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Association Between Body Mass Index (BMI) and Brachial-Ankle Pulse Wave Velocity (baPWV) in Males with Hypertension: A Community-Based Cross-Section Study in North China

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Background: The aim of this study was to investigate the association between body mass index (BMI) and brachial-ankle pulse wave velocity (baPWV) in hypertensive males.

Material/Methods: Altogether, 14 866 male hypertensive participants were included in the analysis. Participants were divided into 3 groups: low BMI group (BMI <24 kg/m^2), moderate BMI group (24 kg/m^2 ≤BMI <28 kg/m^2), and high BMI group (BMI ≥28 kg/m^2). According to baPWV values, arteriosclerosis (AS) was set as 3 degrees: mild AS (baPWV ≥1400 cm/s), moderate AS (baPWV ≥1700 cm/s) and severe AS (baPWV ≥2000 cm/s). Multivariate logistic regression analysis was used to explore the effect of different BMI groups on different degrees of AS. The multivariate linear regression analysis was used to explore the relationship between BMI and baPWV.

Results: Among low BMI, moderate BMI, and high BMI groups, the average baPWV values were 1824±401 cm/s, 1758±363 cm/s, and 1686±341 cm/s, respectively. Prevalence in the mild, moderate and high BMI groups were 91.0%, 87.8%, 81.5%, respectively for mild AS; 55.3%, 48.8%, and 40.0% respectively for moderate AS; and 25.9%, 20.2%, and 14.9% respectively for severe AS. Compared to the low BMI group, multivariate logistic regression analysis showed that odds ratio (OR) and 95% confidence intervals (95%CI) in the moderate BMI group and the high BMI were 0.71 (95%CI, 0.62–0.80), 0.43 (95%CI, 0.38–0.50) for mild AS; and similar trends were shown for moderate AS and severe AS. Based on age-stratification, a negative relationship remained for 35–55 years old participants for different degrees of AS among the moderate BMI group and the high BMI group. A negative relationship was detected between BMI and baPWV in total and different age-stages.

Conclusions: Among male hypertension participants in this study, there was a negative relationship between BMI and baPWV. High BMI was found to be a protective factor for AS especially in the age range of 35–55 years.

MeSH Keywords: Body Mass Index • Hypertension • Pulse Wave Analysis

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Background

BaPWV (brachial-ankle pulse wave velocity), considered as an indicator in assessing the degree of arteriosclerosis, has been proven to be closely related to multiple systematic dysfunctions and has been gradually adopted as an epidemiological investigation method [1,2].

Recent studies have shown that many factors contribute to increased baPWV, including age, gender, and blood pressure [3]. Accelerating vascular aging is an inevitable influence with accumulative characteristics [4].

A study by Ciccone et al. showed that there is a notable different on the markers of arteriosclerosis (AS) between males and females [5]. A positive relationship between systolic blood pressure and baPWV has also been reported [6]. Wang et al. [7] found that the hypertensive patients had a 13.51 times risk on developing AS compared with the non-hypertensive patients (95%CI: 10.87–16.78; $P<0.001$). Hypertension is often accompanied with overweight or obesity. A 2018 study showed that patients who were overweight or obese represented a large part of their study population that had hypertension [8]. Thus, the impact that moderate body mass index (BMI) and obesity have on hypertensive patients needs further study.

BMI is one of the main measures for general obesity, and is commonly used in clinical assessment and screenings. However, researches on the association between BMI and baPWV among hypertensive patients have not shown consistent results; studies have reported an insignificant relationship [9], positive relationship [10], or negative relationship [11,12]. Possible reasons for these conflicts might be study limitations of small sample size or different origins of the study population. Hence, this paper aimed to investigate the relationship between these factors among a group of male hypertensive patients, drawn from the Kailuan Cohort Study (registration number ChiCTR-TNC-11001489) [13].

Material and Methods

Study population

The Kailuan study is a study based on a community population in Tangshan, a city in north China. The study's major focus was on the prevalence of cardiovascular events. The study enrolled 10 1510 participants from 11 hospitals in the Kailuan community and continually carried out biennially questionnaire assessments, clinical examinations, and laboratory tests among the participants. A measurement of baPWV for a subgroup of participants was added in 2010 [14].

Our study enrolled participants from the Kailuan study that had complete the measurement of baPWV from March 1, 2010 to March 31, 2018 (n=43 898). We excluded 1120 participants with incomplete statistics for baPWV, and excluded 1431 participants without BMI measurements. We excluded female participants. Our final study population included 14 866 male participants that meeting the diagnostic criteria of hypertension [15].

This study complied with the Declaration of Helsinki and was approved by the Ethics Committee of Kailuan General Hospital (January 5, 2006); consent from each participant was obtained.

Data collection

Data for participants included baPWV values, clinical examinations, laboratory tests, and questionnaire assessments [16].

For baPWV values we used a BP-203 RPE III networked AS detection device (Omron Health Medical Co., Ltd., China). Participants underwent baPWV measurement after at least 5 minutes of rest in the supine position. Coffee, tea, cigarette use, or alcohol use were not allowed for 30 minutes before the test. Blood pressure cuffs were wrapped on both arms and ankles. The lower edge of the arm cuff was positioned 2–3 cm above the cubital fossa transverse striation, while the lower edge of the ankle cuff was positioned 1–2 cm above the medial malleolus. The heart beat monitor was placed on the left edge of the sternum, and electrocardiogram electrodes value directly. The methodology for baPWV measurement remained the same for all participants.

Clinical measurements followed the standard recommended procedures. Height, weight, and waist circumference (WC) were measured to an accuracy of 0.1 cm. BMI was defined as weight/height squared, (kg/m^2). After a 15-minute rest, participants were asked to sit at the table with their upper arms exposed and placed at the heart level. Cuff was wrapped on the upper arms; the chest piece of the stethoscope was placed on the iliac artery at the elbow. Then inflating the cuff and auscultating the pulsation of brachial artery continuously; stop inflating the cuff when the pulsation disappeared and the column reached 20 to 30 mmHg additionally. Then deflating the cuff slowly and continuously auscultating the pulsation. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) levels were determined by Korotkoff 's first tone and Korotkoff 's fifth tone. The BP was measured twice by standardized mercury sphygmomanometers. If a difference of 5 mmHg or more was showed between SBP or DBP, a third measurement was done. We took the average readings of the measurement for further analysis.

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Laboratory tests were done at the central laboratory of the Kailuan General Hospital. Before the day of the laboratory test, participants were asked to suspend eating after 19: 00 o'clock. Serum blood samples were collected by nurses and put into EDTA tubes. The samples were tested by an auto-analyzer (Hitachi 7600; Tokyo, Japan). The tests included: serum creatinine (SCr), fasting plasma glucose (FBG), and triglyceride (TG). Scr was measured by the Jaffe's assay and FBG was measured by the hexokinase method (BioSino Bio-Technology & Science Inc., China). H12-MA Test Strip (Changchun Dirui Medical Technology Co., Ltd. Changchun, China) was used to evaluate urine protein.

Questionnaires were completed by doctors and included basic information (e.g., name, sex, age), lifestyle habits (e.g., salt consumption, smoking status, physical activity, alcohol consumption), and drug-taking history (e.g., use of anti-hypertensive medications, usage of anti-diabetic medications, use of anti-dyslipidemia medications) were included.

Hypertension definition

The definition of hypertension was based on the 2010 Chinese guidelines for the management of hypertension [15]. Hypertension was defined as elevated BP (SBP ≥140 mmHg or DBP ≥90 mmHg) or patient underwent antihypertensive-medication therapy.

Arteriosclerosis (AS)

The definition of arteriosclerosis (AS) and different degrees of AS was based on previous reports [17–19]; baPWV has been proven to be a good indicator on reflecting the progress of AS. According to the value of baPWV, we stratified 3 degree of AS: mild AS if baPWV ≥1400 cm/s; moderate AS if baPWV ≥1700 cm/s; and severe AS if baPWV ≥2000 cm/s.

BMI

Different BMI groups was based on the Cooperative Meta-analysis Group of China Obesity Task Force report [20]. Then according to BMI, participants were divided into 3 groups: low BMI group if BMI <24 kg/m^2; moderate BMI if BMI ≤24 kg/m^2 and <28 kg/m^2: and high BMI group if BMI ≥28 kg/m^2.

Age-stage

The definition of different age-stages was according to the age when the participant underwent the baPWV measurement. Participants were divided into 6 age groups: 18 to 34 years old, 35 to 44 years old, 45 to 54 years old, 55 to 64 years old, 65 to 74 years old, and 75-years old.

Other study variables

Based on the questionnaire assessments of Kailuan Study, several variables are also defined. Smoking was defined as self-reported history of smoking ≥1 year. Salt consumption was self-reported according to salt preferences and was classified by 3 into 3 groups: "low" (<6 g/day), "medium" (6–10 g/day), or "high" (>10 g/day). High degree of salt consumption was included as a variable in this study. In a random sample of 1000 participants, 24-hour natriuresis was measured to determine the correlation with self-reported use of salt. The correlation was high (r=0.78), indicating that self-reported use of salt was associated with actual salt intake in this study [21,22].

For educational variable, an educational background was considered as high school or above. For consumption (drinking) of alcohol, self-reported as a current drinking or not was used as the variable. For exercise, self-report of up to 30 minutes of physical activity for more than twice a week was used.

Analysis methods

Data on baseline and comparisons were calculated for the 3 BMI groups. For normal distribution data, continuous variables were presented as mean ± standard deviation and tested by the Student's *t*-test. For non-normal distribution data, continuous variables were presented as median (quartile) and tested by non-parametric test. Categorical variables were presented as number (percentage) and compared by chi-squared tests.

The multivariate logistic regression model was used to analyze the effect of different BMI groups on different degrees of arteriosclerosis. The low BMI group was set as the reference group. Analysis was done to assess the OR between the moderate BMI group/high BMI group and the reference group. Besides, BMI was set as independent variable and baPWV was set as a dependent variable. Multivariate linear regression model was used to analyze the relationship between BMI and baPWV.

The aforementioned analyses were done for total participants and for different age-stages. For total participants, 2 models were used (model 1 and model 2). In model 1, no variables were adjusted for; in model 2, age, sex, MAP, heart rates, smoking, alcohol consumption, salt intake, exercise, diabetes mellitus, dyslipidemia, antihypertensive medication, anti-diabetic medication and anti-dyslipidemia medication were adjusted for based on model 1.

For different age-stages, 2 models were used (model 3 and model 4). In model 3, no variables were adjusted for; in model 4, MAP, heart rates, smoking status, alcohol consumption, salt intake, exercise, diabetes mellitus, dyslipidemia, antihypertensive medication, anti-diabetic medication and anti-dyslipidemia medication were adjusted for based on model 3.

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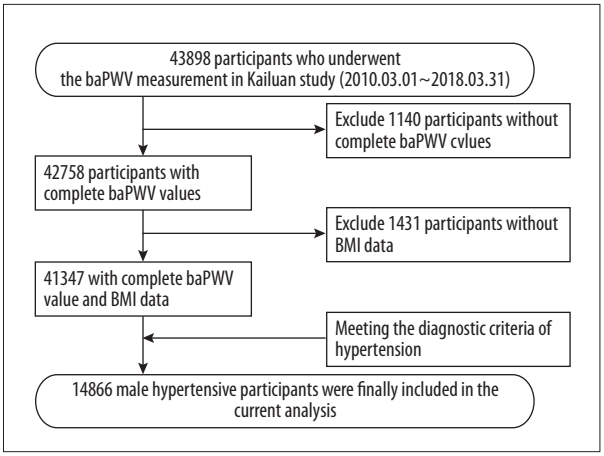

Figure 1. Flow diagram of the participants selection in the current analysis.

The aforementioned analyses were done by a statistical software: SPSS System version 13.0 (SPSS Inc, Chicago, IL, USA)

Results

Baseline characteristics of study population

The detailed approach for participant selection is shown in Figure 1. Overall 14 866 male participants with hypertension were included. The mean age of the participants was 53.53±11.89 years. Table 1 presented the baseline variables of the total participants. In general, a significant difference was observed between different BMI groups for almost all the characteristics except for total cholesterol (TC) (P=0.040), waist-hip ratio (P=0.065), heart rate (P=0.585), alcohol consumption (drinking) (P=0.269), exercise (P=0.219). As for baPWV values, a descending trend was detected among the 3 groups: low BMI, moderate BMI, and high BMI groups (1824±401 cm/s versus 1758±363 cm/s versus 1686±341 cm/s, P<0.001).

Stratification of age: waist and hip circumference, SBP, MAP, and dyslipidemia showed a notable significant difference among the 3 BMI groups (P<0.001). It also showed that the average value of baPWV increased along with aging (Supplementary Table 1).

Prevalence of AS

For total participants, the average baPWV value was 1759±372; and 87.2% of the participants were regarded as having mild AS, 48.5% as having moderate AS, and 20.5% as having severe AS. A significant difference was found in the prevalence of AS among the 3 BMI groups (Tables 1, 2).

Doe age-stratification, the prevalence of AS showed a descending trend among the low BMI group, the moderate BMI group, and the high BMI group, especially in mild AS during 18–34 years of age, 35–44 years of age, and the 45–54 years of age stages. For moderate AS showed a descending trend during 35–44 years of age, and the 45–54 years of age stages and for severe AS during 45–54 years of age and 55–64 years of age stages (P<0.001) (Supplementary Table 2).

BMI groups arteriosclerosis: multiple logistic regression analysis

Logistic regression analysis for total participants showed that compared with the low BMI group, the odds ratio (OR) and 95% confidence interval (95%CI) of moderate BMI group and high BMI group were 0.71 (95%C: 0.62–0.80) and 0.43 (95%CI: 0.38–0.50) for mild AS; 0.77 (95%CI: 0.71–0.83) and 0.54 (95%CI: 0.49–0.59) for moderate AS; and 0.73 (95%CI: 0.66–0.79) and 0.50 (95%CI: 0.45–0.56) for severe AS, respectively (P<0.001) (Table 3, model 1). A similar tendency was found when adjusted for age, MAP, heart rates, smoking history, alcohol consumption, exercise, diabetes mellitus, dyslipidemia, antihypertensive medication, anti-diabetic medication and anti-dyslipidemia medication (Table 3, model 2).

For age-stratification and arteriosclerosis, we found significant differences among all 3 BMI groups during the age groups of 35–44 years and 45–54 years (Supplementary Table 3, model 4).

BMI and baPWV: Multiple linear regression analysis

For total participants, we found a negative relationship between BMI and baPWV (β=–0.148, P<0.001). After adjusting for multiple variables, the negative relationship still existed (β=–0.117, P<0.001) (Table 4).

For age stratification, a negative relationship was detected between BMI and baPWV (Supplementary Table 4).

Discussion

Based on a cross-section study of 14866 hypertensive participants, this study found that baPWV ≥1400 cm/s was universal in hypertensive participants, with a prevalence of 87.2%. It was nearly the same as research by Zhang et al. [23] and Gu et al. [24], although the studies were based on different size of sample. In addition, almost half of the hypertensive participants in our study were considered in one study to be at risk of moderate arteriosclerosis, which has been considered to be an independent factor in indicating the relapse of cardiovascular diseases (CVD) as well as an irreversible progress of AS [25]. About one fifth of the hypertensive participants were at risk of severe AS and this group of participants needs greater attention.

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Table 1. Baseline characteristics of the total participants according to different BMI groups.

Variables	Low BMI	Moderate BMI	High BMI	Total	*P*
Age(years)	54.76±12.30	53.92±11.42	51.29±12.05	53.53±11.89	<0.001
N(%)	4134 (27.8)	7205 (48.5)	3527 (23.7)	14866 (100.0)	<0.001
BM I(kg/m^2)	22.20±1.48	25.91±1.16	30.36±2.34	25.93±3.31	<0.001
Waist (cm)	86.81±8.29	92.65±7.99	100.06±9.93	92.80±9.79	<0.001
baPWV (cm/s)	1824±401	1758±363	1686±341	1759±372	<0.001
Hip (cm)	92.36±8.29	98.26±8.57	105.58±9.60	98.36±9.35	<0.001
WHR	0.95±0.12	0.95±0.11	0.95±0.11	0.95±0.11	0.065
SBP (mmHg)	149.96±18.30	149.98±18.75	151.85±19.82	150.42±18.90	<0.001
DBP (mmHg)	92.14±11.41	92.91±11.91	93.47±11.84	92.83±11.76	<0.001
MAP (mmHg)	111.41±10.80	111.94±11.21	112.93±11.93	112.02±11.29	<0.001
HR (bpm)	77.32±15.46	75.61±15.03	75.82±13.61	76.14±14.85	0.585
TG (mmol/L)	1.73±2.38	2.10±2.70	2.43±2.27	2.08±2.53	<0.001
FBG (mmol/L)	6.17±2.47	6.37±2.65	6.43±2.30	6.33±2.52	<0.001
HDL-C (mmol/L)	1.52±0.69	1.39±0.74	1.32±1.04	1.41±0.41	<0.001
LDL-C (mmol/L)	2.77±1.24	2.84±1.05	2.87±1.19	2.83±1.14	<0.001
SUA (umol/L)	320.72±95.99	340.46±99.09	359.90±102.73	339.58±10011	<0.001
TC (mmol/L)	5.19±1.36	5.23±1.06	5.25±1.04	5.22±1.15	0.040
Salt[n (%)]	443 (10.7)	787 (10.9)	501 (14.2)	1731 (11.6)	<0.001
Smoking [n (%)]	2052 (49.6)	3259 (45.2)	1584 (44.9)	6895 (46.4)	0.001
Drink[n (%)]	427 (10.3)	738 (10.2)	396 (11.2)	1561 (10.5)	0.269
Education [n (%)]	698 (16.9)	1331 (18.5)	777 (22.0)	2806 (18.9)	0.001
Exercise [n (%)]	517 (12.5)	965 (13.4)	436 (12.4)	1918 (12.9)	0.219
Dyslipidimia [n (%)]	1413 (34.2)	3222 (44.7)	1919 (54.4)	6554 (44.1)	<0.001
Diabetes mellitus [n (%)]	861 (20.8)	1738 (24.1)	931 (26.4)	3533 (23.8)	<0.001
Anti-diabetic Medication [n (%)]	302 (7.3)	611 (8.5)	282 (8.0)	1195 (8.0)	0.086
Anti-dyslipidemia medication [n (%)]	40 (1.0)	114 (1.6)	77 (2.2)	231 (15.5)	<0.001
Antihypertensive medication [n (%)]	1864 (45.1)	3690 (51.2)	1911 (54.2)	7465 (50.2)	<0.001

BMI – mody mass index; low BMI – BMI <24 kg/m^2; moderate BMI – 24kg/m^2 ≤BMI <28kg/m^2: high BMI – BMI ≥28 kg/m^2; baPWV – branchial-ankle pulse wave velocity; WHR – waist-hip ratio; SBP – systolic blood pressure; DBP – diastolic blood pressure; MAP – mean artery pressure; bpm: beats per minute; TG – triglyceride; FBG – fasting blood-glucose; HDL-C – high density lipid-cholesterol; LDL-C – low density lipid-cholesterol; SUA – serum uric acid; TC – total cholesterol.

According to the results of our analysis, the average value of baPWV in the high BMI group was 1686±341 cm/s. This finding was almost the same as reported in the Liu et al. study [26]. However, the value of baPWV in the low BMI or the moderate BMI group was notable higher than that reported in the Liu et al. study. One factor that might contribute to the study differences is the origin of study participants. The Liu et al. study was based on 699 male hypertensive patients who were hospitalization or had other complications. The Shen et al. study [27] showed that cfPWV of BMI ≥24 kg/m^2 was significantly lower than BMI <24 kg/m^2 based on 672 hypertensive patients. A similar tendency of prevalence of AS was also found

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Table 2. Prevalence of different degrees of arteriosclerosis according to different BMI groups.

Variables	Mild AS	Moderate AS	Severe AS
Low BMI(n=4134)	3764 (91.0)	2286 (55.3)	1069 (25.9)
Moderate BMI (n=7205)	6325 (87.8)	3517 (48.8)	1455 (20.2)
High BMI (n=3527)	2873 (81.5)	1412 (40.0)	526 (14.9)
Total (n=14866)	12962 (87.2)	7215 (48.5)	3050 (20.5)
P	<0.001	<0.001	<0.001

AS – arteriosclerosis; baPWV – brachial-ankle pulse wave velocity; different degrees of AS: Mild AS (BaPWV ≥1400 cm/s); Moderate AS (BaPWV ≥1700cm/s); Severe AS: (BaPWV ≥2000 cm/s); BMI – body mass index; Low BMI – BMI <24 kg/m^2; Moderate BMI – 24 kg/m^2 ≤BMI <28 kg/m^2; High BMI – BMI ≥28kg/m^2.

Table 3. The multivariate logistic regression analysis between different BMI groups and different levels of arteriosclerosis.

Variables		Mild AS		Moderate AS		Severe AS	
		OR (95%CI)	P	OR (95%CI)	P	OR (95%CI)	P
Model 1	Low BMI (n=4134)	1		1		1	
	Moderate BMI (n=7205)	0.71 (0.62–0.80)	<0.001	0.77 (0.71–0.83)	<0.001	0.73 (0.66–0.79)	<0.001
	High BMI(n=3527)	0.43 (0.38–0.50)	<0.001	0.54 (0.49–0.59)	<0.001	0.50 (0.45–0.56)	<0.001
Model 2	Low BMI (n=4134)	1		1		1	
	Moderate BMI (n=7205)	0.66 (0.56–0.78)	<0.001	0.72 (0.65–0.80)	<0.001	0.67 (0.59–0.75)	<0.001
	High BMI (n=3527)	0.44 (0.37–0.52)	<0.001	0.51 (0.45–0.59)	<0.001	0.46 (0.40–0.54)	<0.001

BMI – body mass index; Low BMI – BMI <24 kg/m^2; Moderate BMI – 24 kg/m^2 ≤BMI <28 kg/m^2; High BMI – BMI ≥28 kg/m^2; baPWV – brachial-ankle pulse wave velocity; AS – arteriosclerosis; different levels of AS: Mild AS (baPWV ≥1400 cm/s); Moderate AS (baPWV ≥1700 cm/s); Severe AS (baPWV ≥2000 cm/s); different levels of AS were set as dependent variable, (Mild AS was set as 1 and non-mild AS was set as 0; Moderate AS was set as 1 and non-moderate AS was set as 0; Severe AS was set as 1 and non-severe AS was set as 0; different BMI groups were set as independent variable; Model 1 – no founding factors were adjusted for; Model 2 – adjusting for age, MAP – heart rates, smoke, drink, exercise, diabetes mellitus, dyslipidimia, antihypertensive medication, anti-diabetic medication, anti-dyslipidemia medication based on model 1.

Table 4. The multivariate linear regression analyses between BMI and baPWV.

Variables	Entered variable	β	t	P
	BaPWV			
Model 1	BMI	–0.148	–18.290	<0.001
Model 2	BMI	–0.117	–15.330	<0.001

BMI – body mass index; baPWV – brachial-ankle pulse wave velocity; baPWV was set as dependent variable, BMI was set as independent variable ; Model 1: No founding factors were adjusted for; Model 2: Adjusting for age, MAP, heart rates, smoke, drink, exercise, diabetes mellitus, dyslipidimia, antihypertensive medication, anti-diabetic medication, anti-dyslipidemia medication based on model 1.

among our 3 groups. The Liu et al. study also showed a similar outcome among a group of participants with type 2 diabetes mellitus [28]. While this has not been found in studies among the participants with hyperlipidemia, hyperuricemia, or in the total study populations [29–32]. We consider it a typical characteristic in the hypertensive group in our study. However, this needs further, multi-regional and larger sample studies to validate these findings.

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According to our multivariate logistic regression analysis, we found that the moderate BMI group and the high BMI group showed lower risk of AS even when adjusted for age, sex, and other confounding factors. Compared with the low BMI group, the moderate BMI group and the high BMI group had 34% and 56% reduction of risk for mild AS, respectively. Similar trends were found among other degrees of AS. According to the multivariate linear regression analysis of the total participants, a negative relationship was found between BMI and baPWV. Result of age-stratification showed no different on prevalence of mild AS among the 3 BMI groups after the age of 55 years old. Also, the protective effect of higher BMI existed until 65 years of age (the moderate BMI group for moderate AS) and 75 years of age (the high BMI group for severe AS). We considered higher BMI as a protective factor at early stages of life among male hypertensive population. And its protective function might delay the progression to severe AS. The protective function might last for several years. However, low BMI was shown to be a protective factor in high baPWV among a health population in previous studies as discussed. There are several reasons that might account for these different study results.

1) For high BMI, as a major manifestations of obesity, hyperemia and the widening diameter of renal arteries can maintain the high perfusion of the kidney. It can relieve the excessive activation of renin-angiotensin-aldosterone system (RAAS) partly, which has been proven to be the most important mechanisms leading to hypertension. And it compensates the stiffness that hypertension causes [33,34].
2) High BMI populations have an increase in lipocytes and mast cells, originating from excessive adipose tissue. Lipocytes secret enough leptin to antagonize the arterial lesion by reactive-oxygen-species (ROS) and other harmful cytokines. While increasing secretion of cyclo-oxygen-ase (COX) and endothelin by mast cell damages endothelium continuously. And these factors regulate the function of the vessels at an early stage. However, secretion of leptin has been found as a downward trend over time and harmful cytokines an upward trend as its accumulative effect in the human body. When aging or under attack by diseases, the balance is destroyed and accelerates the progression of AS [35,36]. This is an irreversible progression toward AS. Actually, further studies are needed to explore the phenomena.
3) According to the study of Wang et al. [8], there is a rising prevalence of hypertension among the young as well as a rise in the accompanied incidence of obesity and metabolic syndrome. In our study, the ages of the moderate BMI group and high BMI group were lower the ages of the low BMI group, while the BMI value was conversed. This indicated to us that hypertension and AS might be the embodiment of the development process. The Corden et al. study showed that a continuously high state of high BMI, but not short-term high BMI was a risk factor for AS, and also reflected an increase of baPWV [37]. In our study, it was our opinion that BMI showed a negative relation to baPWV. Its protective effect on AS existed only in the early stage of hypertension based on this cross-sectional study. However, prospective cohort studies are needed to explore this further.

BaPWV has been widely recognized as a reliable indicator for evaluating arterial stiffness in latest research. High baPWV has been associated to some deadly diseases such as acute myocardial infarction, hemorrhage, and cerebral ischemic stroke [38]. Boutouyrie et al. found that PWV increased by 1 standard deviation (3.15 m/s), the relative risk of cardiovascular and cerebrovascular events was 1.41 (95%CI: 1.17–1.70; P<0.001) [2] used on a group of chronic kidney disease (CKD) population Townsend et al. found that patients with the highest tertile of PWV (> 10.3 m/s) were 1.37 (95%CI: 1.05–1.80) times risk for end-stage renal disease comparing those with lower PWV (<7.9 m/s) [1]. In this research, we found that BMI was negative to baPWV. We did not focus only on the value of baPWV, but need to pay more attention to BMI and those with hypertension. Also, healthy habits, such as quitting smoking, continuously treating of hypertension, or monitoring of fasting blood glucose (FBG), needed to be further study.

There were several strengths to this study. It was based on a population of male hypertensive patients in a community, which made our study more universal and typical. Also, relatively complete characteristics included such as history of chronic diseases and medication, life habits, and laboratory data, etc. supported this study a lot and showed us a more convincing result.

There were limitations to our study. In this study, we could not find causation between BMI and baPWV, likely because of the limitations of the study cross-section design. Also, the participants were from northern China; different areas may have different effects on the result, so we hoped that further research will address this issue.

Conclusions

Among the male hypertension population, there was a negative relationship between BMI and baPWV. High BMI was a protective factor for AS especially at the age group of 35–55 years old.

Acknowledgment

Thanks are due to Shouling Wu and Youren Chen for design of the study and for valuable discussions.

Conflict of interest

None.

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Supplementary Tables

Supplementary Table 1. Baseline characteristics of the different age-stages of total subjects according to BMI.

Variables	Age-stage				
	18–34				
Group	Low BMI (n=161)	Moderate BMI (n=258)	High BMI (n=303)	Total (n=722)	*P*
Age (years)	30.00±3.83	30.41±3.33	30.52±3.21	30.35±3.42	0.209
BMI (kg/m^2)	21.83±1.67	25.96±1.15	31.15±2.49	27.02±4.20	<0.001
Waist (cm)	87.07±9.81	91.77±10.79	100.99±11.38	94.32±12.24	<0.001
baPWV (cm)	1520±360	1507±249	1461±226	1492±272	0.025
Hip (cm)	91.27±8.31	97.14±7.90	106.41±10.49	99.40±10.99	<0.001
WHR	0.96±0.13	0.95±0.12	0.95±0.11	0.95±0.12	0.588
SBP (mmHg)	146.70±12.79	146.49±12.72	150.55±13.99	148.17±13.39	<0.001
DBP (mmHg)	89.10±8.67	88.72±8.97	89.65±10.26	89.19±9.44	0.463
MAP (mmHg)	108.30±8.48	107.98±8.09	109.95±10.52	108.85±9.27	<0.001
HR (bpm)	79.89±14.11	76.87±12.91	77.43±13.12	77.84±13.33	0.099
TG (mmol/L)	1.39±1.35	1.83±1.79	2.52±2.29	2.00±1.97	<0.001
FBG (mmol/L)	5.22±1.41	5.28±1.29	5.60±2.67	5.39±1.99	0.047
HDL-C (mmol/L)	1.39±1.35	1.29±0.32	1.34±2.24	1.37±1.45	0.182
LDL-C (mmol/L)	2.61±0.88	2.71±0.76	2.86±0.79	2.75±0.81	0.002
SUA (umol/L)	330.71±108.36	363.57±111.93	407.48±121.20	373.13±118.86	<0.001
TC (mmol/L)	4.86±0.99	4.86±1.00	5.07±0.89	4.94±0.96	0.009
Salt [n (%)]	14 (8.7)	22 (8.5)	35 (11.6)	71 (9.8)	0.407
Smoking [n (%)]	77 (47.8)	116 (45.0)	152 (50.2)	345 (47.8)	0.054
Drink [n (%)]	7 (4.3)	5 (1.9)	12 (4.0)	24 (3.3)	0.185
Education [n (%)]	60 (37.3)	120 (46.5)	149 (49.2)	329 (45.6)	0.282
Exercise [n (%)]	9 (5.6)	17 (6.6)	13 (4.3)	39 (5.4)	0.614
Dyslipidimia [n (%)]	34 (21.1)	97 (37.6)	161 (53.1)	292 (40.4)	<0.001
Diabetes mellitus [n (%)]	5 (3.1)	10 (3.9)	21 (6.9)	36 (5.0)	0.049
Anti-diabetic Medication [n (%)]	2 (1.2)	1 (0.4)	2 (0.7)	5 (0.7)	0.677
Anti-dyslipidemia medication [n (%)]	0 (0)	1 (0.4)	4 (1.3)	5 (0.7)	0.169
Antihypertensive medication [n (%)]	27 (16.8)	45 (17.4)	54 (17.8)	126 (17.5)	0.953

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Supplementary Table 1 continued. Baseline characteristics of the different age-stages of total subjects according to BMI.

Variables	Age-stage				
	35–44				
Group	Low BMI (n=597)	Moderate BMI (n=1143)	High BMI (n=701)	Total (n=2441)	*P*
Age (years)	40.67±2.86	40.68±2.83	40.18±2.97	40.53±2.89	<0.001
BMI (kg/m^2)	22.22±1.57	25.92±1.17	30.67±2.54	25.94±3.39	<0.001
Waist (cm)	84.94±8.84	90.93±7.83	98.92±8.82	91.60±9.84	<0.001
baPWV (cm)	1598±245	1561±248	1526±234	1561±245	<0.001
Hip (cm)	90.78±8.18	96.54±8.52	104.68±9.65	97.37±10.12	<0.001
WHR	0.94±0.11	0.95±0.10	0.95±0.10	0.95±0.10	0.323
SBP (mmHg)	146.81±16.19	147.50±16.74	149.76±18.31	147.96±17.05	<0.002
DBP (mmHg)	92.47±8.90	93.11±10.54	93.77±11.17	93.14±10.34	0.051
MAP (mmHg)	110.58±9.45	111.24±10.35	112.44±11.24	111.41±10.41	<0.001
HR (bpm)	78.61±12.13	76.50±12.71	76.52±10.79	77.04±12.07	0.003
TG (mmol/L)	1.84±3.80	2.36±4.18	2.52±2.30	2.28±3.65	<0.001
FBG (mmol/L)	5.47±1.30	5.68±2.67	5.86±2.17	5.68±2.26	0.005
HDL-C (mmol/L)	1.54±0.45	1.43±0.79	1.43±0.79	1.42±0.62	<0.001
LDL-C (mmol/L)	2.75±0.81	2.80±0.83	2.83±0.83	2.79±0.82	0.175
SUA (umol/L)	308.64±105.03	340.20±105.53	358.87±107.26	337.45±107.47	<0.001
TC (mmol/L)	5.08±1.04	5.17±1.07	5.22±1.03	5.16±1.05	0.038
Salt [n (%)]	51 (8.5)	120 (10.5)	104 (14.7)	275 (11.3)	<0.001
Smoking [n (%)]	272 (45.6)	532 (46.5)	366 (46.3)	1170 (47.9)	0.914
Drink [n (%)]	48 (8.0)	94 (8.2)	72 (10.3)	214 (8.8)	0.229
Education [n (%)]	161 (27.0)	297 (26.0)	199 (28.4)	657 (26.9)	0.459
Exercise [n (%)]	29 (4.9)	79 (6.9)	55 (7.8)	163 (6.7)	0.068
Dyslipidimia [n (%)]	186 (31.2)	501 (43.8)	380 (54.2)	1067 (43.7)	<0.001
Diabetes mellitus [n (%)]	36 (6.0)	101 (7.7)	85 (12.1)	222 (9.1)	<0.001
Anti-diabetic Medication [n (%)]	5 (0.8)	16 (1.4)	16 (2.3)	37 (1.5)	0.065
Anti-dyslipidemia medication [n (%)]	2 (0.3)	13 (1.0)	13 (1.9)	28 (1.1)	0.017
Antihypertensive medication [n (%)]	176 (29.5)	454 (39.7)	329 (46.9)	959 (39.3)	<0.001

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Supplementary Table 1 continued. Baseline characteristics of the different age-stages of total subjects according to BMI.

Variables	Age-stage				
	45–54				
Group	Low BMI (n=1657)	Moderate BMI (n=2938)	High BMI (n=1339)	Total (n=5934)	*P*
Age (years)	50.13±2.87	50.11±2.88	49.82±2.83	50.05±2.87	<0.001
BMI (kg/m^2)	22.24±1.40	25.91±1.17	30.32±2.30	25.90±3.28	<0.001
Waist (cm)	85.43±7.99	91.32±7.25	98.12±10.79	91.19±9.52	<0.001
baPWV (cm)	1709±313	1668±290	1626±290	1670±298	<0.001
Hip (cm)	91.10±7.99	94.77±10.71	104.25±9.92	97.06±9.93	<0.001
WHR	0.94±0.11	0.95±0.11	0.95±0.13	0.95±0.11	0.269
SBP (mmHg)	147.23±18.74	147.67±19.88	150.42±21.42	147.89±19.98	<0.001
DBP (mmHg)	93.83±11.18	94.77±10.71	95.35±12.20	94.64±11.22	<0.001
MAP (mmHg)	111.63±10.77	112.40±10.88	113.71±12.49	112.49±11.27	<0.001
HR (bpm)	77.47±13.26	76.33±13.87	76.12±13.42	76.61±13.60	0.013
TG (mmol/L)	1.85±2.02	2.19±1.97	2.56±2.42	2.18±2.11	<0.001
FBG (mmol/L)	5.85±2.07	6.01±2.04	6.34±2.13	6.04±2.08	<0.001
HDL-C (mmol/L)	1.56±0.54	1.42±0.71	1.33±0.37	1.44±0.60	<0.001
LDL-C (mmol/L)	2.75±0.90	2.84±0.98	2.88±0.86	2.82±0.93	<0.001
SUA (umol/L)	308.88±96.16	331.07±101.26	342.87±102.22	327.53±100.84	<0.001
TC (mmol/L)	5.23±1.24	5.27±1.02	5.32±1.07	5.27±1.10	0.047
Salt [n (%)]	182 (11.0)	314 (10.7)	187 (14.0)	683 (11.5)	0.002
Smoking [n (%)]	847 (51.1)	1372 (46.7)	561 (41.9)	2780 (46.8)	<0.001
Drink [n (%)]	180 (10.9)	335 (11.4)	145 (10.8)	660 (11.1)	0.766
Education [n (%)]	318 (19.2)	605 (20.6)	265 (19.8)	1188 (20.0)	0.449
Exercise [n (%)]	128 (7.7)	285 (9.7)	108 (8.1)	521 (8.8)	0.021
Dyslipidimia [n (%)]	768 (46.3)	1551 (52.8)	774 (57.8)	3093 (52.1)	<0.001
Diabetes mellitus [n (%)]	202 (12.2)	432 (14.7)	308 (23.0)	942 (15.9).	<0.001
Anti-diabetic Medication [n (%)]	44 (2.7)	115 (3.9)	75 (5.6)	234 (4.0)	<0.001
Anti-dyslipidemia medication [n (%)]	13 (0.8)	50 (1.7)	27 (2.0)	90 (1.5)	0.005
Antihypertensive medication [n (%)]	767 (46.3)	1551 (52.8)	774 (57.8)	3092 (52.1)	<0.001

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Supplementary Table 1 continued. Baseline characteristics of the different age-stages of total subjects according to BMI.

Variables	Age-stage				
	55–64				
Group	Low BMI (n=862)	Moderate BMI (n=1563)	High BMI (n=648)	Total (n=3073)	*P*
Age (years)	59.56±2.68	59.80±2.71	59.74±2.76	59.72±2.72	0.068
BMI (kg/m^2)	22.23±1.45	25.91±1.16	30.25±2.36	25.92±3.28	<0.001
Waist (cm)	86.97±8.85	92.24±9.22	98.10±10.79	99.28±9.72	<0.001
baPWV (cm)	1864±392	1838±377	1787±330	1833±372	<0.001
Hip (cm)	93.50±8.55	99.30±8.26	105.97±9.45	98.11±10.01	<0.001
WHR	0.94±0.13	0.94±0.12	0.94±0.11	0.94±0.11	0.589
SBP (mmHg)	151.25±18.03	152.15±18.22	154.59±19.67	152.48±18.56	<0.001
DBP (mmHg)	90.80±12.26	91.24±13.46	90.72±12.12	91.00±12.85	0.491
MAP (mmHg)	110.95±11.56	111.54±12.27	112.01±12.49	111.49±12.13	<0.001
HR (bpm)	75.68±18.23	74.69±16.58	74.48±14.68	74.91±16.62	0.252
TG (mmol/L)	1.61±1.50	1.99±1.97	2.17±2.10	1.93±1.90	<0.001
FBG (mmol/L)	6.77±2.82	6.97±2.56	7.12±2.51	6.95±2.63	<0.001
HDL-C (mmol/L)	1.48±0.45	1.35±0.49	1.37±1.38	1.39±0.79	<0.001
LDL-C (mmol/L)	2.85±1.74	2.88±1.17	2.93±1.81	2.88±1.51	0.471
SUA (umol/L)	306.65±89.20	320.66±89.15	332.67±89.37	319.57±89.68	<0.001
TC (mmol/L)	5.35±2.45	5.35±1.48	5.40±1.13	5.36±1.74	0.769
Salt [n (%)]	84 (9.7)	159 (10.2)	79 (12.2)	322 (10.5)	0.154
Smoking [n (%)]	326 (37.8)	528 (33.8)	182 (28.1)	1036 (33.6)	<0.001
Drink [n (%)]	78 (9.0)	136 (8.7)	54 (8.2)	268 (8.7)	0.820
Education [n (%)]	118 (13.7)	209 (13.4)	102 (15.8)	429 (14.1)	0.179
Exercise [n (%)]	160 (18.6)	265 (16.9)	120 (18.5)	545 (17.8)	0.389
Dyslipidimia [n (%)]	322 (37.4)	728 (46.6)	334 (51.6)	1384 (45.2)	<0.001
Diabetes mellitus [n (%)]	289 (33.5)	624 (39.9)	284 (43.9)	1197 (39.1)	<0.001
Anti-diabetic Medication [n (%)]	120 (13.9)	241 (15.4)	118 (18.2)	479 (15.7)	0.023
Anti-dyslipidemia medication [n (%)]	16 (1.9)	31 (2.0)	21 (3.3)	68 (2.3)	0.037
Antihypertensive medication [n (%)]	418 (48.5)	830 (53.1)	418 (64.5)	1666 (54.6)	<0.001

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Supplementary Table 1 continued. Baseline characteristics of the different age-stages of total subjects according to BMI.

Variables	Age-stage				
	65–74				
Group	Low BMI (n=537)	Moderate BMI (n=935)	High BMI (n=423)	Total (n=1895)	*P*
Age (years)	69.08±2.97	68.76±2.88	68.62±2.84	68.82±2.90	0.012
BMI (kg/m^2)	22.08±1.55	25.88±1.13	30.27±2.13	25.77±3.31	<0.001
Waist (cm)	87.59±9.41	93.73±7.91	100.80±8.33	93.65±9.89	<0.001
baPWV (cm)	2020±398	1988±382	1944±360	1987±373	0.002
Hip (cm)	93.53±8.23	100.14±8.28	106.56±9.78	99.67±9.81	<0.001
WHR	0.94±0.13	0.94±0.11	0.95±0.11	0.94±0.12	0.331
SBP (mmHg)	154.88±17.23	155.20±16.69	157.97±18.27	155.41±17.26	0.002
DBP (mmHg)	86.37±10.11	87.78±11.15	88.61±11.18	87.56±10.89	<0.001
MAP (mmHg)	109.21±11.10	110.26±11.69	111.73±12.46	110.29±11.73	<0.001
HR (bpm)	74.61±14.30	74.15±13.68	74.88±12.82	74.46±13.67	0.597
TG (mmol/L)	1.38±0.95	1.69±2.85	1.88±1.44	1.65±2.16	<0.001
FBG (mmol/L)	7.01±4.02	7.15±3.45	7.28±2.72	7.14±3.48	0.374
HDL-C (mmol/L)	1.49±0.44	1.38±0.52	1.30±0.34	1.39±0.47	<0.001
LDL-C (mmol/L)	2.77±1.16	2.84±1.42	2.82±0.84	2.82±1.23	0.469
SUA (umol/L)	302.38±85.10	325.43±87.86	333.90±85.90	320.72±87.43	<0.001
TC (mmol/L)	5.29±2.01	5.24±1.08	5.30±1.11	5.26±1.42	0.613
Salt [n (%)]	47 (8.8)	88 (9.4)	47 (11.1)	182 (9.6)	0.308
Smoking [n (%)]	124 (23.1)	189 (20.2)	78 (18.4)	391 (20.7)	0.120
Drink [n (%)]	28 (5.2)	48 (5.1)	34 (8.0)	110 (5.8)	0.044
Education [n (%)]	88 (16.4)	141 (15.1)	51 (12.1)	280 (14.8)	0.092
Exercise [n (%)]	134 (25.0)	234 (25.1)	95 (22.5)	463 (24.5)	0.435
Dyslipidimia [n (%)]	179 (33.3)	374 (40.0)	195 (46.1)	748 (39.4)	<0.001
Diabetes mellitus [n (%)]	212 (39.5)	423 (45.2)	203 (48.0)	838 (44.2)	0.005
Anti-diabetic Medication [n (%)]	90 (16.8)	194 (20.7)	93 (22.0)	377 (19.8)	0.033
Anti-dyslipidemia medication [n (%)]	11 (2.0)	22 (2.4)	14 (3.3)	47 (2.4)	0.387
Antihypertensive medication [n (%)]	265 (49.3)	557 (59.6)	252 (59.6)	1074 (56.7)	<0.001

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Supplementary Table 1 continued. Baseline characteristics of the different age-stages of total subjects according to BMI.

Variables	Age-stage				
	>75				
Group	Low BMI (n=537)	Moderate BMI (n=935)	High BMI (n=423)	Total (n=1895)	*P*
Age (years)	79.76±3.69	78.99±3.41	78.96±3.53	79.30±3.56	0.003
BMI (kg/m^2)	21.78±1.77	25.80±1.12	30.00±1.88	24.74±3.22	<0.001
Waist (cm)	86.90±7.97	95.22±10.74	98.38±16.46	92.48±11.81	<0.001
baPWV (cm)	2277±520	2155±419	2182±431	2209±468	<0.001
Hip (cm)	93.68±9.34	100.23±8.41	106.65±8.95	98.43±9.95	<0.001
WHR	0.93±0.11	0.95±0.14	0.92±0.16	0.94±0.14	0.066
SBP (mmHg)	155.44±17.39	156.89±16.80	163.27±21.08	157.20±17.87	<0.001
DBP (mmHg)	84.58±12.20	85.56±12.87	88.91±10.92	85.63±12.41	0.002
MAP (mmHg)	108.20±12.10	109.34±12.20	113.70±12.88	109.49±12.38	<0.001
HR (bpm)	75.05±15.41	72.66±13.90	75.14±15.84	73.99±14.85	0.053
TG (mmol/L)	1.74±5.24	1.65±1.58	1.70±1.09	1.69±3.54	0.930
FBG (mmol/L)	5.92±1.74	6.67±2.35	6.61±2.18	6.35±2.12	<0.001
HDL-C (mmol/L)	1.66±1.62	1.54±1.94	1.41±0.45	1.57±1.67	0.241
LDL-C (mmol/L)	2.57±1.05	2.74±0.81	2.86±1.26	2.67±0.99	0.004
SUA (umol/L)	321.53±92.64	334.07±87.25	336.05±79.70	329.24±88.56	0.103
TC (mmol/L)	5.24±3.59	5.17±1.17	5.27±1.04	5.21±2.46	0.883
Salt [n (%)]	30 (9.4)	36 (9.8)	14 (12.4)	80 (10.0)	0.481
Smoking [n (%)]	40 (12.5)	52 (14.1)	11 (9.7)	103 (12.9)	0.446
Drink [n (%)]	9 (2.8)	9 (2.4)	4 (3.5)	22 (2.7)	0.793
Education [n (%)]	74 (23.1)	81 (22.0)	20 (17.7)	175 (21.8)	0.416
Exercise [n (%)]	71 (22.2)	99 (26.9)	30 (26.5)	200 (25.0)	0.252
Dyslipidimia [n (%)]	102 (31.9)	152 (41.3)	48 (42.4)	302 (37.7)	0.009
Diabetes mellitus [n (%)]	88 (27.5)	140 (38.0)	44 (38.9)	272 (34.0)	0.002
Anti-diabetic Medication [n (%)]	49 (15.3)	65 (17.7)	18 (15.9)	132 (16.5)	0.626
Anti-dyslipidemia medication [n (%)]	8 (2.5)	5 (1.4)	2 (1.8)	15 (1.9)	0.452
Antihypertensive medication [n (%)]	208 (65.0)	245 (66.6)	77 (68.1)	530 (66.2)	0.799

Age-stages – study participants are divided into 6 stages according to age: 18–34, 35–44, 45–54, 55–64, 65–74, >75. Low BMI – BMI <24 kg/m^2; Moderate BMI – 24 kg/m^2 ≤BMI <28 kg/m^2: High BMI – BMI ≥28 kg/m^2; BMI – body mass index; baPWV – branchial-ankle pulse wave velocity; WHR – waist-hip ratio; SBP – systolic blood pressure; DBP – diastolic blood pressure; MAP – mean artery pressure; bpm – beats per minute; TG – triglyceride; FBG – fasting blood-glucose; HDL-C – high density lipid-cholesterol; LDL-C – low density lipid-cholesterol; SUA – serum uric acid; TC – total cholesterol.

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Supplementary Table 2. Prevalence of different degrees of arteriosclerosis according to different BMI groups(age-stratification).

	Variables	Mild AS		Moderate AS		Severe AS	
18–34	Low BMI (n=161)	117	(72.7)	36	(22.4)	14	(8.7)
	Moderate BMI (n=258)	193	(74.8))	50	(19.4)	9	(3.5)
	High BMI (n=303)	172	(56.8)	32	(10.6)	6	(2.0)
	Total (n=722)	482	(66.8)	118	(16.3)	29	(4.0)
	P	<0.001		0.019		0.002	
35–44	Low BMI (n=597)	507	(84.9)	201	(33.7)	39	(6.5)
	Moderate BMI (n=1143)	879	(76.9)	278	(24.3)	69	(6.0)
	High BMI (n=701)	498	(71.0)	149	(21.3)	28	(4.0)
	Total (n=2441)	1884	(77.2)	628	(25.7)	136	(5.6)
	P	<0.001		<0.001		0.089	
45–54	Low BMI (n=1657)	1487	(89.7)	786	(474)	282	(17.0)
	Moderate BMI (n=2938)	2519	(85.7)	1182	(40.2)	360	(12.3)
	High BMI (n=1339)	1082	(80.8)	452	(33.8)	134	(10.0)
	Total (n=5934)	5088	(85.7)	2420	(40.8)	776	(13.1)
	P	<0.001		<0.001		<0.001	
55–64	Low BMI (n=862)	812	(94.2)	539	(62.5)	273	(31.7)
	Moderate BMI (n=1563)	1459	(93.3)	946	(60.5)	421	(26.9)
	High BMI (n=648)	597	(92.1)	347	(53.5)	132	(20.4)
	Total (n=3073)	2868	(93.3)	1832	(59.6)	826	(26.9)
	P	0.280		<0.001		<0.001	
65–74	Low BMI (n=537)	525	(97.8)	428	(79.7)	245	(45.6)
	Moderate BMI (n=935)	913	(97.6)	731	(78.2)	383	(41.0)
	High BMI (n=423)	423	(97.4)	325	(76.8)	150	(35.5)
	Total (n=1895)	1850	(97.6)	1484	(78.3)	778	(41.1)
	P	0.932		0.558		0.006	
>75	Low BMI (n=320)	316	(98.8)	296	(92.5)	216	(67.5)
	Moderate BMI (n=368)	362	(98.4)	330	(89.7)	213	(57.9)
	High BMI (n=113)	112	(99.1)	107	(94.7)	76	(67.3)
	Total (n=801)	790	(98.6)	733	(91.5)	505	(63.0)
	P	0.813		0.176		0.020	

Age-stages – study subjects were divided into 6 stages according to age: 18–34, 35–44, 45–54, 55–64, 65–74, >75.
baPWV – brachial-ankle pulse wave velocity; AS arteriosclerosis; different degrees of AS: Mild AS (baPWV ≥1400 cm/s); Moderate AS (baPWV ≥1700 cm/s); Severe AS (baPWV ≥2000 cm/s); BMI – body mass index; Low BMI – BMI <24 kg/m^2; Moderate BMI – 24 kg/m^2 ≤BMI <28 kg/m^2; High BMI – BMI ≥28 kg/m^2.

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Supplementary Table 3. The multivariate logistic regression analysis between different BMI groups and different levels of arteriosclerosis (age-stratification).

Variables		Low BMI		Moderate BMI		High BMI	
Age-stages	Model	OR	*P*	OR(95%CI)	*P*	OR(95%CI)	*P*
Mild AS							
18–34	Model 3	1	<0.001	1.12 (0.72–1.75)	0.628	0.50 (0.33–0.75)	<0.001
	Model 4	1	<0.001	1.12 (0.62–2.05)	0.701	0.39 (0.21–0.70)	<0.001
35–44	Model 3	1	<0.001	0.59 (0.46–0.77)	<0.001	0.44 (0.33–0.58)	<0.001
	Model 4	1	<0.001	0.54 (0.38–0.76)	<0.001	0.34 (0.23–0.49)	<0.001
45–54	Model 3	1	<0.001	0.69 (0.57–0.83)	<0.001	0.48 (0.39–0.59)	<0.001
	Model 4	1	<0.001	0.61 (0.51–0.80)	<0.001	0.38 (0.29–0.49)	<0.001
55–64	Model 3	1	0.282	0.87 (0.61–1.22)	0.410	0.72 (0.48–1.08)	0.112
	Model 4	1	0.418	0.77 (0.50–1.18)	0.240	0.74 (0.44–1.23)	0.239
65–74	Model 3	1	0.932	0.95 (0.47–1.93)	0.884	0.86 (0.37–1.96)	0.713
	Model 4	1	0.605	0.71 (0.32–1.59)	0.409	0.64 (0.25–1.61)	0.341
>75	Model 3	1	0.678	0.76 (0.21–2.73)	0.764	1.42 (0.16–12.88)	0.756
	Model 4	1	0.993	0.94 (0.25–3.60)	0.928	1.05 (0.11–10.34)	0.970
Moderate AS							
18–34	Model 3	1	0.002	0.84 (0.52–1.35)	0.463	0.41 (0.24–0.69)	<0.001
	Model 4	1	<0.001	0.64 (0.33–1.21)	0.170	0.18 (0.09–0.39)	<0.001
35–44	Model 3	1	<0.001	0.63 (0.51–0.79)	<0.001	0.53 (0.42–0.68)	<0.001
	Model 4	1	<0.001	0.54 (0.40–0.73)	<0.001	0.34 (0.24–0.48)	<0.001
45–54	Model 3	1	<0.001	0.75 (0.66–0.84)	<0.001	0.57 (0.49–0.66)	<0.001
	Model 4	1	<0.001	0.69 (0.59–0.81)	<0.001	0.44 (0.36–0.54)	<0.001
55–64	Model 3	1	<0.001	0.92 (0.77–1.09)	0.332	0.69 (0.56–0.85)	<0.001
	Model 4	1	<0.001	0.90 (0.72–1.11)	0.323	0.61 (0.47–0.80)	<0.001
65–74	Model 3	1	0.559	0.91 (0.70–1.19)	0.493	0.85 (0.62–1.15)	0.283
	Model 4	1	0.195	0.78 (0.57–1.06)	0.112	0.74 (0.52–1.07)	0.113
>75	Model 3	1	0.183	0.70 (0.41–1.20)	0.756	1.45 (0.58–3.63)	0.433
	Model 4	1	0.289	0.63 (0.35–1.15)	0.133	0.95 (0.34–2.69)	0.949
Severe AS							
18–34	Model 3	1	0.004	0.38 (0.16–0.89)	0.028	0.21 (0.08–0.56)	0.002
	Model 4	1	<0.001	0.27 (0.90–0.78)	0.016	0.06 (0.01–0.27)	<0.001
35–44	Model 3	1	0.093	0.92 (0.61–1.38)	0.684	0.60 (0.28–0.88)	0.021
	Model 4	1	0.006	0.96 (0.57–1.64)	0.890	0.37 (0.19–0.74)	<0.001
45–54	Model 3	1	<0.001	0.68 (0.58–0.81)	<0.001	0.54 (0.44–0.68)	<0.001
	Model 4	1	<0.001	0.66 (0.53–0.82)	<0.001	0.41 (0.31–0.55)	<0.001

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55–64	Model 3	1	0.014	0.80 (0.66–0.95)	<0.001	0.55 (0.44–0.70)	<0.001
	Model 4	1	<0.001	0.68 (0.53–0.83)	<0.001	0.45 (0.33–0.60)	<0.001
65–74	Model 3	1	0.007	0.83 (0.67–1.02)	0.082	0.66 (0.50–0.85)	0.002
	Model 4	1	<0.001	0.68 (0.53–0.88)	0.003	0.45 (0.36–0.68)	<0.001
>75	Model 3	1	0.021	0.66 (0.48–0.90)	0.012	0.99 (0.63–1.56)	0.962
	Model 4	1	0.003	0.69 (0.47–0.87)	<0.010	0.76 (0.45–1.30)	0.323

BMI – body mass index; Low BMI – BMI <24kg/m^2; Moderate BMI – 24kg/m^2 ≤BMI <28 kg/m^2: High BMI – BMI ≥28 kg/m^2; baPWV – brachial-ankle pulse wave velocity; AS – arteriosclerosis; different levels of AS: Mild AS (BaPWV ≥1400 cm/s); Moderate AS (baPWV ≥1700 cm/s); Severe AS (baPWV ≥2000 cm/s); Different levels of AS were set as dependent variable, (Mild AS was set as 1 and non-mild AS was set as 0; Moderate AS was set as 1 and non-moderate AS was set as 0; Severe AS was set as 1 and non-severe AS was set as 0; different BMI groups were set as independent variable; Model 3: No founding factors were adjusted for; Model 4: adjusting for MAP, heart rates, smoke, drink, exercise, diabetes mellitus, dyslipidimia, antihypertensive medication, anti-diabetic medication, anti-dyslipidemia medication based on model 3.

Supplementary Table 4. The multivariate linear regression analyses between BMI and baPWV (age-stratification).

Variables		Entered variable	β	t	*P*
Age-stages	**Models**		**BaPWV**		
18–34	Model 3	BMI	–0.184	–5.019	<0.001
	Model 4	BMI	–0.225	–5.228	<0.001
35–44	Model 3	BMI	–0.128	–6.351	<0.001
	Model 4	BMI	–0.179	–8.204	<0.001
45–54	Model 3	BMI	–0.131	–10.151	<0.001
	Model 4	BMI	–0.159	–11.924	<0.001
55–64	Model 3	BMI	–0.095	–5.310	<0.001
	Model 4	BMI	–0.112	–6.295	<0.001
65–74	Model 3	BMI	–0.075	–3.263	<0.001
	Model 4	BMI	–0.108	–4.791	<0.001
>75	Model 3	BMI	–0.098	–2.775	0.006
	Model 4	BMI	–0.159	–4.496	<0.001

Age-stages – study subjects were divided into 6 stages according to age: 18–34, 35–44, 45–54, 55–64, 65–74, >75. BMI – body mass index; baPWV – brachial-ankle pulse wave velocity; baPWV was set as dependent variable, BMI was set as independent variable; Model 3: no founding factors were adjusted for; Model 4: adjusting for age, sex, MAP, heart rates, smoke, drink, exercise, diabetes mellitus, dyslipidimia, antihypertensive medication, anti-diabetic medication, anti-dyslipidemia medication based on model 3.

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