CORRELATION BETWEEN WAIST-TO-HEIGHT RATIO AND OTHER ANTHROPOMETRIC INDICES IN THE BOSNIAN ELDERLY

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SUMMARY

Objectives: The objective of the present study was to explore whether gender differences exist in waist-to-height ratio (WtHR) values and to assess the correlation between WtHR and other obesity indicators after categorising older adults of Bosnian descent based on the presence or absence of abdominal obesity.

Methods: The study included 151 inhabitants of the Geriatric Centre in Sarajevo, Bosnia and Herzegovina, aged 65 years and older (66 males and 85 females). Anthropometric indices and blood pressure values were measured by standard methods. WtHR was calculated using the following formula: waist circumference (WC) (cm)/height (cm). Differences between compared groups were analysed using the Student's t-test, Mann-Whitney U test or chi-square test. Correlations were assessed by Spearman's or Pearson's test.

Results: Females had significantly higher WtHR values compared to males. Significant positive correlation was determined between WtHR and body mass index (BMI), WC, hip circumference (HC), neck circumference (NC), mid-upper arm circumference (MUAC), calf circumference (CC), and the weight-adjusted waist index (WWI) in both male and female elderly individuals. In elderly participants with abdominal obesity, there was a statistically significant positive correlation between WtHR and all of the tested anthropometric indices. Amongst elderly participants without abdominal obesity, a statistically significant positive correlation was observed between WtHR and BMI, WC, MUAC, and the WWI. However, no statistically significant correlations were observed between WtHR and HC, NC or CC in elderly participants without abdominal obesity.

Conclusions: The results of this study imply that WtHR is a valid parameter for assessing abdominal obesity in elderly individuals. The observed WtHR values indicate that women are at greater health risk than men. Given the high prevalence of sarcopenic obesity in older adults and the demonstrated limitations of BMI, we propose that WtHR should be incorporated into routine clinical practice for obesity assessment in this age group.

Key words: waist-to-height ratio, elderly, anthropometry, obesity, sarcopenia

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INTRODUCTION

Obesity is one of the leading global public health concerns. According to the Global Nutrition Report, the prevalence of obesity in Bosnia and Herzegovina among women aged 18 years and older is 20.3%, while for adult men 19.4% (1). Numerous studies have demonstrated the association between obesity and various cardiometabolic diseases. Different anthropometric indicators are used to assess obesity, with body mass index (BMI) being the most commonly applied in clinical practice. However, despite its numerous advantages, BMI has significant limitations, primarily because it does not assess abdominal obesity, which is a key criterion for diagnosing metabolic syndrome. In addition to abdominal obesity, metabolic syndrome requires the presence of at least two of the following abnormalities: elevated triglycerides or specific treatment for this lipid abnormality, reduced HDL cholesterol or specific treatment for this abnormality, elevated blood pressure or treatment of previously diagnosed hypertension, and raised fasting plasma glucose or previously diagnosed type 2 diabetes (2).

Recently, the waist-to-height ratio (WtHR) has been introduced as a marker of abdominal obesity. Meta-analyses have shown that WtHR has greater predictive power in classifying risk factors for cardiovascular diseases in both children and adults compared to BMI and waist circumference (3, 4). Recent studies suggest that elevated WtHR values are associated with diabetes in individuals aged ≥ 40 years, particularly in women (5). Additionally, a study conducted in China indicates a correlation between WtHR and hypertension, including its subtypes, in individuals younger than 60 years (6). Elevated WtHR values have also been linked to liver cancer (7) and an increased risk of cardiovascular events in postmenopausal women (8).

The findings of an earlier study demonstrated that WtHR is the best indicator of cardiometabolic risk, whereas BMI was the weakest indicator in both sexes (9). More recent prospective cohort studies, such as those from the UK Biobank, have established a linear positive association between WtHR and ischaemic cardiovascular disease (10). Similarly, findings by Pasdar et al. (11) suggest that WtHR is a superior index for assessing cardiovascular disease risk compared to BMI, waist circumference, and waist-to-hip ratio. A study in South Africa also highlighted the utility of WtHR in routine obesity assessment for individuals at cardiometabolic risk (12). Consistent with these findings, the combination of WtHR and waist circumference among Asian Indians in North India yielded better results in identifying individuals at cardiometabolic risk compared to BMI and waist-to-hip ratio (13).

To date, studies indicate that WtHR values above 0.5 are associated with an increased risk of cardiometabolic diseases, regardless of age, sex, or ethnicity (14). However, considering the "obesity paradox" observed in older adults, characterised by weight loss and fat redistribution, there is a need to determine appropriate WtHR values for this population and to examine the relationship between WtHR and other obesity indicators in older adults. In this context, findings from a previously conducted systematic review suggest that WtHR is a valid indicator for assessing obesity in older adults and can be used as a predictor of cardiometabolic disease risk factors in this age group (15). Nevertheless, given the global ageing population and the limited number of studies evaluating WtHR in older adults, the objective of the present study was to explore whether gender differences exist in WtHR values and to assess the correlation between WtHR and other obesity indicators after categorising older adults of Bosnian descent based on the presence or absence of abdominal obesity.

MATERIALS AND METHODS

The study was conducted at the Geriatric Centre Sarajevo, Bosnia and Herzegovina, and included 151 participants aged 65 years or older (66 men and 85 women). The study was designed as an observational, cross-sectional study with cross-testing. Data collection was based on medical history and objective physical examinations. All participants provided written informed consent in accordance with the Declaration of Helsinki (revised in 2013). The study protocol was approved by the local Ethics Committee (approval no. 13-712/19, Sarajevo, 24 May 2019). Specially designed forms/questionnaires were used to collect participant data, which included general information (name, age, gender, and education level), blood pressure values, pulse measurements, anthropometric data such as height, weight, BMI, neck circumference (NC), waist circumference (WC), hip circumference (HC), mid-upper arm circumference (MUAC), and calf circumference (CC). Data on lifestyle habits (alcohol consumption, smoking, and physical activity), history of falls in the past year, family history of cardiovascular disease, diabetes mellitus, and obesity, as well as information on current therapy were also collected.

Anthropometric Measurements

The equipment used included a weighing scale, a portable stadiometer, a flexible measuring tape for anthropometric measurements, a mercury sphygmomanometer, and a stethoscope. Height and weight were measured to calculate BMI. Height was measured in centimetres using a portable stadiometer (seca 213; seca®) with participants standing on a flat surface, feet together, and wearing shoes. A horizontal measuring plate was positioned at the top of the head, and 2 cm were subtracted from the measured value to account for footwear. Body weight was measured in kilogrammes using a digital scale (BS-03; Shenzhen J and E Electronics Co., Ltd.) while participants wore light, casual clothing. BMI was calculated using the formula: weight (kg)/height² (m²). Neck circumference (NC) was measured with the head positioned in the Frankfurt horizontal plane using a non-elastic, calibrated flexible tape placed around the mid-neck at the level of the laryngeal prominence. The upper edge of the tape was positioned just below the laryngeal prominence and perpendicular to the neck's axis. Waist circumference and hip circumference were measured in a standing position using a calibrated tape. Participants stood with feet together and breathed normally during the measurements. WC was measured just above the navel, while HC was measured at the widest part of the hips. Based on the WC, subjects were divided into those with and without abdominal obesity according to International Diabetes Federation guidelines: WC $\geq$ 94 cm for men and $\geq$ 80 cm for women of European descent (2). Weight-adjusted waist index (WWI) was calculated by dividing waist circumference (cm) by the square root of body weight ($\sqrt{}$kg). The waist-to-height ratio was calculated using the formula: WC (cm)/height (cm).

Blood Pressure Measurements

Arterial blood pressure was measured using a standard mercury sphygmomanometer (SCH 11B; Smart Care) with participants seated and resting for 5 minutes prior to measurement. The arm was positioned at heart level, and the sphygmomanometer cuff was placed around the upper arm and inflated. Systolic blood pressure (SBP) was recorded at the first audible Korotkoff sound, and diastolic blood pressure (DBP) was recorded when Korotkoff sounds disappeared. Blood pressure values were documented in mmHg.

Statistical Analysis

The distribution of variables was assessed using the Kolmogorov-Smirnov or Shapiro-Wilk tests. Differences between groups for numerical variables with normal distributions were analysed using Student's t-test. Non-normally distributed numerical variables were presented as medians and interquartile ranges, with differences between groups assessed using the Mann-Whitney U test. Categorical variables were shown as percentages, and differences in the frequency of categorical variables between groups were assessed by the chi-square test. Spearman's rank correlation or Pearson correlation test were used to evaluate correlations between variables. The value of $p < 0.05$ was regarded as statistically significant. The Statistical Package for Social Sciences (SPSS, version 19.0; Chicago, IL, USA) was used for the statistical analyses.

RESULTS

Results presented in Table 1 demonstrate statistically significant differences between genders in age ($p<0.01$), height ($p<0.001$), weight ($p<0.05$), BMI ($p<0.001$), hip circumference ($p<0.05$), neck circumference ($p<0.001$), and the weight-adjusted waist index ($p<0.01$). No statistically significant differences were observed in waist circumference, mid-upper arm circumference, or calf circumference ($p>0.05$) between genders.

Table 1. *Baseline characteristics of study participants*

Variables	Men n = 66	Women n = 85	p-value
Age (years), median (IQR)	76.50 (70.00–85.00)	83.00 (75.00–86.00)	0.010
Height (cm), mean (SD)	176.81 (7.97)	162.67 (7.37)	0.001
Weight (kg), median (IQR)	76.00 (69.50–84.00)	70.00 (65.00–78.00)	0.014
Body mass index (kg/m^2), median (IQR)	24.15 (22.05–26.70)	26.50 (23.85–29.75)	0.001
Waist circumference (cm), mean (SD)	99.23 (11.78)	100.71 (14.55)	0.503
Hip circumference (cm), median (IQR)	104.00 (96.50–106.00)	96.00 (92.00–121.50)	0.022
Mid-upper arm circumference (cm), median (IQR)	27.00 (25.00–29.00)	28.00 (25.00–31.50)	0.073
Neck circumference (cm), median (IQR)	40.00 (38.00–43.25)	37.00 (35.00–39.00)	0.001
Calf circumference (cm), mean (SD)	34.18 (4.54)	34.56 (0.09)	0.924
Weight-adjusted waist index, mean (SD)	11.32 (1.01)	11.87 (1.09)	0.002

SD – standard deviation; IQR – interquartile range

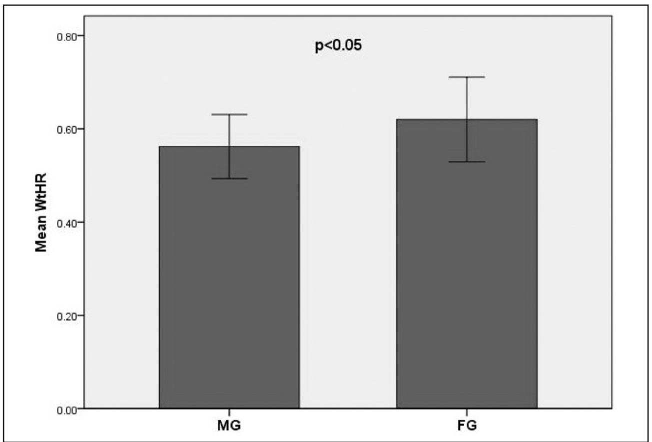

Fig. 1. *Mean WtHR in elderly participants.*

WtHR – waist-to-height ratio; MG – male gender (n = 66); FG – female gender (n = 85)
Results are expressed as the mean and standard deviation (mean ± SD).

Results illustrated in Figure 1 show that the mean WtHR in elderly male participants was 0.56 ± 0.07, whereas in elderly female participants the mean WtHR was 0.62 ± 0.09. The difference in mean WtHR between genders was statistically significant ($p<0.05$), with females exhibiting significantly higher WtHR values compared to males.

Results presented in Table 2 reveal a statistically significant positive correlation in elderly male participants between WtHR and BMI, waist circumference, hip circumference, neck circumference, mid-upper arm circumference, calf circumference, and the weight-adjusted waist circumference index ($p<0.001$). Similarly, a statistically significant positive correlation was found in elderly female participants between WtHR and BMI, waist circumference, hip circumference, neck circumference, mid-upper arm circumference, calf circumference, and the weight-adjusted waist circumference index ($p<0.001$).

Results presented in Table 3 indicate that amongst elderly participants with abdominal obesity, there was a statistically significant positive correlation between WtHR and BMI, waist circumference, hip circumference, mid-upper arm circumference, calf circumference, weight-adjusted waist index ($p<0.001$), and neck circumference ($p<0.05$). Amongst elderly participants without abdominal obesity, a statistically significant positive correlation was observed between WtHR and BMI ($p<0.05$), waist circumference ($p<0.001$), mid-upper arm circumference ($p<0.05$), and the weight-adjusted waist index ($p<0.001$). However, no statistically significant correlations were observed between WtHR and hip circumference, neck circumference, or calf circumference ($p>0.05$) in elderly participants without abdominal obesity.

Table 2. *Correlation between WtHR and other anthropometric measures based on gender*

Variables	Waist-to-height ratio			
	Men n = 66	p-value	Women n = 85	p-value
Body mass index (kg/m^2)	0.688[a]	<0.001	0.801[a]	<0.001
Waist circumference (cm)	0.930[b]	<0.001	0.949[b]	<0.001
Hip circumference (cm)	0.705[a]	<0.001	0.600[a]	<0.001
Neck circumference (cm)	0.711[a]	<0.001	0.589[a]	<0.001
Mid-upper arm circumference (cm)	0.734[a]	<0.001	0.608[a]	<0.001
Calf circumference (cm)	0.542[b]	<0.001	0.621[b]	<0.001
Weight-adjusted waist index	0.762[b]	<0.001	0.739[b]	<0.001

WtHR – waist-to-height ratio; [a]rho – Spearman correlation coefficient; [b]r – Pearson correlation coefficient

Table 3. Correlation between WtHR and other anthropometric measures in participants classified by presence or absence of abdominal obesity

Variables	Waist-to-height ratio			
	Abdominal obesity group n = 119	p-value	Without abdominal obesity group n = 32	p-value
Body mass index (kg/m^2)	0.698[a]	< 0.001	0.409[a]	0.020
Waist circumference (cm)	0.859[b]	< 0.001	0.715[b]	< 0.001
Hip circumference (cm)	0.499[a]	< 0.001	0.284[a]	0.116
Neck circumference (cm)	0.228[a]	0.013	0.240[a]	0.186
Mid-upper arm circumference (cm)	0.470[a]	< 0.001	0.426[a]	0.015
Calf circumference (cm)	0.370[b]	< 0.001	0.150[b]	0.150
Weight-adjusted waist index	0.659[b]	< 0.001	0.602[b]	< 0.001

WtHR – waist-to-height ratio; [a]rho – Spearman correlation coefficient; [b]r – Pearson correlation coefficient

DISCUSSION

To the best of our knowledge, this is the first study to report gender differences in WtHR values amongst Bosnian elderly individuals. The mean WtHR amongst elderly male participants was 0.56 ± 0.07, whereas amongst elderly female participants 0.62 ± 0.09. The results of the study indicate that elderly male participants, based on their WtHR values, can be categorised as having increased central obesity, which is associated with elevated health risks. In contrast, elderly female participants can be classified as having high central obesity, placing them at even greater health risk (16).

These findings align with a study conducted amongst the adult Turkish population, which reported that a WtHR of 0.57 in men and 0.61 in women was associated with moderate to high risk for cardiovascular diseases (9). Similarly, higher WtHR values in women compared to men were observed amongst the adult Kurdish population, where the WtHR for women was 0.65 and 0.56 for men (11). However, our results differ from those of Dong et al. (17), who reported that a WtHR cut-off value of 0.51 in men and 0.49 in women was associated with clusters of metabolic risk factors.

The findings of this study demonstrate that WtHR significantly correlates with all anthropometric indicators of obesity amongst both elderly men and women. Furthermore, when elderly participants were divided into those with and without abdominal obesity, a significant correlation between WtHR and all other assessed obesity parameters was observed in individuals with abdominal obesity. Amongst those without abdominal obesity, WtHR showed a significant correlation with BMI, WC, MUAC, and WWI, but not with hip circumference, neck circumference, or calf circumference.

These findings suggest that WtHR is a valid indicator of obesity in individuals with abdominal obesity and offers significant advantages over BMI as it accounts for both waist circumference and height. According to a recent meta-analysis encompassing 288 studies with 13,233,675 participants, the global prevalence of abdominal obesity is 41.5%, and it is more common among women, older individuals, Caucasians, urban residents, and people in high-income countries (18). Given that abdominal obesity is a major risk factor for cardiometabolic diseases, it is crucial to assess it routinely in clinical practice. WtHR, due to its cost-effectiveness and simplicity of measurement, should be one of the primary markers used to evaluate abdominal obesity. This is particularly important because BMI, while commonly used, cannot independently distinguish between abdominal obesity and obesity in general. In contrast, WtHR, as per the latest guidelines, represents a better surrogate measure of body fat in men, women, and across all age groups compared to traditional obesity indicators (16). Accordingly, the National Institute of Excellence in Health and Care recognises elevated WtHR as a health risk and recommends maintaining waist circumference below half of one's height to minimise potential health problems (19).

In line with the above, a study conducted among the Brazilian population reports that WtHR can serve as a reliable marker of overweight in older individuals. The results of this population-based epidemiological survey, which included 13,756 adults and 7,015 older individuals, highlighted the significance of WtHR in the early identification of health risks (20). The utility of WtHR as a marker of body fat was also demonstrated in a study by Ashtary-Larky et al. (21), which involved individuals undergoing weight loss interventions. Interestingly, findings from a study by Tomas et al. (22) among residents of the Mediterranean island of Vis in Croatia suggest that WtHR, among all tested anthropometric parameters, best reflects psychological and lifestyle factors associated with obesity. Furthermore, a recent study by Guzmán-García et al. (23) also supports the use of WtHR in assessing metabolically healthy obesity. Additionally, the findings of Raele et al. (24) indicate that WtHR can serve as a marker for subclinical atherosclerosis, while Zhang et al. (25) report that WtHR is a valuable indicator for the early detection of carotid atherosclerosis in individuals at high risk of stroke.

The results of a recently conducted systematic literature review indicate that WtHR, WC and BMI can be used interchangeably with caution in the assessment of obesity. However, according to authors, additional studies are needed to account for factors such as sex, age, ethnicity, and weight quantiles (26). In line with these findings, the strength of the present study is the inclusion of elderly individuals, who often present with sarcopenic obesity characterised by a reduction in bone and muscle mass accompanied by an increase in predominantly visceral fat. This condition, often exacerbated by existing obesity, can lead to early disability onset, as well as increased morbidity and mortality (27). Another advantage of this study is its focus on WtHR rather than BMI for obesity assessment. Previous studies have shown that BMI is significantly higher in individuals who survive cardiovascular events compared to those who succumb to them, a phenomenon referred to as the "obesity paradox" (28). Given BMI's limitations in assessing fat and muscle distribution, we believe that WtHR should be the preferred method for obesity assessment in elderly individuals with predominant visceral obesity. Additionally, few studies thus far have assessed abdominal obesity using WtHR in elderly populations. This study establishes WtHR reference values for elderly individuals of Bosnian origin.

Despite its strengths, this study has several limitations. Firstly, its cross-sectional design prevents the establishment of causal relationships between the variables examined. Secondly, the relatively small sample size limits the generalisability of the findings to the general population. Thirdly, although sarcopenic obesity is often present in elderly individuals, we did not assess it by appropriate methods and future studies should try to overcome this shortcoming. Finally, the study did not investigate comorbidities such as vascular or cardiometabolic diseases, or central nervous system disorders, suggesting that future research should focus on exploring these conditions and their potential association with WtHR in elderly populations.

CONCLUSION

The results of this study imply that WtHR is a valid parameter for assessing abdominal obesity in elderly individuals. Furthermore, the observed WtHR values indicate that women are at greater health risk than men. Given the high prevalence of sarcopenic obesity in older adults and the demonstrated limitations of BMI, we propose that WtHR should be incorporated into routine clinical practice for obesity assessment in this age group.

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Conflicts of Interest

None declared

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