Research letter

Obesity

The association between body roundness index and low body mass index-adjusted appendicular lean mass: a cross-sectional analysis of the NHANES 2011–2018 analytic sample

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Sarcopenia involves impaired muscle quantity and function [1, 2]. Low appendicular lean mass (ALM) alone does not establish this diagnosis. Body roundness index (BRI), derived from waist circumference and height [3], describes body shape and has been associated with mortality [4]. We examined its association with prevalent low body mass index (BMI)-adjusted ALM in the National Health and Nutrition Examination Survey (NHANES) 2011–2018 analytic sample.

Methods. This cross-sectional analysis included 10,641 adults aged 20–59 years with available anthropometric and dual-energy X-ray absorptiometry data (Supplementary Figure S1). ALM comprised bone-free lean mass in both arms and legs. Low BMI-adjusted ALM followed Foundation for the National Institutes of Health cutoffs: ALM/BMI < 0.789 in men and < 0.512 in women [5]. Muscle strength and physical performance were not assessed.

Logistic regression estimated odds ratios (ORs) and 95% confidence intervals (CIs) for BRI continuously and by quartiles. Model covariates are specified in Supplementary Table SI. BMI was excluded from primary models because it is part of the outcome denominator; 52 participants with missing physical activity were retained as a separate category. Restricted cubic splines assessed nonlinearity. Exploratory receiver operating characteristic (ROC) analyses described apparent discrimination. Subgroup analyses examined interactions, and sensitivity analysis used absolute ALM cutoffs (< 19.75 kg in men and < 15.02 kg in women), with additional BMI adjustment [5].

Analyses used SPSS Statistics 26 and R 4.3.3. All analyses were unweighted, without NHANES sampling weights, strata, or primary sampling units. Tests were two-sided, with $p < 0.05$ considered significant. NHANES protocols received ethics approval, and participants provided informed consent. Additional methods are provided in the Supplementary Materials.

Results. Among 10,641 participants, 922 (8.7%) met the low BMI-adjusted ALM criterion. Median age was 39.0 years, and 49.6% were male. Median BRI was 7.3 (interquartile range 5.7–9.1) in participants with low BMI-adjusted ALM and 4.6 (3.4–6.0) in those without it (Table I).

Each one-unit increase in BRI was associated with higher odds of low BMI-adjusted ALM: unadjusted OR = 1.50 (95% CI: 1.46–1.54) and ful-

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Table I. Baseline characteristics by low BMI-adjusted ALM status

Characteristic	All participants (*n* = 10,641)	No low ALM (*n* = 9,719)	Low ALM (*n* = 922)	*P*-value
Age [years]	39.0 (29.0, 49.0)	39.0 (29.0, 49.0)	45.5 (34.0, 54.0)	< 0.001
Sex, *n* (%)				0.621
Male	5278 (49.6)	4813 (49.5)	465 (50.4)	
Female	5363 (50.4)	4906 (50.5)	457 (49.6)	
Race/ethnicity, *n* (%)				< 0.001
Mexican American	1582 (14.9)	1262 (13.0)	320 (34.7)	
Non-Hispanic White	3656 (34.4)	3414 (35.1)	242 (26.2)	
Non-Hispanic Black	2268 (21.3)	2214 (22.8)	54 (5.9)	
Other races	3135 (29.5)	2829 (29.1)	306 (33.2)	
BMI [kg/m²]	27.7 (23.9, 32.3)	27.3 (23.6, 31.7)	33.0 (28.6, 38.3)	< 0.001
Hypertension, *n* (%)				< 0.001
Yes	2489 (23.4)	2201 (22.6)	288 (31.2)	
No	8152 (76.6)	7518 (77.4)	634 (68.8)	
Diabetes, *n* (%)				< 0.001
Yes	857 (8.1)	702 (7.2)	155 (16.8)	
No	9784 (91.9)	9017 (92.8)	767 (83.2)	
Cancer, *n* (%)				0.050
Yes	400 (3.8)	354 (3.6)	46 (5.0)	
No	10241 (96.2)	9365 (96.4)	876 (95.0)	
Smoked ≥ 100 cigarettes in life, *n* (%)				0.124
Yes	4158 (39.1)	3820 (39.3)	338 (36.7)	
No	6483 (60.9)	5899 (60.7)	584 (63.3)	
Marital status, *n* (%)				< 0.001
Married/Living with partner	6352 (59.7)	5769 (59.4)	583 (63.2)	
Widowed/Divorced/Separated	1483 (13.9)	1331 (13.7)	152 (16.5)	
Never married	2806 (26.4)	2619 (26.9)	187 (20.3)	
Education level, *n* (%)				< 0.001
Less than high school	1148 (10.8)	945 (9.7)	203 (22.0)	
High school grad or equivalent	7489 (70.4)	6877 (70.8)	612 (66.4)	
College graduate or above	2004 (18.8)	1897 (19.5)	107 (11.6)	
Physical activity, *n* (%)				< 0.001
Insufficient	3345 (31.4)	2938 (30.2)	407 (44.1)	
Sufficient	7244 (68.1)	6734 (69.3)	510 (55.3)	
Missing	52 (0.5)	47 (0.5)	5 (0.5)	
BRI	4.7 (3.5, 6.3)	4.6 (3.4, 6.0)	7.3 (5.7, 9.1)	< 0.001

ALM – appendicular lean mass, BMI – body mass index, BRI – body roundness index. Low ALM denotes low BMI-adjusted ALM. Continuous variables are median (interquartile range); categorical variables are n (%). All data are unweighted. Binary categorical p-values use Yates' continuity correction; multi-category p-values use Pearson χ^2 tests.

ly adjusted OR = 1.62 (95% CI: 1.56–1.67). The fully adjusted OR for the highest versus lowest BRI quartile was 43.76 (26.27–72.88; *p* for trend < 0.001; Supplementary Table SI). Spline analyses showed nonlinear associations in all models (*p* for nonlinearity < 0.001; Supplementary Figure S2).

The apparent area under the ROC curve for BRI was 0.806 (95% CI: 0.793–0.819), compared with 0.619 for age, 0.729 for BMI, and 0.570 for physical activity (Figure 1, Supplementary Table SII). Under the absolute ALM definition, the adjusted OR per BRI unit was 5.25 (4.54–6.09; Supplementary Table SIII). Exploratory interactions suggested heterogeneity by sex, hypertension, diabetes, and physical activity (Supplementary Table SIV).

Discussion. Higher BRI was associated with prevalent low BMI-adjusted ALM in this analytic sample. Central adiposity may relate to muscle loss through inflammation, insulin resistance, and lipotoxicity [6–8], although these pathways were

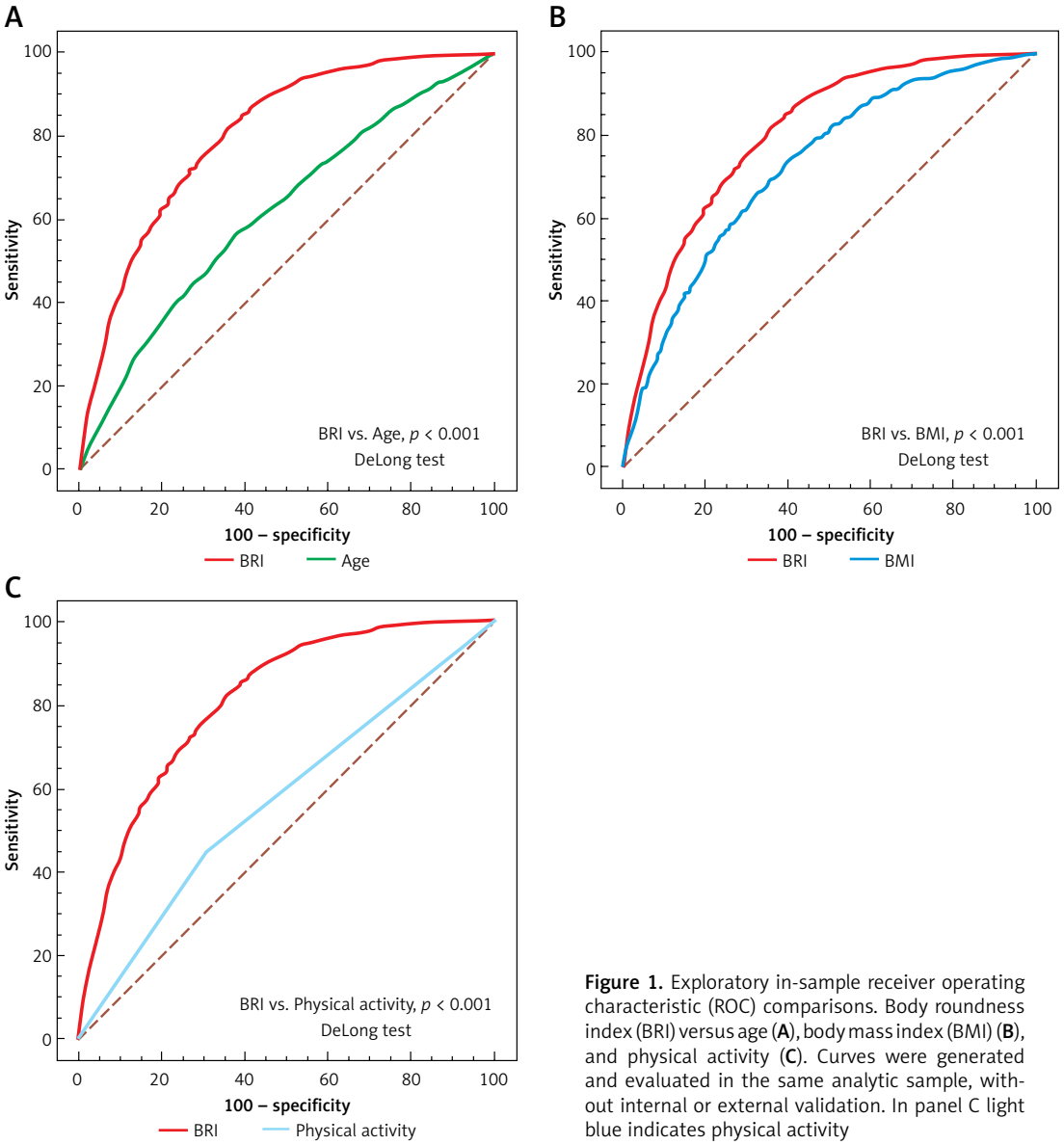

Figure 1. Exploratory in-sample receiver operating characteristic (ROC) comparisons. Body roundness index (BRI) versus age (**A**), body mass index (BMI) (**B**), and physical activity (**C**). Curves were generated and evaluated in the same analytic sample, without internal or external validation. In panel C light blue indicates physical activity

not measured here. BRI depends on waist circumference and height, whereas the outcome divides ALM by BMI, itself derived from weight and height. Shared body-size components and mathematical coupling may therefore amplify the association, particularly the extreme quartile estimate. The larger absolute-ALM estimate also indicates sensitivity to outcome definition and body-size adjustment.

The cross-sectional design precludes temporal or causal inference, and the unweighted results are not nationally representative. Low BMI-adjusted ALM is a body-composition phenotype rather than clinically confirmed sarcopenia. Residual confounding and selection related to availability of body-composition measurements remain possible. Subgroup interactions were exploratory and involved multiple comparisons.

The ROC estimates were obtained and evaluated in the same dataset without internal or external validation. BRI is a strictly increasing transformation of waist-to-height ratio, giving identical rank-based ROC performance in the same sample; waist circumference and waist-to-hip ratio were not separately compared. The findings do not establish predictive validity or clinical screening utility. Prospective studies incorporating the survey design, muscle function, and validated anthropometric comparisons are needed to clarify whether BRI contributes clinically useful information.

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Ethical approval

Not applicable.

Conflict of interest

The authors declare no conflict of interest.

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