

Body Shape Phenotypes and Osteosarcopenia in Older Adults With Sarcopenic Obesity: Insights From the Muscle–Bone–Fat Axis

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Abstract

Background

Osteosarcopenia is a clinically relevant geriatric phenotype characterized by the coexistence of impaired bone health, reduced muscle mass or function, and adiposity-related metabolic dysfunction. Body mass index does not adequately reflect adipose tissue distribution, muscle impairment, or skeletal vulnerability in older adults with sarcopenic obesity. This study investigated whether body shape–based anthropometric indices reflecting central adiposity are associated with osteosarcopenia in this population.

Methods

This retrospective cross-sectional study included 203 older adults aged ≥ 65 years with sarcopenic obesity evaluated at a tertiary geriatric outpatient clinic. Sarcopenic obesity was defined according to ESPEN/EASO criteria using bioelectrical impedance analysis and functional assessments. Osteoporosis was diagnosed by dual-energy X-ray absorptiometry using a T-score ≤ -2.5 . Osteosarcopenia was defined as the coexistence of sarcopenic obesity and osteoporosis. Associations of A Body Shape Index (ABSI), Body Roundness Index (BRI), waist-to-height ratio (WHtR), and weight-adjusted waist index (WWI) with osteosarcopenia were evaluated using receiver operating characteristic (ROC) analysis and multivariable logistic regression.

Results

Among 203 older adults with sarcopenic obesity, 23 (11.3%) had osteosarcopenia. Individuals with osteosarcopenia were older (77 vs. 71 years, $p = 0.001$), had lower handgrip strength (13.4 vs. 20.0 kg, $p < 0.001$), and had higher ABSI (25.30 vs. 21.67, $p = 0.001$), BRI (9.69 vs. 8.13, $p < 0.001$), and WWI (12.96 vs. 12.13, $p < 0.001$). ABSI showed the highest discriminatory performance in ROC analysis (AUC 0.821). In multivariable logistic regression models, ABSI (OR 1.197, 95% CI 1.057–1.357, $p = 0.005$), BRI (OR 1.620, 95% CI 1.221–2.150, $p = 0.001$), and WWI (OR 3.749, 95% CI 1.720–8.169, $p = 0.001$) remained independently associated with osteosarcopenia.

Conclusions

Body shape–based anthropometric indices were independently associated with osteosarcopenia in older adults with sarcopenic obesity. These readily obtainable measures may provide complementary information for risk stratification of musculoskeletal vulnerability beyond conventional obesity assessment. However, they should be interpreted as risk-stratification markers rather than standalone diagnostic measures.

Introduction

Osteoporosis is a chronic skeletal disease characterized by reduced bone mineral density (BMD) and deterioration of bone microarchitecture, resulting in increased susceptibility to fragility fractures, disability, and loss of functional independence in older adults (1). With population aging, osteoporosis-related fractures are expected to contribute increasingly to morbidity, disability, and loss of independence worldwide (2). The rising burden of musculoskeletal disease highlights the need for pragmatic approaches to identify older adults at increased musculoskeletal risk prior to fragility fracture or functional decline. Although dual-energy X-ray absorptiometry (DXA) remains the reference standard for assessing bone mineral density (BMD), it may not always be readily available for broad risk stratification in routine geriatric practice. However, BMD alone does not fully reflect the complex interaction between adiposity, muscle impairment, and skeletal vulnerability. The relationship between obesity and bone health is complex and not always protective. Although increased body weight may be associated with greater mechanical loading on bone and potentially higher BMD, this potential benefit is not observed in all obesity phenotypes (3). Central obesity, particularly visceral adiposity, has been associated with adverse skeletal outcomes, including impaired bone quality and increased fracture risk (4, 5). The relationship between BMI and skeletal outcomes seems to be non-linear, and visceral adipose tissue may promote low-grade inflammation and alter bone remodeling through adipokine, cytokine, and free fatty-acid signaling (6).

Aging is also associated with progressive loss of skeletal muscle mass, strength, and physical performance. Sarcopenic obesity, defined by the coexistence of excess adiposity and impaired muscle mass or function, is a particularly vulnerable phenotype in older adults (7). In older adults with sarcopenic obesity, the coexistence of sarcopenia and osteoporosis represents a particularly vulnerable phenotype termed osteosarcopenia, which is increasingly recognized as a manifestation of dysregulation across the muscle–bone–fat axis (8). Osteosarcopenia reflects the convergence of structural and inflammatory pathways affecting both muscle and bone and is associated with frailty, falls, hospitalizations, and mortality (8, 9). Yet, despite these biological connections, BMI remains the predominant focus of clinical assessment of obesity-related musculoskeletal vulnerability. However, BMI does not distinguish fat mass from lean mass, does not adequately represent fat distribution, and may therefore misclassify musculoskeletal vulnerability in older adults with sarcopenic obesity (10). Waist circumference offers information about abdominal fat accumulation but does not include height standardization and may not accurately describe the geometric shape of the body (11). These limitations are clinically relevant because older adults with similar BMI values may have markedly different patterns of visceral adiposity, muscle impairment, and skeletal fragility. Body shape–based anthropometric indices have been developed to overcome these limitations. A Body Shape Index (ABSI) incorporates waist circumference, height, and BMI to estimate abdominal adiposity independent of overall body size, whereas Body Roundness Index (BRI), Waist-to-height ratio (WHtR), and weight-adjusted waist index (WWI) provide complementary measures of central adiposity and body geometry. Because these indices rely on routinely obtained anthropometric measurements, they may represent practical tools for identifying older adults who may benefit from further musculoskeletal evaluation. However, the

comparative relevance of ABSI, BRI, WHtR, and WWI across skeletal phenotypes, particularly osteosarcopenia, remains insufficiently defined in older adults with sarcopenic obesity. Whether these indices are associated with osteosarcopenia beyond their established relationship with general adiposity or cardiometabolic risk is clinically important but not well understood. Clarifying this relationship may help determine whether simple body shape–based measures can complement BMI, DXA, and functional assessment within a geriatric musculoskeletal risk framework.

Given the biological links among visceral adiposity, muscle dysfunction, and bone fragility, these indices may provide clinically relevant information beyond BMI alone. We therefore examined the associations of ABSI, BRI, WHtR, and WWI with osteosarcopenia in adults aged ≥ 65 years with sarcopenic obesity. Associations with site-specific BMD and other bone-status categories were evaluated as secondary analyses. We hypothesized that higher values of body shape–based anthropometric indices would be associated with osteosarcopenia.

Materials and Methods

Study Design and Participant Selection

This retrospective cross-sectional study included patients evaluated at a tertiary geriatric medicine outpatient clinic from 2022 through 2024. Of 1,332 patients assessed for eligibility, those aged younger than 65 years ($n = 10$), those without bone mineral density (BMD) assessment ($n = 446$), and those who did not meet the criteria for sarcopenic obesity ($n = 371$) were excluded, leaving 505 potentially eligible participants.

Participants were subsequently excluded because of missing data on hypertension, diabetes mellitus, or coronary artery disease ($n = 46$); laboratory variables (including triglycerides, fasting plasma glucose, LDL-C, HDL-C) ($n = 83$); smoking status or sociodemographic characteristics ($n = 37$); or variables required for the calculation of anthropometric and metabolic indices ($n = 136$). The final analytic sample comprised 203 participants, including 54 men and 149 women. The participant selection process is shown in Fig. 1.

Clinical and Geriatric Variables

Demographic, social, clinical, laboratory, and comprehensive geriatric assessment data were obtained retrospectively from medical records. Recorded variables included age, sex, educational attainment, marital status, living arrangement, smoking status, assistive device use, sensory impairment, body mass index (BMI), hypertension, diabetes mellitus (DM), coronary artery disease (CAD), hyperlipidemia, and relevant laboratory measurements (Table 1, **Supplementary Tables**).

Assistive device use was analyzed as a four-level categorical variable: no assistive device, glasses only, cane or walker use, and combined cane or walker and glasses use. The no-assistive-device category was

used as the reference in regression analyses.

Smoking status was classified as never, former, or current smoking according to the 100-cigarette lifetime threshold (15). DM, hypertension, and CAD were identified from documented diagnoses, relevant medication use, or clinical history (16–18). CAD was defined as a documented history of myocardial infarction, coronary revascularization, or physician-diagnosed ischemic heart disease.

Anthropometric Measurements and Derived Indices

Height was measured without shoes using a wall-mounted stadiometer (TEMBEKO 035 × 040, Istanbul, Türkiye). Body weight was measured to the nearest 0.1 kg using a regularly calibrated scale, with participants wearing light clothing and no shoes. Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the upper border of the iliac crest, using a nonstretchable tape positioned horizontally at the end of a normal expiration (19).

BMI was calculated as weight in kilograms divided by height in meters squared. A BMI of 30 kg/m² or greater was required for inclusion.

A Body Shape Index (ABSI), Body Roundness Index (BRI), waist-to-height ratio (WHtR), and weight-adjusted waist index (WWI) were calculated using previously published equations (11–14). The triglyceride–glucose index (TyG), Conicity Index (CI), Cardiometabolic Index (CMI), and Atherogenic Index of Plasma (AIP) were calculated as previously described (20–23). The equations, required measurement units, and calculation details are provided in **Supplementary Methods S1**.

Body Composition and Definition of Sarcopenic Obesity

Body composition was assessed using bioelectrical impedance analysis a Bodystat 4000 device (Bodystat Ltd., Isle of Man, UK). The SARC-F questionnaire was used as a screening instrument, with a score of 4 or greater indicating an increased likelihood of sarcopenia. Handgrip strength was measured using a Takei handgrip dynamometer. Low handgrip strength was defined as less than 27.6 kg in men and less than 16 kg in women. Lower-extremity muscle performance was assessed using the five-times sit-to-stand test (5×STS), with a completion time longer than 17 seconds considered prolonged.

Sarcopenic obesity was defined according to the European Society for Clinical Nutrition and Metabolism/European Association for the Study of Obesity (ESPEN/EASO) consensus framework (24). Excess adiposity was defined as a body fat percentage greater than 43% in women and greater than 31% in men. Skeletal muscle mass was normalized to body weight, and low relative skeletal muscle mass was defined as a skeletal muscle mass-to-weight ratio (SMM/weight) of 37% or less in men and 27.6% or less in women. The diagnostic algorithm is presented in Fig. 2.

Bone Mineral Density and Definition of Osteosarcopenia

BMD was measured at the lumbar spine (L1–L4 and L2–L4), total femur, and femoral neck using dual-energy X-ray absorptiometry (DXA; Hologic, Bedford, MA, USA). BMD was expressed in grams per square centimeter. All scans were performed by trained technicians according to the manufacturer's standard operating procedures. Routine calibration and quality-control procedures were conducted in accordance with institutional protocols.

Osteoporosis was defined as a T-score of -2.5 or lower at any assessed skeletal site, and osteopenia as a T-score greater than -2.5 and lower than -1.0 . Because all participants met the criteria for sarcopenic obesity, osteosarcopenia was defined as the coexistence of sarcopenic obesity and osteoporosis.

Because all participants met the criteria for sarcopenic obesity, osteosarcopenia was defined as the additional presence of osteoporosis, based on a T-score of -2.5 or lower.

Approval of Ethics

This study was approved by the Hacettepe University Health Sciences Research Ethics Committee, Ankara, Türkiye (approval number: 2025/05–54; research registration number: SBA 25/168). The study was conducted in accordance with the Declaration of Helsinki and all relevant guidelines and regulations. Owing to the retrospective design and the use of coded data, the requirement for written informed consent was waived by the ethics committee.

Statistical Analysis

Continuous variables are displayed as the median (interquartile range), while categorical variables are represented as the number (percentage). Because none of the continuous variables had a normal distribution, all analyses used non-parametric methods. The Mann-Whitney U test or the Kruskal-Wallis test were used to compare groups for continuous variables, and the chi-square test or Fisher's exact test were used for categorical variables.

Multivariable logistic regression analyses were performed to evaluate the associations between anthropometric indices and osteosarcopenia. Because of collinearity and shared mathematical components, ABSI, BRI, WHtR, and WWI were entered into separate models using the same hierarchical adjustment strategy. Model 1 was adjusted for age, smoking status, hyperlipidemia, Clinical Frailty Scale score, and marital status. Model 2 was adjusted for assistive device use, sensory impairment, and living arrangement; vertebral compression fracture was not included because it contributed to the definition of osteosarcopenia. Model 3 additionally incorporated physical performance measures, including 4-m walking speed, Timed Up and Go, five-times sit-to-stand tests, and handgrip strength. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported for all models. Model 3 was considered an exploratory model because functional performance measures overlap with the clinical construct of sarcopenia. The adjusted associations between body shape–based anthropometric indices and osteosarcopenia from the primary multivariable model are presented as a forest plot (Fig. 4).

Receiver operating characteristic (ROC) curve analyses were performed separately for ABSI, BRI, WHtR, and WWI to assess their discriminatory ability for osteosarcopenia. Areas under the curve (AUCs) with 95% confidence intervals were calculated, and optimal cutoffs were determined using the Youden index. Statistical analyses were conducted using SPSS version 25 (IBM Corp.), and a two-sided P value < .05 was considered statistically significant.

Results

Characteristics of Participants

Participant Characteristics

A total of 203 older adults with sarcopenic obesity were included. The median age was 72 years (interquartile range [IQR], 68–77), and 23 participants (11.3%) had osteosarcopenia. Participants with osteosarcopenia were older than those without osteosarcopenia (median, 77 [IQR, 71–82] vs 71 [IQR, 68–76] years; $P = .001$), whereas the sex distribution did not differ between groups ($P = .802$) (Table 1, **Supplementary Tables**).

The groups differed in educational attainment ($P = .033$), marital status ($P < .001$), living arrangement ($P = .006$), assistive device use ($P < .001$), smoking status ($P = .004$), and prevalence of hyperlipidemia ($P = .007$). Participants with osteosarcopenia also had higher Clinical Frailty Scale and SARC-F scores and lower Lawton instrumental activities of daily living scores.

Handgrip strength was lower in participants with osteosarcopenia (median, 13.4 [IQR, 11.6–16.2] vs 20.0 [IQR, 15.2–25.8] kg; $P < .001$). Performance also differed between groups on the five-times sit-to-stand test ($P = .049$), 4-m walking test ($P < .001$), and Timed Up and Go test ($P = .002$).

BMI, waist circumference, ABSI, BRI, WHtR, and WWI were higher among participants with osteosarcopenia. In contrast, CMI, CI, AIP, and TyG did not differ significantly between groups. Pairwise comparisons supported the overall group differences in marital status, education, smoking status, assistive device use, and living arrangement.

Discrimination of Osteosarcopenia

The discrimination of the anthropometric indices for osteosarcopenia is shown in Fig. 3 and **Table 2**. ABSI had the highest area under the receiver operating characteristic curve (AUC, 0.821; 95% confidence interval [CI], 0.734–0.909; $P < .001$), with 70% sensitivity and 84% specificity at the optimal cutoff. WWI had an AUC of 0.769 (95% CI, 0.661–0.877; $P < .001$). The AUCs for BRI and WHtR were both 0.748 (95% CI, 0.645–0.851; $P < .001$).

Bone Mineral Density and Anthropometric Indices According to Bone Status

Table 3 (**Supplementary Tables**) presents condition-specific comparisons of BMD and T-scores according to the presence or absence of osteopenia, osteoporosis, osteosarcopenia. These categories were analyzed separately and should not be interpreted as mutually exclusive or sequential stages of skeletal disease.

Participants with osteopenia, osteoporosis, or vertebral compression fracture had lower BMD values and T-scores at the femoral neck, total femur, and lumbar spine than participants without the corresponding condition. Osteosarcopenia was associated with lower femoral neck and total femur BMD values and T-scores, whereas lumbar spine measurements did not differ significantly according to osteosarcopenia status. Overall, femoral measurements showed more consistent associations with the assessed skeletal phenotypes than lumbar spine measurements.

All four body shape–based indices were higher among participants with osteosarcopenia (**Table 5**). Median BRI was 9.7 in participants with osteosarcopenia and 8.1 in those without osteosarcopenia; corresponding values were 25.3 and 21.7 for ABSI, 0.8 and 0.7 for WHtR, and 13.0 and 12.1 for WWI. ABSI was also higher among participants with osteoporosis ($P < .001$) and osteopenia ($P = .003$), whereas BRI, WHtR, and WWI did not differ significantly according to osteoporosis or osteopenia status.

Multivariable Analyses

Because the anthropometric indices share mathematical components and were highly correlated, each index was entered into a separate multivariable logistic regression model (Table 4, **Supplementary Tables**). The adjusted associations between individual anthropometric indices and osteosarcopenia in Model 2 are visually summarized in Fig. 4.

In Model 1, adjusted for age, smoking status, hyperlipidemia, Clinical Frailty Scale score, and marital status, ABSI remained associated with osteosarcopenia (adjusted odds ratio [aOR], 1.27; 95% CI, 1.09–1.50; $P = .003$), as did WWI (aOR, 3.48; 95% CI, 1.43–8.46; $P = .006$). BRI and WHtR were not statistically significant in these models.

In Model 2, adjusted for assistive device use, sensory impairment, and living arrangement, all four indices were associated with osteosarcopenia when entered separately: ABSI (aOR, 1.20; 95% CI, 1.06–1.36; $P = .005$), BRI (aOR, 1.62; 95% CI, 1.22–2.15; $P = .001$), WWI (aOR, 3.75; 95% CI, 1.72–8.17; $P = .001$), and WHtR (aOR, 1.014; 95% CI, 1.006–1.023; $P = .001$). Cane or walker use was strongly associated with osteosarcopenia across models (aOR range, 12.79–16.17), although the cross-sectional design precludes causal interpretation. Glasses use, combined cane or walker and glasses use, sensory impairment, and living arrangement were not consistently associated with the outcome.

In Model 3, which included the physical performance measures, greater handgrip strength was associated with lower odds of osteosarcopenia, whereas the 4-m walking test, Timed Up and Go test, and five-times sit-to-stand test were not independently associated with the outcome. BRI, WHtR, and WWI remained associated with osteosarcopenia in these models.

The effect sizes and precision of the independent predictors are visually summarized in the corresponding forest plots (Figs. 4–6).

Discussion

In this study of older adults with sarcopenic obesity, body shape–based anthropometric indices were associated with osteosarcopenia. ABSI showed the highest discrimination, with an AUC of 0.821. After adjustment for age, smoking status, hyperlipidemia, frailty, and marital status, ABSI and WWI remained associated with osteosarcopenia. In alternative models incorporating assistive device use, sensory impairment, and living arrangement, all four indices remained significant. Rather than replacing conventional skeletal assessment, these indices may complement existing approaches by providing inexpensive, readily obtainable markers for identifying older adults who may benefit from comprehensive musculoskeletal evaluation. (6, 7).

Osteosarcopenia is increasingly understood as more than the coexistence of osteoporosis and sarcopenia. It may represent a broader disturbance of the muscle–bone–fat axis, in which impaired bone strength, reduced muscle function, and adipose tissue dysfunction interact (9, 24). Aging is accompanied by visceral fat accumulation, myosteatosis, and impaired anabolic signaling (10, 25). These changes contribute to chronic low-grade inflammation, characterized by increased proinflammatory mediators that may promote osteoclastogenesis, inhibit osteoblast function, and impair muscle protein synthesis (4, 25). Anthropometric indices that reflect central fat distribution may therefore serve as indirect markers of this adverse metabolic and inflammatory phenotype. These biological interactions support the concept that alterations in body shape are not merely anthropometric findings but may reflect underlying changes in body composition and tissue quality that accompany aging.

Although BMI is widely used, it does not distinguish fat mass from lean mass or adequately characterize fat distribution (10). This limitation is particularly relevant in sarcopenic obesity, in which a relatively preserved or elevated body weight may coexist with reduced muscle strength and impaired physical performance. BMI may consequently underestimate musculoskeletal vulnerability in older adults with excess adiposity (24, 26). Body shape–based indices were developed to address some of these limitations. ABSI incorporates waist circumference, height, and BMI and was designed to characterize abdominal adiposity independently of overall body size (12). Previous studies of ABSI have reported variable associations with chronic disease and skeletal outcomes, but most were conducted in general populations rather than in older adults with concurrent adiposity and muscle impairment (7). Accordingly, two individuals with similar BMI values may differ substantially in visceral adiposity, muscle quality, and skeletal integrity, potentially explaining why body shape–based indices demonstrated stronger associations with osteosarcopenia than BMI alone.

BRI provides a geometric estimate of body roundness based on waist circumference and height and has been associated with visceral adiposity (13). WWI adjusts waist circumference for body weight and may

reflect disproportionate central fat accumulation. Visceral and ectopic adipose tissue may adversely affect bone and muscle through inflammatory signaling, fatty infiltration, and impaired tissue quality (9, 27). These mechanisms provide biological plausibility for the observed associations between body shape–based indices and osteosarcopenia. The present findings therefore support the hypothesis that body shape characteristics may represent clinically relevant markers surrogate for the adverse redistribution of adipose tissue accompanying musculoskeletal aging.

ABSI showed the highest unadjusted discrimination, whereas WWI had larger adjusted odds ratios in several models. Because these indices are measured on different numerical scales and ROC and regression analyses address different statistical questions, these findings should not be interpreted as establishing superiority of one index over another.

Frailty and functional impairment were more common among participants with osteosarcopenia. Higher Clinical Frailty Scale scores, lower handgrip strength, and poorer performance on mobility tests support the view that osteosarcopenia is part of a broader geriatric vulnerability phenotype. Handgrip strength remained associated with lower odds of osteosarcopenia in the physical-performance models, whereas gait, Timed Up and Go, and five-times sit-to-stand performance did not remain independently significant when considered together. This pattern may reflect overlap among these measures and the limited number of outcome events.

Cane or walker use was strongly associated with osteosarcopenia, although estimates were imprecise. Rather than indicating a causal relationship, mobility aid use may represent a clinically observable marker of underlying mobility limitation, frailty, balance impairment, or previous musculoskeletal injury (28).

Smoking status was associated with osteosarcopenia in age- and frailty-adjusted models, but detailed exposure data were unavailable. This association may reflect cumulative exposure, residual confounding, or smoking cessation after chronic illness and should not be interpreted causally.

Femoral neck and total femur measurements showed more consistent associations with osteosarcopenia than lumbar spine measurements. Lumbar spine BMD may be confounded by degenerative changes and vascular calcification in older adults, which may partly explain the stronger femoral associations. Femoral neck and total femur measurements showed more consistent associations with osteosarcopenia than lumbar spine measurements. Lumbar spine BMD may be affected by degenerative changes and vascular calcification in older adults, which may partly explain the stronger femoral associations. These findings are consistent with the recognized limitations of lumbar DXA measurements in older populations and emphasize the importance of interpreting skeletal-site–specific results within their clinical context (29). These findings are consistent with the recognized limitations of lumbar DXA measurements in older populations and emphasize the importance of interpreting skeletal-site–specific results within their clinical context.

In contrast to the body shape–based measures, TyG, AIP, CMI, and CI were not significantly associated with osteosarcopenia. These indices primarily reflect insulin resistance, lipid-related risk, or generalized central adiposity and may be less sensitive to the combined redistribution of fat, loss of muscle quality, and skeletal deterioration that characterizes osteosarcopenia. This finding supports the concept that sarcopenic obesity and osteosarcopenia represent distinct phenotypes within the broader spectrum of age-related metabolic and musculoskeletal dysfunction (8, 24). This may explain why anthropometric indices specifically reflecting body shape and fat distribution appeared to be more informative in the present cohort.

The principal clinical advantage of ABSI, BRI, WHtR, and WWI is that they can be calculated from routinely available anthropometric measurements. They should not be considered diagnostic substitutes for DXA, fracture assessment, muscle strength testing, or comprehensive geriatric assessment. Their potential role is as accessible markers that may help identify older adults who warrant more detailed musculoskeletal evaluation. Given the associations of osteosarcopenia with falls, fractures, disability, and mortality, even modest improvements in case finding may be clinically relevant (30).

Several limitations merit consideration. First, the retrospective cross-sectional design precludes inference about temporality or causality between body shape–based indices and osteosarcopenia. Second, the number of osteosarcopenia cases was small, which limited statistical precision and increased the risk of model overfitting; therefore, the multivariable findings should be interpreted as exploratory. Third, complete-case analysis may have introduced selection bias, and the single-center tertiary geriatric clinic setting may limit generalizability to community-dwelling or less selected older populations. Fourth, residual confounding by physical activity, nutritional status, inflammatory burden, medication use, cumulative smoking exposure, and comorbidity severity could not be excluded. Finally, bioelectrical impedance analysis provides an indirect estimate of body composition, and lumbar DXA measurements in older adults may be affected by degenerative changes or vascular calcification. Accordingly, the present findings should be interpreted primarily as hypothesis-generating and require confirmation in larger prospective multicenter cohorts.

Longitudinal studies are needed to determine whether these indices predict incident fractures, functional decline, disability, or mortality in older adults with sarcopenic obesity (24). Studies incorporating repeated body composition assessment, measures of muscle quality, inflammatory biomarkers, and imaging-based estimates of visceral and ectopic fat may help clarify the mechanisms linking central adiposity with combined bone and muscle deterioration (25).

In conclusion, body shape–based anthropometric indices were associated with osteosarcopenia in older adults with sarcopenic obesity. ABSI showed the highest discrimination, while ABSI and WWI remained associated with osteosarcopenia in the principal adjusted models. If confirmed in prospective studies, these readily obtainable anthropometric indices may contribute to more pragmatic identification of older adults at risk stratification of older adults at increased risk of osteosarcopenia and facilitate earlier comprehensive musculoskeletal assessment. (7, 8, 14).

Declarations

Ethics approval and consent to participate

This study was approved by the Hacettepe University Health Sciences Research Ethics Committee, Ankara, Türkiye (approval number: 2025/05-54; research registration number: SBA 25/168). The study was conducted in accordance with the principles of the Declaration of Helsinki and all relevant institutional and national guidelines and regulations. The requirement for written informed consent was waived by the ethics committee because of the retrospective study design and the use of coded data.

Consent for publication

Not applicable.

Clinical trial number

Clinical trial number: not applicable.

Data Availability Statement

The data supporting the findings of this study are not publicly available due to privacy and ethical restrictions but are available from the corresponding author upon reasonable request.

Conflict of Interest

Elif Gecegelen, Didem Karaduman, Cansu Atbaş, Yasemin Polat Özer, Mihriban Güngör, Ayşegül Erdoğan Bakır, Meryem Aslan, Mustafa Levent, Mete Üçdal, Karya Yurtsever, Mert Eşme, Cafer Balcı, Meltem Gülhan Halil, Mustafa Cankurtaran, and Burcu Balam Doğu declare that they have no conflict of interest.

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Author Contribution

Author Contributions (CRediT) Elif Gecegelen: Conceptualization, Methodology, Investigation, Data curation, Data verification, Formal analysis, Visualization, Writing – Original Draft, Writing – Review & Editing. Mete Tuğcan Üçdal: Conceptualization, Visualization. Burcu Balam Doğu: Conceptualization, , Project administration, Methodology, Supervision, Formal analysis, Data verification, Review & Editing. Mustafa Cankurtaran, Meltem Gülhan Halil, Cafer Balcı, and Mert Eşme: Supervision, Methodology. Didem Karaduman, Yasemin Polat Özer, Mihriban Güngör, Ayşegül Erdoğan Bakır, Meryem Aslan, Mustafa Levent, and Karya Yurtsever: Investigation, Data curation, Methodology. All authors read and approved the final manuscript.

References

1. Curry SJ, Krist AH, Owens DK, et al. Screening for osteoporosis to prevent fractures: US Preventive Services Task Force recommendation statement. *JAMA*. 2018;319(24):2521–31.
2. Zhu Z, Yu P, Wu Y, et al. Global burden of osteoporosis and high body mass index, 1990–2030. *J Nutr Health Aging*. 2023;27(9):767–74.
3. Bim MA, Pinto AA, et al. Relationship between body composition and bone mass. *PeerJ*. 2022;10:e14108.
4. Pinar-Gutierrez A, Garcia-Fontana C, et al. Obesity and bone health. *Int J Mol Sci*. 2022;23(12):6906.
5. Jain RK, Vokes T. Visceral adipose tissue and bone mineral density. *J Endocr Soc*. 2023;7(8):bvad096.
6. Zhang X, Zhang J, et al. Body fat distribution and bone mineral density. *Prev Med*. 2024;186:108092.
7. Batsis JA, Villareal DT. Sarcopenic obesity in older adults: aetiology, epidemiology and treatment strategies. *Nat Rev Endocrinol*. 2018;14(9):513–37.
8. Hirschfeld HP, Kinsella R, Duque G. Osteosarcopenia: where bone, muscle, and fat collide. *J Cachexia Sarcopenia Muscle*. 2017;8(2):35–52.
9. Yoo JI, Kim H, Ha YC, et al. Osteosarcopenia in patients with hip fracture is related with high mortality. *J Korean Med Sci*. 2018;33(4):e27.
10. Prado CM, Wells JC, Smith SR, Stephan BC, Siervo M. Sarcopenic obesity: a critical appraisal of the current evidence. *Clin Nutr*. 2012;31(5):583–601.
11. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. *Obes Rev*. 2012;13(3):275–86.
12. Krakauer NY, Krakauer JC. A new body shape index predicts mortality hazard independently of body mass index. *PLoS ONE*. 2012;7(7):e39504.
13. Thomas DM, Bredlau C, Bosy-Westphal A, et al. Relationships between body roundness with body fat and visceral adipose tissue emerging from a new geometrical model. *Obes (Silver Spring)*. 2013;21(11):2264–71.
14. Wang X, Yang S, He G, Xie L. Association between weight-adjusted-waist index and total bone mineral density. *Front Endocrinol (Lausanne)*. 2023;14:1191501.
15. Bondy SJ, Victor JC, Diemert LM. Origin and use of the 100-cigarette criterion in tobacco surveys. *Tob Control*. 2009;18(4):317–23.
16. American Diabetes Association Professional Practice Committee. 2. Diagnosis and classification of diabetes: Standards of Care in Diabetes-2024. *Diabetes Care*. 2024;47(suppl 1):S20-S42.
17. Whelton PK, Carey RM, Aronow WS et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults. Hypertension. 2018;71(6):e13-e115.

18. Virani SS, Newby LK, Arnold SV, et al. 2023 AHA/ACC/ACCP/ASPC/NLA/PCNA guideline for the management of patients with chronic coronary disease. *J Am Coll Cardiol.* 2023;82(9):833–955.
19. World Health Organization. Waist Circumference and Waist-Hip Ratio: Report of a WHO Expert Consultation, Geneva, 8–11 December 2008. World Health Organization; 2011.
20. Simental-Mendia LE, Rodriguez-Moran M, Guerrero-Romero F. The product of fasting glucose and triglycerides as a surrogate for identifying insulin resistance. *Metab Syndr Relat Disord.* 2008;6(4):299–304.
21. Valdez R. A simple model-based index of abdominal adiposity. *J Clin Epidemiol.* 1991;44(9):955–6.
22. Wakabayashi I, Daimon T. The cardiometabolic index as a new predictor of diabetes mellitus. *Clin Chim Acta.* 2015;438:274–8.
23. Dobiasova M. Atherogenic index of plasma [log(triglycerides/HDL-cholesterol)]: theoretical and practical implications. *Clin Chem.* 2004;50(7):1113–5.
24. Donini LM, Busetto L, Bischoff SC, et al. Definition and diagnostic criteria for sarcopenic obesity: ESPEN and EASO consensus statement. *Clin Nutr.* 2022;41(4):990–1000.
25. Franceschi C, Garagnani P, Parini P, Giuliani C, Santoro A. Inflammaging: a new immune-metabolic viewpoint for age-related diseases. *Nat Rev Endocrinol.* 2018;14(10):576–90.
26. Ferrucci L, Fabbri E. Inflammageing: chronic inflammation in ageing, cardiovascular disease and frailty. *Nat Rev Cardiol.* 2018;15(9):505–22.
27. Bredella MA. Sex differences in body composition. *Adv Exp Med Biol.* 2017;1043:9–27.
28. Montero-Odasso M, van der Velde N, Martin FC, et al. World guidelines for falls prevention and management for older adults: a global initiative. *Age Ageing.* 2022;51(9):afac205.
29. Schousboe JT, Vokes T, Broy SB, et al. Vertebral fracture assessment: the 2007 ISCD official positions. *J Clin Densitom.* 2008;11(1):92–108.
30. Huo YR, Suriyaarachchi P, Gomez F, et al. Phenotype of osteosarcopenia predicts fracture risk and mortality in older adults. *J Bone Min Res.* 2015;30(6):1167–74.

Figures

Figure 1. Study flowchart.

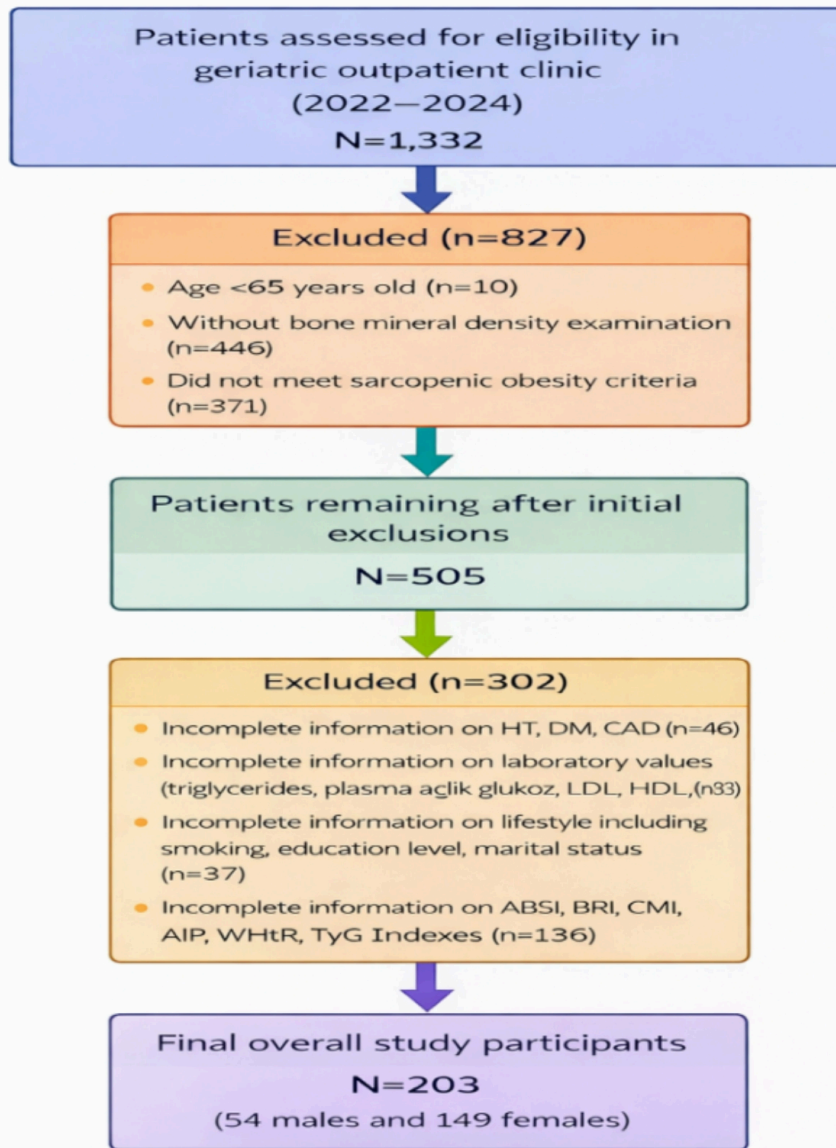


Figure 1

See image above for figure legend

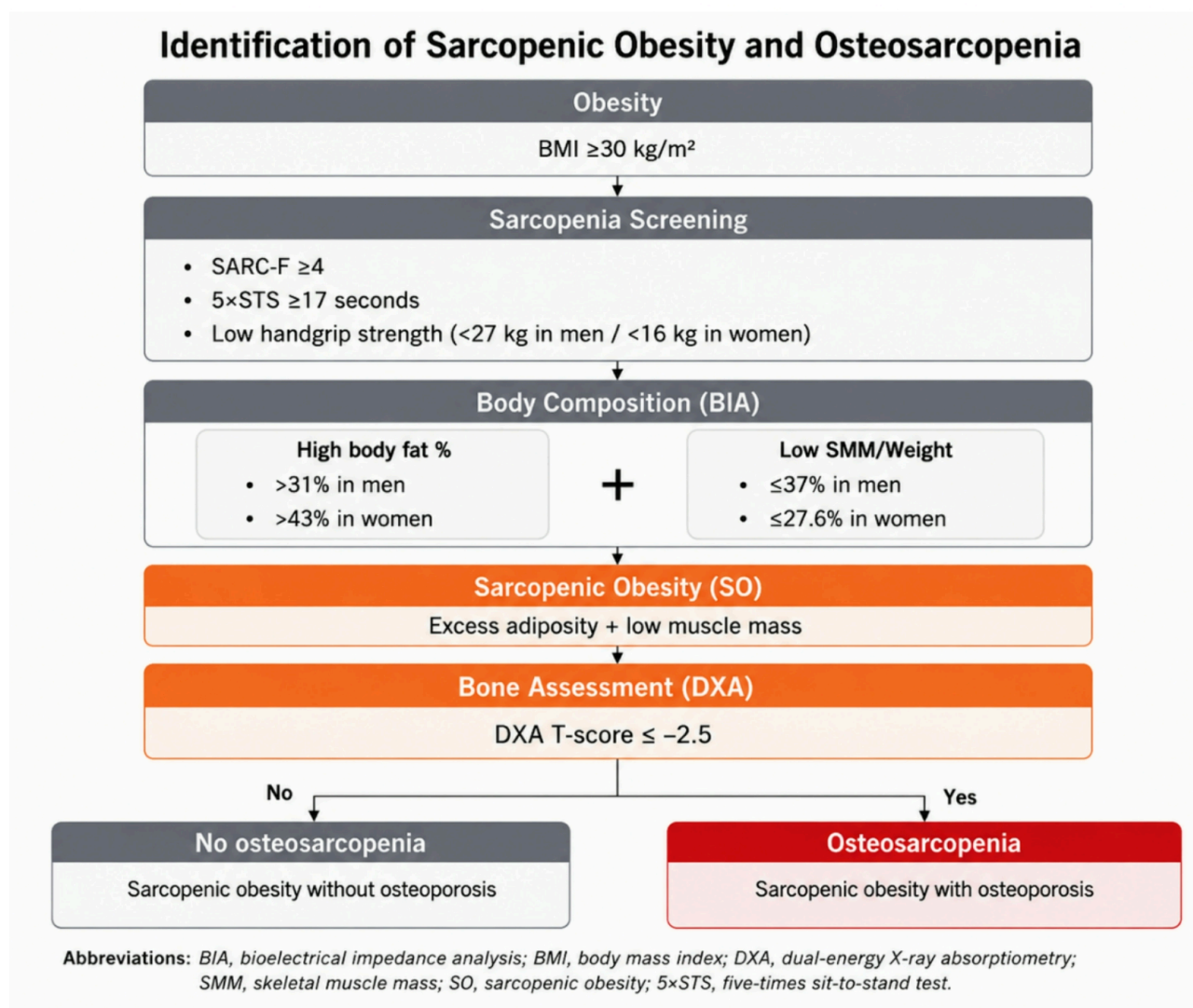


Figure 2

Diagnostic Algorithm for Identifying Sarcopenic Obesity and Osteosarcopenia in Older Adults

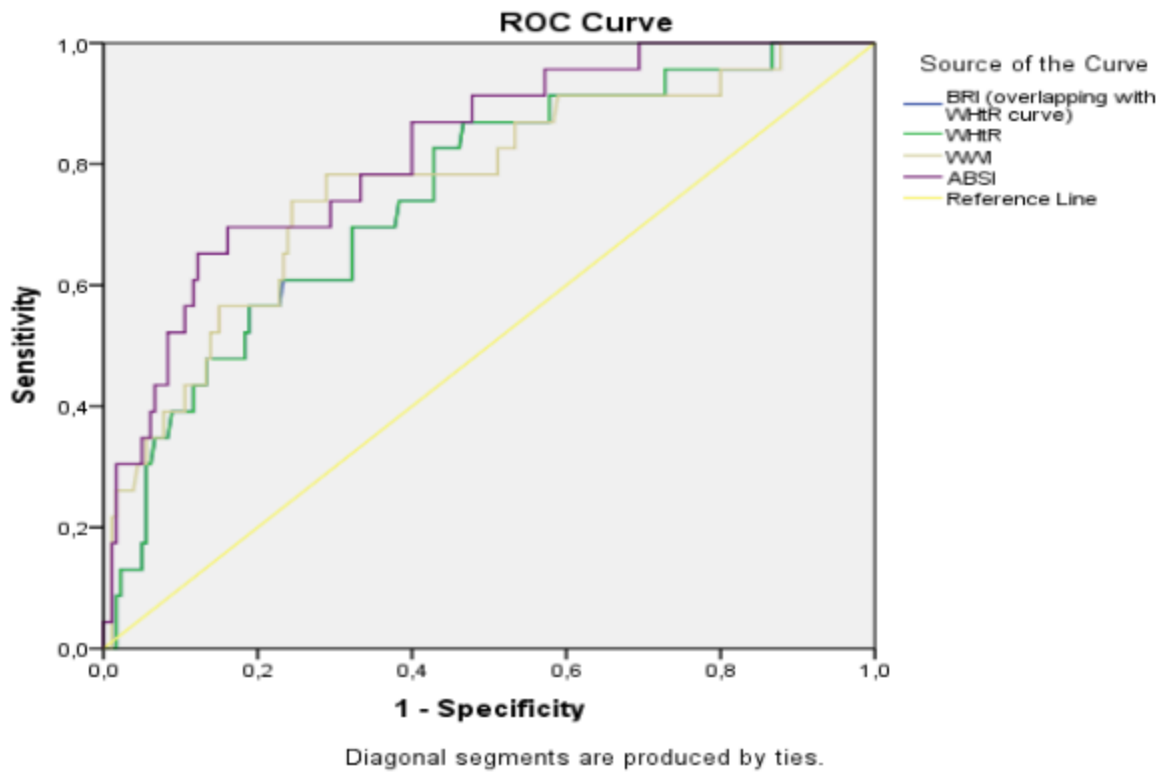


Figure 3

Receiver Operating Characteristic (ROC) Curves of Anthropometric Indices for the Identification of Osteosarcopenia

ROC curves comparing ABSI, BRI, WHtR, and WWI in discriminating osteosarcopenia. The diagonal line represents the reference line (AUC = 0.50).

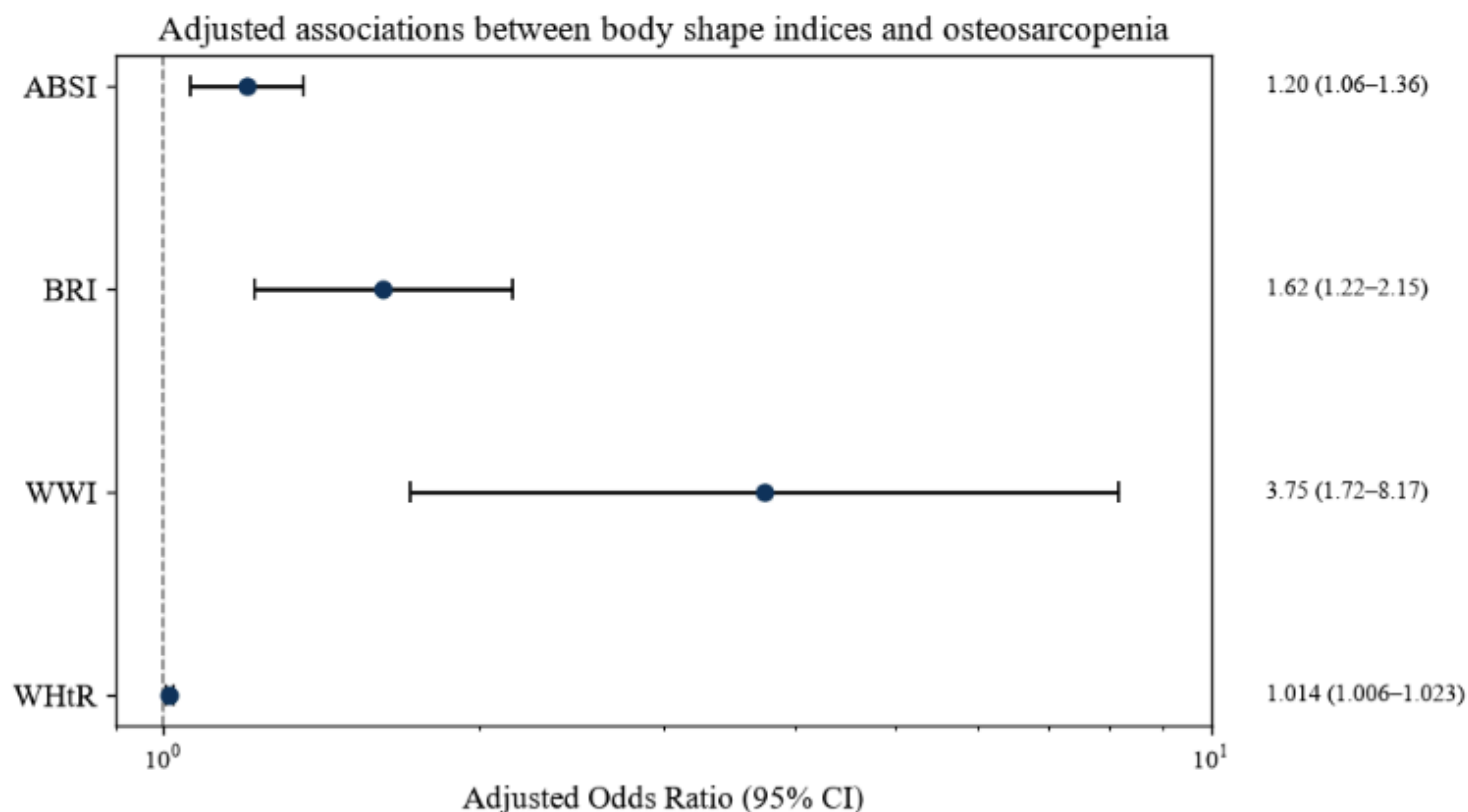


Figure 4

Adjusted associations between body shape–based anthropometric indices and osteosarcopenia.

Forest plot showing adjusted odds ratios (ORs) and 95% confidence intervals (CIs) from Model 2 multivariable logistic regression analyses. Each anthropometric index was entered separately because of collinearity and shared mathematical components. Models were adjusted for assistive device use, sensory impairment, and living arrangement.

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