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ORIGINAL ARTICLE

Serum lipid/lipoprotein and arterial blood pressure among Chinese nonagenarians/centenarians

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Abstract

Objective. In the present study, we detected a relationship between serum lipid/lipoprotein [serum triglyceride (TG), total cholesterol (TC), low-density lipoprotein (LDL)-cholesterol and high-density lipoprotein (HDL)-cholesterol] and arterial blood pressure among Chinese nonagenarians/centenarian. *Methods*. The present study analyzed data from the survey that was conducted on all residents aged 90 years or more in a district; there were 2,311,709 inhabitants in 2005. Arterial blood pressure included systolic blood pressure (SBP) and diastolic blood pressure (DBP). *Results*. The subjects included in the statistical analysis were 217 men and 444 women. Subjects with hypertension (1.29 ± 0.74 vs 1.13 ± 0.45, $t = 3.362$, $p = 0.001$) or systolic hypertension (1.30 ± 0.74 vs 1.12 ± 0.45, $t = 3.534$, $p < 0.0001$) had higher levels of TG than those without. Subjects with abnormal levels of serum TG had higher SBP (145 ± 22 vs 139 ± 23, $t = 2.223$, $p = 0.027$). The Pearson correlation showed a significant relationship between SBP and serum TG levels ($r = 0.088$, $p = 0.024$). Unadjusted and adjusted multiple logistic regressions showed that hypertension or systolic hypertension was associated with an increased risk of abnormal of serum TG levels. *Conclusions*. In summary, we found that among Chinese nonagenarians and centenarians, the levels of serum lipid/lipoprotein were associated with arterial blood pressure. Hypertriglyceridemia was associated with SBP.

Key Words: *Arterial blood pressure, nonagenarians/centenarians, serum lipid/lipoprotein*

Introduction

Dyslipidemia and hypertension occurred together more often than could be explained by chance (1–3). Atherogenic dyslipidemias could lead to hypertension by several mechanisms. First, atherosclerosis could result in structural changes in large conduit arteries, leading to reduced elasticity (4). Second, endothelial dysfunction related to lipid abnormalities (5–7), resulting in reduced nitric oxide production, release, and activity and abnormal vasomotor activity, could manifest as hypertension (8). Endothelium-dependent vasodilatation was impaired by elevated total cholesterol (TC) levels (9). Third, lipid-mediated damage to the renal microvasculature could manifest as hypertension, illustrated by an association between lipid abnormalities and early renal dysfunction (10). On the other hand, dyslipidemia and hypertension represent two of several components of the metabolic syndrome that might share common mechanistic pathways (11,12). Hypertension and dyslipidemia were both major risk factors for the development of cardiovascular disease (CVD) (1).

Dyslipidemia as a risk of hypertension (4–7), both dyslipidemia and hypertension as components of the metabolic syndrome (11,12), hypertension and dyslipidemia as risk factors of CVD (1), the associations of cognitive function with hypertension and dyslipidemia in long-lived subjects being different from those in general population (13,14), and hypertension and dyslipidemia both relating with age have all been confirmed (15) . From all of these, we can conclude that in the long-lived subjects (aged 90 years or more), there is close association between hypertension and dyslipidemia, which may be different from that in general older adults (aged 60 years or more). However, to date, few studies have examined it. Using data from a sample of Chinese nonagenarians and centenarians, we examined the association

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between hypertension and dyslipidemia in the long-lived subjects.

Subjects and methods

Study subjects

The methods were reported previously (13,14). In brief, on the basis of the Dujiangyan (located in Sichuan province, southwest China) 2005 census, a cross-sectional study for age-related diseases was conducted in 870 long-lived subjects (>90 years), which was a part of the Project of Longevity and Aging in Doujiangyan (PLAD). The PLAD aimed to investigate the relationship between environments, lifestyle, genetic, longevity and age-related diseases. Volunteers were examined by trained professional physicians according to basic health criteria, and the results were filled in the standard form. In this analysis, long-lived subjects with cancer, secondary hypertension, severe heart failure and terminal stage of chronic obstructive pulmonary disease were excluded. The subjects, who had no biological specimen for measurement levels serum lipid/lipoprotein, or reported the use of drugs affecting the serum lipid/lipoprotein levels and arterial blood pressure, were also excluded. The study population ultimately consisted of 661 long-lived subjects. Informed consents were obtained from all participants (as well as their legal proxies). The Research Ethics Committee of the Sichuan University approved the study.

Data collection and measurements

Measurement of blood pressure. The methods were reported previously (13). In a sitting or recumbent position, right arm blood pressure (BP) was measured twice to the nearest 2 mmHg using a standard mercury sphygmomanometer (Korotkoff phases I and V) by trained nurses or physicians. The mean value of two measurements was used to calculate systolic BP (SBP) and diastolic BP (DBP), and the SBP and DBP were calculated as the mean of right and left arm values in exceptional subjects. The mean of two readings was used for classification of BP according to Joint National Committee (JNC) VII criteria into normal (SBP <120 mmHg and DBP <80 mmHg), pre-hypertension (SBP 120–139 mmHgand/or DBP 80–89 mmHg), stage 1 hypertension(SBP 140–159 mmHg and/or DBP 90–99 mmHg), stage 2 hypertension (SBP >160 mmHg and/or DBP >100 mmHg), systolic hypertension was defined as an SBP >140 mmHg, isolated systolic hypertension (ISH) was defined as an SBP >140 mmHg and a DBP <90 mmHg, diastolic hypertension was defined as a DBP >90 mmHg, and isolated diastolic hypertension (IDH) was defined as an SBP <140 mmHg and a DBP >90 mmHg. Hypertension was defined as an SBP >140 mmHg and/or a DBP >90 mmHg and/or receiving anti-hypertensive treatment. Subjects with confirmed hypertension and no identified cause of secondary hypertension were diagnosed with essential hypertension.

Measurement of serum lipid/lipoprotein. The methods were reported previously (14). Blood samples were collected after an overnight fast (at least 8 h) for measurement of serum lipid/lipoprotein. Lipid/lipoprotein levels including serum triglyceride (TG), TC, low-density lipoprotein (LDL) and high-density lipoprotein (HDL) were determined by standard laboratory techniques (performed by a technician in the biochemistry laboratory of Sichuan University). Abnormal levels of serum lipid/lipoprotein were defined according to the criteria provided by the Chinese Medical Association (2004). Abnormal criteria were: TC >5.18 mmol/l, TG >1.7 mmol/l, LDL >3.37 mmol/l and HDL <1.04 mmol/l.

Assessment of covariates

Trained study personnel carried out the face-to-face interviews; participants underwent a standardized enquiry for the self-reported medical history, medication and standardized physical examination, based on the prepared questionnaire for the medical record. We obtained information on: age (years), gender (female/male), body mass index (kg/m^2, BMI), habits of smoking, alcohol consumption, tea consumption and exercise. BMI was calculated as body weight in kilograms divided by height in meters squared. Habits of smoking, alcohol consumption, tea consumption and exercise, which included former and current, were collected by using a general questionnaire. In the questionnaire, every item had two options (yes or no). Fasting blood glucose (FBG) and serum uric acid (SUA) were detected by standard laboratory techniques (performed by a technician in the biochemistry laboratory of Sichuan University).

Statistical analysis

All of the statistical analyses for this study were performed with the SPSS for Windows software package, version11.5 (SPSS Inc, Chicago, IL, USA). Baseline characteristics were compared between those with and without prevalent abnormal levels of serum lipid/lipoprotein or between those with and without hypertension using χ^2 or Fisher's exact test (where an expected cell count was <5) for categorical variables and unpaired Student's *t*-test for continuous variables. Pearson correlation was used to assess relationship between levels of serum lipid/lipoprotein and arterial blood pressure. Multiple logistic regression was used to estimate the odds ratio (OR) and 95% confidence interval (CI) of hypertension as a function of increased abnormal levels of

serum lipid/lipoprotein. To assess the association between hypertension and levels of serum lipid/lipoprotein that demographic and clinical factors do not explain, multivariate-adjusted ORs were calculated for each hypertension. Considering meanings of systolic and diastolic blood pressure were different in older subjects, statistical analyses were performed, respectively. A p-value < 0.05 was considered statistically significant, and all of the p-values have two sides.

Results

Prevalence of abnormal serum lipid/lipoprotein and hypertension

Among the 661 participants, mean age was 93.51 years, 69 were centenarians and 444 were women. Ninety percent of participants lived in the countryside. The mean (± SD) SBP and DBP in the population were 139.93 ± 22.88 mmHg and 72.00 ± 12.06 mmHg. There were 150 (22.7%) subjects with normal arterial blood pressure, 133 (20.1%) with pre-hypertension, 216 (32.7%) with stage 1 hypertension, 162 (24.5%) with stage 2 hypertension, 364 (55.1%) with systolic hypertension and 86 with (13.0%) with diastolic hypertension, 292 (44.2%) with isolated systolic hypertension, and 14 (2.1%) with isolated diastolic hypertension.

Among the sample, the means of serum lipid/lipoprotein were 4.15 ± 0.85 mmol/l, 1.22 ± 0.64 mmol/l, 2.28 ± 0.97 mmol/l, 1.58 ± 0.59 mmol/l for TC, TG, LDL and HDL, respectively. According to TC, TG, LDL and HDL, the prevalence of abnormal serum lipid/lipoprotein were 75 (11.3%), 89 (13.5%), 35 (5.3%) and 37 (5.6%), respectively.

Baseline characteristics according to hypertension and abnormal serum lipid/lipoprotein

In order to examine the association of the main demographic and clinical characteristics with hypertension, the means (or percentages) of various demographic and clinical characteristics grouped by arterial blood pressure were given in Table I. There were significantly higher BMI in subjects with hypertension and systolic hypertension than those without (19.49 ± 3.85 vs 18.44 ± 3.25, $t = 3.672$, $p < 0.0001$; 19.50 ± 3.88 vs 18.49 ± 3.24, $t = 3.510$, $p < 0.0001$ for hypertension and systolic hypertension, respectively). There were no significant differences in the other covariates (age, smoking habits, alcohol consumption, tea consumption, exercise, FBG and SUA).

In order to examine the association of the main demographic and clinical characteristics with serum lipid/lipoprotein, the means (or percentages) of various demographic and clinical characteristics grouped by serum lipid/lipoprotein level were given in Table II. There were significantly higher SUA (320 ± 87 vs 299 ± 81, $t = 1.930$, $p = 0.047$) and younger in age (92.52 ± 2.42 vs 93.65 ± 3.45, $t = 2.736$, $p = 0.006$) in subjects with abnormal level of TC, higher BMI (20.59 ± 3.81 vs 18.81 ± 3.56, $t = 4.278$, $p < 0.0001$) in subjects with abnormal level of TG, higher BMI (20.71 ± 4.08 vs 18.96 ± 3.59, $t = 2.778$, $p = 0.006$), younger in age (92.05 ± 2.08 vs 93.60 ± 3.41, $t = 2.577$, $p = 0.008$), more in women (6.97% vs 5.00%, $\chi^2 = 4.077$, $p = 0.043$) in subjects with abnormal level of LDL, and higher SUA (346 ± 118 vs 317 ± 85, $t = 1.911$, $p = 0.052$) in subjects with abnormal level of HDL.

Relationship between serum lipid/lipoprotein levels and arterial blood pressure

There was higher level of serum TG in subjects with hypertension and systolic hypertension than those without (1.29 ± 0.74 vs 1.13 ± 0.45, $t = 3.362$, $p = 0.001$; 1.30 ± 0.74 vs 1.12 ± 0.45, $t = 3.534$, $p < 0.0001$), subjects with diastolic hypertension had higher TC levels than without (4.36 ± 0.79 vs 4.12 ± 0.85, $t = 2.476$, $p = 0.014$). The other serum lipid/lipoprotein levels were no different between subjects with and without hypertension, systolic hypertension or diastolic hypertension.

Subjects with abnormal level of serum TG had higher SBP (145 ± 22 vs 139 ± 231, $t = 2.223$, $p = 0.027$) and a higher prevalence of hypertension (71.91% vs 54.89%, $\chi^2 = 9.107$, $p = 0.003$) than those with normal. Subjects with abnormal level of serum LDL had a higher DBP (76 ± 10 vs 72 ± 12, $t = 1.905$, $p = 0.048$). None of the differences in SBP, DBP and the prevalence of hypertension between subjects with and without abnormal TC and HDL was significant (Table II).

Pearson correlation showed that there was a significant relationship between SBP and serum TG levels ($r = 0.088$, $p = 0.024$); none of the associations of SBP with the other serum lipid/lipoprotein levels, and none of the associations of DBP with these serum lipid/lipoprotein levels was significant (Table III).

Unadjusted and adjusted the clinical factors, which might be associated with levels of serum lipid/lipoprotein or hypertension, and multiple logistic regressions showed that hypertension and systolic hypertension had a function of increased abnormal TG, but not of increased other abnormal serum lipid/lipoprotein levels. (Table IV).

Discussion

This study evaluated the association between serum lipid/lipoprotein and arterial blood pressure in the long-lived subjects. Among Chinese nonagenarians and centenarians, levels of serum lipid/lipoprotein

Table I. Baseline characteristics according to arterial blood pressure (n = 661).

Characteristics	Arterial blood pressure				SBP				DBP			
	Normal (n = 283)	Abnormal (n = 378)	χ^2 or MD	p-value	Normal (n = 297)	Abnormal (n = 364)	χ^2 or MD	p-value	Normal (n = 575)	Abnormal (n = 86)	χ^2 or MD	p-value
Age (years)	93.52 ± 3.29	93.51 ± 3.43	0.032	0.971	93.48 ± 3.29	93.54 ± 3.43	0.247	0.9805	93.47 ± 3.29	93.77 ± 3.43	0.772	0.440
Gender[a]												
Male/female	100/183	116/262	1.671	0.209	107/190	109/255	2.854	0.096	191/383	25/261	0.601	0.463
TG (mmol/l)	1.13 ± 0.45	1.29 ± 0.74**	3.362	0.001	1.12 ± 0.45	1.30 ± 0.74**	3.534	<0.0001	1.22 ± 0.65	1.24 ± 0.54	0.818	0.231
TC (mmol/l)	4.10 ± 0.82	4.19 ± 0.87	1.347	0.178	4.10 ± 0.82	4.19 ± 0.87	1.131	0.184	4.12 ± 0.85	4.36 ± 0.79*	2.476	0.014
HDL (mmol/l)	1.58 ± 0.61	1.57 ± 0.57	0.759	0.222	1.58 ± 0.61	1.57 ± 0.57	0.759	0.222	1.57 ± 0.61	1.60 ± 0.38	0.346	0.729
LDL (mmol/l)	2.21 ± 0.59	2.32 ± 1.17	1.463	0.144	2.21 ± 0.59	2.32 ± 1.19	1.424	0.155	2.26 ± 1.01	2.38 ± 0.59	1.080	0.281
FBG (mmol/l)	4.52 ± 1.52	4.42 ± 1.40	0.795	0.427	4.52 ± 1.52	4.42 ± 1.40	0.927	0.354	4.48 ± 1.52	4.57 ± 1.40	0.716	0.474
SUA (μmol/l)	321.17 ± 92.73	316.88 ± 82.53	0.623	0.534	321.99 ± 92.53	31604 ± 82.25	0.873	0.383	319.33 ± 87.91	314.70 ± 81.18	0.460	0.646
BMI	18.44 ± 3.25	19.49 ± 3.85**	3.672	<0.0001	18.49 ± 3.24	19.50 ± 3.88**	3.510	<0.0001	19.00 ± 3.56	19.33 ± 4.13	0.452	0.345
Smoking habits												
Former (no/yes)[a]	179/97	220/150	2.695	0.260	191/99	208/148	2.566	0.084	348/213	51/34	0.281	0.869
Current (no/yes)[a]	157/126	209/167	0.01	0.978	161/136	205/157	0.387	0.534	317/257	46/39	0.176	0.726
Alcoholic												
Former (no/yes)[a]	170/109	216155/	0.486	0.519	176/117	210/147	0.103	0810	345/223	41/41	3.426	0.071
Current (no/yes)[a]	211/72	271/104	0.432	0.534	222/75	260/101	0.618	0.479	425/149	57/27	1.431	0.237
Tea habits												
Former (no/yes)[a]	150/126	204/165	0.056	0.853	155/135	299/156	0.438	0.525	315/248	43/39	2.304	0.156
Current (no/yes)[a]	159/124	222/155	0.484	0.524	164/133	217147/	1.392	0.268	337/238	44/41	0.233	0.241
Exercise habits												
Former (no/yes)[a]	184/92	243/124	0.015	0.904	154/95	233/121	0.122	0.738	374/187	29/53	0.132	0.904
Current (no/yes)[a]	117/108	214/161	1.179	0.297	177/115	208/154	0.666	0.425	336/233	49/36	0.060	0.814

Baseline characteristics were compared between different arterial blood pressure groups. *$p < 0.05$, **$p < 0.01$ vs normotension. Using χ^2 or Fisher's exact test (where [a]an expected cell count was <5) for categorical variables and unpaired Student's t-test for continuous variables. In the testing, a p-value <0.05 was considered statistically significant. MD, mean difference; SUA, serum uric acid; BMI, body mass index; FBG, fasting blood glucose; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TC, total cholesterol; TG, triglyceride; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table II. Baseline characteristics according to abnormal serum lipid/lipoprotein (n = 661).

	TC				TG				LDL				HDL			
Characteristics	Normal (n = 586)	Abnormal (n = 75)	χ^2 or MD	p-value	Normal (n = 572)	Abnormal (n = 89)	χ^2 or MD	p-value	Normal (n = 626)	Abnormal (n = 35)	χ^2 or MD	p-value	Normal (n = 624)	Abnormal (n = 37)	χ^2 or MD	p-value
Age (years)	93.65 ± 3.45	92.52 ± 2.42**	2.736	0.006	93.54 ± 3.36	93.35 ± 2.92	0.509	0.611	93.60 ± 3.41	92.05 ± 2.08**	2.577	0.0080	93.50 ± 3.36	94.03 ± 3.51	0.947	0.344
Gender[a]																
Male/female	195/391	21/54	0.859	0.433	191/381	25/64	1.005	0.314	210/416	6/29*	4.077	0.043	201/423	15/22	1.087	0.367
Blood pressure																
Norm/hyper	254/332	29/46	0.594	0.460	258/314	25/64**	9.107	0.003	270/356	13/22	0.485	0.599	272/352	11/26	2.741	0.123
FBG (mmol/l)	4.48 ± 1.46	4.35 ± 1.33	0.830	0.447	4.46 ± 1.44	4.51 ± 1.49	0.311	0.984	4.47 ± 1.48	4.26 ± 0.81	0.831	0.406	4.44 ± 1.41	4.89 ± 2.50	1.827	0.069
SUA (μmol/l)	299 ± 81	320 ± 87*	1.930	0.047	332 ± 84	317 ± 105	1.527	0.127	319 ± 87	306 ± 79	0.897	0.370	317 ± 85	346 ± 118*	1.911	0.052
SBP (mmHg)	140 ± 23	141 ± 23	0.434	0.503	139 ± 23	145 ± 22*	2.223	0.027	140 ± 23	142 ± 23	0.656	0.512	140 ± 23	143 ± 20	0.980	0.327
DBP (mmHg)	72 ± 12	74 ± 13	0.698	0.486	73 ± 12	73 ± 12	0.179	0.858	72 ± 12	76 ± 10*	1.905	0.048	73 ± 12	73 ± 13	0.134	0.893
BMI	19.00 ± 3.52	19.39 ± 4.40	0.858	0.391	18.81 ± 3.56	20.59 ± 3.81**	4.278	<0.0001	18.95 ± 3.59	20.71 ± 4.08**	2.753	0.006	19.02 ± 3.66	19.39 ± 3.37	0.588	0.557
Smoking habits																
Former (no/yes)[a]	215/357	32/42	1.018	0.601	210/352	37/47	0.532	0.440	232/379	10/25	0.392	0.822	236/373	11/26	1.265	0.631
Current (no/yes)[a]	266/318	27/48	2.454	0.138	258/312	35/54	1.009	0.305	283/341	15/20	3.379	0.056	273/349	20/17	1.461	0.238
Alcoholic																
Former (no/yes)[a]	233/344	31/42	0.117	0.800	233/329	31/57	1.225	0.295	251/364	13/22	0.185	0.726	246/368	18/18	1.392	0.305
Current (no/yes)[a]	154/429	22/53	0.289	0.582	152/417	24/65	0.003	1.000	168/455	8/27	0.286	0.897	261/362	18/39	0.178	0.703
Tea habits																
Former (no/yes)[a]	256/316	35/38	0.266	0.619	250/309	41/45	0.262	0.642	275/336	16/18	0.055	0.861	272/337	19/17	0.904	0.360
Current (no/yes)[a]	249/336	30/45	0.179	0.711	236/335	43/46	1.539	0.249	264/361	15/20	0.005	1.000	261/362	18/19	0.653	0.454
Exercise habits																
Former (no/yes)[a]	295/374	21/53	1.019	0.361	188/367	28/60	0.144	0.808	205/403	11/24	0.078	0.856	204/403	12/24	0.0001	1.000
Current (no/yes)[a]	240/339	29/46	0.213	0.709	228/337	41/48	1.037	0.354	253/366	16/19	0.321	0.599	258/360	11/25	1.760	0.224

Baseline characteristics were compared between normal and abnormal levels of serum lipid/lipoprotein. *$p < 0.05$, **$p < 0.01$ vs normal serum lipid/lipoprotein. Using χ^2 or Fisher's exact test (where [a]an expected cell count was < 5) for categorical variables and unpaired Student's t-test for continuous variables. In the testing, a p-value < 0.05 was considered statistically significant. MD, mean difference; SUA, serum uric acid; BMI, body mass index; FBG, fasting blood glucose; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TC, total cholesterol; TG, triglyceride; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table III. Pearson correlation between arterial blood pressure and serum lipid/lipoprotein ($n = 661$).

	SBP		DBP	
Variable	Coefficient	*p*-value	Coefficient	*p*-value
TC	0.064	0.102	0.072	0.063
TG	0.088	0.024*	0.031	0.430
LDL	0.035	0.370	0.054	0.169
HDL	−0.013	0.741	−0.015	0.701

*$p < 0.05$, **$p < 0.01$. In the testing, a p-value < 0.05 was considered statistically significant. HDL, high-density lipoprotein; LDL, low-density lipoprotein; TG, total cholesterol; TC, triglyceride; SBP, systolic blood pressure; DBP, diastolic blood pressure.

are associated with arterial blood pressure. There was association between hypertriglyceridemia and hypertension or systolic hypertension.

Lipids and BP have been associated in several cross-sectional studies (3,4,16). Gaziano et al. (3) and Oparil et al. (4) found that BP and serum cholesterol were strongly correlated among hypertensive patients, which led to early recommendations to treat elevated cholesterol in patients with hypertension. Several studies have looked prospectively at the relationship between plasma lipids and the future development of hypertension, and found that elevated lipid levels appear to predate the onset of hypertension by several years (17–20).

To the best of our knowledge, this was the first research that focused on the association of hypertension and serum lipid/lipoprotein in the nonagenarian/centenarian. Although the association between dyslipidemia and hypertension had been confirmed by previous studies, our findings provided the evidence from long-lived subjects and extended this association to long-lived people. In our previous study, we reported that the association between cognitive function and hypertension or dyslipidemia in long-lived subjects was different from that in general population (13,14). In the elderly and very elderly, the mortality could remove the subjects with both hypertension and dyslipidemia, leaving those with one of them, and remove the association between hypertension and dyslipidemia. Our study showed that the association of hypertension and serum lipid/lipoprotein could be preserved up to the very elderly (>90 years). This study was only a cross-sectional study; we could not draw causal conclusions, but we could conclude that dyslipidemia and hypertension were associated with each other in the very elderly.

With age increasing, arterial wall elasticity declines, and this lead to an elevated blood pressure, particularly systolic blood pressure, and a higher incidence and prevalence of hypertension, mainly systolic hypertension. Therefore, in the elderly, ISP (with both normal diastolic and abnormal elevated systolic blood pressure) and DSP (with both normal systolic and abnormal elevated diastolic blood pressure) had different clinical implications. The present study provided evidence for it, the association of serum lipid/lipoprotein, and there was difference between systolic and diastolic blood pressure. In long-lived subjects, hypertriglyceridemia was associated with

Table IV. Multiple logistic regression for the relationship between arterial blood pressure and serum lipid/lipoprotein.

	Hypertension		SBP		DBP	
Characteristics	OR	95% CI	OR	95% CI	OR	95% CI
TC						
Unadjusted	1.214	0.742–1.986	1.180	0.725–1.912	1.473	0.772–2.812
Model 1	1.282	0.764–2.151	1.236	0.742–2.059	1.520	0.789–2.526
Model 2	1.130	0.677–1.888	1.081	0.650–1.798	1.497	0.757–2.962
Model 3	1.166	0.676–2.013	1.117	0.652–1.915	1.537	0.761–3.104
TG						
Unadjusted	1.829	1.094–3.055	2.050	1.227–3.424	0.963	0.470–1.975
Model 1	2.191	1.298–3.696	2.410	1.427–4.067	0.591	0.084–4.147
Model 2	1.863	1.075–3.229	2.087	1.204–3.619	0.948	0.448–2.005
Model 3	2.103	1.288–3.436	2.321	1.421–3.791	0.935	0.475–1.838
LDL						
Unadjusted	1.283	0.635–2.594	1.238	0.618–2.478	2.082	0.913–4.745
Model 1	1.168	0.559–2.441	1.123	0.543–2.320	2.100	0.906–4.870
Model 2	1.412	0.680–2.931	1.340	0.653–2.752	2.264	0.974–5.262
Model 3	1.324	0.605–2.901	1.293	0.597–2.801	2.120	0.870–5.161
HDL						
Unadjusted	1.826	0.887–3.762	1.751	0.864–3.549	0.801	0.277–2.320
Model 1	1.724	0.818–3.635	1.666	0.802–3.460	0.831	0.284–2432
Model 2	1.779	0.849–3.726	1.705	0.826–3.517	0.618	0.183–2.084
Model 3	1.678	0.783–3.635	1.623	0.764–3.447	0.644	0.187–2.216

OR, odds ratio. Unadjusted: Wald chi-square test with df = 1 was used; adjusted multiple logistic regression was used to adjust for covariates, Model 1: Adjustment made with components of metabolic syndrome (blood sugar, uric acid, body mass index); Model 2: Adjustment made with living habits might related to serum lipid/lipoprotein (smoking habits, alcoholic, tea habits, exercise habits); Model 3: Adjustment made with all the covariates (showed in Tables I and II). HDL, high-density lipoprotein; LDL, low-density lipoprotein; TC, total cholesterol; TG, triglyceride.

systolic hypertension, and serum lipid/lipoprotein seemed not associated with diastolic hypertension. The different association is still unknown, and should be further explored.

There are potential limitations to this study. First, insulin resistance or serum insulin level, which was an important component of metabolic syndrome, was not measured and, thus, the role of insulin resistance in the relationship between hypertension and abnormal serum lipid/lipoprotein levels could not be determined. Second, adjustment for other potential confounders, such as diet habits, socio-economic status and family history of metabolic syndrome, was not performed because it was not collected. Finally, several confounding variables such as smoking, exercise and the exact daily consumption of alcohol could not be accurately evaluated. There were a considerable number of subjects who quit drinking and/or smoking in their 80s.

In conclusion, this study uniquely provided evidence for association between dyslipidemia and hypertension in long-lived subjects. In the very elderly, systolic and diastolic blood pressure had different associations with serum lipid/lipoprotein, hypertriglyceridemia was associated with systolic blood pressure and serum lipid/lipoprotein seemed not associated with diastolic hypertension.

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Conflicts of interest

None.

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