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# Beyond Body Shape: Exploring the Complex Link between ABSI and Arterial Stiffness in a Chinese Population

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## Abstract

**Background:** Obesity, particularly abdominal obesity, is a well-established risk factor for arterial stiffness (AS) and cardiovascular diseases. A Body Shape Index (ABSI) is a novel anthropometric measure designed to assess abdominal obesity, yet its association with AS remains inconclusive. This study aims to investigate the relationship between ABSI and AS indicators in a general population. **Methods:** This cross-sectional study included 721 participants from the general population of Dali, Yunnan Province, China. ABSI was calculated using a standardized formula. Univariate and multivariate linear regression analyses were performed to examine the associations between ABSI and AS indicators, including brachial-ankle pulse wave velocity (ba-PWV) and carotid-femoral pulse wave velocity (cf-PWV). **Results:** Higher ABSI tertiles were significantly associated with increased ba-PWV and cf-PWV compared to the lowest tertile ($P \leq 0.007$). However, after adjusting for potential confounders, these associations became non-significant ($P \geq 0.058$), suggesting that ABSI is not an independent predictor of AS. **Conclusions:** The initial association between ABSI and AS was attenuated after covariate adjustment, suggesting ABSI is not an independent AS marker. Further research is warranted to understand the complex interactions between ABSI and other cardiovascular risk factors and its potential role in AS risk assessment.

## Keywords

A Body Shape Index, Anthropometric Index, Pulse Wave Velocity, Arterial Stiffness

## 1. Introduction

Arterial stiffness (AS) is a key indicator of hypertension risk and a significant predictor of cardiovascular health [1]. Preventing AS development, particularly during adolescence, may substantially benefit cardiovascular and metabolic health [2]. In recent years, China has witnessed a rapid increase in overweight and obesity rates, with approximately half of adults and one-fifth of children affected [3]. This trend is concerning, as obesity is a well-established risk factor for AS, contributing to its progression through various mechanisms, including inflammatory responses [4] [5], oxidative stress [6], and insulin resistance [7].

Abdominal obesity has been strongly associated with an increased risk of cardiovascular and metabolic diseases [8] [9]. However, conventional anthropometric measures, such as the body mass index (BMI), exhibit limitations in evaluating abdominal obesity owing to their inability to differentiate between adipose and muscular tissues [10]-[12]. A body shape index (ABSI) was developed to address this issue. ABSI, which is calculated by combining waist circumference (WC) with adjustments for height and BMI, has shown promise in assessing body shape as a potential risk factor for premature death [13] and various diseases, including metabolic syndrome [14], elevated urinary protein-to-creatinine ratio [15], diabetes mellitus [9], and even anxiety and depression [16].

The potential of ABSI as a predictor of AS has sparked debate in recent research. While some studies suggest that ABSI is significantly related to AS [17], others indicate a weak correlation with brachial-ankle pulse wave velocity (ba-PWV) [18]. The relationship seems further complicated by gender differences in fat metabolism and distribution. For example, ABSI has shown significant correlations with carotid-femoral pulse wave velocity (cf-PWV) in overweight men but not in overweight women [19]. Additionally, some researchers argue that other indices, such as body roundness index (BRI) and waist-to-height ratio (WHtR), might be more effective than ABSI in predicting AS [20].

The conflicting evidence regarding ABSI's utility in predicting AS and its potential significance in cardiovascular risk stratification underscores the need for a comprehensive investigation to resolve these discrepancies. This study focuses on Dali, Yunnan Province—a multiethnic region characterized by unique dietary patterns (e.g., high salt intake) and lifestyle practices distinct from urbanized coastal Chinese populations. By targeting this understudied semi-urban cohort, our study addresses critical gaps in understanding how regional and sociocultural factors modulate obesity-related cardiovascular risks. Utilizing a tertile-based stratification of ABSI and adjusting for weight status, gender, and key confounders, we systematically evaluate ABSI's independent association with AS markers. These analyses aim to clarify ABSI's clinical relevance while advancing tailored risk assessment strategies for diverse populations.

## 2. Methods

### 2.1. Study Design and Participants

This cross-sectional study was conducted in Dali City, Yunnan Province, China, to offer insights into the early diagnosis and prevention of cardiovascular diseases.

From October to December 2018, we recruited 721 adult residents who provided complete information. The Ethics Committee of Dali University approved the study protocol, and all participants gave written informed consent.

## 2.2. Data Collection

Demographic and clinical data were collected using a standardized questionnaire, including age, smoking status, alcohol consumption, and medical history of diabetes mellitus and hypertension. Smoking was defined as consuming an average of at least one cigarette per day for six months or more, while regular alcohol consumption was defined as drinking at least once per week.

Venous blood samples were collected early in the morning after a minimum overnight fast of 12 hours. The Department of Laboratory Medicine at the First Affiliated Hospital of Dali University analyzed these samples for uric acid (UA), creatinine (CREA), fasting blood glucose (FBG), lipid profile, and other biochemical indicators. Diabetes mellitus was confirmed based on past medical history or current diagnostic criteria [21].

## 2.3. Anthropometric Measurements

Anthropometric measurements were performed by trained healthcare professionals from the Department of Geriatrics at the First Affiliated Hospital of Dali University. Participants were measured in light clothing without shoes, standing upright with feet together and arms hanging naturally. Body height, weight, waist circumference (WC), and hip circumference (HipC) were recorded.

The following anthropometric indices were calculated:

1) Body mass index $(\text{BMI}) = \text{weight (kg)} / (\text{height (m)})^2$ [12]
2) Waist-to-hip ratio $(\text{WHR}) = \text{WC (cm)} / \text{HipC (cm)}$ [10]
3) Waist-to-height ratio $(\text{WHtR}) = \text{WC (cm)} / \text{height (cm)}$ [22]
4) A body shape index $(\text{ABSI}) = \dfrac{\text{WC (m)}}{(\text{BMI (kg/m}^2))^{\frac{2}{3}} * (\text{height (m)})^{\frac{1}{2}}}$ [13]
5) Body roundness index $(\text{BRI}) = 364.2 - 365.5 \times \sqrt{1 - \left( \dfrac{\left(\dfrac{\text{WC (m)}}{2\pi}\right)^2}{(0.5\,\text{height (m)})^2} \right)}$

[11] [12]

6) Body adiposity index $(\text{BAI}) = \left(\text{HipC (cm)} / (\text{height (m)})^{1.5}\right) - 18$ [23] [24]
7) Visceral adiposity index (VAI) [25]:

Males:

$$\text{VAI} = \left( \frac{\text{WC (cm)}}{39.68 + (1.88 \times \text{BMI (kg/m}^2))} \right) \times \left( \frac{\text{TG (mmol/L)}}{1.03} \right) \times \left( \frac{1.31}{\text{HDL (mmol/L)}} \right)$$

Females:

$$\text{VAI} = \left( \frac{\text{WC (cm)}}{36.58 + (1.89 \times \text{BMI (kg/m}^2))} \right) \times \left( \frac{\text{TG (mmol/L)}}{0.81} \right) \times \left( \frac{1.52}{\text{HDL (mmol/L)}} \right)$$

8) Conicity index (CI) = $\dfrac{\text{WC (m)}}{0.109\sqrt{\dfrac{\text{weight (kg)}}{\text{height (m)}}}}$ [26]

All indices were calculated using their respective established formulas.

### 2.4. Measurement of Arterial Stiffness Indicators

Arterial stiffness was evaluated using the OMRON VP-2000 (OMRON, Japan) and the SphygmoCor XCEL system. The OMRON VP-2000 and SphygmoCor XCEL devices were calibrated weekly according to the manufacturer's recommended protocols. These instruments assessed ba-PWV, cf-PWV, ankle-brachial index (ABI), and peripheral and central arterial pressures. Blood pressure was measured consecutively five times for each participant, and the average reading was recorded. Hypertension was diagnosed based on established criteria [27].

### 2.5. Definitions of Arterial Stiffness and Obesity

Obesity categories (underweight, normal weight, overweight, and obese) were defined according to the 2019 primary care guidelines for obesity developed by the Chinese Medical Association [28]. AS was defined as ba-PWV ≥ 1400 cm/s [29] [30] or cf-PWV ≥ 11 m/s [31].

### 2.6. Statistical Analysis

Statistical analyses were conducted using SPSS version 25.0 (IBM Corp., Armonk, NY, USA) and EmpowerStats version 4.2 (X&Y Solutions, Inc., Boston, MA, USA). Continuous variables were compared with one-way analysis of variance (ANOVA), while categorical variables were evaluated using chi-square tests. We used Pearson's and Spearman's correlation coefficients as appropriate to assess the relationship between anthropometric indices and AS for both genders across different weight subgroups. Multiple linear regression analyzed the correlations between ABSI and ABI, cf-PWV, and ba-PWV while adjusting for age, sex, smoking, alcohol consumption, diabetes, and hypertension. Covariates were chosen based on their established roles in the pathogenesis of arterial stiffness.

ABSI, WHR, WHtR, and CI were standardized using Z-scores to harmonize the scales of various anthropometric indicators. Subsequently, the relationships between these standardized indicators and AS (applying both diagnostic criteria) were analyzed through binary logistic regression, controlling for relevant covariates. A p-value of less than 0.05 was considered statistically significant for all analyses.

## 3. Results

### 3.1. Characteristics of the Study Population

Table 1 presents the overall and clinical characteristics of 721 participants (253 males and 468 females) categorized by ABSI tertiles. The highest tertile group was significantly older (57.36 ± 12.17 years, P < 0.001) and had the greatest prevalence of diabetes (P = 0.005) and hypertension (P = 0.008). This group also showed significantly higher WC, HipC, WHR, WHtR, BRI, BAI, VAI, and CI values than the other tertiles (P < 0.001). Interestingly, the middle tertile had the highest BMI values (P = 0.017). Both cf-PWV and ba-PWV increased significantly with higher ABSI levels (P < 0.001).

### 3.2. Correlation of Anthropometric Indicators with AS in Different Weight Groups

Table 2 and Table 3 illustrate the correlation analysis between various anthropometric indicators and AS measures for both sexes across weight categories. ABSI displayed a stronger correlation with ABI in underweight men (r = 0.612, P = 0.035) than in overweight women (r = 0.252, P = 0.002). In normal-weight and overweight individuals of both sexes, ABSI was less strongly correlated with ba-PWV than BRI (P ≤ 0.010). Underweight men exhibited the strongest correlation between ABSI and cf-PWV (r = 0.667, P = 0.018). BMI exhibited weak correlations with ba-PWV and cf-PWV only in normal-weight women (P ≤ 0.005) and was not associated with ABI in any group (P ≥ 0.112).

### 3.3. Correlation of ABSI with ba-PWV, cf-PWV, and ABI

Table 4 illustrates the relationship between ABSI and AS measures across ABSI tertiles. ABSI exhibited no significant association with ABI in any group (P ≥ 0.139). However, ABSI was weakly associated with ba-PWV in the lowest and highest tertile groups (P ≤ 0.037) and with cf-PWV in the lowest and middle tertile groups (P ≤ 0.029). Smooth curve fits (Figure 1, Figure 2) showed a gradual increase in cf-PWV with rising ABSI (P = 0.067). The relationship between ABSI and ba-PWV was curvilinear (P = 0.033).

Multiple linear regression analysis (Table 5) indicated that prior to adjusting for covariates, ABSI was associated with ABI, ba-PWV, and cf-PWV (P ≤ 0.025), demonstrating strong associations with ba-PWV and cf-PWV (P < 0.001). After adjusting for age, sex, smoking, alcohol consumption, hypertension, and diabetes, ABSI remained positively associated solely with ba-PWV (P = 0.028). The middle and highest ABSI tertiles displayed significantly stronger correlations with ba-PWV and cf-PWV compared to the lowest tertile before adjustment (P≤0.007). Nevertheless, these associations became non-significant after adjusting for covariates (P ≥ 0.058). Importantly, the middle and highest ABSI tertiles showed no association with ABI, regardless of covariate adjustment (P ≥ 0.069).

Table 6 and Table 7 investigate the correlation between ABSI and AS, using ba-PWV ≥ 1400 cm/s and cf-PWV ≥ 11 m/s as diagnostic criteria, respectively. Before adjusting for covariates, all anthropometric indicators exhibited significant positive correlations with AS (P ≤ 0.044). Specifically, each standard deviation increase in ABSI was associated with a 1.53-fold and 1.50-fold increased risk of AS under the two criteria, respectively (P < 0.001). The odds ratios for ABSI were lower than those for WHtR and CI (P < 0.001) but higher than those for BMI, BAI, and VAI (P ≤ 0.044). However, after adjusting for covariates, ABSI showed no significant correlation with AS under either diagnostic criterion (P ≥ 0.271).

**Table 1.** Characteristics of the study population.

| Variables | ABSI | | | *P* |
|---|---|---|---|---|
| | T1 (<0.079) | T2 (0.079 - 0.083) | T3 (>0.083) | |
| N | 240 | 240 | 241 | |
| Age, years | 47.30 ± 11.69 | 51.04 ± 11.91 | 57.36 ± 12.17 | <0.001 |
| Diabetes, n (%) | 15 (2.08%) | 24 (3.33%) | 37 (5.13%) | 0.005 |
| Hypertension, n (%) | 58 (8.04%) | 82 (11.37%) | 88 (12.21%) | 0.008 |
| Smoking, n (%) | 41 (5.69%) | 57 (7.91%) | 49 (6.80%) | 0.193 |
| Drinking, n (%) | 15 (2.08%) | 39 (5.41%) | 28 (3.88%) | 0.003 |
| CSBP, mmHg | 112 (102 - 121) | 115 (105 - 127) | 116 (105 - 126) | 0.002 |
| CDBP, mmHg | 75 (69 - 82) | 79 (71 - 86) | 78 (72 - 86) | 0.003 |
| PSBP, mmHg | 114 (104 - 124) | 119 (107 - 130) | 121 (108 - 132) | <0.001 |
| PDBP, mmHg | 75 (68 - 82) | 78 (70 - 86) | 78 (70 - 85) | 0.023 |
| CREA, μmol/L | 66.45 (59.10 - 80.08) | 69.90 (59.25 - 83.08) | 68.70 (59.30 - 82.85) | 0.290 |
| FBG, mmol/L | 5.14 (4.91 - 5.42) | 5.36 (4.97 - 5.77) | 5.33 (5.01 - 5.97) | <0.001 |
| TC, mmol/L | 4.55 (4.09 - 5.20) | 4.76 (4.12 - 5.38) | 4.86 (4.28 - 5.41) | 0.035 |
| TG, mmol/L | 1.33 (0.95 - 1.90) | 1.54 (1.09 - 2.37) | 1.61 (1.22 - 2.10) | <0.001 |
| ABI, m/s | 1.07 ± 0.08 | 1.07 ± 0.08 | 1.08 ± 0.08 | 0.095 |
| cf-PWV, m/s | 9.86 ± 1.66 | 10.36 ± 1.87 | 10.97 ± 2.32 | <0.001 |
| ba-PWV, cm/s | 1394.00 (1257.25 - 1566.50) | 1468.00 (1298.00 - 1682.75) | 1555.00 (1360.00 - 1880.00) | <0.001 |
| WC, cm | 79.41 ± 8.76 | 86.55 ± 8.72 | 89.48 ± 7.63 | <0.001 |
| HipC, cm | 92.98 ± 7.68 | 96.44 ± 7.70 | 96.79 ± 6.10 | <0.001 |
| BMI, kg/m$^2$ | 23.71 ± 3.57 | 24.42 ± 3.40 | 23.64 ± 2.91 | 0.017 |
| WHR | 0.85 ± 0.05 | 0.90 ± 0.05 | 0.92 ± 0.04 | <0.001 |
| WHtR | 0.50 ± 0.05 | 0.53 ± 0.05 | 0.56 ± 0.05 | <0.001 |
| ABSI | 0.08 ± 0.002 | 0.08 ± 0.001 | 0.09 ± 0.003 | <0.001 |
| BRI | 3.21 (2.63 - 3.92) | 4.07 (3.38 - 4.72) | 4.43 (3.80 - 5.12) | <0.001 |
| BAI | 27.88 ± 4.35 | 28.92 ± 4.27 | 29.70 ± 4.49 | <0.001 |
| VAI | 1.62 (1.10 - 2.40) | 1.89 (1.33 - 2.85) | 2.07 (1.50 - 2.93) | <0.001 |
| CI | 1.18 ± 0.05 | 1.26 ± 0.03 | 1.33 ± 0.05 | <0.001 |

T1, T2, and T3 refer to the first, second, and third Tertile of ABSI, respectively. The values in the table are presented as mean ± standard deviation, median (interquartile range), or n (%). CSBP, central systolic blood pressure; CDBP, central diastolic blood pressure; PSBP, peripheral systolic blood pressure; PDBP, peripheral diastolic blood pressure; CREA, creatinine; FBG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; ABI, ankle-brachial index; cf-PWV, carotid-femoral pulse wave velocity; ba-PWV, brachial-ankle pulse wave velocity; WC, waist circumference; HipC, hip circumference; BMI, body mass index; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio; ABSI, a body shape index; BRI, body roundness index; BAI, body adiposity index; VAI, visceral adiposity index; CI, conicity index.

**Table 2.** Correlation analysis of anthropometric indicators with AS measures in men.

| Dependent variables | Variables | Underweight (n = 12) | | Normal weight (n = 100) | | Overweight (n = 103) | | Obese (n = 38) | |
|---|---|---|---|---|---|---|---|---|---|
| | | r | *P* | r | *P* | r | *P* | r | *P* |
| ABI | WC | 0.528 | 0.078 | −0.063 | 0.536 | −0.133 | 0.181 | 0.048 | 0.775 |
| | HipC | 0.329 | 0.296 | −0.101 | 0.316 | −0.084 | 0.400 | 0.297 | 0.070 |
| | BMI | −0.483 | 0.112 | 0.033 | 0.742 | −0.087 | 0.382 | 0.174 | 0.295 |
| | WHR | −0.292 | 0.357 | 0.015 | 0.884 | −0.056 | 0.571 | −0.226 | 0.173 |
| | WHtR | 0.474 | 0.119 | 0.047 | 0.644 | −0.012 | 0.904 | 0.062 | 0.709 |
| | ABSI | 0.612 | 0.035 | −0.048 | 0.638 | −0.026 | 0.791 | −0.076 | 0.651 |
| | BRI | 0.466 | 0.127 | 0.110 | 0.277 | −0.028 | 0.777 | 0.132 | 0.431 |
| | BAI | 0.159 | 0.621 | 0.093 | 0.356 | 0.094 | 0.343 | 0.228 | 0.168 |
| | VAI | −0.032 | 0.922 | −0.216 | 0.031 | −0.093 | 0.352 | −0.001 | 0.998 |
| | CI | 0.594 | 0.042 | −0.038 | 0.705 | −0.041 | 0.677 | −0.039 | 0.816 |
| ba-PWV | WC | 0.425 | 0.169 | 0.179 | 0.076 | 0.147 | 0.138 | 0.182 | 0.274 |
| | HipC | 0.519 | 0.084 | 0.152 | 0.130 | 0.161 | 0.104 | 0.103 | 0.537 |
| | BMI | −0.238 | 0.457 | 0.126 | 0.213 | −0.002 | 0.983 | 0.083 | 0.619 |
| | WHR | −0.014 | 0.966 | 0.113 | 0.261 | −0.049 | 0.621 | 0.099 | 0.553 |
| | WHtR | 0.329 | 0.297 | 0.374 | <0.001 | 0.308 | 0.002 | 0.292 | 0.076 |
| | ABSI | 0.350 | 0.265 | 0.319 | 0.001 | 0.251 | 0.010 | 0.396 | 0.014 |
| | BRI | 0.329 | 0.297 | 0.374 | <0.001 | 0.308 | 0.002 | 0.292 | 0.076 |
| | BAI | 0.312 | 0.324 | 0.462 | <0.001 | 0.403 | <0.001 | 0.270 | 0.101 |
| | VAI | 0.147 | 0.649 | −0.198 | 0.048 | 0.069 | 0.487 | −0.143 | 0.393 |
| | CI | 0.378 | 0.226 | 0.325 | 0.001 | 0.258 | 0.009 | 0.379 | 0.019 |
| cf-PWV | WC | 0.601 | 0.039 | 0.212 | 0.034 | 0.226 | 0.022 | 0.132 | 0.428 |
| | HipC | 0.292 | 0.358 | 0.159 | 0.113 | 0.222 | 0.024 | 0.204 | 0.218 |
| | BMI | −0.360 | 0.250 | 0.071 | 0.480 | −0.124 | 0.213 | 0.059 | 0.723 |
| | WHR | 0.438 | 0.154 | 0.150 | 0.137 | 0.006 | 0.955 | −0.018 | 0.915 |
| | WHtR | 0.596 | 0.041 | 0.312 | 0.002 | 0.249 | 0.011 | 0.164 | 0.324 |
| | ABSI | 0.667 | 0.018 | 0.290 | 0.003 | 0.375 | <0.001 | 0.141 | 0.400 |
| | BRI | 0.455 | 0.138 | 0.337 | 0.001 | 0.258 | 0.008 | 0.133 | 0.427 |
| | BAI | 0.191 | 0.553 | 0.265 | 0.008 | 0.248 | 0.011 | 0.162 | 0.331 |
| | VAI | 0.343 | 0.276 | 0.013 | 0.897 | 0.121 | 0.223 | −0.245 | 0.139 |
| | CI | 0.659 | 0.020 | 0.298 | 0.003 | 0.356 | <0.001 | 0.154 | 0.355 |

ABI, ankle-brachial index; cf-PWV, carotid-femoral pulse wave velocity; ba-PWV, brachial-ankle pulse wave velocity; WC, waist circumference; HipC, hip circumference; BMI, body mass index; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio; ABSI, a body shape index; BRI, body roundness index; BAI, body adiposity index; VAI, visceral adiposity index; CI, conicity index.

**Table 3.** Correlation analysis of anthropometric indicators with AS measures in women.

| Dependent variables | Variables | Underweight (n = 17) | | Normal weight (n = 262) | | Overweight (n = 143) | | Obese (n = 46) | |
|---|---|---|---|---|---|---|---|---|---|
| | | r | *P* | r | *P* | r | *P* | r | *P* |
| ABI | WC | 0.604 | 0.010 | 0.036 | 0.567 | 0.251 | 0.003 | 0.276 | 0.063 |
| | HipC | 0.309 | 0.228 | 0.027 | 0.658 | 0.065 | 0.440 | 0.263 | 0.077 |
| | BMI | 0.087 | 0.739 | 0.073 | 0.238 | 0.035 | 0.675 | 0.056 | 0.712 |
| | WHR | 0.252 | 0.330 | 0.010 | 0.870 | 0.255 | 0.002 | 0.081 | 0.594 |
| | WHtR | 0.153 | 0.558 | 0.108 | 0.082 | 0.234 | 0.005 | 0.218 | 0.146 |
| | ABSI | 0.385 | 0.127 | 0.042 | 0.503 | 0.252 | 0.002 | 0.276 | 0.064 |
| | BRI | 0.020 | 0.940 | 0.114 | 0.066 | 0.219 | 0.009 | 0.215 | 0.151 |
| | BAI | −0.316 | 0.216 | 0.165 | 0.007 | 0.034 | 0.684 | 0.153 | 0.308 |
| | VAI | 0.254 | 0.325 | 0.056 | 0.364 | 0.066 | 0.433 | 0.128 | 0.395 |
| | CI | 0.403 | 0.109 | 0.054 | 0.385 | 0.257 | 0.002 | 0.282 | 0.058 |
| ba-PWV | WC | 0.466 | 0.060 | 0.226 | <0.001 | 0.199 | 0.017 | 0.371 | 0.011 |
| | HipC | 0.908 | <0.001 | 0.278 | <0.001 | 0.053 | 0.527 | 0.279 | 0.061 |
| | BMI | 0.172 | 0.510 | 0.196 | 0.001 | −0.119 | 0.156 | 0.203 | 0.175 |
| | WHR | −0.603 | 0.010 | 0.026 | 0.677 | 0.206 | 0.014 | 0.207 | 0.168 |
| | WHtR | 0.221 | 0.395 | 0.265 | <0.001 | 0.337 | <0.001 | 0.403 | 0.005 |
| | ABSI | 0.201 | 0.439 | 0.174 | 0.005 | 0.330 | <0.001 | 0.351 | 0.017 |
| | BRI | 0.221 | 0.395 | 0.265 | <0.001 | 0.337 | <0.001 | 0.403 | 0.005 |
| | BAI | 0.510 | 0.037 | 0.344 | <0.001 | 0.232 | 0.005 | 0.349 | 0.017 |
| | VAI | 0.600 | 0.011 | 0.236 | <0.001 | 0.221 | 0.008 | 0.044 | 0.771 |
| | CI | 0.235 | 0.363 | 0.202 | 0.001 | 0.326 | <0.001 | 0.367 | 0.012 |
| cf-PWV | WC | 0.335 | 0.189 | 0.214 | <0.001 | 0.135 | 0.109 | 0.469 | 0.001 |
| | HipC | 0.578 | 0.015 | 0.244 | <0.001 | 0.147 | 0.080 | 0.279 | 0.061 |
| | BMI | 0.447 | 0.072 | 0.174 | 0.005 | −0.091 | 0.278 | 0.224 | 0.135 |
| | WHR | −0.296 | 0.249 | 0.048 | 0.441 | 0.051 | 0.544 | 0.345 | 0.019 |
| | WHtR | 0.202 | 0.437 | 0.222 | <0.001 | 0.187 | 0.026 | 0.365 | 0.013 |
| | ABSI | 0.106 | 0.686 | 0.167 | 0.007 | 0.229 | 0.006 | 0.370 | 0.011 |
| | BRI | −0.032 | 0.903 | 0.193 | 0.002 | 0.224 | 0.007 | 0.353 | 0.016 |
| | BAI | 0.312 | 0.223 | 0.244 | <0.001 | 0.207 | 0.013 | 0.108 | 0.474 |
| | VAI | 0.387 | 0.125 | 0.264 | <0.001 | 0.228 | 0.006 | 0.122 | 0.420 |
| | CI | 0.154 | 0.554 | 0.192 | 0.002 | 0.217 | 0.009 | 0.405 | 0.005 |

ABI, ankle-brachial index; cf-PWV, carotid-femoral pulse wave velocity; ba-PWV, brachial-ankle pulse wave velocity; WC, waist circumference; HipC, hip circumference; BMI, body mass index; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio; ABSI, a body shape index; BRI, body roundness index; BAI, body adiposity index; VAI, visceral adiposity index; CI, conicity index.

**Table 4.** Correlation analysis of ABSI with arterial stiffness indicators and blood pressure.

| Variables | ABSI | | | | | |
|---|---|---|---|---|---|---|
| | T1 (n = 240) | | T2 (n = 240) | | T3 (n = 241) | |
| | r | *P* | r | *P* | r | *P* |
| Age | 0.211 | 0.001 | 0.053 | 0.416 | 0.250 | <0.001 |
| Diabetes | 0.146 | 0.024 | 0.155 | 0.016 | −0.043 | 0.506 |
| Hypertension | 0.093 | 0.153 | 0.096 | 0.137 | 0.103 | 0.110 |
| ABI | −0.008 | 0.906 | 0.090 | 0.167 | 0.096 | 0.139 |
| cf-PWV | 0.170 | 0.008 | 0.141 | 0.029 | 0.107 | 0.096 |
| ba-PWV | 0.151 | 0.019 | 0.127 | 0.050 | 0.134 | 0.037 |
| CSBP | 0.108 | 0.096 | 0.074 | 0.251 | 0.108 | 0.093 |
| CDBP | 0.054 | 0.403 | 0.072 | 0.269 | −0.011 | 0.868 |
| CMBP | 0.079 | 0.223 | 0.089 | 0.167 | 0.023 | 0.727 |
| CPP | 0.119 | 0.066 | 0.040 | 0.538 | 0.195 | 0.002 |
| PSBP | 0.127 | 0.049 | 0.091 | 0.161 | 0.119 | 0.065 |
| PDBP | 0.050 | 0.440 | 0.065 | 0.317 | 0.016 | 0.804 |
| PMBP | 0.096 | 0.139 | 0.083 | 0.197 | 0.060 | 0.354 |
| PPP | 0.143 | 0.026 | 0.037 | 0.573 | 0.155 | 0.016 |

T1, T2, and T3 refer to the first, second, and third Tertile of ABSI, respectively. ABSI, a body shape index; ABI, ankle-brachial index; cf-PWV, carotid-femoral pulse wave velocity; ba-PWV, brachial-ankle pulse wave velocity; CSBP, central systolic blood pressure; CDBP, central diastolic blood pressure; CMBP, central mean blood pressure; CPP, central pulse pressure; PSBP, peripheral systolic blood pressure; PDBP, peripheral diastolic blood pressure; PMBP, peripheral mean blood pressure; PPP, peripheral pulse pressure.

**Table 5.** Multiple linear regression analysis of ABSI with ba-PWV, cf-PWV, and ABI.

| Dependent variables | Variables | Unadjusted | | | Model 1 | | |
|---|---|---|---|---|---|---|---|
| | | *β* | 95%CI | *P* | *β* | 95%CI | *P* |
| ba-PWV | ABSI | 24640.019 | (18805.077 - 30474.960) | <0.001 | 5155.541 | (558.815 - 9752.267) | 0.028 |
| | T1 | 0 | 0 | | 0 | 0 | |
| | T2 | 91.575 | (25.517 - 157.633) | 0.007 | 2.152 | (−46.401 - 50.704) | 0.931 |
| | T3 | 238.494 | (172.505 - 304.483) | <0.001 | 47.099 | (−3.478 - 97.676) | 0.058 |
| cf-PWV | ABSI | 113.167 | (81.901 - 144.432) | <0.001 | 24.075 | (−1.640 - 49.791) | 0.066 |
| | T1 | 0 | 0 | | 0 | 0 | |
| | T2 | 0.499 | (0.146 - 0.852) | 0.006 | −0.031 | (−0.302 - 0.241) | 0.824 |
| | T3 | 1.108 | (0.755 - 1.460) | <0.001 | 0.211 | (−0.071 - 0.494) | 0.143 |
| ABI | ABSI | 1.438 | (0.185 - 2.691) | 0.025 | −0.525 | (−1.814 - 0.765) | 0.425 |
| | T1 | 0 | 0 | | 0 | 0 | |
| | T2 | −0.001 | (−0.015 - 0.013) | 0.903 | −0.008 | (−0.022 - 0.006) | 0.249 |
| | T3 | 0.013 | (−0.001 - 0.027) | 0.069 | −0.006 | (−0.020 - 0.008) | 0.384 |

Model 1 adjusts age, sex, smoking, alcohol consumption, hypertension, and diabetes; T1, T2, and T3 refer to the first, second, and third Tertiles of ABSI, respectively; ABSI, a body shape index; ba-PWV, brachial-ankle pulse wave velocity; cf-PWV, carotid-femoral pulse wave velocity; ABI, ankle-brachial index.s.

**Table 6.** Association between anthropometric indicators and AS measured by ba-PWV.

| Variables | Unadjusted | | | Model 1 | | |
|---|---|---|---|---|---|---|
| | OR | 95%CI | *P* | OR | 95%CI | *P* |
| WC | 1.06 | (1.04 - 1.08) | <0.001 | 1.02 | (1.00 - 1.04) | 0.099 |
| HipC | 1.08 | (1.06 - 1.10) | <0.001 | 1.04 | (1.01 - 1.07) | 0.013 |
| BMI | 1.14 | (1.09 - 1.20) | <0.001 | 1.07 | (1.00 - 1.14) | 0.045 |
| WHR Z-score | 1.33 | (1.14 - 1.55) | <0.001 | 0.99 | (0.81 - 1.21) | 0.900 |
| WHtR Z-score | 1.94 | (1.63 - 2.30) | <0.001 | 1.25 | (1.01 - 1.54) | 0.043 |
| ABSI Z-score | 1.53 | (1.30 - 1.80) | <0.001 | 1.02 | (0.83 - 1.24) | 0.882 |
| BRI | 1.79 | (1.54 - 2.09) | <0.001 | 1.21 | (1.00 - 1.46) | 0.045 |
| BAI | 1.14 | (1.10 - 1.19) | <0.001 | 1.08 | (1.03 - 1.14) | 0.004 |
| VAI | 1.21 | (1.08 - 1.36) | 0.001 | 1.11 | (0.99 - 1.23) | 0.074 |
| CI Z-score | 1.79 | (1.51 - 2.11) | <0.001 | 1.10 | (0.90 - 1.36) | 0.351 |

Model 1, adjust age, sex, smoking, alcohol consumption, hypertension and diabetes; WC, waist circumference; HipC, hip circumference; BMI, body mass index; WHR Z-score, standardized waist-to-hip ratio; WHtR Z-score, standardized waist-to-height ratio; ABSI Z-score, standardized a body shape index; BRI, body roundness index; BAI, body adiposity index; VAI, visceral adiposity index; CI Z-score, standardized conicity index.

**Table 7.** Association between anthropometric indicators and AS measured by cf-PWV.

| Variables | Unadjusted | | | Model 1 | | |
|---|---|---|---|---|---|---|
| | OR | 95%CI | *P* | OR | 95%CI | *P* |
| WC | 1.06 | (1.05 - 1.08) | <0.001 | 1.02 | (0.99 - 1.04) | 0.153 |
| HipC | 1.07 | (1.05 - 1.09) | <0.001 | 1.03 | (1.00 - 1.05) | 0.087 |
| BMI | 1.11 | (1.06 - 1.17) | <0.001 | 1.02 | (0.96 - 1.09) | 0.506 |
| WHR Z-score | 1.51 | (1.28 - 1.78) | <0.001 | 1.03 | (0.84 - 1.27) | 0.777 |
| WHtR Z-score | 1.58 | (1.34 - 1.87) | <0.001 | 1.11 | (0.90 - 1.36) | 0.336 |
| ABSI Z-score | 1.50 | (1.27 - 1.77) | <0.001 | 1.12 | (0.91 - 1.38) | 0.271 |
| BRI | 1.46 | (1.27 - 1.68) | <0.001 | 1.08 | (0.91 - 1.28) | 0.390 |
| BAI | 1.04 | (1.01 - 1.08) | 0.017 | 1.02 | (0.97 - 1.07) | 0.454 |
| VAI | 1.07 | (1.00 - 1.15) | 0.044 | 1.04 | (0.96 - 1.13) | 0.352 |
| CI Z-score | 1.71 | (1.44 - 2.03) | <0.001 | 1.15 | (0.94 - 1.42) | 0.181 |

Model 1, adjust age, sex, smoking, alcohol consumption, hypertension and diabetes; WC, waist circumference; HipC, hip circumference; BMI, body mass index; WHR Z-score, standardized waist-to-hip ratio; WHtR Z-score, standardized waist-to-height ratio; ABSI Z-score, standardized a body shape index; BRI, body roundness index; BAI, body adiposity index; VAI, visceral adiposity index; CI Z-score, standardized conicity index.

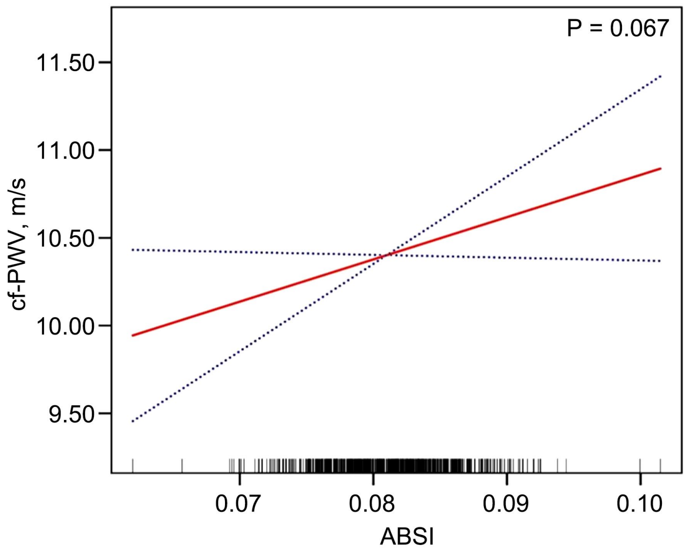


**Figure 1.** Smooth curve fitting of the relationship between ABSI and cf-PWV ABSI, a body shape index; cf-PWV, carotid-femoral pulse wave velocity.

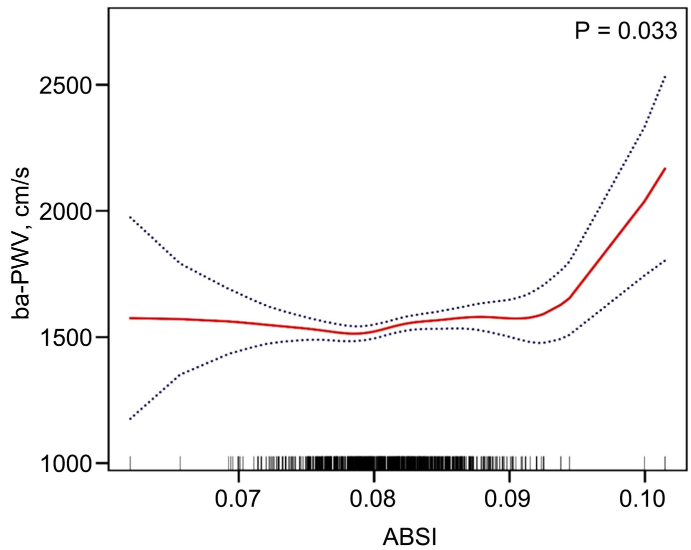


**Figure 2.** Smooth curve fitting of the relationship between ABSI and ba-PWV ABSI, a body shape index; ba-PWV, brachial-ankle pulse wave velocity.

## 4. Discussion

AS plays a crucial role in the pathogenesis of cardiovascular and cerebrovascular diseases. While obesity in children and adolescents has been associated with AS [32], public awareness of peripheral vascular disease remains limited, often resulting in neglected AS screening. Consequently, early detection and standardized prevention and treatment of AS have become urgent priorities in public health. This is the first study to comprehensively evaluate ABSI and AS in a Southwest Chinese population, highlighting the mediating role of covariates like age. Our findings contrast with prior studies in East Asian cohorts, suggesting regional or ethnic variations in obesity-AS relationships.

Our study identified a positive correlation between ABSI and arterial stiffness (AS) across all weight categories except underweight individuals. However, this association was no longer significant after adjusting for covariates, irrespective of the diagnostic criteria used for AS. Before covariate adjustment, ABSI demonstrated a significant positive relationship with both ba-PWV and cf-PWV ($P \le 0.007$). Yet, after controlling for key confounders such as age and sex, this association became non-significant ($P \ge 0.058$). Among these covariates, age appeared to exert the greatest influence, likely due to its strong correlation with AS, potentially mediating the observed relationship. These results indicate that these covariates largely drive the initial association between ABSI and AS rather than ABSI itself as an independent marker. This finding diverges from previous studies and may be attributed to several factors: 1) gender-specific variations in metabolism and fat distribution, 2) racial differences, 3) the criteria used for weight categorization, and 4) the selection of AS indices.

The mechanisms through which obesity contributes to AS are not fully understood. However, obese and overweight individuals without cardiovascular disease are at an increased risk of AS [33], with white adipose tissue playing a key role in the relative risk of cardiometabolic disease and hypertension [5] [34]. Our previous studies have outlined the complex pathways by which obesity can lead to AS, including the secretion of substances such as adiponectin and leptin [35], inflammatory factors [5], and free fatty acids [7]. These substances induce oxidative stress [6], chronic inflammatory responses, and insulin resistance [36]. Min Sun *et al.* aimed to identify intermediate mediators and found that the connection between visceral adiposity and AS is primarily mediated by systolic blood pressure and pulse pressure [37]. Our study supports this finding, as we noted that the lowest tertile group of ABSI was linked to ba-PWV ($P = 0.019$), peripheral systolic blood pressure (PSBP) ($P = 0.049$), and pulse pressure (PPP) ($P = 0.026$). However, our study lacked a mediation analysis to explore these relationships further.

The association between obesity and AS necessitates an analysis of specific gender and weight categories. A Japanese study reported that fat distribution influences ba-PWV, with ABSI in non-obese men correlating with ba-PWV ($\beta = 0.087$, $P = 0.002$). Meanwhile, BRI was the preferred indicator for assessing metabolism in women [38]. In contrast, our study identified that ABSI in both genders showed a weak correlation with ba-PWV across normal weight, overweight, and obese groups ($P \le 0.017$). We hypothesize that this discrepancy may arise from the influence of body weight changes on substance metabolism, insulin resistance-induced vascular endothelial cell dysfunction [39], and the association of low weight with anorexia nervosa, which impacts adiponectin secretion [40] [41]. Furthermore, variations in ethnicity and diagnostic criteria for obesity may also contribute to these differences in findings.

Selecting AS indicators and considering the study population's vascular conditions are crucial. Previous studies have reported conflicting results regarding the association between ABSI and various AS indices [10] [12] [19] [38]. Our comprehensive comparison of three AS indices revealed that before adjusting for covariates, ABSI was associated with ABI, ba-PWV, and cf-PWV ($P \leq 0.025$). However, after adjusting for covariates, ABSI was only positively associated with ba-PWV ($P = 0.028$). This discrepancy might be attributed to differences in the types of vessels assessed by each index. Ba-PWV reflects AS of peripheral arteries, aorta, and middle arteries [42] [43], while cf-PWV primarily indicates aortic stiffness. Furthermore, ABI is crucial in assessing peripheral vascular disease, with values lesser than 0.4 suggesting critical ischemia [44]. It is important to note that ba-PWV is not a perfect index for AS, as it may be underestimated in cases of lower limb arterial or aortic stenosis [45] [46]. The presence of underlying diseases in the general population of Dali may mask the true relationship between ABSI and AS.

Dynamic changes in ABSI may influence its correlation with AS. Jiamin Tang *et al*. found that the highest quartile of ABSI, BRI, and WHR was associated with a greater risk of AS compared to the lowest quartile [12]. Our smoothed curve fitting revealed a curvilinear correlation between ABSI and ba-PWV ($P = 0.033$), highlighting the importance of considering the range of ABSI values when discussing their relationship. This non-linear association suggests that the effect of ABSI on AS may differ across various ABSI ranges and could be influenced by other factors. Therefore, it is essential to consider covariates and implement dynamic monitoring of ABSI in future studies.

This study has several limitations that should be acknowledged. First, the study population was limited to the general population of Dali, which may limit the generalizability of our findings to other populations. Second, we did not perform quantitative measurements and comparisons of adipose tissue, which may introduce bias in our findings. Finally, our study lacked follow-up and detection of changes in ABSI over time, which could provide valuable insights into the dynamic relationship between ABSI and AS.

## 5. Conclusions and Future Directions

In this general population study, we found that although ABSI is associated with body shape, obesity indicators, and AS, its direct association with AS is insignificant after adjusting for covariates. This finding highlights the complex relationship between body shape indices and arterial stiffness.

Future research should focus on expanding our understanding of the relationship between body composition indices and AS through a multifaceted approach. Longitudinal studies are essential to investigate the dynamic changes in ABSI over time and their impact on AS progression, providing insights into the temporal dynamics of these indices. Mechanistic investigations are also critical to explore the underlying biological pathways linking body shape indices to AS, which could enhance our understanding of the molecular and cellular mechanisms involved. Additionally, studies across diverse ethnic groups are necessary to assess the generalizability of findings and identify population-specific risk factors. To further advance AS risk prediction, advanced imaging techniques for comprehensive adiposity assessment and the development of composite indices that integrate ABSI with other relevant measures could improve the accuracy and utility of AS risk prediction tools. Furthermore, intervention studies targeting body shape modification may provide valuable insights into preventive strategies for cardiovascular diseases. By pursuing these research directions, we can enhance our understanding of the intricate relationships between body composition, obesity, and arterial health, ultimately leading to improved risk assessment and prevention strategies for cardiovascular diseases.

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## List of Abbreviations

ABSI, a body shape index; BMI, body mass index; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio; BRI, body roundness index; BAI, body adiposity index; ABI, ankle-brachial index; cf-PWV, carotid-femoral pulse wave velocity; ba-PWV, brachial-ankle pulse wave velocity.

## Authors' Contribution

LLH designed the study. CXQ, YJY, YJY, and CX assisted with data acquisition. LLH and CXQ performed the statistical analyses. CXQ drafted the manuscript. All authors read and approved the final manuscript.

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## Availability of Data and Materials

The datasets used during the study are available from the corresponding author (Prof. Li-Hua Li) upon reasonable request.

## Ethics Approval and Consent to Participate

The Ethics Committees of Dali University approved the study. Participants gave informed consent to participate before taking part.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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