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Association of body roundness index with diabetes and prediabetes in US adults from NHANES 2007–2018: a cross-sectional study

Liting Qiu¹, Zixuan Xiao¹, Boyan Fan¹, Ling Li^{1*} and Guixiang Sun^{1*}

Abstract

Objective The present study examined the ability of the body roundness index (BRI) to predict the incidence of diabetes and prediabetes among adults in the USA.

Method The study enrolled 11,980 adults aged ≥ 20 years from the National Health and Nutrition Examination Survey (NHANES). Logistic regression served as the primary method for analyzing the relevant link between BRI and the incidence of diabetes and prediabetes, including univariate analysis, multivariate regression analysis, smooth curve fitting analysis, and subgroup analysis. What's more, receiver operating characteristic (ROC) analysis was applied to confirm the predictive values of BRI for diabetes and prediabetes.

Results Each unit higher than BRI was associated with a 17% increased risk of diabetes and prediabetes after covariate adjustments (OR: 1.17, 95% CI: 1.07–1.27). Those with BRI in the high scores (Q4) possessed an increased likelihood of having diabetes and prediabetes than individuals in the reference group (OR: 1.83, 95% CI: 1.29–2.58). A smooth curve fitting analysis revealed a non-linear trend. The results across all population subgroups were uniform to those of the total population. The ROC curve indicated that the BRI was the best predictor of diabetes and prediabetes among other anthropometric indices.

Conclusions Diabetes and prediabetes occurrence rates and BRI have a positive and non-linear relationship in American adults. The BRI indices could function as predictive markers for diabetes and prediabetes.

Keywords NHANES, Body roundness index, Diabetes, Prediabetes

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Introduction

Characterized by persistent hyperglycemia, type 2 diabetes mellitus (diabetes) is a metabolic disorder that can result in multi-organ complications and stands as a leading global cause of mortality [1]. The International Diabetes Federation predicts that the diabetes prevalence is projected to rise from 9.3 to 10.9% in the range of 2019 to 2045, resulting in a rise in the affected population from 463 million up to 693 million [2]. Prior to diagnosis, the majority of individuals with diabetes undergo a phase of prediabetes. This phase represents an aberrant glucose metabolism state that falls between normal glucose tolerance to diabetes [3]. The yearly transition rate from prediabetes to diabetes is projected to be around 5–10% [3]. Of significant importance, projections indicate that by the year 2030, the number of individuals affected by prediabetes will reach nearly 470 million [3]. Research findings indicate that prediabetes can lead to various complications, including cardiovascular disease (CVD), diabetic retinopathy, neuropathies, and kidney disease [4–7]. The rising incidence of prediabetes and diabetes poses a significant economic burden on the healthcare system, families, and society as a whole. As a result, early risk factor identification and reduction for prediabetes and diabetes are important in effectively preventing and alleviating the disease burden.

There is substantial evidence indicating that obesity, especially in viscera, poses a substantial risk towards diabetes [8–10]. Within various methods used in assessing intra-abdominal fat, there are two most accurate methods for evaluating fat distribution, one is magnetic resonance imaging (MRI) and the other is computed tomography (CT), but their practical utility is constrained by high costs, time-intensive procedures, and the employment of ionizing radiation. Non-invasive and readily available measures, such as body mass index (BMI) and waist circumference (WC), offer limited information on visceral fat, body composition, and fat distribution [11, 12]. The body roundness index (BRI), a novel obesity metric that assesses the percentage of visceral and total body fat using WC and height, was first presented by Thomas et al. in 2013 [13]. BRI addresses the limitations of conventional indicators like BMI and WC [13]. Although earlier research has demonstrated the BRI's potential to detect diabetes [14–17], there is currently no evidence linking the BRI to diabetes in Americans. Furthermore, prior studies have predominantly centered on diabetic patients, with limited investigations into prediabetic individuals. Therefore, the hypothesis of this study is that the BRI is significantly associated with both diabetes and prediabetes in a diverse American adult population. The novel aspect of this research lies in its focus on a large and representative sample of various ethnic groups among American adults, as well as its inclusion of

prediabetic individuals, which has been underexplored in previous studies.

Considering this, this article intends to study the potential correlation between BRI and diabetes and prediabetes in a larger and more representative sample of various ethnic groups among American adults.

Methods

Research methodology and subjects

12 years of data (2007 to 2018) from the National Health and Nutrition Examination Survey (NHANES) were applied. As for the NHANES, a nationwide cross-sectional survey, evaluates the nutritional status as well as general health of noninstitutionalized individuals in the United States. It consisted of interviews, clinical assessments, and diagnostic tests. The design, methodologies, as well as data of the survey were made openly available through its website (<http://www.cdc.gov/nchs/nhanes.htm>). Every participant has given their written consent for the NHANES study, and the project has also received ethical approval [18]. Therefore, this study did not necessitate any specific approval or ethical review.

Out of the initial 59,842 participants recruited for the study, 25,072 individuals aged under 20 and 372 participants who were pregnant were not included in the analysis. Subsequently, individuals who missed BRI data ($N=3,397$), incomplete diabetes information including diagnoses ($N=158$), and absent covariates ($N=18,863$) were sequentially excluded. The final analysis had 11,980 individuals in total (Fig. 1).

Exposure variable and outcomes

Based on Diabetes Association Guidelines in 2023, according to at least one of the following conditions, an individual was identified as suffering from prodromal diabetes: the level of glycosylated haemoglobin (HbA1c) ranged between 5.7% and 6.4%, the range of the fasting blood glucose (FPG) was 5.6 mM to 7.0 mM, the 2-hour oral glucose tolerance test (OGTT) blood glucose level content ranged from 7.8 mM up to 11.1 mM, or obtained the clinical identification about prodromal diabetes from the health care provider [19]. Subjects were recognized to possess diabetes as long as individual up to grade one of the following conditions: an FPG level ≥ 7.0 mM, an HbA1c level $\geq 6.5\%$, the blood glucose content of random blood glucose or 2-hour OGTT of ≥ 11.1 mM, reported by a doctor diagnosing to prove diabetes, or taking oral hypoglycemic drugs or insulin [19]. BRI was calculated using $364.2-365.5 \cdot (1 - [WC(m)/2\pi]^2 / [0.5 \cdot \text{height}(m)]^2)^{1/2}$ [13].

Covariates

The potential confounding factors of diabetes and prediabetes were selected based on previous studies, mainly

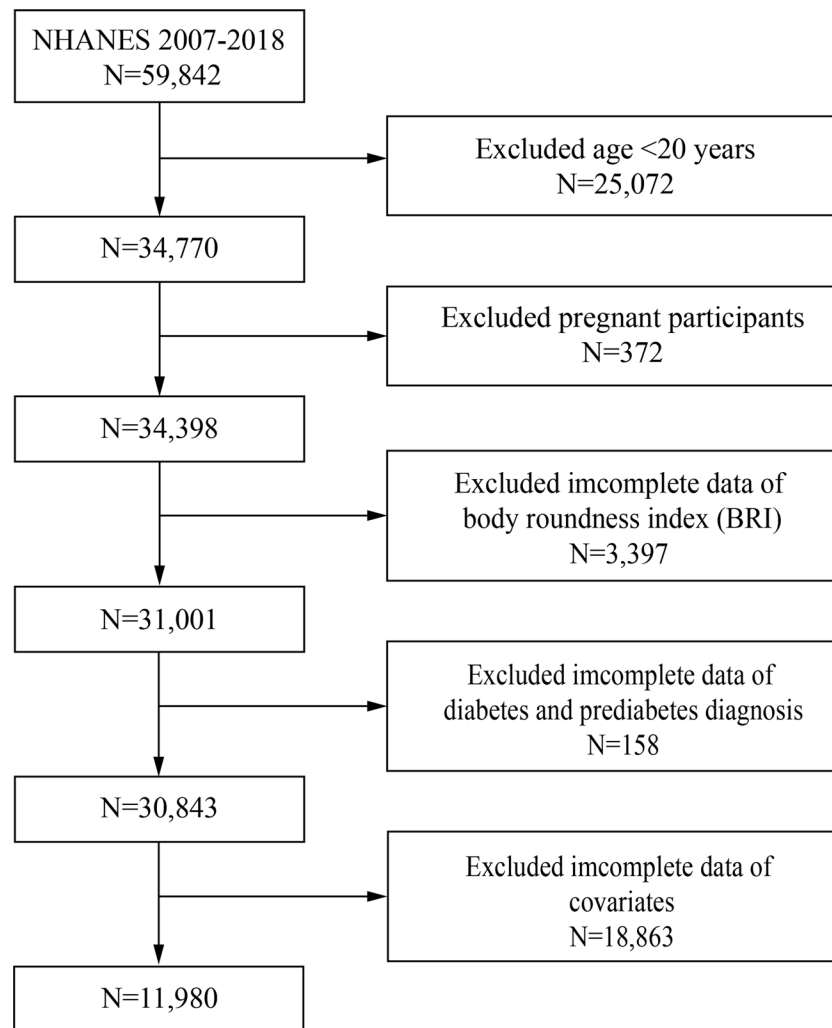


Fig. 1 Flowchart of participant selection. *Abbreviation* NHANES: National Health and Nutrition Examination Surveys

including age, gender, race, degree of education, smoking status, alcohol use, marital status, poverty income ratio (PIR), physical activity, daily energy intake, BMI, WC, HbA1c, high density lipoprotein (HDL), total cholesterol (TC), hyperlipidemia, hypertension, cancer, and CVD. The smoking habits of participants were categorized into the following distinct types: never smoked, used to smoke, currently smoke. Participants' drinking habits were assessed based on whether they drink a minimum of 12 glasses of various kinds of alcohol each year. Physical activity could be assessed by metabolic equivalent scores (METs)=sum of walking+moderate+vigorous MET [20]. The total daily energy intake (kcal) was computed based on the dietary recall data from the first day of 24-hour. HbA1c, HDL, and TC were measured using the NHANES laboratory protocol. Hyperlipidemia was evaluated by considering the use of lipid-lowering medications, a clinical diagnosis of hyperlipidemia, or laboratory results suggestive of elevated lipid levels [21]. The

characteristics of hypertension included blood pressure $\geq 140/90$ mmHg, a history of hypertension, or currently using antihypertensive drugs. The presence of cancer was determined through a positive answer to this issue, "Did a doctor inform you that you had cancer or a malignancy?" The criteria used to identify a history of CVD required a medically confirmed diagnosis of coronary artery disease or stroke.

Statistical analysis

In line with NHANES analysis guidelines, sample weights were applied to address the complexities of the sampling design. Chi-square tests were used to compare the percentages (%) that represented the categorical variables. Continuous variables were assessed using the Kruskal-Wallis H test, with results shown as mean values accompanied by standard deviations (SD). Multivariate logistic regression and univariate analysis were conducted to assess the potential correlation of BRI with

diabetes and prediabetes. This study used three different models. While Model 2 had controls for age, race, and gender, Model 1 did not have any covariate adjustments. Covariates were included in Model 3 if they resulted in a greater than 10% change in the effect estimate. The possible relationship among BRI with diabetes and prediabetes was further analyzed by curve fitting. Subgroup analyses were conducted by age, gender, smoking status, alcohol use, marital status, PIR, physical activity, hypertension, hyperlipidemia, cancer, and CVD. Interaction *P*-values were utilized to assess the consistency of effects across subgroups. Finally, a comparison between BMI, a body shape index (ABSI), and WC was made in order to ascertain the diagnostic significance of the BRI in predicting diabetes and prediabetes using receiver operating characteristic (ROC) curve analysis. The $P < 0.05$ exhibited significance. EmpowerStats (www.empowerstats.com) was employed in whole statistical assessments.

Results

Participant characteristics

Out of a total of 11,980 individuals, there were 6,468 individuals diagnosed with diabetes ($N=2,090$) and prediabetes ($N=4,378$), while 5,512 individuals had normal blood glucose levels, as indicated in Table 1. Different from the group with normal blood glucose content, individuals within the group of diabetes and prediabetes were generally older, female, Mexican American, other Hispanic and non-Hispanic black, less educated, fewer never-married, were former smokers, non-drinkers, had lower family PIR, lacked physical activity, had lower daily energy intake, had lower HDL levels, and had significantly higher levels of BMI, WC, HbA1c, and BRI ($P < 0.05$). Moreover, they exhibited an increased risk of hyperlipidemia, hypertension, cancer, and CVD ($P < 0.05$).

Univariate analysis of diabetes and prediabetes

Table 2 displays a favourable correlation ($P < 0.05$) between age, daily energy intake, BMI, HbA1c, WC, and BRI with prediabetes and diabetes. Education level, physical activity, HDL were negatively related to diabetes and prediabetes ($P < 0.05$). When contrasted to males, females were at an elevated risk of diabetes development and prediabetes development. Non-Hispanic whites exhibited a reduced incidence of diabetes and prediabetes compared to Mexican Americans, while non-Hispanic blacks demonstrated an elevated risk. Being widowed/divorced/separated was at an elevated risk of diabetes and prediabetes than those who were being married/living with a partner. Individuals who were never married exhibited a decreased incidence of diabetes and prediabetes. Former smokers had an increased likelihood of developing diabetes and prediabetes compared to nonsmokers. Current alcohol drinkers showed a reduced risk of diabetes

and prediabetes than non-drinkers. Individuals with a high PIR (> 3.5) had a lower incidence of diabetes and prediabetes than those with a low PIR (≤ 1.3). Moreover, diabetes and prediabetes were strongly correlated with hyperlipidemia, hypertension, malignancy, and CVD.

BRI level and diabetes and prediabetes

There was a marked positive relationship among BRI and diabetes and prediabetes in models 1, 2, and 3 (odds ratio [OR]: 1.17, 95% confidence intervals [CI]: 1.07–1.27). When BRI was categorized into quartiles, those who were in the top quartile ($Q4: \geq 6.40$) demonstrated a significantly increased risk of diabetes and prediabetes development across models 1, 2, and 3 (OR: 1.83, 95% CI: 1.29–2.58) compared to the reference group ($Q1: < 3.81$). All $P < 0.05$ (as shown in Table 3). Furthermore, full adjustment of the smooth curve fitting revealed a non-linear relationship existed in BRI with diabetes as well as prediabetes (P for non-linear = 0.01 < 0.05) (Fig. 2). As demonstrated in Table S1 and Figure S1, this investigation also identifies a non-linear positive association between BRI and prediabetes.

Subgroup analysis

In order to test the reliability of the link between the BRI and diabetes and prediabetes, further subgroup analyses were conducted. The findings study revealed that this positive relationship among BRI with diabetes and prediabetes could be observed across all subgroups ($P < 0.05$) (Fig. 3). Interactions terms were not significant in all subgroups (all *P*-values for interaction were > 0.05).

BRI as a predictor for diabetes and prediabetes

Figure 4 shows the area under the curve (AUC) of diagnostic capability in the prediction of diabetes and prediabetes. These results revealed that both BMI, WC, ABSI, and BRI had statistically significant diagnostic capability for the detection of diabetes and prediabetes ($AUC > 0.5$) (Fig. 4). Furthermore, BRI performed better than BMI, ABSI, and WC indices ($AUC = 0.68$).

Discussion

This study is the first to merge and analyze data from the 2007–2018 NHANES for exploring the link between BRI values and being of diabetes and prediabetes within individuals in the USA. The statistical analysis shows a strong and stable positive correlation between BRI as well as the risk of both prediabetes and diabetes. This association remained consistent even after adjusting for confounding variables, suggesting that diabetes and prediabetes could be impacted by BRI. The likelihood of diabetes and prediabetes increased by 17% with each one-unit rise in BRI. Individuals with high BRI scores (Q4) exhibited greater odds of diabetes and prediabetes

Table 1 Characteristics of study population divided by different disease states, NHANES 2007–2018

Variable	Normal blood glucose (N=5,512)	Diabetes and prediabetes (N=6,468)	P-value
Age (years)	43.00 ± 16.41	54.68 ± 15.52	< 0.001
Gender			< 0.001
Male	3865 (70.12)	4194 (64.84)	
Female	1647 (29.88)	2274 (35.16)	
Race and ethnicity			< 0.001
Mexican American	688 (12.48)	1009 (15.60)	
Other Hispanic	490 (8.89)	656 (10.14)	
Non-Hispanic white	2911 (52.81)	2782 (43.01)	
Non-Hispanic black	851 (15.44)	1395 (21.57)	
Other races	572 (10.38)	626 (9.68)	
Education level			< 0.001
< 9th grade	294 (5.33)	656 (10.14)	
9–11th grade	646 (11.72)	920 (14.22)	
High school graduate	1207 (21.90)	1548 (23.93)	
Some college	1729 (31.37)	1900 (29.38)	
College graduate or above	1636 (29.68)	1444 (22.33)	
Marital status			< 0.001
Married/Living with partner	3243 (58.84)	4159 (64.30)	
Widowed/Divorced/Separated	890 (16.15)	1506 (23.28)	
Never married	1379 (25.02)	803 (12.41)	
Smoking status			< 0.001
Never	3011 (54.63)	3231 (49.95)	
Former	1219 (22.12)	1937 (29.95)	
Now	1282 (23.26)	1300 (20.10)	
Alcohol use			< 0.001
No	1024 (18.58)	1670 (25.82)	
Yes	4488 (81.42)	4798 (74.18)	
PIR			< 0.001
≤ 1.3	1547 (28.07)	1907 (29.48)	
> 1.3 and ≤ 3.5	1911 (34.67)	2484 (38.40)	
> 3.5	2054 (37.26)	2077 (32.11)	
Physical activity			< 0.001
< 600	2162 (39.22%)	3276 (50.65%)	
600–1500	1704 (30.91%)	1698 (26.25%)	
> 1500	1646 (29.86%)	1494 (23.10%)	
Daily energy intake (kcal)	2373.62 ± 1094.98	2146.40 ± 981.79	< 0.001
BMI (kg/m ²)	27.37 ± 5.50	30.11 ± 6.48	< 0.001
WC (cm)	95.26 ± 14.20	103.44 ± 15.44	< 0.001
HbA1c (%)	5.26 ± 0.29	6.18 ± 1.28	< 0.001
HDL (mmol/L)	1.39 ± 0.44	1.31 ± 0.41	< 0.001
TC (mmol/L)	5.16 ± 1.04	5.18 ± 1.14	0.388
BRI	4.63 ± 1.85	5.89 ± 2.21	
Hyperlipidemia			< 0.001
No	1550 (28.12)	933 (14.42)	
Yes	3962 (71.88)	5535 (85.58)	
Hypertension			< 0.001
No	4889 (88.70)	5092 (78.73)	
Yes	623 (11.30)	1376 (21.27)	
Cancer			< 0.001
No	5122 (92.92)	5716 (88.37)	
Yes	390 (7.08)	752 (11.63)	

Table 1 (continued)

Variable	Normal blood glucose (N=5,512)	Diabetes and prediabetes (N=6,468)	P-value
CVD			< 0.001
No	5194 (94.23)	5463 (84.46)	
Yes	318 (5.77)	1005 (15.54)	

Abbreviation BMI: body mass index; BRI: body roundness index; CVD: cardiovascular diseases; HDL: high density lipoprotein; HbA1c: glycosylated haemoglobin; NHANES: National Health and Nutrition Examination Surveys; PIR: poverty income ratio; TC: total cholesterol; WC: waist circumference

compared to those in the Q1 category. In this study, this was further by fund a non-linear relationship among BRI with diabetes and prediabetes. Furthermore, subgroup analysis and interaction assessments revealed that these consistent relationships were upheld across diverse population groups. Moreover, BRI exhibited the highest predictive value for diabetes and prediabetes compared to BMI, ABSI, and WC, as indicated by the largest AUC. Therefore, these results highly implied the latent availability of BRI acting to be the predictor for diabetes and prediabetes.

Obesity undoubtedly contributes significantly to the development of diabetes. Specifically, deposition of visceral organs of the abdomen with adipose tissue (abdominal obesity) exhibits a stronger correlation among insulin resistance and the threats of diabetes compared to subcutaneous fat [22, 23]. BMI is a commonly used indicator in diagnosing obesity, but it cannot fully reflect the actual body fat content [24], nor can it evaluate the risk of diseases associated with obesity in individuals possessing high body fat and low muscle mass [25]. Although WC is used as a diagnostic measure for identifying increased abdominal fat, it cannot distinguish between visceral fat and subcutaneous fat. Existing techniques for assessing abdominal fat through MRI or CT are expensive and require considerable time to perform, limiting their use in research and clinical settings. Consequently, the development and use of novel anthropometric indices have continued. Consequently, BRI is developed, and it has the ability to reflect body roundness related to height, and compared to traditional anthropometric indices, it can more accurately approximate visceral fat levels [13] and is highly correlated with visceral adipose tissue as assessed by CT imaging [26, 27].

The correlation between BRI level and diabetes is better than BMI, WC, and ABSI, as confirmed by a longitudinal study in Japan [16]. An investigation that was cross-sectional in the Northeast region of China also yielded similar conclusions [28]. Another retrospective cohort study found that BRI is more accurate than BMI in predicting diabetes [17]. A cohort study of 7,902 participants in China showed that BRI was significantly associated with diabetes among both sexes [14]. Zhang et al. [29] likewise found a favorable association between middle-aged and older Chinese individuals'

BRI levels with diabetes. Additionally, Zhao et al. [15] suggested that BRI displayed a positive correlation with diabetes risk in women and a curvilinear association in men. In terms of predicting diabetes in both sexes, BRI is superior to BMI and WC [15]. Nevertheless, the aforementioned studies had limited focus on the pre-disease stage of diabetes. A 4-year investigation carried out in Chinese adults revealed that a decrease in initial BRI levels was found to be correlated with a positive outcome of prediabetes regression, and its attributable fractions were around 20% [30]. However, among the population of Montenegro, there was no association between BRI and prediabetes [31]. For these inconsistent results, differences in race, subject characteristics, region, sample size, and study design may account for the differences between these studies. Additionally, it has not explored the connection among BRI with diabetes as well as prediabetes in the USA; therefore, this study validated the relationship among BRI to diabetes and prediabetes within American adults. Consistent with earlier findings in other populations, this study demonstrates that the BRI can be used as an indicator to evaluate risk factors for diabetes and prediabetes. Moreover, the consistent positive association between BRI and diabetes and prediabetes persisted across all subgroup analyses, underscoring the robustness of these results.

The following are a few plausible relationships that may explain the connection among BRI and diabetes and prediabetes. Initially, dysregulated lipid accumulation triggers endoplasmic reticulum stress and oxidative stress responses, leading to reduced gene expression, secretion, and increased apoptosis of pancreatic β -cells, culminating in β -cell dysfunction, resulting in reduced insulin sensitivity and secretion, which causes persistent hyperglycemia [32]. Additionally, elevated visceral fat levels reduce adiponectin (a protective adipokine) levels, leading to a rise in pro-inflammatory cytokines, including tumor necrosis factor and interleukin 6, potentially worsening insulin resistance [33]. Furthermore, compromised inhibition of lipolysis in adipocytes of individuals with obesity results in elevated levels of liver fatty acids, contributing to the accumulation of liver lipids. This process reduces liver insulin sensitivity, enhances hepatic gluconeogenesis, and ultimately results in dysglycemia [34].

Table 2 Association of unadjusted variables with diabetes and prediabetes

Variables	OR (95%CI)	P-value
Age, years	1.04 (1.04, 1.05)	< 0.001
Gender		
Male	Reference	
Female	1.23 (1.12, 1.34)	< 0.001
Race and ethnicity		
Mexican American	Reference	
Other Hispanic	0.86 (0.72, 1.03)	0.105
Non-Hispanic white	0.76 (0.67, 0.86)	< 0.001
Non-Hispanic black	1.30 (1.14, 1.49)	< 0.001
Other races	0.99 (0.79, 1.23)	0.914
Education		
< 9th grade	Reference	
9 – 11th grade	0.65 (0.52, 0.82)	< 0.001
High school graduate	0.61 (0.50, 0.73)	< 0.001
Some college	0.51 (0.43, 0.62)	< 0.001
College graduate or above	0.40 (0.33, 0.49)	< 0.001
Marital status		
Married/Living with partner	Reference	
Widowed/Divorced/Separated	1.26 (1.12, 1.43)	< 0.001
Never married	0.46 (0.41, 0.53)	< 0.001
Smoking status		
Never	Reference	
Former	1.54 (1.36, 1.76)	< 0.001
Now	1.05 (0.91, 1.22)	0.513
Alcohol use		
No	Reference	
Yes	0.66 (0.57, 0.75)	< 0.001
PIR		
≤ 1.3	Reference	
> 1.3 and ≤ 3.5	1.07 (0.91, 1.25)	0.412
> 3.5	0.82 (0.70, 0.95)	0.012
Physical activity		
< 600	Reference	
600–1500	0.67 (0.59, 0.75)	< 0.001
> 1500	0.61 (0.54, 0.68)	< 0.001
Daily energy intake (kcal)	1.00 (1.00, 1.00)	< 0.001
BMI (kg/m ²)	1.09 (1.07, 1.10)	< 0.001
WC (cm)	1.04 (1.04, 1.04)	< 0.001
HbA1c (%)	65.83 (49.16, 88.15)	< 0.001
HDL (mmol/L)	0.59 (0.53, 0.66)	< 0.001
TC (mmol/L)	1.00 (0.95, 1.04)	0.906
BRI	1.39 (1.34, 1.43)	< 0.001
Hyperlipidemia		
No	Reference	
Yes	2.20 (1.96, 2.47)	< 0.001
Hypertension		
No	Reference	
Yes	2.17 (1.90, 2.49)	< 0.001
Cancer		
No	Reference	
Yes	1.81 (1.56, 2.09)	< 0.001

Table 2 (continued)

Variables	OR (95%CI)	P-value
CVD		
No	Reference	
Yes	3.38 (2.82, 4.04)	<0.001

Abbreviation BMI: body mass index; BRI: body roundness index; CI: confidence interval; CVD: cardiovascular diseases; HDL: high density lipoprotein; HbA1c: glycosylated haemoglobin; OR: odds ratio; PIR: poverty income ratio; TC: total cholesterol; WC: waist circumference

Table 3 Relationship between BRI and diabetes and prediabetes in different models

Variables	OR (95% CI), P-value		
	Model 1 ^a	Model 2 ^b	Model 3 ^c
BRI (continuous)	1.39 (1.34, 1.43), <0.0001	1.33 (1.29, 1.37), <0.0001	1.17 (1.07, 1.27), 0.0011
Quartile of BRI			
Q1 (< 3.81)	Reference	Reference	Reference
Q2 (3.81–4.99)	2.05 (1.80, 2.34), <0.0001	1.61 (1.41, 1.83), <0.0001	1.29 (1.09, 1.53), 0.0057
Q3 (4.99–6.39)	3.27 (2.87, 3.73), <0.0001	2.37 (2.06, 2.73), <0.0001	1.47 (1.16, 1.86), 0.0028
Q4 (≥ 6.40)	6.06 (5.21, 7.06), <0.0001	4.70 (3.98, 5.57), <0.0001	1.83 (1.29, 2.58), 0.0013
P for trend	<0.0001	<0.0001	0.0017

^aModel 1: adjusted for no covariates

^bModel 2: adjusted for age, gender, race

^cModel 3: adjusted for age, gender, race, education, marital, smoking status, alcohol use, PIR, physical activity, daily energy intake, BMI, HDL, HbA1c, hyperlipidemia, hypertension, cancer and CVD

Abbreviation BMI: body mass index; BRI: body roundness index; CI: confidence interval; CVD: cardiovascular diseases; HDL: high density lipoprotein; HbA1c: glycosylated haemoglobin; OR: odds ratio; PIR: poverty income ratio

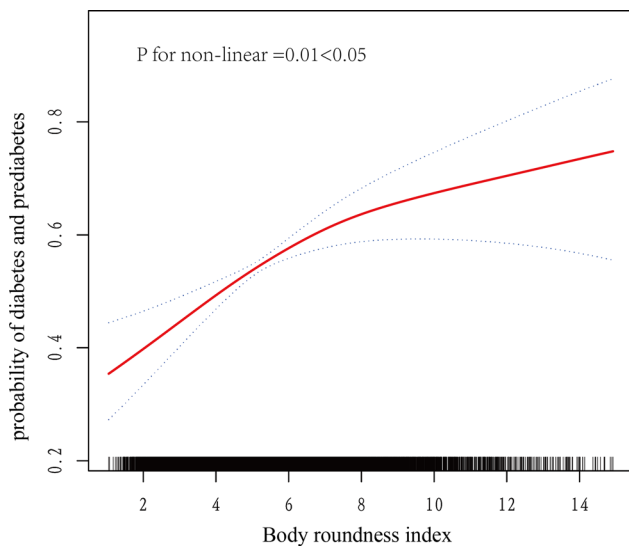


Fig. 2 The non-linear relationship between BRI and incident of diabetes and prediabetes after adjusting for confounding variables

Study the advantages and disadvantages

This study had two important advantages. Initially, the data was reliably analyzed to provide a good representation of the current state of the U.S. population. Secondly, the correlation between BRI and diabetes and prediabetes was consistent across various subgroup analyses, indicating the robustness of the findings. In spite of these important advantages, it also existed certain limitations that should not be overlooked. At first, based on a cross-sectional design, the study could not establish a causal connection among BRI with the development of diabetes and prediabetes. Furthermore, while this study accounted for potential confounders in the data analysis, residual confounding stemming from undisclosed or unmeasured variables may remain. Finally, this study population consisted of only American participants, so the generalizability of this study to other national populations is uncertain.

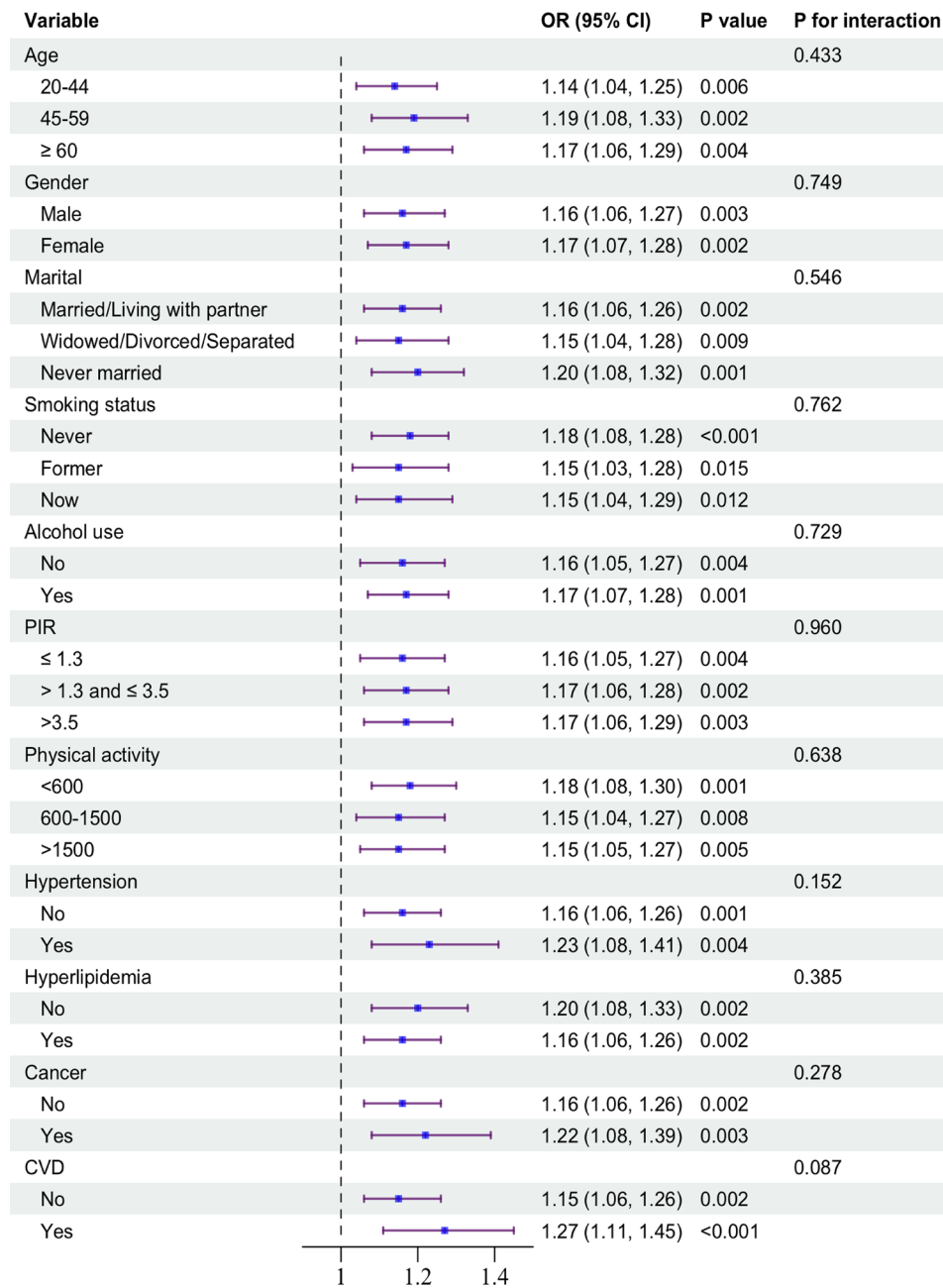


Fig. 3 Subgroup analysis for the association between BRI and diabetes and prediabetes. *Abbreviation* BRI: body roundness index; CI: confidence interval; CVD: cardiovascular diseases; OR: odds ratio; PIR: poverty income ratio

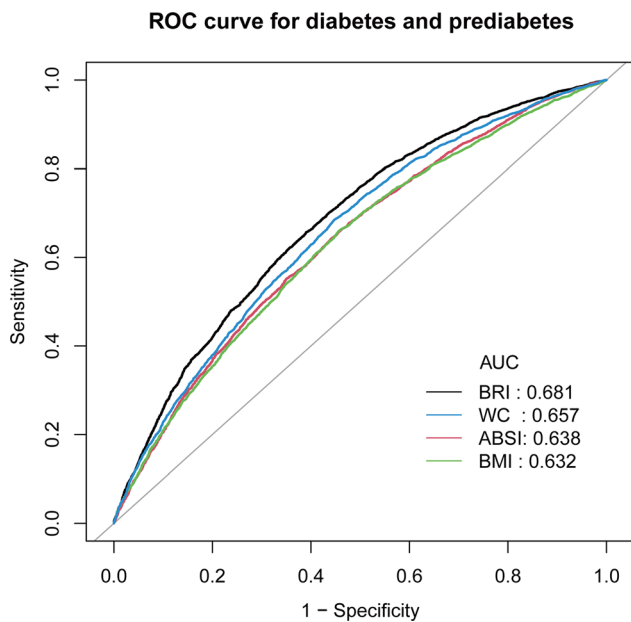


Fig. 4 ROC curves for BMI, WC, ABSI, and BRI for predicting diabetes and prediabetes. *Abbreviation* ABSI: a body shape index; AUC: area under the curve; BMI: body mass index; BRI: body roundness index; ROC: receiver operating characteristic; WC: waist circumference

Conclusion

In this study, the increased BRI had a nonlinear positive association to the prevalence of diabetes and prediabetes among American adults. The predictive capacity of BRI outperformed that of BMI, ABSI, and WC. As a non-invasive and straightforward anthropometric tool, the BRI can offer clinicians a practical method to screen for prediabetes and diabetes in high-risk populations. Physicians should advise patients with higher BRI values to lead healthy lifestyles, which include eating a balanced diet and doing regular exercise, to manage their weight and abdominal fat and reduce their risk of developing prediabetes and diabetes.

Abbreviations

ABSI	A body shape index
AUC	Area under the curve
BMI	Body mass index
BRI	Body roundness index
CI	Confidence interval
CT	Computed tomography
CVD	Cardiovascular diseases
FPG	Fasting blood glucose
HDL	High density lipoprotein
HbA1c	Glycosylated haemoglobin
METS	Metabolic equivalent scores
MRI	Magnetic resonance imaging
NHANES	The National Health and Nutrition Examination Survey
OGTT	Oral glucose tolerance test
OR	Odds ratio
PIR	Poverty income ratio
ROC	Receiver operating characteristic
SD	Standard deviations
TC	Total cholesterol
WC	Waist circumference

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12944-024-02238-2>.

Supplementary Material 1

Supplementary Material 2

Author contributions

LQ: article conception, methodology, software, and writing-original draft. ZX: analysis, review, and data integration. BF: methodology and software. LL: review and methodological guidance. GS: writing review and editing, and methodology. All authors approved the final manuscript as submitted and agreed to be accountable for all aspects of the work.

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Data availability

No datasets were generated or analysed during the current study. <https://www.cdc.gov/nchs/nhanes>.

Declarations

Ethics approval and consent to participate

This investigation was approved by the National Center for Health Statistics. Ethics Review Board. Informed consent was obtained from all subjects involved in the NHANES.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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