



OPEN Exploring the link between the ZJU index and sarcopenia in adults aged 20–59 using NHANES and machine learning

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Sarcopenia, characterized by progressive loss of muscle mass and function, is a growing public health concern. The ZJU index, a novel metabolic marker, integrates lipid metabolism and glucose regulation parameters. While its association with metabolic disorders has been established, its relationship with sarcopenia remains underexplored, especially in middle-aged adults. This cross-sectional study analyzed data from 4,012 U.S. adults aged 20–59 years in the 2011–2018 NHANES dataset. The association between ZJU and sarcopenia was assessed using multivariable logistic regression, restricted cubic splines (RCS) for smooth curve fitting, and subgroup analyses. To improve risk stratification and identify key predictors, machine learning techniques—including Random Forest, SHAP, and the Boruta algorithm—were applied. Each standard deviation increase in ZJU was associated with an 13% higher likelihood of sarcopenia [OR = 1.13, 95% CI 1.08–1.17]. Individuals in the highest ZJU quartile faced a 12.6-fold greater likelihood than those in the lowest quartile [OR = 13.6, 95% CI 3.08–60.2]. Subgroup analysis showed notable interactions with gender and diabetes ($p < 0.05$). Machine learning models consistently ranked ZJU, education level, and race as the most influential predictors of sarcopenia, emphasizing the interplay between metabolic health and socioeconomic factors. Higher ZJU scores are linked to increased sarcopenia risk in adults aged 20–59 years, supporting its role as an early metabolic biomarker. Machine learning identified ZJU, education, and race as key predictors, underscoring the impact of socioeconomic factors.

Keywords Sarcopenia, ZJU index, Machine learning, Random forest, SHAP, Boruta algorithm, NHANES

Abbreviations

NCHS	National Center for Health Statistics
NHANES	National Health and Nutrition Examination Survey
OR	Odds ratio
CI	Confidence interval
PIR	Ratio of family income to poverty
TC	Total cholesterol
DM	Diabetes
HP	hypertension

Sarcopenia is characterized by a progressive loss of muscle mass and strength. It affects about 30% of older adults and nearly 50% of those over 80 years¹. This condition is associated with higher frailty, lower mobility, and increased risks of falls and fractures. These problems lead to reduced quality of life and loss of independence among older people². However, some studies suggest that sarcopenia also occurs in younger adults. A study from South Korea by Bae and Kim³ reported that sarcopenia was present in 19.2% of people aged 20–39 and 29.1% of those aged 40–64. Dodds et al.⁴ showed that muscle mass and strength reach their peak in the 30s and 40s and then decline gradually. These findings highlight the need to recognize sarcopenia early in younger adults. Early muscle loss may increase the risk of worse physical problems later in life. In the U.S., sarcopenia adds over \$18

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billion to healthcare costs each year due to its complications and the need for more medical care⁵. Sarcopenia is also linked to metabolic problems, such as diabetes, heart disease, and osteoporosis^{6,7}. This connection shows why early action is important even for middle-aged people.

Growing evidence highlights the impact of lipid metabolism on sarcopenia development. Dysregulation of lipid storage, mobilization, and metabolism can accelerate muscle atrophy by promoting systemic inflammation, insulin resistance, and oxidative stress⁸. Notably, elevated triglyceride (TG) levels and abnormalities in enzymes such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST) have been shown to correlate with increased muscle wasting and sarcopenia risk^{9,10}. Although some studies have focused on the elderly, the role of lipid-related factors in the development of sarcopenia among younger adults remains underexplored.

The ZJU index, a novel composite metabolic marker, combines measures of AST, ALT, TG, and body mass index (BMI), and blood glucose to provide a comprehensive view of metabolic health. By considering these factors, the ZJU index provides a comprehensive view of lipid and glucose metabolism, successfully identifying metabolic disturbances and their possible connections to conditions including insulin resistance, obesity, and non-alcoholic fatty liver disease¹¹. Studies have demonstrated that higher ZJU scores correlate with elevated risks of metabolic disorders, yet the connection between ZJU and sarcopenia remains underexplored^{12,13}. Given that metabolic dysfunctions, especially those involving lipid metabolism, have been implicated in muscle degeneration, understanding the role of ZJU in sarcopenia risk assessment could provide valuable insights for at-risk populations.

This study examined the link between the ZJU index and sarcopenia risk. We used data from the National Health and Nutrition Examination Survey (NHANES). We also applied machine learning methods. These included Random Forest, SHAP, and the Boruta algorithm. These methods helped us identify and confirm key predictors of sarcopenia. Our study tested the value of ZJU as a possible biomarker for sarcopenia. We focused on U.S. adults aged 20–59 years. Our goal was to stress the value of early detection in younger people. Early screening is key to timely treatment and the prevention of future decline. Our results improve understanding of sarcopenia risk factors and support better prevention and early treatment strategies for at-risk groups.

Methods

Study population

This research analyzed information obtained from NHANES—a survey conducted at a specific point in time that assesses the nutritional and health conditions of the U.S. population—and, as such, represents a cross-sectional study. Data were collected through structured interviews and physical assessments carried out in mobile examination facilities. Our analysis covered NHANES cycles from 2011 to 2018, spanning four survey periods and including an initial sample of 39,156 participants. Exclusions were applied for participants without a sarcopenia diagnosis ($n = 21,363$) and those missing data for key variables ($n = 13,781$), such as education level, marital status, poverty income ratio (PIR), total cholesterol levels, as well as alcohol use, smoking status, hypertension, and the ZJU index. After these exclusions, the final analytical sample consisted of 4,012 adults (see Fig. 1). Although NHANES 2011–2018 provides DXA data for individuals aged 8–59 years, after filtering out cases with missing values necessary for sarcopenia diagnosis, our final sample comprised only those aged 20–59 years. Consequently, our study focused on this age group. All participants gave informed consent, and the anonymized data is available to the public.

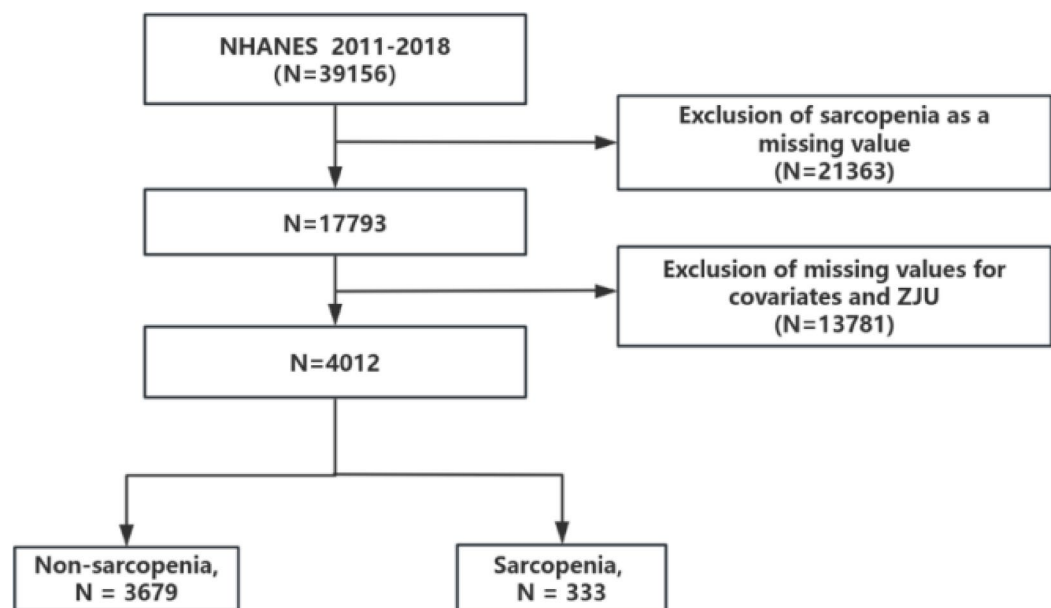


Fig. 1. A flow diagram of eligible participant selection in the National Health and Nutrition Examination Survey.

Description of ZJU index

The ZJU index was calculated as follows: $\text{ZJU index} = \text{FPG (mmol/L)} + \text{BMI (kg/m}^2) + 3 \times \text{ALT(U/L)/AST(U/L) ratio} + 2 \text{ if female} + \text{TG (mmol/L)}^3$. This index integrates fasting plasma glucose (FPG), BMI, ALT/AST ratio, and TG to provide an overview of metabolic health.

Definition of sarcopenia

Sarcopenia in this study was determined using appendicular lean mass (ALM), assessed via dual-energy X-ray absorptiometry (DEXA) in the NHANES dataset. Participants were excluded if they exceeded 192.5 cm in height, weighed over 136.4 kg, or were pregnant. To determine sarcopenia, we utilized the sarcopenia index (ALM/BMI), with an ALM/BMI ratio indicating sarcopenia if it falls below 0.789 kg/m² for men or 0.512 kg/m² for women, according to the criteria established by the Foundation for the National Institutes of Health (FNIH)⁴.

Covariates

To minimize confounding, adjustments were made for demographic and clinical variables, including age, gender, ethnicity, education attainment, marital status, poverty-income ratio, usage of tobacco and alcohol, along with the presence of diabetes, hypertension, levels of total cholesterol, frail, nutritional status (energy intake and protein intake), physical activity, and osteoporosis (see Supplementary Table S1). The selection of these variables was guided by prior research^{14–17}.

Statistical analysis

The analyses were performed utilizing R software (version 4.3.2). Continuous variables are represented as means accompanied by standard deviations (SD), whereas categorical variables are shown as frequencies and percentages. Given NHANES's complex, multistage probability sampling, we incorporated sampling weights, clusters, and strata. T-tests with weights and chi-square analyses were employed to assess the differences between the ZJU group and the sarcopenia group.

To investigate the association between ZJU and the risk of sarcopenia, we employed multivariable logistic regression models organized into three phases: (1) unadjusted, (2) adjusted for factors such as age, gender, education, marital status, PIR, and race, and (3) additionally adjusted for total cholesterol, smoking habits, alcohol consumption, hypertension, diabetes, frail, nutritional status (energy intake and protein intake), physical activity, and osteoporosis. Smooth curve fitting was utilized to assess linear associations between ZJU and sarcopenia, including subgroup analyses for particular demographic groups.

To identify key predictors of sarcopenia in adults aged 20–59 years, we used several machine learning methods. These included Random Forest, SHAP (SHapley Additive exPlanations), and the Boruta algorithm. The Random Forest model ranked the importance of predictors. These predictors covered both covariates and exposure variables from the study. SHAP values showed how each predictor influenced sarcopenia risk. The Boruta algorithm tested the strength of predictors by comparing them with “shadow features”. We measured model performance with Receiver Operating Characteristic (ROC) curve analysis. This analysis was applied to both Random Forest and SHAP-based models. We used the area under the curve (AUC) to assess how well the models distinguished sarcopenia cases. A p-value of less than 0.05 was set as the threshold for statistical significance in all analyses.

Results

Baseline characteristics of sarcopenia

This study examined data from 4,012 participants, representing approximately 48.73 million U.S. adults. Among them, 333 had sarcopenia. The remaining 3,679 did not. The average ZJU score was 40 (SD = 8). Early analysis showed that those with sarcopenia tended to be older. They also had lower poverty income ratios (PIR). They had higher total cholesterol levels and higher ZJU scores than those without sarcopenia. We found sarcopenia was more common in Non-Hispanic Whites. Higher rates appeared among participants with a university degree or above. Heavy alcohol drinkers also showed increased sarcopenia prevalence. See Table 1 for complete participant characteristics.

Association between ZJU and sarcopenia

Table 2 shows results from three models that examined the link between ZJU and sarcopenia. In Model 3, after adjusting for all covariates, each one standard deviation increase in ZJU raised the odds of sarcopenia by 13% [OR = 1.13, 95% CI: 1.08 – 1.17]. Participants in the highest ZJU quartile (Q4) had a 12.6-fold higher risk of sarcopenia compared to those in the lowest quartile (Q1) [OR = 13.6, 95% CI: 3.08 – 60.2]. The odds ratios increased stepwise across quartiles. This confirmed a statistically significant association ($p < 0.05$) between higher ZJU levels and sarcopenia risk. Restricted cubic spline (RCS) analysis (Figure 2) also supported a linear relationship between ZJU and sarcopenia. No evidence of nonlinearity was found ($p = 0.104$).

Subgroup analysis of ZJU and sarcopenia

The outcomes from the subgroup analysis examining the relationship between ZJU and sarcopenia across different covariates, such as age, gender, educational background, marital situation, PIR, ethnicity, smoking habits, alcohol consumption, as well as hypertension, diabetes, and overall cholesterol levels, are illustrated in Fig. 3. A positive relationship between ZJU and the risk of sarcopenia was consistently observed across all subgroups. Notably, significant interactions were found with gender and diabetes ($p < 0.05$), indicating that the effect of ZJU on sarcopenia risk could be stronger in certain populations.

Characteristic	N ¹	Overall N = 48,733,182 ²	Non-sarcopenia, N = 45,431,067 ²	Sarcopenia, N = 3,302,115 ²	p-value ³
Gender	4012				0.3
Male		2000 (51%)	1833 (51%)	167 (55%)	
Female		2012 (49%)	1846 (49%)	166 (45%)	
Age	4012	39 ± (12)	39 ± (12)	43 ± (11)	< 0.001
Race	4012				< 0.001
Mexican American		592 (10%)	484 (9.2%)	108 (24%)	
Non-Hispanic White		1503 (64%)	1401 (65%)	102 (53%)	
Non-Hispanic Black		789 (10%)	770 (11%)	19 (3.2%)	
Other Race		1128 (16%)	1024 (15%)	104 (20%)	
Education level	4012				< 0.001
Less than 9 th grade		203 (3.3%)	152 (2.8%)	51 (11%)	
9-11 th grade		478 (9.1%)	429 (8.8%)	49 (12%)	
High school graduate		868 (22%)	789 (21%)	79 (25%)	
University and above		2463 (66%)	2309 (67%)	154 (52%)	
Married/live with partner	4012				0.7
Yes		2365 (62%)	2154 (62%)	211 (63%)	
No		1647 (38%)	1525 (38%)	122 (37%)	
PIR	4012	2.92 ± (1.67)	2.96 ± (1.66)	2.38 ± (1.64)	< 0.001
TC	4012	190 ± (40)	190 ± (40)	199 ± (41)	0.001
Smoking	4012				0.4
Never		2383 (58%)	2183 (58%)	200 (57%)	
Now		921 (22%)	861 (22%)	60 (19%)	
Former		708 (20%)	635 (20%)	73 (24%)	
Drinking	4012				< 0.001
Never		488 (9.1%)	419 (8.5%)	69 (18%)	
Mild		1349 (35%)	1262 (35%)	87 (25%)	
Moderate		764 (21%)	722 (21%)	42 (14%)	
Heavy		1039 (27%)	957 (27%)	82 (27%)	
Former		372 (8.4%)	319 (7.8%)	53 (17%)	
Diabetes	4012				< 0.001
Yes		510 (10%)	434 (9.5%)	76 (23%)	
No		3502 (90%)	3245 (91%)	257 (77%)	
Hypertension	4012				< 0.001
Yes		1124 (28%)	982 (27%)	142 (44%)	
No		2888 (72%)	2697 (73%)	191 (56%)	
ZJU	4012	40 ± (8)	39 ± (8)	47 ± (9)	< 0.001
ZJU.quantile	4012				< 0.001
Q1		1020 (25%)	1003 (27%)	17 (4.0%)	
Q2		943 (25%)	898 (26%)	45 (12%)	
Q3		1000 (25%)	912 (25%)	88 (26%)	
Q4		1049 (25%)	866 (23%)	183 (58%)	

Table 1. Baseline characteristics of all participants were stratified by sarcopenia. 1 N not Missing (unweighted). 2 n (unweighted) (%); Mean ± (SD). 3 Pearson's χ^2 : Rao & Scott adjustment; Design-based KruskalWallis test. Mean (SD) for continuous variables: the P value was calculated by the weighted Students T-test. Percentages (weighted N, %) for categorical variables: the P value was calculated by the weighted chi-square test. Abbreviation: PIR, Ratio of family income to poverty; TC, Total cholesterol.

Predictive performance and key risk factors for sarcopenia identified by random forest model

The Random Forest model showed moderate performance, with an AUC of 0.763 on the test set (Fig. 4A), indicating a reliable ability to distinguish between sarcopenia and non-sarcopenia cases. The variable importance analysis (Fig. 4B) highlighted ZJU, Education level, and Race as the most influential predictors of sarcopenia, with DM and Drinking following closely. These findings highlight the importance of these factors in evaluating sarcopenia risk and suggest their potential role in the early detection and targeted intervention strategies for individuals at risk.

Characteristics	Model 1 [OR (95% CI)]	p-value	Model 2 [OR (95% CI)]	p-value	Model 3 [OR (95% CI)]	p-value
ZJU-Sarcopenia						
Continuous	1.10 (1.08, 1.11)	< 0.001	1.11 (1.09, 1.12)	< 0.001	1.13 (1.08, 1.17)	< 0.001
Quartile						
Q1	1 (ref.)		1 (ref.)		1 (ref.)	
Q2	3.18 (1.69, 6.01)	< 0.001	2.80 (1.46, 5.39)	0.003	1.85 (0.07, 46.5)	0.5
Q3	6.91 (3.78, 12.6)	< 0.001	5.21 (2.69, 10.1)	< 0.001	3.45 (0.48, 24.8)	0.11
Q4	16.9 (10.1, 28.3)	< 0.001	14.8 (8.69, 25.1)	< 0.001	13.6 (3.08, 60.2)	0.017
P for trend	< 2e-16		8.86e-14		0.018	

Table 2. Association between ZJU and sarcopenia. Model 1: no covariates were adjusted. Model 2: age, gender, education level, marital, PIR, and race were adjusted. Model 3: age, gender, education level, marital, PIR, race, smoking, drinking, hypertension, diabetes, total cholesterol, frail, nutritional status, physical activity, and osteoporosis were adjusted. Abbreviation: PIR, Ratio of family income to poverty; TC, Total cholesterol.

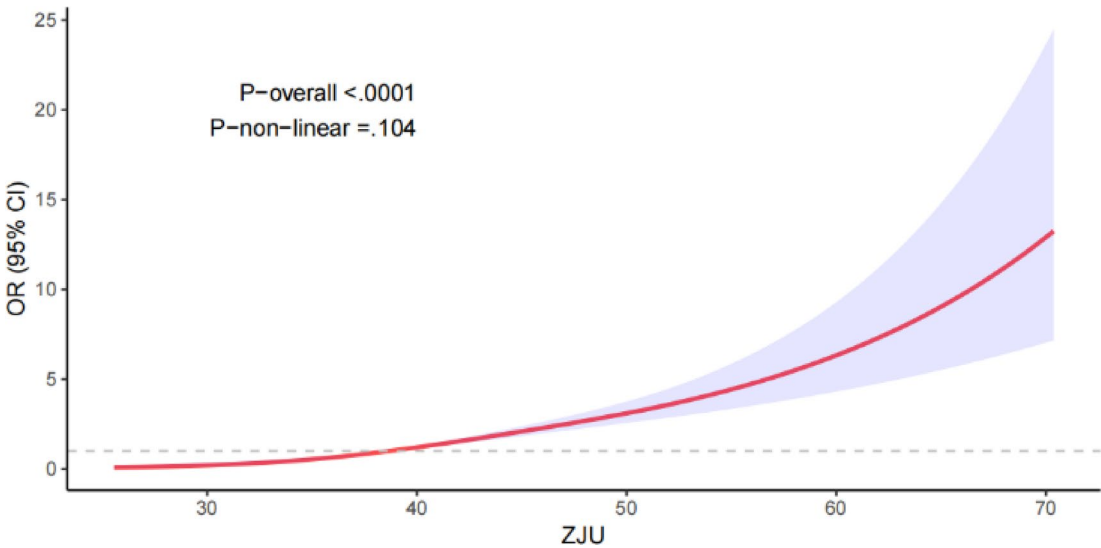


Fig. 2. Dose-response relationships between ZJU and Sarcopenia. OR (solid lines) and 95% confidence levels (shaded areas) were adjusted for age, gender, education level, marital, PIR, race, smoking, drinking, hypertension, diabetes, and total cholesterol.

SHAP analysis and key predictors of sarcopenia identified by XGBoost model

The XGBoost model demonstrated moderate predictive performance, achieving an AUC of 0.752 on the test set, which indicates a reasonable ability to differentiate between sarcopenia cases (Fig. 5B). SHAP analysis identified “ZJU”, “Race” and “Education level” as the most impactful features related to sarcopenia risk (Fig. 5A), with higher SHAP values correlating with an increased likelihood of developing the condition. The variable importance plot (Fig. 5C) further validated these features as key predictors. These findings highlight the multifactorial nature of sarcopenia, offering valuable insights for targeted preventive strategies and early risk identification.

Boruta algorithm for feature selection in sarcopenia risk prediction

Discussion

This research offers the link between the ZJU index and sarcopenia risk in U.S. adults aged 20–59 years. Our results show a clear positive association between higher ZJU scores and increased sarcopenia risk. This finding suggests that ZJU could serve as an early biomarker for sarcopenia within this specific age group. The results align with earlier studies that connect metabolic dysfunction, especially lipid imbalance, with muscle loss and sarcopenia¹⁸. Our focus on a younger group emphasizes the need for early detection. Early intervention can help prevent further muscle deterioration and functional decline later in life.

The ZJU index combines AST, ALT, triglycerides, BMI, and fasting glucose. Each of these markers links to sarcopenia or related metabolic disturbances^{19,20}. BMI in particular reflects overall adiposity and obesity-related metabolic dysfunction²¹. Obesity drives chronic inflammation and worsens insulin resistance. These processes fuel muscle degradation and sarcopenic obesity, where excess fat coexists with low muscle mass^{22,23}. Elevated TG levels promote systemic inflammation and insulin resistance. Both contribute to muscle atrophy²⁴. Chronic

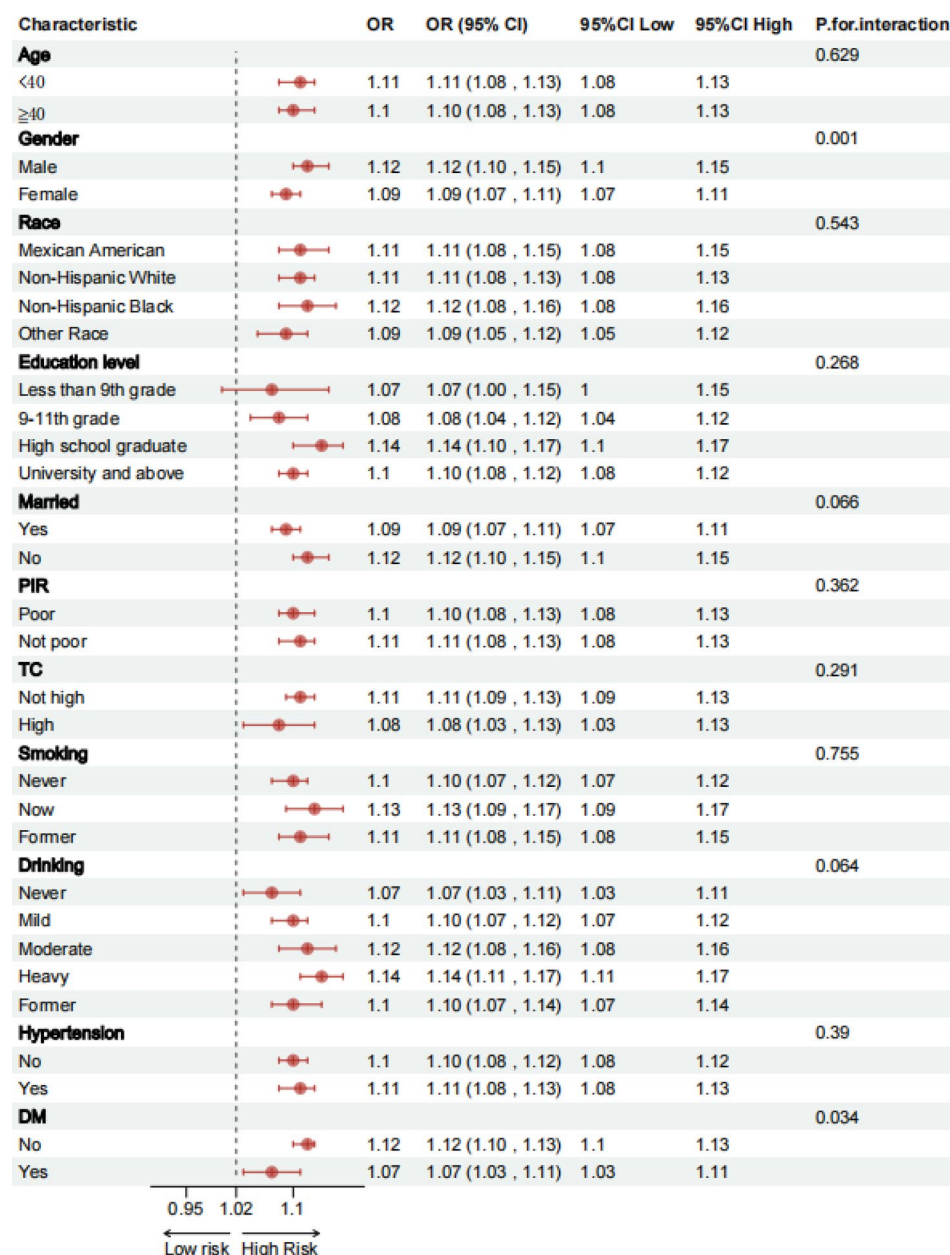


Fig. 3. Subgroup analysis between ZJU and sarcopenia.

inflammation activates catabolic pathways, such as NF- κ B signaling. This increases muscle protein breakdown²⁵. High fasting glucose indicates insulin resistance. It reduces muscle glucose uptake, impairing energy supply and protein synthesis. The result is greater muscle wasting²⁶. Elevated AST and ALT signal liver stress. This stress disrupts amino acid metabolism necessary for muscle protein turnover²⁷. Mitochondrial dysfunction impairs energy metabolism and raises oxidative stress. This damages muscle fibers and accelerates sarcopenia progression²⁸. Insulin resistance also disrupts the Akt/mTOR pathway, crucial for muscle protein synthesis^{29,30}. Oxidative stress occurs when reactive oxygen species exceed antioxidant defenses. It causes cellular injury and promotes muscle degeneration^{31,32}. Together, these mechanisms show how metabolic disturbances captured by the ZJU index drive sarcopenia risk. This aligns with broader literature linking metabolic health to muscle aging^{33,34}.

Subgroup analyses revealed a more pronounced association between the ZJU index and sarcopenia in males and non-diabetic adults. This observation aligns with findings suggesting that men, due to lower estrogen levels, may experience accelerated muscle loss under metabolic stress³⁵. In non-diabetic individuals, even subtle metabolic disturbances can significantly impact muscle health. Such disturbances impair insulin sensitivity and disrupt lipid metabolism, leading to the accumulation of fatty acids within muscle tissue. This accumulation activates inflammatory pathways and promotes protein degradation³⁶. These insights underscore the necessity for targeted preventive measures for men without diabetes exhibiting elevated ZJU scores.

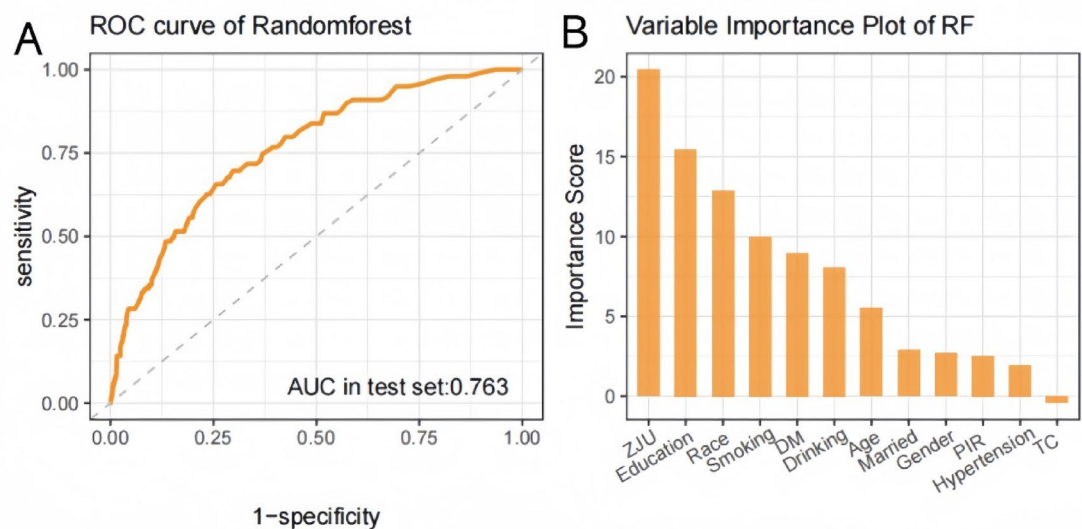


Fig. 4. Performance and variable importance of random forest model in predicting sarcopenia. **(A)** ROC curve for random forest model – the receiver operating characteristic (ROC) curve of the Random Forest model applied to the test set, with an Area Under the Curve (AUC) of 0.763, reflecting moderate performance in distinguishing between sarcopenia and non-sarcopenia cases. **(B)** Variable Importance Plot – A variable importance plot showing the top predictive factors for sarcopenia, where “ZJU”, “Education level” and “Race” have the highest importance scores.

Our findings align with existing research on metabolic health and sarcopenia. Many studies focus on older adults. Our study adds that sarcopenia also affects middle-aged adults (20–59 years). Early intervention can prevent severe muscle loss. He Y et al. reported that elevated ALT and AST levels associate with higher sarcopenia prevalence in elderly groups³⁷. Unfavorable metabolic conditions increase sarcopenia risk. Our results confirm a strong link between ZJU components and sarcopenia³⁸. Focusing on middle-aged adults highlights the need to identify risk factors sooner. This creates opportunities for prevention and may reduce the burden of sarcopenia later in life.

Our study focused on adults aged 20–59 years. We used machine learning methods, including Random Forest, SHAP, and the Boruta algorithm, to identify key predictors of sarcopenia linked to the ZJU index. Machine learning captures complex, non-linear interactions. Traditional statistical models cannot. We combined regression with machine learning to improve robustness and accuracy in large datasets. Hao et al.³⁹ relied solely on ROC analysis. Our approach adds SHAP analysis to quantify individual feature contributions. We also applied Boruta to refine predictor selection and reduce overfitting. Our study identifies demographic and metabolic factors—such as education level and race—as significant drivers of sarcopenia risk. These findings highlight the need for personalized prevention and intervention. These methods and the inclusion of socioeconomic factors expand sarcopenia risk assessment. They provide a more complete framework for evaluating metabolic and social influences on muscle health.

While our study has several strengths, there are important limitations that warrant consideration. First, the cross-sectional design of the NHANES data restricts our ability to draw causal inferences regarding the relationship between the ZJU index and sarcopenia; thus, longitudinal studies are needed to establish causality. Second, although our machine learning methods provided robust insights into predictor importance, future studies employing depth analysis could further elucidate the pathways through which ZJU components impact muscle health. Third, while we adjusted for a comprehensive set of confounding variables—including demographic, lifestyle, metabolic factors, osteoporosis, and physical activity—we acknowledge that some important confounders were not included. For instance, the ratio of extracellular water to total body water (ECW/TBW), which has been identified as a critical factor in sarcopenia diagnosis, was not available in the NHANES 2011–2018 cycles and therefore could not be assessed. Fourth, our findings are derived from U.S. data, and external validation in other populations is necessary to determine the generalizability of the ZJU index as a biomarker for sarcopenia risk. Finally, the relatively young mean age of our study sample (39 ± 12 years) may not fully capture the age-related progression of sarcopenia, a condition that predominantly affects the elderly. Therefore, the results should be interpreted with caution, as unmeasured confounders and potential biases cannot be entirely ruled out. Consequently, additional studies including older populations are essential to evaluate the clinical applicability of the ZJU index among those at highest risk.

Conclusion

Our study reveals a significant association between high ZJU scores and sarcopenia risk. This finding suggests that ZJU could serve as a valuable biomarker for sarcopenia assessment. Machine learning methods helped us pinpoint key predictors, including education level and race. These insights support targeted prevention strategies

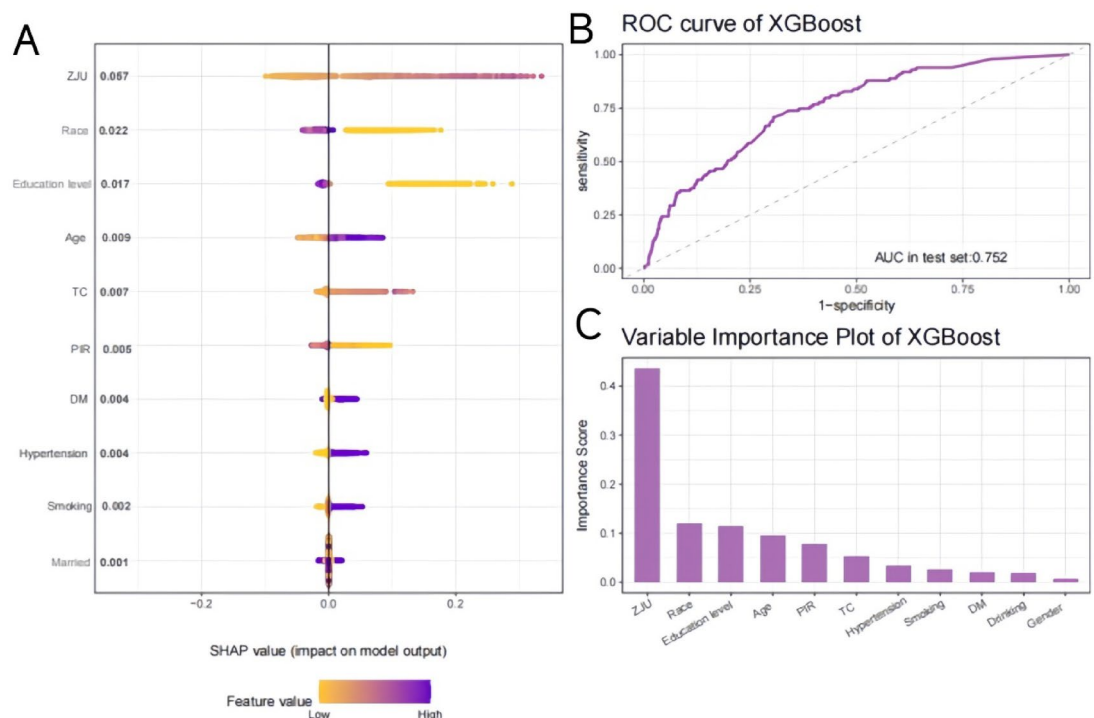


Fig. 5. SHAP summary plot, model performance, and variable importance in predicting sarcopenia using XGBoost. **(A)** SHAP Summary Plot – The SHAP (SHapley Additive exPlanations) summary plot displays the impact and importance of each feature in predicting sarcopenia. The features are ranked from top to bottom by importance, with the top features having the most significant impact on model predictions. “ZJU”, “Race” and “Education level” have the greatest influence on the model output. **(B)** ROC Curve of XGBoost Model – The ROC curve for the XGBoost model applied to the test set, with an Area Under the Curve (AUC) of 0.752. This demonstrates the model’s moderate performance in distinguishing between sarcopenia and non-sarcopenia cases. **(C)** Variable Importance Plot – This variable importance plot from XGBoost ranks the most significant features for predicting sarcopenia. Features are arranged from left to right in descending order of importance, with “ZJU”, “Race” and “Education level” being the top contributors, followed by other factors like “Age” and “PIR” (Poverty Income Ratio).

for individuals with elevated ZJU scores. Future research should include longitudinal studies to validate these associations and evaluate ZJU’s clinical utility in sarcopenia risk assessment.

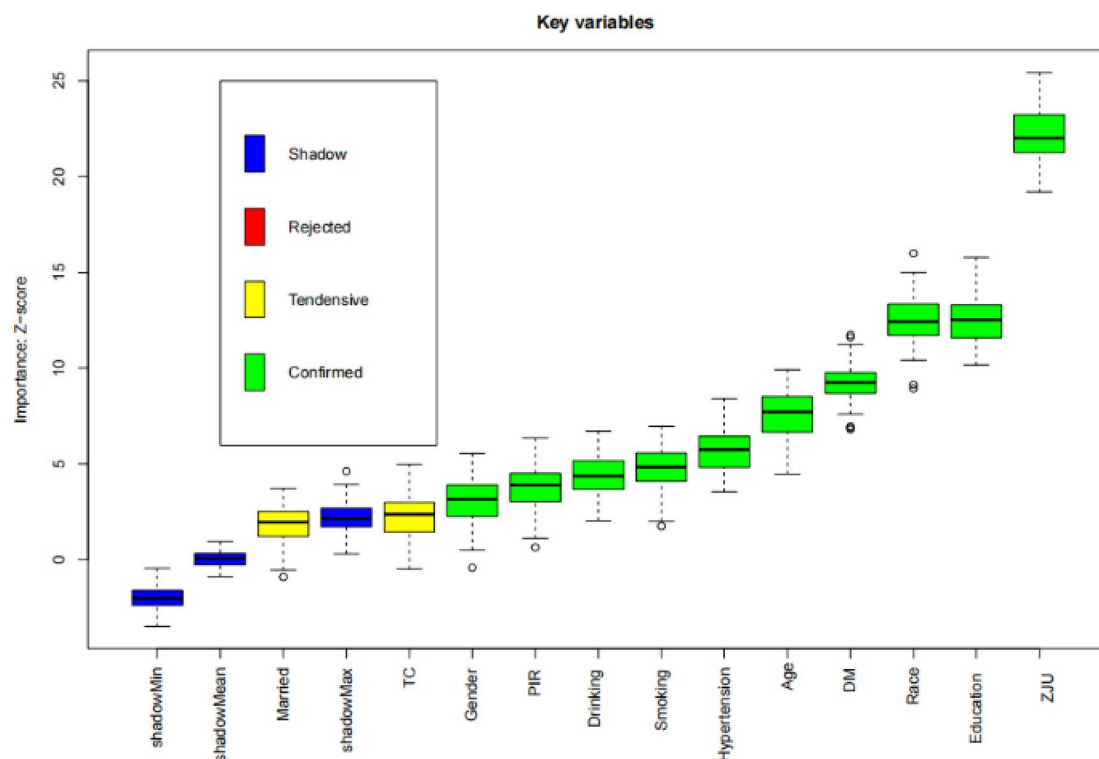


Fig. 6. Important characteristic variables identified as associated with the risk of sarcopenia by the Boruta algorithm.

Data availability

This research includes an examination of datasets that are publicly accessible. This information can be retrieved through the following website: <https://www.cdc.gov/nchs/nhanes/>.

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Author contributions

Huan Chen conceptualized the study, conducted the analysis, and drafted the manuscript. Zhao Wang provided designed and critical instructions. Ning Du supervised the statistical analysis and provided methodological guidance. Hong Xiao assisted in data curation, validation, and reviewed the manuscript for intellectual content.

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Declarations

Competing interests

The authors declare no competing interests.

Ethical approval

The National Center for Health Statistics (NCHS) Research Ethics Review Board has granted approval for research that includes human participants. This study was carried out in compliance with relevant local laws and the requirements of the institution. Prior to participating in the research, all participants gave their written informed consent.

Additional information

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