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Original Article

Correlation between 24-hour ambulatory systolic blood pressure and brachial-ankle pulse wave velocity: higher correlation 24-h with baPWV

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Abstract: Objective: Brachial ankle pulse wave velocity (baPWV) is a sensitive indicator of arterial stiffness. Few studies correlated cumulative systolic blood pressure (SBP) with arterial stiffness. Evidence underlying the factors related to baPWV in the clinical SBP, cumulative SBP and 24 h ambulatory SBP (24 h ABPM) is unavailable. This study was aimed to explore the correlation between cumulative, 24-h ambulatory systolic BP and brachial-ankle pulse wave velocity. Methods: The medical examination was administered to participants who were working and retired employees of the Kailuan community in Tangshan city (China). Relevant data were collected from 2006 to 2007, 2008 to 2009, and 2010 to 2011. We randomly selected participants aged ≥ 60 years and retired from the Tangshan Kailuan community in the third examination. Finally, a total of 2,464 eligible participants were enrolled for the 24-h ambulatory systolic BP (ABPM) and baPWV measurements. Multiple linear and logistic regression were used to quantify the effects of clinical, cumulative, 24-h, daytime, and nocturnal systolic BP on baPWV. Results: Of the 2,464 participants, 787 were subjected to statistical analysis (average age 67. 45, male, 62.2%). In fully adjusted models, the baPWV values increased by 178.40, 87.74, 149.39, 143.45, 137.58 cm/s for each additional 1-SD of clinical, cumulative, 24-h, diurnal and nocturnal systolic BP. Similar adjusted logistic-regression analyses showed that the OR values (95% CI) of baPWV were 2.21 (1.96~2.88), 1.71 (1.34~2.17), 0.96 (0.66~1.40), and 1.81 (1.24~2.46), respectively, for each additional SD (interaction term > 0.05). Conclusion: The 24-h, and nocturnal SBP exhibited significantly higher correlation with baPWV than cumulative SBP.

Keywords: Cumulative blood pressure exposure, brachial-ankle pulse wave velocity (baPWV)

Introduction

Brachial ankle pulse wave velocity (baPWV) is a sensitive indicator of arterial stiffness. Previous studies have confirmed that clinical [1-3] and 24-h dynamic systolic blood pressure (SBP) [3-6] were closely related to baPWV. However, they only reflected the blood pressure value in a single measure or short period of time. Further, many factors influenced the blood pressure levels, and the increased value of baPWV was a slow process. Therefore, monitoring a single or a short duration of blood pressure may not adequately demonstrate the effects of chronic blood pressure on baPWV.

Cumulative exposure, which reflects the long-term impact of an individual risk factor accurately, was calculated based on the exposure dose and time. The cumulative exposure to blood pressure was associated with target organ damage (such as left ventricular hypertrophy [7], renal damage [8]). However, few studies correlated cumulative SBP with arterial stiffness. Evidence underlying the factors related to baPWV in the clinical SBP, cumulative SBP

and 24 h ambulatory SBP (24 h ABPM) is unavailable. Therefore, this study, which was based on the study of Kailuan group (registration number: chiCTR-TNC - 1100-1489), analyzed the effects of cumulative, clinical, and 24-h dynamic SBP on baPWV in an older population.

Materials and methods

This study was approved by the Ethics Committee of Kailuan Hospital. Written informed consent was obtained from all patients.

Study design and population

The design and methods of Kailuan study have been described elsewhere. [9, 10] Briefly, the Kailuan study is a prospective, ongoing community health study based on the Kailuan community in Tangshan city, which is a large and littoral modern city located in the southeast of China. Eleven hospitals are affiliated with the Kailuan Company: Kailuan General Hospital, Kailuan Lindsey Hospital, Kailuan Zhaogezhuang Hospital, Kailuan Tang Village Hospital, Kailuan Fangezhuang Hospital, Kailuan Jinggezhuang Hospital, Kailuan Lujiatuo Hospital, Kailuan Linnancang Hospital, Kailuan Qianjiaying Hospital, Kailuan Majiagou Hospital, and Kailuan Hospital Branch. Medical examinations were administered to about 100,000 working and retired employees of the Kailuan Group, and relevant data were collected from the 11 hospitals from 2006 to 2007, 2008 to 2009, and 2010 to 2011.

After the three physical examinations, we randomly selected participants who were aged at least 60 years old and retired from the Tangshan Kailuan Hospital, Kailuan Linxi Hospital, Kailuan Zhaogezhuang Hospital, and then enrolled 3064 cases. A total of 2860 participants agreed to participate in the study (response rate 93.34%). However, due to various reasons, 46 participants failed to attend. A total of 2814 eventually completed the baseline data collection (actual response rate was 91.84%). Among these 2814 individuals, 350 participants failed to meet the following inclusion criteria: (1) no serious physical disability, and (2) inability to complete the questionnaires and sign informed consent. Finally, a total of 2464 participants were found eligible and were evaluated. 2464 objectives participated in the third+ visit for added items after the third visit. These participants were chosen form the objectives who have participated in the third visit through cluster sampling method. They also participated in the fourth visit.

Blood pressure measurements

Clinical SBP measurements: SBP was measured in millimeters of mercury (mmHg) using a manual sphygmomanometer in the three examinations, at yearly intervals. At each visit, 3 measurements were obtained with the patient in the sitting position for at least 5 minutes. The average of the three SBP values was used as the representative value for each visit.

In our regression models, the clinical SBP in the 3+ examination was used. The SBP was measured three times consecutively in the sitting position, after a resting interval of at least 2 min, by a doctor using an automatic device (HEM907; Omron Healthcare Co. Ltd, Kyoto, Japan) during the baPWV testing. The average of the three readings was defined as clinical SBP.

Calculation of cumSBP: CumSBP was defined as the cumulative average SBP for each pair of consecutive examinations multiplied by the time between the two consecutive visits annually: $[(SBP_1 + SBP_2)/2*time_{1\text{-}2}] + [(SBP_2 + SBP_3)/2*time_{2\text{-}3}]$, where SBP_1, SBP_2, SBP_3 indicate SBP at the baseline, second, and third time. The $time_{1\text{-}2}$ and $time_{2\text{-}3}$ indicate the participant time intervals between consecutive examinations 1-3 in 4 years.

Measurement of 24 h ambulatory SBP: Ambulatory BP was measured after the baPWV examination using a device validated by CE, FDA and SFDA (Sun Tech Oscar2; Spacelabs Ultralite 90217). Strict inspection of the monitoring device for formatting and battery function was proposed before using the ABPM device. Participants were trained to manage cuff displacement and degree of tightness and maintain the cuff at the heart level as well as adjust it to the non-dominant arm. During cuff inflation, the arm was held immobile, relaxed and still. Furthermore, the device was protected from contact or moisture. Strict registration was conducted after installation. The participants undergoing ABPM were instructed to engage in normal activities and rest. During sleep, the participants were advised to prevent displacement of the cuff and body compres-

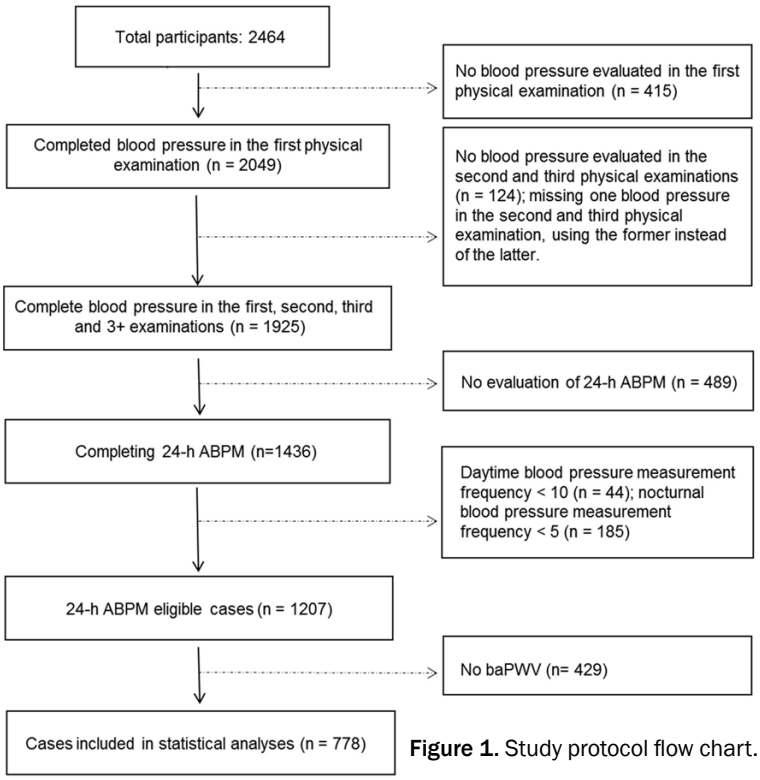

Figure 1. Study protocol flow chart.

sion, which affected BP readings. Definitions of daytime and night time were, respectively, 6:00 AM-10:00 PM and 10:00 PM-6:00 AM. Data were recorded every 15 min during the day (6:00 AM to 10:00 PM) and every 30 min at night (10:00 AM to 6:00 AM). The registration was considered valid if there were at least 10 readings during the day, and five readings at night [11].

Brachial-ankle pulse wave velocity measurement: In this study, baPWV was measured twice independently by trained volunteers from local medical colleges using a noninvasive vascular screening device (OMRON, BP-203RPE III, Japan) at the third+ visit. Participants were examined in supine position after resting in air-conditioned room (22-25°C) for at least 5 min. The arms and ankles were wrapped in cuffs, electrodes of the electrocardiogram were placed on both wrists, and a microphone to detect heart sounds was placed on the left edge of the sternum. The lower edge of the arm cuff was placed 2-3 cm above the transverse striation of the cubital fossa, while the lower edge of the ankle cuff was placed 1-2 cm above the superior aspect of the medial malleolus. All participants were measured twice, and the second was used. The higher value of the left and right sides was used for data analyses. The higher value represented severe arterial stenosis of the whole body.

Assessment of potential covariates (Third visit)

Body mass index was calculated as weight (kilograms) divided by height (meters) squared. Whole blood samples were drawn from all participants, generally after an overnight fast and analyzed in the Central Laboratory of Kailuan General Hospital on the same day. The biochemical parameters, including blood glucose, creatinine, triglyceride, high density lipoprotein cholesterol and low density lipoprotein cholesterol, were measured using an auto-analyzer (Hitachi 747; Hitachi, Tokyo, Japan), as detailed previously. Plasma high-sensitivity C-reactive protein concentrations were measured using a high-sensitivity particle-enhanced immunonephelometry assay (Cias Latex CRP-H, Kanto Chemical Co. Inc, Japan).

Statistical analyses

Statistical analyses were performed using SPSS 19.0. Continuous variables were described by mean ± standard deviation (SD) and compared using independent sample t-test. Categorical variables were described by percentages and compared using Chi square tests. The correlation between clinical, cumulative, 24-h ambulatory SBP and baPWV was analyzed by rank test. Multivariable linear regression models were used to assess the association between above SBP and baPWV. Logistic regression analyses were also undertaken to correlate SBP with baPWV. Chi-square goodness-of-fit tests were performed on observation models. The level of statistical significance was set at $p < 0.05$ (two-sided).

Results

In 2464 cases under observation, we deleted the 415 cases showing loss in the first medical

Table 1. Clinical demographics

	Total (n = 778)	baPWV < 1700 cm/s (n = 353)	baPWV ≥ 1700 cm/s (n = 425)	P
Age	67.45±5.89	65.60±5.28	68.98±5.94	< 0.001
Male (%)	484 (62.2)	226 (64.0)	258 (60.7)	0.342
Clinic SBP (mmHg)	143.34±20.39	134.14±17.70	151.01±19.31	< 0.001
Cumulative SBP(mmHg)	588.38±93.91	553.21±80.45	617.58±94.36	< 0.001
24-h SBP (mmHg)	129.49±15.49	124.19±14.37	133.89±15.03	< 0.001
Daytime SBP (mmHg)	131.63±15.81	126.55±14.89	135.84±15.32	< 0.001
Nocturnal SBP (mmHg)	122.97±16.86	117.13±14.99	127.82±16.81	< 0.001
BM I (kg/m^2)	25.18±3.19	25.20±3.18	25.16±3.20	0.864
FBG (mmol/L)	5.84±1.58	5.67±1.25	5.99±1.80	0.008
LDL_C (mmol/L)	2.82±0.96	2.84±1.15	2.80±0.77	0.609
LghsCRP	0.11±0.47	0.10±0.48	0.12±0.46	0.581
LgTG	0.13±0.23	0.12±0.23	0.14±0.23	0.109
Smoking (%)	137 (17.6)	75 (21.2)	62 (14.6)	0.015
Drinking (%)	137 (17.6)	66 (18.7)	71 (16.7)	0.468
Exercise (%)	193 (24.8)	94 (26.6)	99 (23.3)	0.284
Antihypertensive drugs (%)	214 (27.5)	60 (17.0)	154 (36.2)	< 0.001

Note: baPWV: Brachial ankle pulse wave velocity; SBP: systolic blood pressure; BMI: body mass index; FBG: fasting plasma glucose; lgTG: triglycerides after logarithmic transformation; lghsCRP: high-sensitivity c-reactive protein after logarithmic transformation; 1 mmHg = 0.133 kPa.

blood pressure and 124 cases missing the second and third blood pressure. Using the first instead of the missing second blood pressure value (n = 129), the second instead of the missing third blood pressure value (n = 266), we acquired the blood pressure data of 1925 cases, eventually. Of these cases, a total of 1436 completed the 24-h ambulatory blood pressure measurement. However, only 1207 were consistent with the 24-h ABPM (deleted daytime blood pressure measurements < 10 (n = 44), and nocturnal blood pressure measurements < 5 (n = 185). After deleting 429 cases without baPWV, 778 cases with complete data were included in the final statistical analysis (**Figure 1**).

Characteristics of study participants

Table 1 summarizes the baseline demographic data, with the clinical and hemodynamic parameters of the 778 study subjects. The mean age of the subjects was 67.45 years; 62.2% were men. Compared with the group showing a baPWV ≥ 1700 cm/s, the group with baPWV < 1700 cm/s had higher age, clinical/cumulative/24-h dynamic SBP, FBG, smoking and antihypertensive drug usage.

Multivariable linear regression of baPWV

Multivariable linear regression was used to assess the correlation between clinical, cumulative, 24-h ambulatory systolic BP and baPWV. In fully adjusted models, the baPWV values increased by 178.40, 87.74, 149.39, 143.45 cm/s, and 137.58 cm/s for each additional SD of clinical, cumulative, 24-h, daytime, and nocturnal systolic BP, respectively.

Adjusting for age, gender, and body mass index, the results showed that clinical and 24-h SBP was linearly related to baPWV (beta values were 0.36, 0.19, P < 0.001), while cumulative SBP and baPWV showed no linear correlation (P > 0.05). Similar findings showed that the clinical and daytime SBP was linearly associated with baPWV adjusting for other factors (beta values were 0.36, 0.17, P < 0.001), while the cumulative SBP and baPWV showed no linear correlation (P > 0.05). We also found that the clinical and nocturnal SBP was linearly correlated with baPWV adjusted for other factors (beta values were 0.38, 0.18, P < 0.001), while the cumulative SBP and baPWV had no linear correlation (P > 0.05). Finally, we compared the correlation between clinical, cumulative, day-

Table 2. Multivariable linear regression of baPWV (n = 778)

	Parameter	B (95% CI)	Beta	P	VIF	R^2
24 h SBP						0.374
	Clinical SBP (+ 20.37 mmHg)	149.84 (116.50~183.17)	0.36	< 0.001	1.54	
	Cumulative SBP (+ 93.68 mmHg·year)	18.45 (-12.69~49.60)	0.05	0.245	1.39	
	24-h SBP (+ 15.44 mmHg)	78.79 (45.86~111.73)	0.19	< 0.001	1.51	
Daytime SBP						0.370
	Clinical SBP (+ 20.37 mmHg)	151.94 (118.37~185.51)	0.36	< 0.001	1.56	
	Cumulative SBP (+ 93.68 mmHg·year)	20.09 (-11.11~51.28)	0.05	0.206	1.38	
	Daytime SBP (+ 15.76 mmHg)	72.11 (39.28~104.94)	0.17	< 0.001	1.48	
Nocturnal SBP						0.375
	Clinical SBP (+ 20.37 mmHg)	158.35 (126.49~190.21)	0.38	< 0.001	1.41	
	Cumulative SBP (+ 93.68 mmHg·year)	18.28 (-12.85~49.41)	0.04	0.249	1.39	
	Nocturnal SBP (+ 16.80 mmHg)	76.75 (45.16~108.34)	0.18	< 0.001	1.39	
Daytime + Nocturnal SBP						0.375
	Clinical SBP (+ 20.37 mmHg)	153.02 (119.56~186.48)	0.37	< 0.001	1.56	
	Cumulative SBP (+ 93.68 mmHg·year)	18.16 (-12.97~49.29)	0.04	0.252	0.39	
	Daytime SBP (+ 16.80 mmHg)	26.73 (-25.60~78.05)	0.06	0.307	3.65	
	Nocturnal SBP (+ 15.76 mmHg)	56.87 (7.32~106.42)	0.14	0.025	3.41	

Note: baPWV continuous variables are the dependent variables, Model 1: clinical, cumulative, 24-h SBP (increased 1-SD) were the independent variables, adjusted for age, gender, BMI, FBG, TG, LDL_C, hsCRP, smoking, drinking, exercise, and antihypertensive drug use; Model 2: clinical, cumulative, daytime SBP (increased 1-SD) as the independent variables, and adjusting for other similar variables; Model 3: clinical, cumulative, nocturnal SBP as the independent variables, adjusted for other similar variables; Model 4: clinical, cumulative, daytime and nocturnal SBP as the independent variables, and adjusted for similar variables.

Table 3. Multivariable logistic regression of baPWV

BP variable	Univariate analysis[a]			Multivariable analysis[b]		
	OR (95% CI)	Beta	*P* Value	OR (95% CI)	Beta	*P* Value
Clinical SBP	2.77 (2.29~3.35)	0.36	< 0.001	2.93 (2.30~3.74)	0.35	< 0.001
Cumulative SBP	2.13 (1.81~2.52)	0.45	< 0.001	2.10 (1.70~2.61)	0.42	< 0.001
24-h SBP	2.77 (2.29~3.35)	0.17	< 0.001	2.93 (2.30~3.74)	0.22	< 0.001
Daytime SBP	2.13 (1.81~2.52)	0.25	< 0.001	2.10 (1.70~2.61)	0.10	< 0.001
Nocturnal SBP	2.01 (1.70~2.37)	0.13	< 0.001	2.29 (1.84~2.85)	0.31	< 0.001

Note: baPWV (< 1700 assignment is 0, ≥ 1700 assignment is 1) as the dependent variable; clinical, cumulative, 24-h dynamic SBP (every increase 1-SD) as the independent variables; a is univariate logistic regression analysis; b is multivariable logistic regression analysis, adjusted for age, gender, BMI, FBG, LDL_C, TG, hsCRP, smoking, drinking, exercise, and antihypertensive drugs.

time SBP, nighttime SBP, and baPWV adjusting for other factors. We found that clinical, nocturnal SBP and baPWV were linearly correlated (beta values were 0.37, 0.14, P < 0.05), while the daytime, accumulated SBP and baPWV showed no linear correlation (P > 0.05) (**Table 2**).

Multivariable logistic regression of baPWV

We also analyzed the influence of clinical, cumulative, 24-h dynamic SBP on baPWV in the complete clinical SBP and baPWV data (n = 1747), cumulative SBP and baPWV data (n = 1407), 24 h dynamic SBP and baPWV data (n = 1004), respectively, and arrived at the same conclusion.

Subsequently, we conducted a subgroup analysis and arrived at similar conclusion. We incorporated the clinical, accumulated and 24-h SBP into the equation and adjusted for other factors such as age and gender. The results showed that clinical, cumulative and 24-h SBP were still the risk factors for baPWV ≥ 1700 cm/s (OR (95% CI): 2.14 (1.64~2.77), 1.70 (1.34~2.16), and 1.34 (1.28~1.28), respectively). We correlated the clinical, cumulative, 24-h SBP and baPWV by also analyzing other subgroups similarly (**Table 3**).

Logistic regression: test of goodness-of-fit

Table 4 showed that clinical SBP improved the goodness-of-fit of the model including cumula-

Table 4. Regression analysis: test of goodness-of-fit

BP variable	LR χ^2	*P* Value
1. clinical	191.97	...
2. clinical + cumulative*	22.56	< 0.001
3. clinical + 24 h*	18.58	< 0.001
4. clinical + daytime*	13.24	< 0.001
5. clinical + nocturnal*	24.23	< 0.001
6. clinical + cumulative + 24 h†	15.76	< 0.001
7. clinical + cumulative + daytime†	12.03	< 0.001
8. clinical + cumulative + nocturnal†	21.50	< 0.001

Note: χ^2 value of 3.8 corresponds to *P* value of 0.05, 6.6 to 0.01, and 10.8 to 0.001. Data are adjusted for age, gender, BMI, FBG, LDL_C, CRP, smoking, drinking, exercise, and antihypertensive drugs. LR indicates likelihood ratio. *Increases in likelihood ratio χ^2 vs. model 1. †Increases in likelihood ratio χ^2 vs. model 2.

tive, 24-h, daytime and nocturnal SBP (increased values were 22.56, 18.58, 13.24, and 24.23, respectively; P < 0.001). Similarly, clinical and cumulative SBP improved the goodness-of-fit in the model when 24-h, daytime and nocturnal SBP (increase values were 15.76, 12.03, and 21.50, respectively; P < 0.001) were added.

Discussion

Several investigators have reported the association between clinical, 24-h ambulatory blood pressure and baPWV. However, limited evidence supports the correlation between cumulative blood pressure exposure and baPWV. Cumulative blood pressure exposure not only includes the blood pressure levels, but also the duration of exposure, and might be more closely associated with target organ damage. Studies involving cumulative exposure include: cumulative environmental exposure and health research; [11] cumulative exposure to hyperglycemia and diabetes complications; [12] cumulative exposure to high cholesterol and the risk of coronary heart disease; [13, 14] cumulative exposure to blood pressure and left ventricular hypertrophy and kidney damage. [7, 8] In our study, we not only analyzed the relationship between cumulative SBP and baPWV, but also compared the correlation between clinical, cumulative, 24-h dynamic SBP and baPWV in the same group.

This study showed that the baPWV was correlated with clinical, 24-h dynamic, and accumulated SBP in the rank correlation analysis. Linear regression analysis demonstrated that clinical, cumulative, and 24-h dynamic SBP showed positive linear correlation with baPWV (Schedule 1), which was consistent with previous results. [3] No study correlated the cumulative SBP with baPWV. However, Wei [3] demonstrated that the average SBP was positively correlated with cfPWV over several days. Wilson [15] found that compared with the average SBP, the cumulative SBP was more strongly correlated with the degree of carotid stenosis.

We also found that clinical, cumulative, 24-h dynamic SBP were risk factors for baPWV ≥ 1700 cm/s in logistic regression analysis (**Table 3**), which was consistent with previous studies. [3] In the study correlating 24-h ambulatory blood pressure and baPWV, Motoko [5] found that the 24-h and nocturnal SBP and baPWV were positively correlated. In our study, we not only showed that the clinical and 24-h dynamic SBP was closely related to baPWV, but also reinforced the findings correlating cumulative blood pressure exposure and target-organ damage.

In addition, we also found that clinical, cumulative, and 24-h dynamic SBP were risk factors for baPWV ≥ 1700 cm/s, and clinical SBP showed more significant association with baPWV ≥ 1700 cm/s (**Table 5**). This finding was also consistent with the results of goodness-of-fit test (**Table 4**), which demonstrated that both cumulative and 24-h dynamic SBP improved the goodness of fit. Although Nikpour M [14] reports that the predictive value of cumulative blood pressure exposure was superior to a single measure of blood pressure in systemic lupus erythematosus patients, our results suggested that clinical SBP was superior to nocturnal SBP, which was superior to the cumulative SBP predicted by baPWV.

To demonstrate the correlation between clinical, cumulative, 24-h SBP and baPWV, we compared the cumulative SBP, the first clinical SBP and 3+ 24 h SBP. We found that the 24-h dynamic SBP was superior to cumulative and clinical SBP in linear or logistic regression, which indicated that baPWV was associated with the frequency and duration of blood pressure measurement. Our study was cross-sectional and not etiological. Therefore, a prospective study is needed with additional data.

Table 5. Multivariable logistic regression of baPWV

	OR (95% CI)[a]	Beta	*P* value	OR (95% CI)[b]	Beta	*P* value
	Unadjusted			Adjusted		
M1						
Clinical SBP	2.10 (1.70~2.59)	0.10	< 0.001	2.14 (1.64~2.77)	0.01	< 0.001
Cumulative SBP	1.62 (1.35~1.94)	0.15	< 0.001	1.70 (1.34~2.16)	0.02	< 0.001
24-h SBP	1.29 (1.06~1.56)	0.05	0.010	1.64 (1.28~2.10)	0.05	< 0.001
M2						
Clinic SBP	2.14 (1.74~2.64)	0.35	< 0.001	2.18 (1.68~2.83)	0.03	< 0.001
Cumulative SBP	1.64 (1.37~1.96)	0.27	< 0.001	1.71 (1.35~2.17)	0.01	< 0.001
Daytime SBP	1.22 (1.01~1.47)	0.01	0.042	1.52 (1.19~1.94)	0.27	0.001
M3						
Clinic SBP	2.09 (1.71~2.57)	0.36	< 0.001	2.19 (1.70~2.84)	0.01	< 0.001
Cumulative SBP	1.59 (1.33~1.91)	0.18	< 0.001	1.70 (1.34~2.17)	0.02	< 0.001
Nocturnal SBP	1.41 (1.17~1.71)	0.28	< 0.001	1.76 (1.38~2.25)	0.03	< 0.001
M4						
Clinical SBP	2.16 (1.75~2.67)	0.36	< 0.001	2.21 (1.96~2.88)	0.01	< 0.001
Cumulative SBP	1.60 (1.33~1.92)	0.29	< 0.001	1.71 (1.34~2.17)	0.03	< 0.001
Daytime SBP	0.84 (0.63~1.13)	0.01	0.251	0.96 (0.66~1.40)	0.28	0.847
Nocturnal SBP	1.61 (1.20~2.14)	0.02	0.001	1.81 (1.24~2.46)	0.35	0.002

Note: baPWV (< 1700 assignment is 0, ≥ 1700 assignment is 1) represents the dependent variable; M1: clinical, cumulative, 24-h dynamic SBP (every increase 1-SD) are the independent variables; M2: clinical, cumulative, daytime SBP (every 1-SD) represent independent variables; M3: clinical, cumulative, nocturnal SBP are the independent variables; M4: clinical, cumulative, diurnal and nocturnal SBP are the independent variables; a: unadjusted variable; b: adjustment for age, gender, BMI, FBG, LDL_C, TG, hsCRP, smoking, drinking, exercise, and antihypertensive drugs

Our work supports the close association between clinical or 24-h dynamic SBP with baPWV compared with cumulative SBP. The mechanism has yet to be elucidated. However, we speculate that clinical BP and baPWV were strongly correlated. Berry [16] reported that cfPWV value was determined by the BP measurement levels. Further, several factors affected the cumulative BP and variation in in blood pressure, while 24-h ambulatory blood pressure better reflected the vascular stiffness. Previous studies suggested that [17-19] the 24-h ambulatory blood pressure was superior to the clinical blood pressure in predicting target organ damage or cardiovascular disease.

The study demonstrated a significant association between cumulative blood pressure and target-organ damage. Therefore, elderly individuals should maintain a steady cumulative blood pressure in addition to clinical and 24-h ambulatory blood pressure to reduce the risk of arterial sclerosis. In addition, Vasan [20] suggested that the duration of cumulative blood pressure is a key factor in the prediction of coronary heart disease. Cumulative blood pressure reflects the dynamic BP changes [8, 21] and chronic exposure, [7] which are parameters for further investigation.

In brief, we found that increased clinical, cumulative and 24-h dynamic SBP were risk factors for baPWV, and clinical or 24-h dynamic SBP was closely associated with baPWV compared with cumulative SBP. However, our study still had some limitations. First, we used data from only three physical examinations investigating cumulative SBP, and our results are not robust in correlating cumulative blood pressure and target-organ damage. Second, we failed to determine the mechanism of cumulative SBP and baPWV, and the reasons for the superiority of clinical and nocturnal SBP to cumulative SBP in predicting the value of baPWV ≥ 1700 cm/s. Third, our data deleted several missing values of baPWV. However, we compared the included and excluded individuals, and found no statistical difference between the variables in addition to the gender group.

Therefore, our findings are reliable. Finally, our research subjects included northern popula-

tion, which is not representative of the total population, and therefore cannot be generalized.

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Disclosure of conflict of interest

None.

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