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ORIGINAL ARTICLE

Five-year change in systolic blood pressure is independently associated with carotid atherosclerosis progression: a population-based cohort study

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The aim of this study was to investigate whether long-term changes in traditional risk factors affect the progression of carotid atherosclerosis in a Chinese population. This study included 1590 individuals (aged 56.9 ± 8.1 years) with no evidence of carotid plaque at baseline (2002). In 2007, these individuals completed the second risk factors survey and underwent carotid plaque measurement. The incidence of carotid plaque and the total plaque area of maximum plaques (TPA) were used to evaluate the progression of carotid atherosclerosis. In addition to baseline age, systolic blood pressure (SBP), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), triglyceride (TG), common carotid intima-media thickness (CIMT) and current smoking, a 5-year change in SBP was also associated with the incidence of carotid plaque (odds ratio = 1.01, 95% confidence interval: 1.01–1.02, *P* = 0.029). Furthermore, multiple linear regression analysis revealed that a 5-year change in SBP had a linear association with TPA after adjusting for baseline risk factors (standardized regression coefficient = 0.071, *P* = 0.014). TPA increased both by increasing baseline SBP and by a 5-year SBP change when adjusted for sex, baseline age, TC, HDL-C, CIMT and current smoking (*P* for trend < 0.001 and 0.004). Our study demonstrates that a 5-year change in SBP is independently associated with the progression of carotid atherosclerosis in the Chinese population. These findings underline the importance of early detection and control of SBP for the prevention of atherosclerosis progression. The progression of atherosclerosis is not only associated with hypertension but can also progress silently with the development of SBP.
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Keywords: atherosclerosis; carotid plaque; progression; risk factors; total plaque area

INTRODUCTION

Events due to cardiovascular disease (CVD), including coronary heart disease and stroke, often occur in individuals without prior symptoms.[1] The key element for primary prevention of CVD events is the identification of large numbers of asymptomatic individuals who are clinically free of CVD, but are at a sufficiently high risk for a future CVD event.[2] Atherosclerosis, which is fundamental to the occurrence of CVD, could be reflected by non-invasively evaluating carotid atherosclerosis. Carotid plaque, which is a marker of atherosclerosis, has been shown to be an independent predictor of CVD in asymptomatic populations.[3,4] In a recent meta-analysis, carotid plaques were found to more accurately predict coronary artery disease events than intima-media thickness (IMT),[5] and carotid plaque was considered to be superior to IMT.[6] However, factors associated with the occurrence and development of atherosclerosis in human arteries are still not entirely clear.[7] Several studies have investigated the baseline risk factors associated with future carotid plaque formation and found that baseline age, hypertension, hypercholesterolemia and smoking were significant predictors.[8,9]

Results from clinical trials have found that anti-hypertensive medications and statin therapy can slow the progression of carotid atherosclerosis.[10,11] These observations suggest that changes in blood pressure and lipids could affect the progression of atherosclerosis. These clinical trials demonstrated that a decrease in a risk factor slowed progression. However, the amount of impact that an increase in a particular risk factor could have on the progression of atherosclerosis is largely unknown. We therefore designed a prospective cohort study in a general population to address this question. To our knowledge, few prospective studies have investigated the association between changes in risk factors and the progression of carotid atherosclerosis. We conducted a cohort study in the Chinese population to investigate the association between 5-year (2002–2007) changes in traditional risk factors and the progression of carotid atherosclerosis.

METHODS

Study population

In 2002, we selected two communities (Peking University and Shijingshan communities) in Beijing to construct our research cohort. A total of 1541

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participants from Peking University community were part of the study population in the Chinese Multi-Provincial Cohort Study,[12] in which stratified random sampling for each sex and 10-year age group was performed. A total of 1202 participants from Shijingshan community were part of the study population in the PRC-USA Collaborative Study of Cardiovascular and Cardiopulmonary Epidemiology,[13] in which all age-eligible (35–54 years) men and women in the community were enrolled. All of the 2743 participants gave informed consent and underwent a baseline carotid ultrasound examination between October and November 2002.

Between October and November 2007, we invited all of participants for a second ultrasound examination. Of the 2743 study subjects, 720 individuals were excluded because of a history of CVD ($n=62$), missing laboratory results ($n=27$) or the presence of carotid plaques ($n=631$) at baseline. An additional 433 individuals were excluded because a re-examination was not performed ($n=379$), carotid plaque data were absent from re-examination ($n=14$), laboratory results ($n=37$) or blood pressure data ($n=3$). The remaining 1590 participants with complete data from the two examinations were used for the analysis.

Written informed consent was obtained from all participants. The Fuwai Hospital Ethics Committee and Anzhen Hospital Ethics Committee approved the baseline examination, and the Peking University Health Science Center Ethics Committee approved the second examination.

Risk factor measurement

All surveys were conducted during the same season using the same protocol for risk factor surveys. A standardized questionnaire was used to record demographic data, smoking status, history of diabetes and hypertension, and the use of anti-hypertensive and anti-diabetic medications. Blood pressure was measured from the right arm in the sitting position using a mercury sphygmomanometer. The subjects were instructed to relax as much as possible and not talk during the measurement procedure. Five minutes elapsed before the first reading was taken. The mean value of two consecutive blood pressure readings (an interval of 30 s) was used. All three observers were properly trained in the techniques of blood pressure measurement before starting the survey. Glucose and lipids were measured from overnight fasting venous blood samples. Fasting blood glucose (FBG), triglycerides (TG) and total cholesterol (TC) were determined by an enzymatic method. High-density lipoprotein cholesterol (HDL-C) levels were measured by a homogeneous assay. Low-density lipoprotein cholesterol (LDL-C) levels were measured directly only among individuals with TG $>4.52\,\mathrm{mmol\,l^{-1}}$. In the other participants, LDL-C levels were estimated using the Friedewald equation.[14]

Definition of risk factors

Current smoking was defined as having smoked at least one cigarette per day in the past year. Body mass index was calculated with the following formula: weight (kg) per height (m^2). Hypertension was considered as a systolic blood pressure (SBP) of $\geqslant 140$ mm Hg and/or a diastolic blood pressure (DBP) of $\geqslant 90$ mm Hg, or the use of anti-hypertensive drugs in the past 2 weeks.[15] We defined diabetes as either FBG $\geqslant 7.0\,\mathrm{mmol\,l^{-1}}$ or the use of anti-diabetic therapy in the past month.[16]

Carotid ultrasound protocol

We used the same measurement protocol and definition of carotid plaques at the two ultrasound examinations. The presence of carotid plaques was inspected and measured over an area that included six segments: the far and near walls of the entire common carotid artery, the bifurcations and internal carotid arteries. A carotid plaque was defined as a thickness of $\geqslant 1.3$ mm measured from the media-adventitia interface to the intima-lumen interface, or a focal raised lesion of $\geqslant 0.5$ mm.[17] We used the total plaque area of maximum plaques (TPA) to evaluate the progression of carotid atherosclerosis among individuals with evidence of new carotid plaque formation. As shown in Supplementary Figure 1, the maximum plaque at each segment was measured offline by tracing the perimeter with a cursor on the screen in a longitudinal view, and the area of the plaque was computed using customized software packages (EchoPac, GE Healthcare, Little Chalfont, UK). In individuals with one or more plaques, the areas of all (one to six) maximum plaques were summed to give the TPA. The maximum IMT values at the far walls of the common carotid artery were measured, and the mean-maximum common carotid IMT (CIMT) was used for analysis.

Reproducibility study

Three independent reproducibility studies, using the same protocol, were conducted to evaluate the intra-observer and inter-observer agreement for the presence or absence of plaques in the same segment. Image sequences were selected to be analyzed twice by the same observer (1 week apart), and they were also analyzed once by another observer. First, a baseline reproducibility study was conducted in a random sample of 50 participants from the original cohort. Inter-observer agreement was associated with a κ-value of 0.69 and intra-observer agreement with a κ-value of 0.76.[3] Second, at the re-examination, we relied on a single experienced sonographer to read all ultrasound images and make judgments about the presence of carotid plaques. A re-examination reproducibility study was performed in a random sample of 20 individuals from the cohort. The intra-observer agreement was associated with a κ-value of 1.00. Additionally, considering that the observers were different between the two examinations, we conducted a third independent reproducibility study to evaluate the consistency between the two ultrasound examinations. A single observer in the re-examination was required to read images from 76 individuals that were randomly selected from the baseline examination. The inter-observer agreement had a κ-value of 0.69.

Statistical analysis

Continuous variables were expressed as the mean ± s.d. and categorical variables were presented as counts (percentages). The paired-sample *t*-test or the McNemar paired χ^2-test was used to compare the means or percentages between the two examinations.

Stepwise logistic regression (entry, 0.05; removal, 0.05) was used to explore the effect of traditional risk factors and their changes on the incidence of carotid plaque. Stepwise multiple linear regression (entry, 0.05; removal, 0.05) was used to analyze the linear association between traditional risk factors and their changes and TPA. The distribution of TPA among individuals was skewed to the left, and natural logarithmic transformation of TPA was performed before linear regression. TPA by baseline SBP and SBP change was also calculated to explore whether the change in SBP could be independently associated with atherosclerosis progression. The mean values of TPA were adjusted for sex, baseline age, TC, HDL-C, CIMT and current smoking by using the analysis of covariance. Subgroup analyses were conducted to evaluate whether 5-year SBP change had a different predictive power for carotid atherosclerosis progression between individuals with and those without hypertension at baseline.

Statistical analyses were performed using SAS software, version 9.2 (SAS Institute Inc., Cary, NC, USA). All analyses were two-sided with a *P*-value of 0.05 considered to indicate statistical significance.

RESULTS

Five-year progression of carotid atherosclerosis

A total of 1590 individuals, 993 women and 597 men, with a mean (s.d.) age of 56.9 ± 8.1 years, were enrolled in this study. As shown in Table 1, the incidence of carotid plaque was 45.5% in women, 54.9% in men, and 49.1% overall. Table 1 also describes the age and sex distribution of TPA that increased by age in both men and women. Moreover, the respective incidence of carotid plaque at each segment is shown in Supplementary Table. The incidence at bifurcation is much higher than that at common carotid artery and internal carotid artery.

Risk factors at baseline and at re-examination

Baseline and re-examination characteristics of this study population are summarized in Table 2. Mean SBP, DBP, pulse pressure, TG, FBG and the prevalence of hypertension and diabetes mellitus were all significantly higher at re-examination than at baseline in both men

Table 1 Five-year progression of carotid atherosclerosis by baseline age and sex

	Incidence (%) of carotid plaque				*Total plaque area (mm^2)*			
	Women		*Men*		*Women*		*Men*	
Age (years)	N	n (%)	N	n (%)	N	*TPA*	N	*TPA*
<50	271	79 (29.2)	153	70 (45.8)	271	18.00 ± 9.27	153	24.07 ± 21.59
50–59	387	167 (43.2)	181	93 (51.4)	387	19.49 ± 12.02	181	28.43 ± 28.06
⩾60	335	206 (61.5)	263	165 (62.7)	335	24.72 ± 20.00	263	33.04 ± 32.25
Total	993	452 (45.5)	597	328 (54.9)	993	20.85 ± 14.91	597	29.35 ± 28.76

Table 2 Characteristics of study participants at baseline (2002) and at re-examination (2007)

	Women (N = 993)		*Men (N = 597)*		*Total (N = 1590)*	
Characteristic[a]	*2002*	*2007*	*2002*	*2007*	*2002*	*2007*
Age, years	56.4 ± 7.7	61.4 ± 7.7	57.8 ± 8.6	62.8 ± 8.6	56.9 ± 8.1	61.9 ± 8.1
SBP, mm Hg	127.8 ± 19.4	134.5 ± 18.5[b]	131.2 ± 18.1	136.8 ± 17.4[b]	129.1 ± 19.0	135.3 ± 18.1[b]
DBP, mm Hg	77.6 ± 10.0	80.5 ± 10.0[b]	82.8 ± 10.5	84.1 ± 10.1[b]	79.6 ± 10.5	81.9 ± 10.2[b]
PP, mm Hg	50.2 ± 14.6	53.9 ± 13.4[b]	48.4 ± 14.0	52.7 ± 12.7[b]	49.5 ± 14.4	53.5 ± 13.1[b]
TC, mmol l^{-1}	5.36 ± 1.03	5.51 ± 1.00[b]	5.16 ± 0.92	5.05 ± 0.86[b]	5.28 ± 1.00	5.34 ± 0.98[b]
LDL-C, mmol l^{-1}	3.51 ± 0.94	3.31 ± 0.86[b]	3.48 ± 0.89	3.15 ± 0.79[b]	3.50 ± 0.92	3.25 ± 0.84[b]
HDL-C, mmol l^{-1}	1.37 ± 0.32	1.40 ± 0.24[b]	1.24 ± 0.28	1.25 ± 0.23	1.32 ± 0.31	1.34 ± 0.25[b]
TG, mmol l^{-1}	1.53 ± 0.98	1.82 ± 1.16[b]	1.55 ± 1.03	1.73 ± 1.40[b]	1.54 ± 1.00	1.79 ± 1.26[b]
FBG, mmol l^{-1}	4.95 ± 1.09	5.80 ± 1.39[b]	5.06 ± 1.39	5.90 ± 1.36[b]	4.99 ± 1.21	5.84 ± 1.38[b]
BMI, kg m^{-2}	25.6 ± 3.6	25.5 ± 3.6	25.5 ± 3.1	25.2 ± 3.1	25.5 ± 3.4	25.4 ± 3.4
Current smoking	64 (6.5)	54 (5.4)[b]	205 (34.3)	181 (30.3)[b]	269 (16.9)	235 (14.8)[b]
Hypertension	396 (39.9)	516 (52.0)[b]	290 (48.6)	353 (59.1)[b]	686 (43.1)	869 (54.7)[b]
Diabetes	70 (7.1)	135 (13.6)[b]	36 (6.0)	82 (13.7)[b]	106 (6.7)	217 (13.7)[b]

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; FBG, fasting blood glucose; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; PP, pulse pressure; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides.
[a]Continuous variables were expressed as mean ± s.d. and categorical variables were presented as counts (percentages).
[b]$P<0.05$, compared with the value at baseline (2002) by using the paired-sample *t*-test or the McNemar paired χ^2-test.

and women. In contrast, mean LDL-C and the prevalence of current smoking were significantly lower at re-examination than at baseline in men and women. Mean TC increased during 5 years in women but decreased in men compared with baseline (Table 2).

Five-year changes in traditional risk factors and carotid atherosclerosis progression

Table 3 shows that in addition to baseline age, SBP, TC, HDL-C, TG, CIMT and current smoking, a 5-year change in SBP was also associated with the incidence of carotid plaque. Further, Table 4 shows that a 5-year change in SBP has a linear association with TPA after adjusting for baseline risk factors.

We also analyzed the association between pulse pressure and the progression of carotid atherosclerosis (Supplementary Tables 2 and 3), and found that the 5-year change in pulse pressure was independently associated with TPA but not with the incidence of carotid plaques.

Association between SBP change and TPA by baseline SBP

As shown in Figure 1, TPA increased both by increasing baseline SBP and by a 5-year SBP change when adjusted for sex, baseline age, TC, HDL-C, CIMT and current smoking (*P* for trend <0.001 and 0.004). The interaction between baseline SBP and SBP change was not significant ($P = 0.154$).

Subgroup analyses

Among 904 individuals without hypertension at baseline, the 5-year change in SBP was significantly associated with the occurrence of new carotid plaques ($P = 0.043$) and was also associated with the total plaque area of new plaques ($P = 0.015$, Table 5). However, baseline SBP could not be entered into multiple logistic and linear regression models. Conversely, among 686 individuals with hypertension at baseline, the 5-year change in SBP change was not significantly associated with the occurrence of new plaques or total plaque area, but baseline SBP was associated with these variables ($P = 0.018$ and 0.012, Table 5).

DISCUSSION

The primary finding in our study was that in addition to baseline age, SBP, TC, HDL-C, TG, CIMT and current smoking, a 5-year change in SBP was also associated with the carotid atherosclerosis progression in our study population. To the best of our knowledge, this is the first study to investigate the association between changes in risk factors and the progression of carotid atherosclerosis in a general population.

Table 3 ORs of traditional risk factors and their changes for the incidence of carotid plaque, results from stepwise logistic regression (entry, 0.05; removal, 0.05)

Variables in the model[a]	β	*OR (95% CI)*	P-*value*
Risk factors at baseline			
Age, years	0.039	1.04 (1.02–1.06)	<0.001
SBP, mm Hg	0.019	1.02 (1.01–1.03)	<0.001
TC, mmol l^{-1}	0.472	1.60 (1.40–1.84)	<0.001
HDL-C, mmol l^{-1}	−1.041	0.35 (0.23–0.55)	<0.001
TG, mmol l^{-1}	−0.208	0.81 (0.71–0.93)	0.003
CIMT, mm	1.309	3.70 (1.91–7.17)	<0.001
Current smoking, 1 = yes and 0 = no	0.470	1.60 (1.18–2.16)	0.002
Five-year change			
SBP, mm Hg	0.009	1.01 (1.01–1.02)	0.029

Abbreviations: BMI, body mass index; CI, confidence interval; CIMT, common intima-media thickness; FBG, fasting blood glucose; HDL-C, high-density lipoprotein cholesterol; OR, odds ratio; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides.
[a]Sex, baseline age, SBP, TC, HDL-C, TG, FBG, BMI, CIMT, current smoking and anti-hypertensive medication use, and 5-year changes in SBP, TC, HDL-C, TG, FBG and BMI entered logistic regression model using the stepwise selection method.

Table 4 Predictors of total plaque area at follow-up in stepwise multiple linear regression analysis (entry, 0.05; removal, 0.05)

Variables in the model[a]	β[b]	R^2	P-*value*
Risk factors at baseline			
Age, years	0.071	0.003	<0.001
Sex, 1 = male and 0 = female	0.095	0.018	<0.001
SBP, mm Hg	0.147	0.022	<0.001
TC, mmol l^{-1}	0.129	0.012	<0.001
HDL-C, mmol l^{-1}	−0.123	0.014	<0.001
CIMT, mm	0.161	0.051	<0.001
Current smoking, 1 = yes and 0 = no	0.067	0.004	0.015
5-year change			
SBP, mm Hg	0.071	0.004	0.014
Summarized model R^2		0.127	

Abbreviations: BMI, body mass index; CIMT, common intima-media thickness; FBG, fasting blood glucose; HDL-C, high-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides.
[a]Sex, baseline age, SBP, TC, HDL-C, TG, FBG, BMI, CIMT, current smoking and anti-hypertensive medication use, and 5-year changes in SBP, TC, HDL-C, TG, FBG and BMI entered multiple linear regression model using the stepwise selection method.
[b]Standardized regression coefficients.

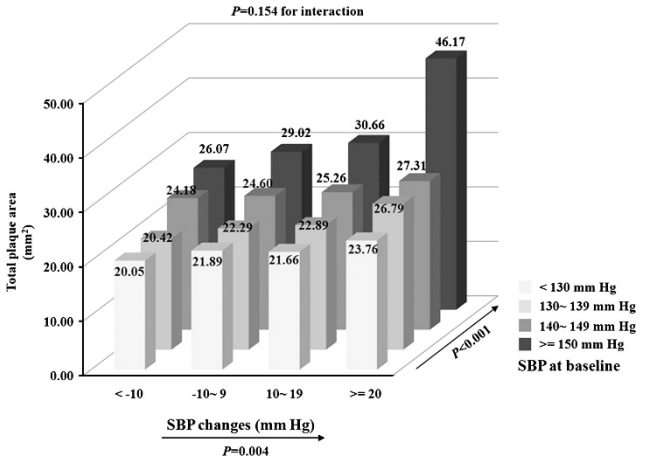

Figure 1 The mean values (mm^2) of the total plaque area by baseline systolic blood pressure (SBP) and 5-year SBP change by using the analysis of covariance, adjusted for sex, baseline age, total cholesterol, high-density lipoprotein cholesterol, common carotid intima-media thickness and current smoking. A full color version of this figure is available at *Hypertension Research* online.

These findings underline the importance of early detection and control of SBP for the prevention of atherosclerosis progression. The progression of atherosclerosis is not only associated with hypertension, but can also develop silently in the face with increasing SBP.

Carotid plaque formation represents a later stage in the development of atherosclerosis that is related to the oxidation of lipids, transmigration and infiltration of monocytes and lymphocytes, inflammation, and smooth muscle cell proliferation.[18] Thickening of intima-media layer is usually caused by smooth muscle cell hypertrophy in the media layer. However, the progression of atherosclerosis, particularly in its early phase, is restricted to the intimal layer. Recently, Spence[6] suggested that carotid plaque measurement is superior to IMT. First, the former was a stronger predictive index for myocardial infarction and stroke than the latter.[19,20] Second, TPA provided more detailed information about atherosclerosis progression than IMT because the longitudinal growth of plaque along the carotid axis of flow occurred at twice the rate of thickening toward the lumen.[21] Finally, the dynamic scale range of TPA was much wider than that of IMT.[6]

The Mannheim Carotid IMT and Plaque Consensus also emphasized the importance of carotid plaque measurement, and recommended that plaque location, thickness, area and number should be recorded.[22] In this study, we used the incidence of carotid plaque and the TPA of maximum plaques to evaluate the progression of carotid atherosclerosis. However, unlike the TPA suggested by Spence *et al.*,[23] we did not measure the areas for all plaques, but only for those maximum plaques according to Tromsø Study.[24]

The present study demonstrates that baseline age, SBP, TC, HDL-C, TG, CIMT and current smoking are independent predictors of future carotid plaque development. This is consistent with previous findings from five large-scale and population-based prospective studies conducted in European countries (Germany, Italy, France, Norway and the Netherlands).[9,25–28] Few similar cohort studies have been conducted among the East Asian population, for whom stroke rather than coronary heart disease is the predominant type of CVD. A cross-sectional study conducted in 8144 Japanese individuals found hypertension to be the greatest contributor to the formation of carotid plaque.[29] To our knowledge, this is the first study to investigate the risk factors associated with carotid atherosclerosis progression in a general Chinese population.

In this study, a 5-year change in SBP had a relatively weak association with the progression of carotid atherosclerosis compared with baseline SBP and other risk factors. This finding suggests that the short-term effect of a change in SBP on the progression of atherosclerosis is less than the effect of baseline SBP that may represent a long-term effect on atherosclerosis. Our finding also indicated that maintaining SBP at optimal levels is essential because individuals with long-term optimal SBP levels had the lowest progression of atherosclerosis. Additionally, it is never too late to initiate control of SBP because individuals with a small increase in SBP in the short-term had less progression of atherosclerosis compared with those with large increases in SBP.

Table 5 Predictive powers of baseline SBP and 5-year SBP change for new carotid plaque occurrence and total plaque area at follow-up, results from stepwise multiple logistic and linear regression analysis (entry, 0.05; removal, 0.05)[a], by with or without hypertension at baseline

	Without baseline hypertension (N = 904)				*With baseline hypertension (N = 686)*			
	Logistic regression		*Linear regression*		*Logistic regression*		*Linear regression*	
	OR (95% CI)	P-*value*	β[b]	P-*value*	*OR (95% CI)*	P-*value*	β[b]	P-*value*
Baseline SBP	/[c]	/	/	/	1.01 (1.00–1.02)	0.018	0.121	0.012
Five-year SBP change	1.01 (1.00–1.02)	0.043	0.081	0.015	/	/	/	/

Abbreviations: BMI, body mass index; CI, confidence interval; CIMT, common intima-media thickness; FBG, fasting blood glucose; HDL-C, high-density lipoprotein cholesterol; OR, odds ratio; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides.
[a]Sex, baseline age, SBP, TC, HDL-C, TG, FBG, BMI, CIMT, current smoking and anti-hypertensive medication use, and 5-year changes in SBP, TC, HDL-C, TG, FBG and BMI entered logistic regression or linear regression model using the stepwise selection method.
[b]Standardized regression coefficients.
[c]Indicates that the variable cannot enter into the model at the significant level of 0.05.

In addition, our study found that pseudo-R^2 from the logistic regression (Table 3) was 0.124 and R^2 from the linear regression (Table 4) was 0.127, indicating that further research is needed to explore and identify the underlying risk factors for the occurrence and development of atherosclerosis in human arteries.

Our study has several limitations. First, 433 individuals with complete baseline data were excluded from the study because either they did not undergo a re-examination or re-examination data were missing. As a result, the possibility of selection bias exists. This group of excluded participants was older (58.5 ± 8.2 years) and had healthy LDL-C, HDL-C and body mass index levels. Nevertheless, the differences in SBP, DBP and the prevalence of hypertension were not significant (Supplementary Table 4). Therefore, we believe that selection bias should not affect our primary findings. Second, despite showing an association between a 5-year change in SBP and the progression of carotid atherosclerosis, we could not confirm that the former predicted the latter because it could not be determined with certainty whether a change in SBP preceded the development of atherosclerosis. Third, we did not consider the effect of statin therapy on the change in LDL-C status because we did not collect information on the use of lipid-lowering medications at baseline in the PRC-USA Collaborative Study. According to the information collected at re-examination, however, only eight individuals (1.4%) reported having taken statins. Therefore, even though we failed to consider statin therapy at the outset of our study, the effect on our results should have been limited.

In conclusion, our study demonstrates that in addition to baseline age, SBP, TC, HDL-C, TG, CIMT and current smoking, 5-year change in SBP was also associated with the progression of carotid atherosclerosis. The progression of atherosclerosis is not only dependent on the presence of hypertension but also silently influenced by increases in SBP.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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