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Original Article

Correlation between obesity-related indices and hypertension

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Abstract: Objectives: To explore the correlation between obesity-related indices and hypertension, as well as their predictive ability for hypertension, to provide new insights for the prevention and treatment of the disease. Methods: This retrospective study included participants aged over 18 years from Chongqing General Hospital, spanning January 2023 to January 2024. Based on the presence or absence of hypertension, 160 participants were divided into two groups: an observation group (with hypertension, n=83) and a control group (without hypertension, n=77). Demographic and obesity-related indices were collected to assess their correlation with hypertension. Results: The mean waist circumference (WC) was significantly higher in the observation group 82.46 (78.87-84.35) compared to the control group 82.64 (78.00-84.87), albeit with a typographical error in reporting (P=0.012). The mean A Body Shape Index (ABSI) was significantly higher in the observation group 0.778 (0.078-0.081) compared to the control group 0.076 (0.083-0.087) (P=0.004). The mean body roundness index (BRI) was also significantly higher in the observation group 3.38 (3.07-3.84) than in the control group 3.40 (2.98-3.87) (P=0.02). Logistic regression revealed ABSI (OR=1.15, 95% CI 1.06-1.28, P=0.014), BRI (OR=1.14, 95% CI 1.03-1.23, P=0.048), and WC/BRI (OR=1.13, 95% CI 1.04-1.34, P=0.031) as statistically significant risk factors. The area under the curve values for ABSI, BRI, WC/BRI, and their combination were 0.572, 0.629, 0.652, and 0.731, respectively. Conclusion: ABSI, BRI, and WC/BRI may serve as independent risk factors for hypertension. These indices, individually or combined, could aid in predicting the risk of hypertension.

Keywords: Obesity-related indices, hypertension, correlation

Introduction

Hypertension is a clinical syndrome defined by a sustained elevation in arterial blood pressure (greater than 140/90 mmHg), which can lead to organ damage in the heart, brain, and kidneys. If left uncontrolled, hypertension may result in severe health consequences such as stroke, atherosclerotic cardiovascular disease, heart failure, and end-stage renal disease [1]. It is a major cause of mortality nationally. Recent epidemiological data indicate that approximately 244 million adults are affected by hypertension, constituting about 23.2% of the population [2, 3]. Hypertension frequently coexists with conditions such as obesity, high cholesterol, diabetes, and kidney disease, which can exacerbate the risk of complications [4]. Obesity notably heightens the risk of developing hypertension, insulin resistance, metabolic syndrome, and heart failure [5]. The interrelationship between hypertension and obesity significantly contributes to both overall and cardiovascular mortality [6]. Studies suggest that up to three-quarters of hypertension cases are directly associated with obesity [7-9]. Further, an epidemiological survey revealed that about 30% of individuals aged 40 to 79 are obese, with a substantial proportion also presenting with hypertension, representing 22.8% of the total population [10].

Obesity-related indices serve as tools for assessing an individual's risk of obesity and its associated health complications [11]. These indices include metrics such as weight, height, body fat percentage, and waist circumference. The body mass index (BMI), for instance, calculates obesity by dividing a person's weight in kilograms by their height in meters squared

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[12], where a BMI over 30 categorizes obesity, and a BMI between 25 and 29.9 denotes being overweight. Another useful measure is the waist-to-hip ratio [13], which gauges the ratio of WC to hip circumference, with higher values indicating increased risks of obesity-related health issues like heart disease and diabetes. Numerous studies affirm a robust link between obesity and hypertension, particularly among individuals who are overweight or obese [14-16]. Ming et al. demonstrated a significantly higher hypertension risk in women, showing a 1.96-fold increase associated with female gender and WC [17]. Despite existing research, findings on the predictive effectiveness of abdominal obesity indices for chronic diseases remain inconsistent across different populations [18, 19], necessitating further investigation to identify the most predictive indices for hypertension.

This study aims to elucidate the correlation between obesity-related indices and the risk of hypertension and to evaluate their predictive utility in assessing hypertension risk across different obesity statuses. By identifying populations at high risk for developing hypertension, this research seeks to support early prevention and improve hypertension management strategies.

Methods and participants

Participants selection

This retrospective study, conducted from January 2023 to January 2024 at Chongqing General Hospital, included participants aged over 18 years with or without hypertension. Based on their hypertension status, 160 participants were allocated into two groups: an observation group with hypertension (n=83) and a control group without hypertension (n=77). Hypertension was defined following the "Chinese Guidelines for the Prevention and Treatment of Hypertension 2018" [20] criteria, which specify: (1) A systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg across three separate measurements on different days without antihypertensive medication; (2) A diagnosis of hypertension in individuals currently under antihypertensive treatment if their blood pressure was controlled below 140/90 mmHg. Exclusion criteria were: secondary hypertension, renal artery stenosis, severe cardiovascular conditions (e.g., acute myocardial infarction, decompensated congestive heart failure), primary aldosteronism, moderate to severe liver dysfunction, malignant tumors, kidney parenchymal diseases leading to proteinuria, and moderate to severe obstructive sleep apnea syndrome. The selection process for the study subjects is illustrated in **Figure 1**. Conducted in line with the Declaration of Helsinki, this study was approved by the Ethics Committee of Chongqing General Hospital. Written informed consent was waived due to the retrospective nature of the study. Personally identifiable information, such as names, addresses, and phone numbers, was not recorded. All collected data were maintained confidentially and used solely for research purposes.

Clinical data

We collected general demographic and laboratory data from the two patient groups. Demographic data included age, gender, smoking history, alcohol consumption, medical history, height, weight, WC, and blood pressure. The study focused on several obesity-related indices, such as the BMI, WC, waist-to-height ratio (WHtR), body roundness index (BRI), WC/BRI ratio, triglyceride to high-density lipoprotein cholesterol ratio (TG/HDL-C), A Body Shape Index (ABSI) and total cholesterol to HDL-C ratio (TC/HDL-C). The formulas for these indices are defined as follows: BMI = weight (kg)/height $(m)^2$; WHtR = WC (cm)/height (cm); BRI = $364.2 - 365.5 \times \{1 - [(WC/2\pi)/(0.5 \times height)]^2\}^{0.5}$; ABSI = WC (m)/(BMI $(kg/m^2)^{1.5}$ × Height $(m)^{0.5}$).

Statistical analysis

Data analysis was performed using SPSS version 20.0. The sample size was determined based on preliminary studies and using a sample size calculation formula [21], with the result of 160 patients. Categorical data were represented as percentages and analyzed using the chi-square test to evaluate the significance of differences between the two groups. Continuous data were tested for normal distribution using the Kolmogorov-Smirnov test (K-S test). Data with a normal distribution and homogeneity of variance (K-S test, $P<0.05$) were analyzed using an independent samples t-test, with results presented as mean ± standard deviation. For data not following a normal distribu-

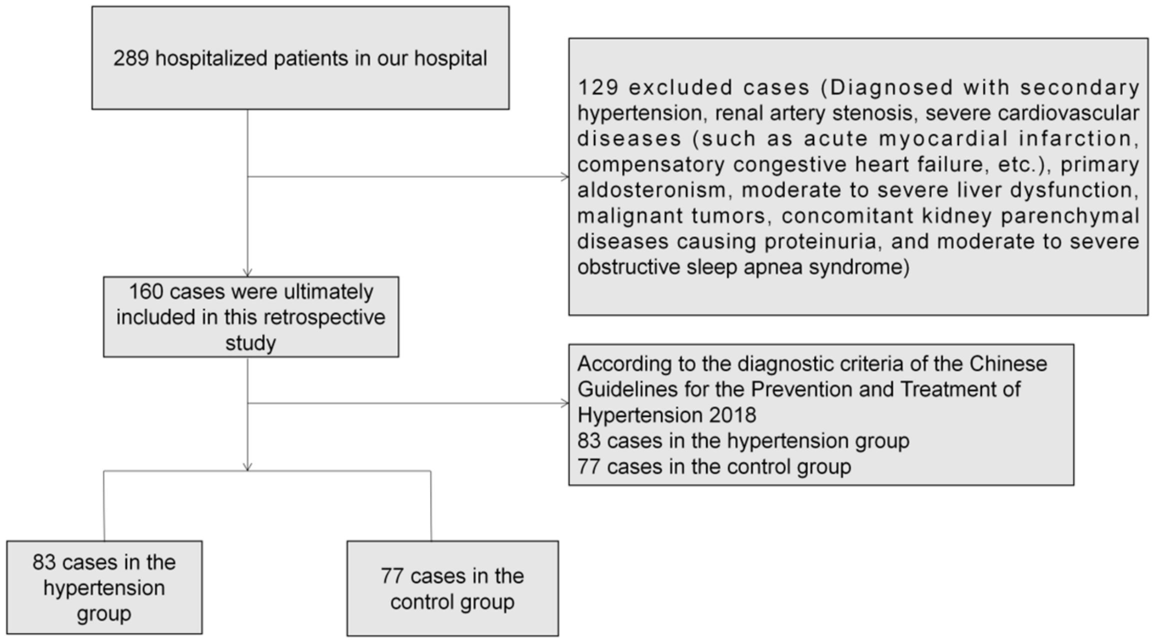

Figure 1. Study flowchart.

Table 1. Comparison of general information between the two groups

	Observation group (n=83)	Control group (n=77)	χ^2/t/Z	P
Gender			0.624	0.468
Male	41 (49.40%)	40 (51.95%)		
Female	42 (51.60%)	37 (48.05%)		
Age	42.56±12.02	43.02±10.32	1.087	0.289
Height	1.64±0.05	1.65±0.09	0.223	0.847
Smoking history	26 (31.33%)	27 (35.06%)	1.785	0.187
Drinking history	14 (16.87%)	7 (9.10%)	5.687	0.024
Comorbidities				
Coronary heart disease	32 (38.55%)	10 (13.00%)	4.487	0.032
Diabetes	7 (8.43%)	2 (2.60%)	55.487	<0.001
Abnormal blood lipids	12 (14.46%)	5 (6.5%)	23.56	<0.001
Chronic kidney disease	24 (28.92%)	9 (11.69%)	198.574	<0.001
Hyperuricemia	23 (27.71%)	6 (7.79%)	36.541	<0.001

tion or lacking homogeneity of variance, the Mann-Whitney U test was applied, with results reported as median and interquartile range (P50 (P25-P75)). The correlation between obesity-related indices and hypertension was assessed using Spearman's correlation analysis. Binary logistic regression was utilized to determine whether each obesity-related index was an independent risk factor for hypertension. A *P*-value <0.05 was considered statistically significant.

Results

Comparison of general information

Table 1 outlines the demographic and health characteristics of the participants, distinguishing between those with and without hypertension. Notably, the observation group showed significantly higher incidences of drinking history, diabetes, chronic kidney disease, hyperuricemia, and abnormal blood lipids (all P<0.05).

Table 2. Comparison of behaviors and health status

Variable	Observation group (n=83)	Control group (n=77)	χ^2	P
Total static behavior time			6.351	0.098
<2 hours	8 (9.64%)	7 (9.09%)		
2-3 hours	20 (24.10%)	8 (10.39%)		
3-4 hours	17 (20.48%)	9 (11.69%)		
≥4 hours	38 (45.78%)	53 (68.83%)		
Red meat intake			10.987	0.001
Appropriate amount	75 (90.36%)	69 (89.61%)		
Slightly high	8 (9.64%)	8 (10.39%)		
Grain intake			8.657	0.002
Appropriate amount	24 (28.92%)	26 (33.77%)		
Low	48 (57.83%)	32 (41.56%)		
Slightly high	11 (13.25%)	19 (24.67%)		
Vegetable intake			1.001	0.608
Appropriate amount	32 (38.55%)	38 (49.36%)		
Low	33 (39.76%)	26 (33.77%)		
Slightly high	16 (12.29%)	23 (29.87%)		
Fruit intake			2.321	0.321
Appropriate amount	12 (14.46%)	9 (11.69%)		
Low	67 (80.72%)	62 (80.52%)		
Slightly high	4 (4.82%)	6 (7.79%)		

Comparison of behaviors and health status

As shown in **Table 2**, dietary habits such as red meat and grain consumption significantly differed between the groups, correlating with the prevalence of hypertension (P=0.001 and P=0.002, respectively). In the observation group, there were 7 diabetic patients (8.43% prevalence) and 12 patients with abnormal blood lipids (14.46% prevalence). Both conditions were associated with a higher prevalence of hypertension (both P<0.001). There was no significant difference in total sedentary time, vegetable intake, or fruit intake between the groups (all P>0.05).

Comparison of obesity related indicators

Table 3 presents the mean values of obesity-related anthropometric indices. The mean values for ABSI, BRI, WC, TG/HDL-C, and TC/HDL-C were significantly higher in the observation group compared to those in the control group. Specifically, the mean WC in the observation group was 82.46 (78.87-84.35) compared to 82.64 (78.00-84.87) in the control group (P=0.012). The mean ABSI was notably higher at 0.778 (0.078-0.081) in the observation group than in the control group at 0.076 (0.083-0.087) (P=0.004). The mean BRI was also higher in the observation group at 3.38 (3.07-3.84) compared to 3.40 (2.98-3.87) in the control group (P=0.02). There were no significant differences in mean BMI, WHtR, and WC/BRI between the groups (all P>0.05).

Regression analysis of obesity index

Logistic regression analysis was performed on obesity indices categorized by quartiles across the entire study population. The results from Models 1, 2, and 3 indicated that higher levels of WC, BMI, WHtR, and BRI are associated with an increased risk of hypertension (all P<0.05). No association was found between the WC/BMI index and hypertension risk (P>0.05) (**Table 4**).

Spearman correlation analysis of obesity-related index and hypertension

To examine the correlations between obesity-related indices and hypertension, we employed Spearman correlation analysis. We observed no significant correlation between BMI and hypertension (rs=0.038, P=0.861). However, other indices, such as WC, WHtR, ABSI, and WC/BRI, demonstrated significant correlations

Table 3. Comparison of obesity related indicators

	Observation group (n=83)	Control group (n=77)	χ²/t/Z	P
BMI	24.61±3.25	24.65±3.34	-0.541	0.654
ABSI	0.778 (0.078-0.081)	0.076 (0.083-0.087)	2.874	0.004
WHtR	0.51 (0.49-0.56)	0.53 (0.48-0.52)	0.143	0.157
BRI	3.38 (3.07-3.84)	3.40 (2.98-3.87	2.398	0.020
WC	82.46 (78.87-84.35)	82.64 (78.00-84.87)	2.564	0.012
WC/BRI	3.48 (3.34, 3.78)	3.56 (3.27, 3.69)	-1.124	0.254
TG/HDL-C	1.38 (0.87, 2.38)	1.08 (0.68, 1.84)	-6.698	<0.001
TC/HDL-C	4.47 (3.45, 5.28)	3.87 (3.07, 4.76)	-6.781	<0.001

Note: BMI: body mass index. ABSI: A Body Shape Index. WHtR: Waist-to-Height Ratio. BRI: Body Roundness Index. WC: waist circumference. TG: Triglycerides. HDL-C: High-Density Lipoprotein Cholesterol. TC: total cholesterol.

Table 4. Regression analysis of obesity index

Index	Group	Model One		Model Two		Model Three	
		OR (95% CI)	P_{-trend}	OR (95% CI)	P_{-trend}	OR (95% CI)	P_{-trend}
WC	Q1	1.000	<0.001	1.000	<0.001	1.000	0.001
	Q2	1.348 (1.023, 1.784)		1.178 (0.897, 1.578)		1.178 (0.879, 1.567)	
	Q3	1.774 (1.364, 2.364)		1.354 (1.003, 1.789)		1.295 (0.987, 1.748)	
	Q4	2.456 (1.887, 3.129)		1.987 (1.258, 2.267)		1.607 (1.212, 2.157)	
BMI	Q1	1.000	<0.001	1.000	<0.001	1.000	<0.001
	Q2	1.154 (0.889, 1.584)		1.312 (0.875, 1.564)		1.115 (0.847, 1.487)	
	Q3	1.625 (1.245, 2.098)		1.387 (1.068, 1.897)		1.367 (1.087, 1.498)	
	Q4	1.987 (1.543, 2.488)		1.654 (1.224, 2.148)		1.574 (1.156, 1.994)	
WC/BRI	Q1	1.000	0.278	1.000	0.978	1.000	0.849
	Q2	1.168 (0.974, 1.487)		1.168 (0.847, 1.487)		1.156 (0.887, 1.497)	
	Q3	1.026 (0.789, 1.357)		0.974 (0.754, 1.254)		0.987 (0.721, 1.268)	
	Q4	1.203 (0.946, 1.564)		1.087 (0.857, 1.387)		1.087 (0.845, 1.454)	
WHRt	Q1	1.000	<0.001	1.000	<0.001	1.000	<0.001
	Q2	1.487 (1.108, 2.067)		1.207 (0.887, 1.687)		1.187 (0.879, 1.697)	
	Q3	2.564 (1.947, 2.356)		1.741 (1.284, 2.387)		1.687 (1.268, 2.267)	
	Q4	3.498 (2.668, 4.598)		1.945 (1.448, 2.647)		1.587 (1.397, 2.597)	
BRI	Q1	1.000	<0.001	1.000	<0.001	1.000	<0.001
	Q2	1.487 (1.107, 2.054)		1.208 (0.877, 1.687)		1.197 (0.879, 1.654)	
	Q3	2.569 (1.978, 3.365)		1.741 (1.274, 2.354)		1.687 (1.354, 2.354)	
	Q4	3.498 (2.668, 4.598)		1.987 (1.449, 2.687)		1.874 (1.257, 2.349)	

Note: The median of each quartile group for each measurement indicator is included in the model calculation as a continuous variable P_{-trend}. BMI: body mass index. ABSI: A Body Shape Index. WHtR: Waist-to-Height Ratio. BRI: Body Roundness Index. WC: waist circumference. TG: Triglycerides. HDL-C: High-Density Lipoprotein Cholesterol. TC: total cholesterol.

with hypertension, with ABSI showing the strongest association (all P<0.001) (**Table 5**).

Logistic regression analysis of obesity index and hypertension

Further analysis revealed significant associations between several obesity indices and hypertension. Binary logistic regression was used to determine their relationship with hypertension risk. Increases in ABSI and BRI were associated with an increased risk of hypertension. After adjusting for confounding factors, ABSI (OR=1.15, 95% CI 1.06-1.28, P=0.014), BRI (OR=1.14, 95% CI 1.03-1.23, P=0.048), and WC/BRI (OR=1.13, 95% CI 1.04-1.34, P=0.031) remained statistically significant (**Table 6**). In contrast, BMI, WC, and WHtR were

Table 5. Spearman correlation analysis of obesity-related index and hypertension

	BMI	WC	WHtR	ABSI	BRI	WC/BRI
	r_s	r_s	r_s	r_s	r_s	r_s
BMI	1.000	0.800**	0.785**	-0.542**	0.787**	0.054*
WC	0.841**	1.000	0.748**	-0.664**	0.785**	-0.489**
WHtR	0.785**	0.784**	1.000	-0.048	0.984**	-0.057**
ABSI	-0.534**	-0.066**	-0.044	1.000	-0.009	-0.065*
BRI	0.786**	0.875**	0.587**	-0.008	1.000	-0.321**
Age	-0.110**	-0.109**	0.009	0.157**	0.015	-0.078**
Weight	0.789**	0.854**	0.442**	-0.425**	0.426**	0.178*
Height	0.045	0.366**	-0.278**	-0.062*	-0.287**	0.068*
Gender	0.056*	-0.489**	-0.065*	-0.324**	-0.078**	0.041**
Hypertension	0.038	0.479**	0.046*	0.357***	0.085**	0.012**

Note: BMI: body mass index. ABSI: A Body Shape Index. WHtR: Waist-to-Height Ratio. BRI: Body Roundness Index. WC: waist circumference. TG: Triglycerides. HDL-C: High-Density Lipoprotein Cholesterol. TC: total cholesterol. **P<0.05, **P<0.01, ***P<0.001* the difference is statistically significant.

Table 6. Logistic regression analysis of obesity index and hypertension

	BMI	WC	WHtR	ABSI	BRI	WC/BRI
OR value	0.97	1.12	1.08	1.23	1.08	1.13
Corrected OR value	1.00	1.02	1.07	1.15	1.14	1.09
95% CI	0.98-1.12	0.98-1.04	0.97-1.16	1.06-1.28	1.03-1.23	1.04-1.34
P	0.312	0.456	0.237	0.014	0.048	0.031

Note: BMI: body mass index. ABSI: A Body Shape Index. WHtR: Waist-to-Height Ratio. BRI: Body Roundness Index. WC: waist circumference.

not statistically significant, suggesting that ABSI, BRI, and WC/BRI may be independent risk factors for hypertension.

ROC curve analysis

Based on the logistic regression results, ROC curve analysis was conducted to evaluate the predictive value of the obesity-related indices for hypertension. The AUC values for ABSI, BRI, WC/BRI, and their combined diagnosis were 0.572, 0.629, 0.652, and 0.731, respectively, all above 0.5 (**Figure 2** and **Table 7**), indicating that ABSI, BRI, WC/BRI, and their combination have diagnostic value for hypertension.

Discussion

Our findings indicate that the observation group exhibited significantly higher values of ABSI, BRI, WC, TG/HDL-C, and TC/HDL-C compared to the control group. ABSI, BRI, and WC/BRI have been identified as potential independent risk factors for hypertension. According to the ROC curve analysis, these indices, alone or in combination, could assist in the predictive diagnosis of hypertension.

Obesity is a significant risk factor for developing hypertension, commonly known as high blood pressure. The additional body fat necessitates more blood to supply oxygen and nutrients, increasing blood volume and thereby elevating arterial pressure [22]. Obesity is often linked to insulin resistance, a condition where cells diminish their response to insulin. This resistance can increase insulin production, which may lead to vasoconstriction and elevated blood pressure [23]. Furthermore, obesity can trigger an overactivation of the sympathetic nervous system, responsible for the “fight or flight” response, resulting in faster heart rates and constricted blood vessels, thus raising blood pressure [24]. Adipose tissue secretes inflammatory substances that may damage blood vessels and contribute to hypertension. Often, obesity is associated with sedentary lifestyles and poor dietary habits, which can also play a role in the development of hypertension.

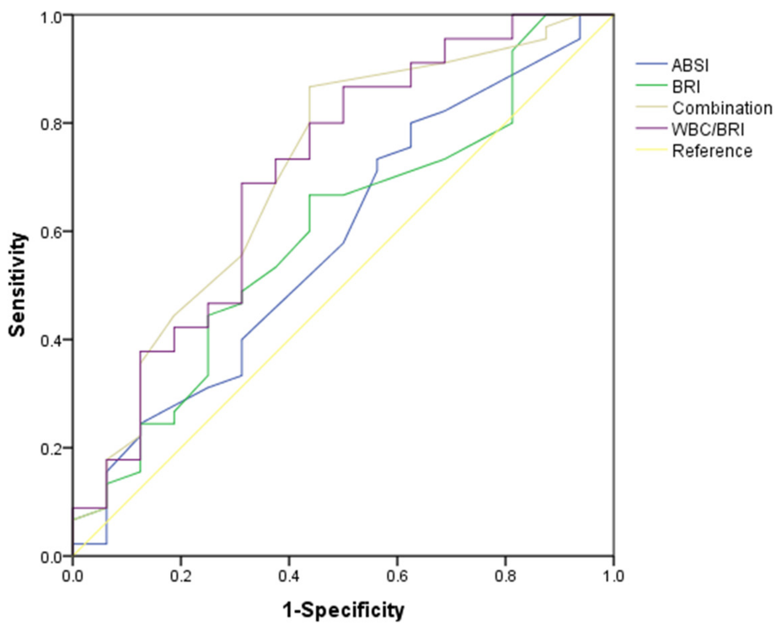

Figure 2. ROC curve. Note: ABSI: A Body Shape Index. BRI: Body Roundness Index. WC: waist circumference.

Table 7. The predictive value of obesity-related indices for hypertension

	Sensitivity	Specificity	AUC (95% CI)	P	Cut-off
ABSI	67.88	51.43	0.572 (0.547-0.599)	0.004	0.700
BRI	67.66	53.52	0.629 (0.609-0.689)	0.002	4.047
WC/BRI	52.74	71.11	0.652 (0.630-0.712)	0.008	3.341
Combination	69.90	73.98	0.731 (0.701-0.798)	0.001	5.984

Note: ABSI: A Body Shape Index. BRI: Body Roundness Index. WC: waist circumference.

The ABSI is a relatively new metric that considers WC alongside height and weight [25]. Research indicates that a higher ABSI is associated with an increased risk of hypertension, suggesting that individuals with greater ABSI values are more likely to have hypertension compared to those with lower values [26, 27]. The link between ABSI and hypertension is primarily attributed to abdominal obesity, as indicated by a high ABSI. Excess abdominal fat can lead to insulin resistance, inflammation, and other metabolic disturbances that promote hypertension [28]. In terms of diagnostic utility, ABSI offers a comprehensive evaluation of body composition and fat distribution, providing a more complete assessment than BMI alone. This enables healthcare providers to better identify individuals at risk for hypertension and guide preventive or therapeutic interventions effectively. The BRI is a relatively new anthropometric index designed to evaluate body fat distribution and overall obesity. It is calculated using waist and hip circumferences, height, and weight [29]. Our study has demonstrated a positive correlation between BRI and hypertension. BRI offers a more precise assessment of body fat distribution compared to traditional metrics such as the BMI. By incorporating measurements of waist and hip circumferences, BRI effectively identifies individuals at higher risk for hypertension due to central obesity.

This study does present some limitations. Firstly, it is a retrospective study, and the research population is derived from a single hospital, which may limit the generalizability of the findings. Consequently, whether the prediction model is applicable to other populations remains uncertain. Thus, a multi-center study with a larger sample size is necessary for further validation. Secondly, the underlying mechanisms by which obesity-related indices predict hypertension require more extensive investigation.

In conclusion, there is a significant correlation between obesity-related indices and the development of hypertension, with an increase in these indices being an independent risk factor for the condition. For patients suspected of having hypertension, measuring obesity-related indices can aid in disease prevention and prognosis assessment, enhance patient compliance with treatment, and provide guidance on weight management in daily life.

Disclosure of conflict of interest

None.

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