TST	1331.13	2	665.56	13993.4	622	22.79	29.20	0.00
SIST	2417.90	2	1208.95	17656.5	622	28.75	42.04	0.00
SSST	2868.49	2	1434.24	14874.4	622	24.22	59.20	0.00

Table 7. Tukey HSD test of the average TST in relation to the WHtR

TST / WHtR	{1} - M=11.827	{2} - M=16.642	{3} - M=21.667
No risk {1}		**0.000022**	**0.001090**
Increased risk / High risk {2}	**0.000022**		0.179509
Very high risk {3}	**0.001090**	0.179509	

Table 8. Tukey HSD test of the average SIST in relation to the WHtR

SIST / WHtR	{1} - M=13.188	{2} - M=20.320	{3} - M=19.000
No risk {1}		**0.000022**	0.146767
Increased risk / High risk {2}	**0.000022**		0.909820
Very high risk {3}	0.146767	0.909820	

Table 9. Tukey HSD test of the average SSST in relation to the WHtR

SSST / WHtR	{1} - M=11.673	{2} - M=19.422	{3} - M=18.400
No risk {1}		**0.000022**	**0.047876**
Increased risk / High risk {2}	**0.000022**		0.934956
Very high risk {3}	**0.047876**	0.934956	

According to the Analysis of the Variance test, the difference between the mean values of TST concerning the WHtR is statistically significant with p<0.05 (p=.000000) (Tables 6 and 7). The post-hoc-Tukey HSD test shows that the difference is statistically significant with p<0.05 (p=0.000022) between the mean value

of 11.8 mm versus 16.6 mm and with $p<0.05$ ($p=0.00102290$) between the average value 11.8 mm versus 21.7 mm (Table 7). According to the Analysis of the Variance test, the difference between the mean values of the SIST concerning the WHtR is statistically significant with $p<0.05$ ($p=.000000$) (Tables 6 and 8). The post-hoc-Tukey HSD test shows that the difference is statistically significant with $p <0.05$ ($p=0.000022$) between the mean value of 13.2 mm versus 20.3 mm (Table 8). According to the Analysis of the Variance test, the difference between the mean values of the SSST concerning the WHtR is statistically significant with $p<0.05$ ($p=.000000$) (Tables 6 and 9). The post-hoc-Tukey HSD test shows that the difference is statistically significant with $p<0.05$ ($p=0.000022$) between the mean value of 11.7 mm versus 16.6 mm and with $p <0.05$ ($p=0.047876$) between the average value 11.7 mm versus 18.4 mm (Table 9).

5. Discussion

There are several different anthropometric measurements and indices used to assess aspects of body composition and body-related health status. With these measures, there are various methods used to determine different health statuses, such as 'overweight' and 'obesity'. Previous research has found that the WHtR is much safer than BMI and waist circumference in prognosis and is more strongly associated with cardiovascular disease as well as better in predicting metabolic syndrome in adults, and the risks that can come from cardiovascular diseases, such as hypertension and high blood cholesterol in adolescents and adults [9,10,11]. Comparing the results of this study with the same data of young people and adolescents from different geographical regions and different ethnic backgrounds can be noticed with some differences, but it is very important to note that our results show that the WHtR of boys and girls is in line with the natural growth and development that occurs at these ages according to the adolescent growth and development standards set by the WHO, and all age groups of the surveyed students are within the recommended range of 5 to 95 percent, according to the WHO [12]. In all studies conducted at adults, the value of the WHtR of ≥ 0.5, was found an association with a greater risk for metabolic syndrome, regardless of whether the person is classified or not as overweight by BMI categorization. The ≥ 0.5 limit is used as the indicative limit for both males and females of all ages and ethnicities [10,11,13].
Previous research has also shown that:

- Anthropometric dimensions change more during adolescence (a period of rapid growth and development) and the health of the adolescent is the result of the development of previous stages and the effects of current circumstances.
- The importance of detecting obesity at these ages is not only personal but also a social benefit.
- The WHtR and skinfold thickness are more strongly related to children's body fat than BMI [14].
- WHO recognizes that "the health of adolescents and young people is crucial to society, as the future depends on them and the conditions in which they live and their way of life will follow them forever" [15].

6. Conclusions

- The WHtR should be used as a priority tool for detecting obesity, because it is a measurement with a simple procedure to be performed and is a much better predictor of body fat than BMI;
- The WHtR, in contrast to BMI, has shown a stronger correlation with the skinfold thickness (which is also used to detect obesity in children);
- The WHtR is a reliable and well-known index for predicting cardiovascular problems and is easy to use, as well as not age-dependent for identifying people at increased cardiometabolic risk, associated with central obesity (around the abdomen).

7. Recommendations

Based on the results obtained and the conclusions are drawn, it is necessary and very important to take the following measures:

- To assess the size and distribution of the cases of overweight and obesity at the level of this age group of the population;
- Creating and providing models for healthy nutrition for children and adolescents;
- Organizing intervention projects in schools with the sole purpose of promoting and encouraging children to acquire correct behavior towards food and physical activity;
- Raising the awareness of parents and their active involvement in promotions, to enable the creation of lasting lifestyle changes for children and adolescents;
- The role of the physician during systematic screening should become a strong point of reference for parents, children, and adolescents;
- Encouraging participation in sports activities, and increasing the time for physical education in schools, would show obvious benefits, not only in their physical development but also in the social behavior of children and adolescents.

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Abbreviations

WHtR - Waist-to-height ratio, ST - Skinfold thickness, TST - Triceps skinfold thickness, SIST - Suprailiac skinfold thickness, SSST - Subscapular skinfold thickness, BMI - Body mass index, SD - Standard Deviation.

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Ethics approval and consent to participate

The authors complied with all laws and rules of the ethical committee. The intervention protocols were used following the guidelines of the Helsinki Declaration and were approved by the Regional Bureau for Development of Education in the respective municipalities of the Polog region. Written consent was obtained from each participant in this study.