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Evaluation of different anthropometric indices for predicting metabolic syndrome

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Abstract. – OBJECTIVE: Metabolic syndrome is a condition characterized by metabolic abnormalities. Its overall prevalence increases with age, in turn resulting in a substantial burden of disease all around the world. The aim of this study is to evaluate the efficacy of several anthropometric indices for predicting metabolic syndrome among the elderly people.

SUBJECTS AND METHODS: This study was conducted on 348 elderly people aged 65 and over, including those who were diagnosed with metabolic syndrome based on the National Cholesterol Education Program's Adult Treatment Panel III criteria and those who did not suffer from metabolic syndrome. A trained dietitian performed body weight, height, waist circumference, and hip circumference measurements. Furthermore, body mass index, waist-hip ratio, waist-height ratio, conicity index, abdominal volume index, body shape index, and body roundness index values were measured. The receiver operating characteristic (ROC) curve was applied to assess the capability of these indices to predict metabolic syndrome.

RESULTS: Of the 348 subjects recruited, 56.0% had metabolic syndrome. Body Roundness Index had the largest area under the curve for predicting metabolic syndrome in both males and females (0.678 and 0.645, respectively), followed by abdominal volume index (0.673 and 0.626, respectively) and waist circumference (0.672 and 0.626, respectively).

CONCLUSIONS: Body roundness index was more effective compared to the other seven indices for predicting metabolic syndrome in the elderly population in Turkey.

Key Words:
Metabolic syndrome, Anthropometric indices, Elderly.

Introduction

Metabolic syndrome (MetS) has become a public health concern, with its increasing overall prevalence. MetS refers to a cluster of metabolic abnormalities including dysglycemia, high blood pressure, high triglyceride levels, low high density lipoprotein cholesterol (HDL), and abdominal obesity. The prevalence of MetS differs across the world based on the examined diagnostic criteria, geographical location, and population[1]. For instance, its prevalence is about 25% in Middle Eastern countries[2], higher than 30% in the United States[3], and varies between 13% and 36% in European populations[4-6]. According to METSAR Research[7] conducted in Turkey, its prevalence is about 34%. In their study Onat et al[8] reported that this rate was 45.1% in males and 54.5% in females. MetS can be attributed to increased sedentary activities, as well as an unfavorable diet, and modification of several lifestyle behaviors associated with MetS[1]. Also, the body undergoes physiological changes as it ages; that can indirectly increase one's risk of developing MetS[9]. Early detection and intervention of MetS in people at risk can prevent this syndrome from progressing and also causing other chronic diseases, so that the individual's health is affected positively and the individual and societal burden of associated diseases reduces[10]. Therefore, recent studies[11-16] have focused on the effectiveness of anthropometric indices for predicting MetS. Body Mass Index (BMI), Waist Circumference (WC), Waist-Hip Ratio (WHR), Waist-Height Ratio (WHtR), Conicity Index (Cl), Abdominal Volume Index (AVI), A Body Shape Index (ABSI), and Body Roundness Index (BRI), are cost-effective, non-invasive, and usable in practice and all of them were used to predict MetS in the present study. BMI is an index that is commonly used for categorizing total body weight. Despite its widespread use, BMI does not accurately reflect body composition and its measurement differs based on age, gender, and ethnic differences[17]. WC, WHR, and WHtR are frequently employed

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to assess central obesity[18,19]. Cl and AVI are also recommended for assessment of central obesity. CI includes an integrated modification of body weight, height, and WC[20]. AVI is an anthropometric index for measuring general volume and is associated with dysglycemia[21]. Recently, two indices, ABSI and BRI, have been associated with the risk of premature death[22]. It is also suggested that there is a significant correlation between ABSI, abdominal obesity[23] and visceral obesity[24]. BRI, which is derived from WC and height, is a predictor that could improve estimates of body fat percentage and visceral adipose tissue[22].

Although studies have been carried out to predict the risk of MetS in different societies, no studies on this subject have been conducted in Turkish society. This research was conducted to assess the efficacy of anthropometric indices for predicting MetS among elderly individuals, who are a vulnerable group in the society.

Subjects and Methods

Study Population

A total of 348 elderly people aged 65 and over, who were receiving treatment in the Gaziantep University Şahinbey Research and Application Hospital were included in the study. Elderly people who suffer from malignancy, dementia, neurological disorders, as well as severe respiratory problems or disabilities were excluded. The study was conducted in accordance with the Declaration of Helsinki. The study was approved by the Ethics Committee of the Gaziantep Islam Science and Technology University (protocol code 2022/76). All the participants were informed about the study and they signed an informed consent form confirming that they were voluntary to participate in the study. Also, permission was obtained from Gaziantep University Şahinbey Research and Application Hospital.

Data Collection

All the participants underwent comprehensive interviews and health examinations by a trained staff. After an overnight fast, their anthropometric and blood pressure measurements were taken, as well as venous blood collection for lipid profile and blood glucose evaluation.

Anthopometric Measurements

The trained dietician also took the anthropometric measurements of the participants. These measurements were performed twice in order to minimize errors in values. If the difference between the two measurements was less than 1 cm, these values were averaged; if the difference was greater than 1 cm, both measurements were repeated. The participants' height, body weight, waist and hip circumference were all measured. Body weight was measured by using a body composition monitor scale (Tanita BC-730, Japan). The participants wore light clothes and no socks during the measurement. Furthermore, they were asked to avoid drinking alcohol before the analysis, doing vigorous exercises 24 hours before, consuming drinks containing caffeine four hours before, eating food two hours before, and drinking water before the test. Their height was measured to the nearest 0.1 cm using a stadiometer (Seca, Germany). WC was found using an inflexible measuring tape by measuring the circumference around the middle point between the iliac prominence and the lowest rib of the individual. The hip circumference was measured using an inflexible measuring tape parallel to the ground from the highest point on the hip. All measurements were acquired as described previously[25].

The equation of body weight (kg)/height^2 (m^2) was used to calculate BMI. After measuring the waist and hip circumferences, WHR was calculated by the equation WC (cm) / hip circumference (cm), and the WHtR was calculated by the equation WC (cm)/height length (cm).

The below formulae were used to calculate CI, AVI, ABSI, and BRI[10,14].

$$CI = WC(m) / [0.109 \sqrt{(\text{body weight (kg)/Height (m)}})]$$

$$AVI = [2\ cm \times (WC\ (cm))^2 + 0.7\ cm \times (WC\ (cm) - \text{hip circumference (cm)})^2]/1000$$

$$ABSI = WC\ (m) / [\ (BMI^{2/3} \times \text{height (m)}^{1/2})]$$

$$BRI = 364.2 - 365.5 \times \sqrt{1 - [\ (WC\ (cm)/(2\pi))^2/(0.5 \times \text{Height (cm)})^2]}$$

Blood Pressure and Biochemical Parameters

Blood pressure of the participants was measured in sitting position at the morning hours using a calibrated OMRON automatic blood pressure monitor (Omron Healthcare, Kyoto, Japan) with an upper arm cuff after they took a rest for about 5 minutes. The average of two blood pressure measurements taken from right arms of the participants was recorded. The fasting blood glucose (FBG), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C) were measured in the blood samples taken after 8-12 hours of fasting. Standard assays were used to measure FBG, TG, and HDL-C.

Definition of Metabolic Syndrome

The NCEP ATP III criteria[26] require the presence of three or more of the following criteria: (1) high blood pressure (elevated BP): ≥130/85 mmHg or known treatment for hypertension; (2) hypertriglyceridemia (high TG concentration): TG of ≥ 150 mg/dl; (3) low HDL-C (low HDL cholesterol): <40 and < 50 mg/dL in males and females, respectively; (4) hyperglycemia (high glucose concentration): FBG of ≥100 mg/dL or known treatment for diabetes; (5) WC: ≥ 102 cm in males or ≥ 88 cm in females.

Statistical Analysis

SPSS 23.0 Statistical software (SPSS Inc., IBM, Armonk, NY, USA) was utilized for statistical analysis of the findings. Based on the diagnosis of MetS, the participants were assigned to MetS group or non-MetS group at first. Data was presented as the minimum and maximum values, mean (*X*) and standard deviation (SD) for continuous variables and frequencies (n) and percentages (%) for categorical variables. The independent two-sample *t*-test was used to evaluate the difference between anthropometric indices and biochemical factors of the individuals based on the presence of metabolic syndrome. The area under the receiver operating curve (ROC) was determined to assess the capability of anthropometric indices to discriminate between MetS and its components. Sensitivity, specificity, Youden index (Sensitivity + Specificity–1) and cut-off value of each predicting variable were determined. The indices with the largest area under the curve (AUC) were considered the best. The significance level was accepted as $p < 0.05$.

Results

A total of 348 elderly people (147 males and 201 females) with a mean age of 71.70±5.82 years (range of 65-91 years) participated in the study. Based on the criteria of ATPIII-2005, MetS was present in 56.0% of the subjects (53.7% in males and 57.7% in females). Table I shows anthropometric indices and metabolic characteristics of the participants based on gender. Anthropometric indices (BMI, WC, WHR, WHtR, AVI, ABSI, and BRI) were significantly higher in females compared to their male counterparts. There was no difference between males and females in terms of Cl. Biochemical factors (SBP, DBP, FBG, TG) were significantly higher in males compared to their female counterparts.

Table I. The anthropometric indices and metabolic characteristics of the participants.

	Total (n = 348) $\bar{x} \pm SD$	Male (n = 147) $\bar{x} \pm SD$	Female (n = 201) $\bar{x} \pm SD$	*p*
Age	71.70 ± 5.82	72.40 ± 6.02	71.20 ± 5.64	
Anthropometric indices				
BMI (kg/m^2)	29.94 ± 5.78	27.38 ± 4.33	31.81 ± 5.99	< 0.001
WC (cm)	105.15 ± 12.20	102.85 ± 11.75	106.84 ± 12.28	0.003
WHR	0.94 ± 0.09	0.97 ± 0.12	0.92 ± 0.06	< 0.001
WHtR	0.66 ± 0.10	0.61 ± 0.08	0.69 ± 0.09	< 0.001
CI (m$^{3/2}$ kg$^{1/2}$)	1.40 ± 0.11	1.4 ± 0.11	1.4 ± 0.10	0.604
AVI (cm^2)	22.50 ± 5.01	21.51 ± 4.61	23.22 ± 5.17	0.002
ABSI (m11/6 kg$^{-2/3}$)	0.97 ± 0.06	0.99 ± 0.03	0.95 ± 0.07	< 0.001
BRI	6.99 ± 2.23	5.86 ± 1.72	7.81 ± 2.21	< 0.001
Biochemical factors				
SBP (mmHg)	128.62 ± 20.92	133.1 ± 13.92	112.66 ± 24.07	< 0.001
DBP (mmHg)	75.04 ± 15.54	83.81 ± 12.49	68.63 ± 14.38	< 0.001
FBG (mg/dl)	105.16 ± 19.91	109.21 ± 23.34	102.19 ± 16.41	0.001
TG (mg/dl)	129.71 ± 43.29	135.29 ± 47.73	125.47 ± 39.36	0.040
HDL-C (mg/dl)	53.29 ± 16.98	50.05 ± 19.13	55.66 ± 14.84	0.002
MetS (n; %)	195; 56.0	79; 53.7	116; 57.7	

BMI: Body Mass Index, WC: Waist Circumference, WHR: Waist to Hip Ratio, WHtR: Waist to Height Ratio; CI: Conicity Index, AVI: Abdominal Volume Index, ABSI: Body Shape Index, BRI: Body Roundness Index, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, FBG: Fasting Blood Glucose, TG: triglyceride, HDL-C: High Density Lipoprotein Cholesterol, MetS: Metabolic syndrome.

Table II compares the area under the curve of anthropometric indices based on gender for predicting metabolic syndrome. Of the eight indices examined, the largest AUC was related to BRI, which was 0.678 in males (95% CI=0.591-0.764) and 0.645 in females (95% CI=0.568-0.723). BRI was followed by AVI and WC. The AUC value of AVI and WC of female participants was the same, namely 0.626 (95% CI=0.547-0.706 and 0.547-0.705, respectively). In male participants, the AUC of AVI was 0.673 (95% CI=0.584-0.761), and the AUC of WC was 0.672 (95% CI=0.584-9.760). The optimal cut-off values were 5.70 in males and 4.43 in females for BRI, 21.25 in males and female: 22.70 in females for AVI), and 93.50 in males and 96.50 in females for AVI). The lowest AUC in both gender belonged to ABSI (male: 0.597 (95% CI=0.504-0.691) and female: 0.587 (95% CI=0.506-0.668)).

The largest AUC for high blood pressure belonged to BRI (0.723) for males (95% CI=0.634-0.812) and WC (0.712) for females (95% CI=0.638 -0.785). In addition, BRI had the largest AUC for high fasting blood glucose, high triglyceride, and low high density lipoprotein-cholesterol in males and this area was 0.728 (95% CI=0.646-0.810) for high fasting blood glucose, 0.675 (95% CI=0.587-0.763) for high triglyceride and 0.734 (95% CI=0.646-0.821) for low high density lipoprotein-cholesterol. Moreover, the largest AUC for low HDL-C and high FBG in females belonged to BRI and this area was 0.806 (95% CI=0.750-0.870) for low HDL-C and 0.709 (95% CI=0.640-0.780) for high FBG (Table III).

Discussion

This study was conducted to predict the risk of MetS among the elderly in Turkish society using both traditional anthropometric measurements (WC, WHR, WHtR, and BMI), and innovative indices (Cl, AVI, ABSI, and BRI). There is no consensus in the literature among studies conducted to predict the metabolic syndrome, and several different anthropometric measurements are recommended.

Some studies[27,28] from the Middle East region have reported that WC is a better predictor of MetS compared to BMI, WHR, and WHtR. On the other hand, a cross-sectional study conducted on Chinese adult population indicated that WC, WHR, and BMI were equally useful indicators to discriminate MetS[29]. Also in a prospective cohort study conducted in Korea, it was found that WHR had a greater predictive ability for MetS[30]. Additionally, a cross-sectional study conducted on elderly in Japan[31] and a prospective study conducted on elderly in northern Iran[12] reported that WHtR was more predictive for MetS. The studies conducted on the elderly Colombians[32] and the Polish population[16] reported that WHR and BRI were the best predictors of MetS. A study conducted on elderly people in Iran[9] and also a cohort study conducted in western Iran[11] indicated that BRI was a good predictor for MetS. In a systematic review and meta-analysis study, BRI was found to be a good predictor for MetS in both genders and different populations[33].

In the present study, which was conducted on elderly Turkish individuals, BRI was the most effective anthropometric index for predicting metabolic syndrome in both genders (AUC: 0.678 for males and AUC: 0.645 for females), which is also compatible with the literature[9,11,13,33]. The optimal cut-off point of BRI in predicting MetS was 5.70 in males and 4.43 in females in the present study. The optimal cut-off points for BRI differ in studies conducted in different regions. For example, it was determined as 4.75 for males and 6.17 for females in a study conducted on adults living in western Iran[11]; 6.0 for males and 4.02 for females in a study conducted on the elderly in southern Iran[9]; 4.71 for males and 6.20 for females in a study conducted with elderly Colombians[32]; and 3.60 for males and 3.46 for females in a study conducted in China[13].

Likewise, some studies have revealed that BRI to predict MetS and its components was effective when compared to ABSI, BMI, and WC[15,32]. BRI is associated with both insulin resistance as well as inflammatory factors, which are main causes of MetS[34] so that BRI can predict metabolic syndrome. The results of the present study also revealed that AVI (AUC: 0.672 for male and AUC: 0.626 for female) had a good discriminatory capability in predicting MetS. The AUC value for AVI to predict MetS was reported to be 0.745 in a study conducted on elderly in Iran[12]. In the present study, an optimal cut-off point was obtained for AVI (21.25 in males and 22.70 in females). A study conducted in Northern Iran reported that the cut-off value for AVI was 16.5 in males and 17.3 in females[35]. The differences in the performance of these indices between the male and female populations are due to the differences in waist and hip circumference and the resulting effect of differences in overall body fat distribution.

Table II. Area under the ROC curve, optimal cut-off points, and validity parameters of different anthropometric indices predicting the MetS according to gender.

	Male						Female					
	AUC (95% CI)	***p***	**Cut-off**	**Sensitivity**	**Specificity**	**Youden index**	**AUC (95% CI)**	***p***	**Cut-off**	**Sensitivity**	**Specificity**	**Youden index**
BMI	0.608 (0.513-0.703)	0.025	≥ 26.75	63.2 (51.6-73.8)	63.2 (50.6-74.6)	0.242	0.624 (0.546-0.703)	0.003	≥ 31.10	59.5 (49.9-68.5)	57.6 (46.4-68.3)	0.199
W C	0.672 (0.584-0.760)	< 0.001	≥ 93.50	58.3 (46.5-69.2)	60.2 (47.7-71.9)	0.185	0.626 (0.547-0.705)	0.002	≥ 96.50	57.8 (48.2-66.8)	57.6 (46.4-68.3)	0.235
WHR	0.608 (0.516- 0.700)	0.025	≥ 0.95	58.2 (46.5-69.2)	57.3 (44.7-69.2)	0.199	0.612 (0.534-0.690)	0.007	≥ 0.92	53.5 (43.9-62.7)	50.9 (39.5-61.6)	0.113
WHtR	0.630 (0.537-0.723)	0.007	≥ 0.60	67.1 (55.6-77.2)	60.3 (47.7-71.9)	0.276	0.589 (0.508-0.670)	0.032	≥ 0.68	88.7 (81.6-93.9)	25.8 (16.9-36.5)	0.173
CI	0.659 (0.568-0.75)	0.001	≥ 1.40	56.9 (45.3-68.1)	55.8 (43.3-67.9)	0.168	0.592 (0.511-0.672)	0.002	≥ 1.40	57.7 (48.2-66.8)	50.9 (39.5-61.6)	0.104
AVI	0.673 (0.584-0.761)	< 0.001	≥ 21.25	59.4 (47.8-70.4)	58.8 (46.2-70.6)	0.268	0.626 (0.547- 0.706)	0.026	≥ 22.70	60.2 (51.7-69.5)	40.5 (31.5-50.3)	0.246
ABSI	0.597 (0.504- 0.691)	0.043	≥ 0.09	60.7 (49.1-71.6)	48.5 (36.2-60.9)	0.151	0.587 (0.506-0.668)	0.035	≥ 0.09	50.9 (41.4-60.2)	50.6 (39.5-61.6)	0.086
BRI	0.678 (0.591-0.764)	< 0.001	≥ 5.70	62.2 (51.5-72.7)	56.4 (43.3-69.7)	0.310	0.645 (0.568-0.723)	< 0.001	≥ 4.43	77.4 (72.6-79.4)	27.6 (22.6-34.7)	0.244

BMI: Body Mass Index, WC: Waist Circumference, WHR: Waist to Hip Ratio, WHtR: Waist to Height Ratio; CI: Conicity Index, AVI: Abdominal Volume Index, ABSI: Body Shape Index, BRI: Body Roundness Index.

Table III. Area under the ROC curve, optimal cut-off points, and validity parameters of different anthropometric indices predicting the MetS according to gender.

	Male								Female							
	High BP		High FBG		High TG		Low HDL-C		High BP		High FBG		High TG		Low HDL-C	
	AUC	*p*	AUC	*p*	AUC	*p*	AUC	*p*	AUC	*p*	AUC	*p*	AUC	*p*	AUC	*p*
BMI	0.705 (0.615-0.796)	< 0.001	0.641 (0.551-0.731)	0.003	0.635 (0.545-0.725)	0.005	0.614 (0.517-0.712)	0.026	0.683 (0.609-0.756)	< 0.001	0.655 (0.580-0.730)	< 0.001	0.633 (0.549-0.716)	0.002	0.706 (0.635-0.777)	< 0.001
WC	0.641 (0.545-0.737)	0.004	0.653 (0.565-0.741)	0.001	0.600 (0.507-0.693)	0.038	0.702 (0.610-0.793)	< 0.001	0.712 (0.638-0.785)	< 0.001	0.701 (0.63-0.772)	< 0.001	0.717 (0.628-0.807)	< 0.001	0.787 (0.725-0.850)	< 0.001
WHR	0.654 (0.562-0.746)	0.002	0.595 (0.503-0.687)	0.048	0.642 (0.552-0.731)	0.003	0.656 (0.553-0.758)	0.002	0.628 (0.551-0.704)	0.002	0.604 (0.527-0.682)	0.011	0.654 (0.573-0.734)	< 0.001	0.655 (0.58-0.730)	<0.001
WHtR	0.707 (0.618-0.797)	< 0.001	0.665 0.577-(0.753)	0.001	0.654 0.565-(0.743)	0.001	0.717 (0.625-0.809)	< 0.001	0.693 (0.619-0.768)	< 0.001	0.653 (0.579-0.728)	< 0.001	0.667 (0.579--0.755)	< 0.001	0.746 (0.678-0.813)	< 0.001
CI	0.644 0.550-0.738)	0.003	0.656 (0.567-0.745)	0.001	0.633 (0.542-0.723)	0.006	0.657 (0.561-0.754)	0.002	0.605 (0.526-0.683)	0.011	0.62 (0.543-0.697)	0.003	0.605 (0.52-0.691)	0.016	0.659 (0.584-0.735)	<0.001
AVI	0.687 (0.595-0.779)	< 0.001	0.741 (0.662-0.82)	< 0.001	0.642 (0.552-0.732)	0.003	0.722 (0.634-0.810)	< 0.001	0.711 (0.637-0.784)	< 0.001	0.702 (0.631 -0.772)	< 0.001	0.716 (0.627-0.806)	< 0.001	0.786 (0.724 -0.849)	< 0.001
ABSI	0.642 (0.547-0.736)	0.004	0.615 (0.524 -0.706)	0.017	0.595 (0.503-0.687)	0.049	0.682 (0.593-0.772)	< 0.001	0.609 (0.530-0.688)	0.008	0.612 (0.534-0.689)	0.006	0.606 (0.524-0.688)	0.015	0.636 (0.559-0.713)	0.001
BRI	0.723 (0.634-0.812)	< 0.001	0.728 (0.646-0.810)	< 0.001	0.675 (0.587-0.763)	< 0.001	0.734 (0.646-0.821)	< 0.001	0.694 (0.620-0.770)	< 0.001	0.709 (0.640-0.780)	< 0.001	0.714 (0.63-0.800)	< 0.001	0.806 (0.750-0.870)	< 0.001

High BP (High Blood Pressure): ≥ 130/85 mmHg; High FBG (High Fasting Blood Glucose): FBG ≥ 100 mg/dl, High TG: (High Triglyceride): ≥ 150 mg/dl; Low HDL-C: (Low High Density Lipoprotein Cholesterol): < 40 and < 50 mg/dL in males and females, respectively.

When WC is less than the hip circumference in the calculation of AVI, an increment in the hip circumference increases the AVI value. Given that females' hip circumferences are generally larger than their WCs, any increment in hip circumference increased the AVI value, which explains the difference in the cut-off value of AVI between the genders[14].

In this study, the optimal cut-off point for WC was 93.50 cm in males and 96.50 cm in females. The optimal cut-off point for WC in predicting MetS was reported as 92 cm in males and 87 cm in females in Saudi population[12].

The difference between cut-off points can be associated with the difference in ethnicity, lifestyle, socio-cultural characteristics, geographical features of the study area, age groups, gender, and genetic characteristics of the elderly[36]. Moreover, hormonal factors related to gender and aging factors increase body fat; therefore, they have an effect on anthropometric indices and their cut-off points for predicting elderly people at the risk of MetS[9]. Also different criteria have been used for MetS (IDF, ATP III, AHA, WHO) in the studies[11].

In addition, the present study revealed different discriminatory abilities for different MetS components. BRI had the largest AUC for elevated blood pressure, triglyceride, HDL-C in males and fasting blood glucose and HDL-C in females. On the other hand, WC had the largest AUC for high blood pressure and triglycerides in females. These results are compatible with previous studies[37,38].

Despite its strengths and contributions to the literature, some limitations of the present study should be noted. Firstly, it is important to note that this analysis is limited to the cross-sectional design of the study; therefore, the study could not be used broadly to determine the predictive power. Secondly, although the study has a large population, there is a need for further studies with a large sample size from different settings representing the general population. Another limitation is that it did not consider the effects of medication use and the dietary pattern of the elderly on metabolic components of the syndrome because these variables may play a role in the relationship between metabolic syndrome and anthropometric indicators. Despite these limitations, this is the first attempt to investigate the predictive power of different anthropometric indices to identify the metabolic risk of the syndrome in the Turkish elderly, a vulnerable group in the society.

Conclusions

The present study indicated that BRI is useful for predicting the risk of metabolic syndrome in Turkish male and female elder people. Prospective studies are needed to identify those indices in which value changes predict the development of metabolic disorders best. Early detection of MetS as well as lifestyle interventions in old age may help to reduce the burden of this syndrome and other related diseases.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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Authors' Contribution

Conceptualization, E.E.O.; methodology E.E.O. and H.Y; formal analysis, E.E.O. and H.Y.; investigation, E.E.O. and H.Y.; resources; E.E.O. and H.Y; data curation, E.E.O. and H.Y.; writing—original draft preparation, E.E.O.; writing—review and editing, E.E.O. and H.Y. All authors read and agreed to the published version of the manuscript.

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Ethics Approval

The study was approved by the Ethics Committee of the Gaziantep Islam Science and Technology University (protocol code 2022/76). The study was conducted in accordance with the Declaration of Helsinki.

Informed Consent

Informed consent was obtained from all the subjects participating in the study.

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