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Correlation between 25-hydroxyvitamin D level and arterial elasticity in middle-aged and elderly cadres in Guiyang, China

A retrospective observational study

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Abstract

There is evidence that serum 25-hydroxyvitamin D [25-(OH) D] levels may be associated with cardiovascular disease and its risk factors. This study aimed to investigate the relationship between 25-(OH) D levels and blood pressure (BP), blood lipids, and arterial elasticity in middle-aged and elderly cadres in China.

In this retrospective study, we included 401 civil servants and cadres aged >42 years who underwent medical examinations at Guiyang Municipal First People's Hospital, China in 2018. The participants were assigned to deficiency (≤20 ng/mL), insufficiency (20–30 ng/mL), and sufficiency (≥30 ng/mL) groups according to 25-(OH) D levels in their blood. Demographics, brachial–ankle pulse wave velocity (baPWV), BP, ankle–brachial index (ABI), and blood lipids were compared among groups. The associations between 25-(OH) D and other parameters were evaluated using linear regression analysis.

Median (range) 25-(OH) D levels in the deficiency (n = 162), insufficiency (n = 162), and sufficiency (n = 77) groups were 15.32 (2.93–19.88), 25.12 (20.07–29.91), and 33.91 (30.23–82.42) ng/mL, respectively. There were significant differences in systolic BP, pulse pressure, baPWV (left and right sides), ABI (left side), high-density lipoprotein-cholesterol, and triglycerides (TGs; all $P < .05$) among groups. Multivariate linear regression revealed that TG, left baPWV, and right baPWV were significantly negatively correlated with 25-(OH) D levels (all $P < .05$).

In this study, 25-(OH) D levels were found to be associated with TG, left baPWV, and right baPWV values. 25-(OH) D deficiency may be associated with reduced arterial elasticity.

Abbreviations: ABI = ankle–brachial index, baPWV = brachial–ankle PWV, BMI = body mass index, BP = blood pressure, CVD = cardiovascular disease, DBP = diastolic BP, DM = diabetes mellitus, HDL-C = high-density lipoprotein-cholesterol, LDL-C = low-density lipoprotein-cholesterol, PP = pulse pressure, PWV = pulse wave velocity, SBP = systolic BP, TC = total cholesterol, TG = triglyceride.

Keywords: arterial elasticity, blood pressure, cholesterol, elderly, middle aged, pulse wave velocity, triglycerides, vitamin D

1. Introduction

Cardiovascular disease (CVD) is the leading cause of mortality worldwide. CVD was responsible for nearly 18 million deaths in 2017 (around 32% of all deaths), with most of these due to ischemic heart disease or stroke.[1] Risk factors associated with CVD include older age, gender, smoking, family history of CVD, hypertension, diabetes mellitus (DM), obesity, increased levels of low-density lipoprotein-cholesterol (LDL-C), increased levels of triglycerides (TGs), and decreased levels of high-density lipoprotein-cholesterol (HDL-C).[2] Risk stratification plays an important role in decision-making regarding the management of CVD, as the identification of specific risks in patients can guide in lifestyle modifications and medical interventions to reduce morbidity and prolong survival. Therefore, identifying novel biomarkers and modifiable risk factors for CVD and evaluating their association with the established risk factors are of great interest.[3]

Atherosclerosis is the pathological basis of CVD. At the early stage, atherosclerosis manifests as reduced arterial elasticity and compliance as well as increased arterial stiffness. Importantly,

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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changes in arterial stiffness occur before alterations in vascular wall structure and the appearance of clinical manifestations.[4] Furthermore, arterial stiffness is known to be a predictor of adverse cardiovascular outcomes.[5] Therefore, screening for changes in arterial stiffness may be a useful approach for identifying early-stage vascular diseases, which in turn would facilitate the prevention and treatment of CVD. Pulse wave velocity (PWV) is universally acknowledged as a "gold-standard" indicator for the evaluation of arterial stiffness.[6] Brachial–ankle PWV (baPWV) is a convenient measurement that has been widely applied for the assessment of vascular risk in the general population in Asia.[7,8] Blood pressure (BP) measurements can also be used to identify the presence of vascular diseases. In particular, simultaneous measurements of BP in all 4 limbs allows the calculation of differences in BP and ratios that are valuable in the prediction of cardiovascular risk.[9] The ankle–brachial index (ABI) is a useful parameter for the diagnosis of peripheral arterial disease in the lower extremities. Furthermore, studies have reported that ABI can be used to predict cerebrovascular and cardiovascular morbidity and mortality.[10,11]

Vitamin D status is generally evaluated by measuring the serum level of 25-hydroxyvitamin D [25-(OH) D]. When the serum level of 25-(OH) D is <20 ng/mL, the individual is said to be deficient in vitamin D. Vitamin D deficiency is widespread worldwide. At present, about one billion people in the world suffer from vitamin D deficiency. It is a common health problem in many countries, with a reported prevalence of 40% in Europe,[12] 29% in the USA,[13] and 52% in China.[14] The role of vitamin D in bone metabolism and growth are well established. Therefore, vitamin D deficiency can lead to abnormal bone metabolism and diseases, such as rickets in children and osteopenia and osteoporosis in adults. In recent years, more and more studies have found that vitamin D deficiency can lead to a series of CVDs, including coronary artery disease, myocardial infarction, heart failure, stroke, and adverse cardiovascular outcomes, and various risk factors or metabolic disorders underlying CVD, such as hypertension, DM, hyperlipidemia, and peripheral vascular diseases.[15–18] However, so far, there are only a few studies on the correlation between vitamin D deficiency and arteriosclerosis, which remains a controversy, especially among middle-aged and elderly people who are at high risk of CVDs.

Due to long-term indoor work and lack of adequate sunlight exposure, civil servants and cadres are likely to have vitamin D deficiency; therefore, studies on such population are needed. Therefore, the aim of this retrospective study was to explore the correlation of 25-(OH) D, which is a measurement factor for vitamin D deficiency, with BP, blood lipid levels, and arterial elasticity, which are the major predictive factors related to CVDs.

2. Patients and Methods

2.1. Study design and participants

In this study, we retrospectively analyzed the clinical data of working or retired civil servants and cadres from Guiyang City who underwent medical examinations at Guiyang Municipal First People's Hospital (Guiyang, Guizhou, China) in 2018. We included participants in this study based on the inclusion criteria of

1. age >42 years; and
2. no obvious discomfort during the physical examination.

The exclusion criteria were:

1. heart valve disorders;
2. cardiomyopathy;
3. frequent premature ventricular contractions;
4. atrial fibrillation;
5. atrial conduction block;
6. history of cerebrovascular events;
7. history of myocardial infarction;
8. acute or chronic heart failure;
9. cancer;
10. thyroid disease; and
11. lack of data required for the analysis.

This study was approved by the ethics review board at Guiyang Municipal First People's Hospital. Informed consent was waived by the committee because of the retrospective nature of the study.

2.2. Clinical examination

All clinical examinations and measurements were made by fully trained and experienced physicians with more than 20 years of clinical experience. All participants were asked to empty their bladder and not to smoke or drink alcohol or coffee within 30 minutes before the examination. Height and body weight were measured, and body mass index (BMI) was calculated as weight (in kg) divided by the square of height (in m). A mercury sphygmomanometer was used to measure BP in the right arm with the participant in a seated position and after resting for 5 minutes. BP was measured twice by the same specialist, and the mean systolic BP (SBP), diastolic BP (DBP), and pulse pressure (PP) were calculated.

2.3. Measurement of baPWV and ABI

The baPWV and ABI values were measured by professional technologists using an automated analyzer (BP-203RPE III, Omron, Kyoto, Japan). The participant was asked to rest in the supine position for 5 to 10 minutes before the measurements were made. First, information, including the participant's age, sex, and height was input into the device. Then, cuffs were wrapped around the upper arms and ankles of the participant. The balloon mark of the upper cuff was positioned at the brachial artery with the lower margin about 2 to 3 cm from the antecubital fossa. The balloon mark of the lower cuff was positioned at the medial lower limb with the lower margin about 1 to 2 cm from the medial malleolus. The length of the blood vessel between the upper limb and the ankle as well as the pulse transit time (PTT) were automatically measured by the system. The equipment then automatically analyzed the baPWV and ABI values for the left and right sides. The ABI value was calculated by dividing the ankle SBP value by the highest bilateral brachial SBP value.

2.4. Blood biochemistry

Fasting venous blood samples were obtained from all participants on the morning of the medical examination. Total cholesterol (TC), TGs, HDL-C, and LDL-C were measured using an automatic biochemical analyzer. A chemiluminescence method (ADVIA Centaur XP immunoassay system, Siemens, Munich, Germany) was used to measure the 25-(OH) D levels. All intra-assay coefficients of variation for 25-(OH) D were <10%.

2.5. Data collection

The following data were extracted from the medical records: age, sex, BMI, SBP, DBP, PP, TC, TG, HDL-C, LDL-C, left and right baPWV, and left and right ABI.

2.6. Statistical analysis

In this study, data were analyzed using SPSS 23.0 (IBM, Armonk, NY, USA). The participants were divided into 3 groups according to their 25-(OH) D levels, based on International Osteoporosis Foundation definitions: 25-(OH) D deficiency (≤20 ng/mL), 25-(OH) D insufficiency (>20 ng/mL and <30 ng/mL), and 25-(OH) D sufficiency (≥30 ng/mL). Continuous data were tested for normality using Kolmogorov–Smirnov test. Normally distributed quantitative data were described as mean ± standard deviation and compared among groups using one-way analysis of variance and the LSD posthoc test. Non-normally distributed quantitative data were presented as median (range) and compared among groups using Kruskal–Wallis and Dunn tests. Count data were described as n (%) and compared among groups using Chi-Squared test. A general linear regression model was used to analyze the correlation between 25-(OH) D levels and other parameters. All parameters with $P < .05$ in the univariate linear regression model were entered into multivariate analysis, and backward selection was used to construct the final model. For a more accurate analysis of the dynamics by years, the Friedman test is performed. All reported P values were two-tailed, and the level of statistical significance was set at $P < .05$.

3. Results

3.1. Baseline clinical characteristics of the participants

The final analysis included 401 participants (324 males, 80.8%) with a median age of 67 years and a median 25-(OH) D level of 22.76 ng/mL. The median 25-(OH) D levels in the 25-(OH) D deficiency (n = 162, 40.4%), 25-(OH) D insufficiency (n = 162, 40.4%), and 25-(OH) D sufficiency (n = 77, 19.2%) groups were 15.32 (2.93–19.88), 25.12 (20.07–29.91), and 33.91 (30.23–82.42) ng/mL, respectively. As detailed in Table 1, there were significant differences in SBP, PP, baPWV (left and right sides), ABI (left side), HDL-C, and TG among groups ($P < .05$). However, age, BMI, DBP, TC, and LDL-C did not differ significantly among the 3 groups (Table 1).

3.2. Linear regression analysis of factors associated with 25-(OH) D

Univariate linear regression analysis showed that age ($P = .015$), sex ($P = .011$), PP ($P = .043$), TG ($P = .004$), left baPWV ($P < .001$), and right baPWV ($P = .001$) were all significantly associated with 25-(OH) D levels (Table 2). Due to collinearity between left baPWV and right baPWV, these parameters, including age, sex, PP, and TG (significant variables in the univariate analysis), were entered individually into 2 separate multivariate linear regression analyses. The first multivariate linear regression analysis revealed that TG ($B = -1.468$, $P = .001$) and left baPWV ($B = -0.004$, $P < .001$) were significantly associated with 25-(OH) D levels (Table 3). Similarly, the second multivariate analysis demonstrated that TG ($B = -1.428$, $P = .001$) and right baPWV ($B = -0.003$, $P < .001$) were significantly associated with 25-(OH) D levels (Table 4). Therefore, the 2 multivariate analyses showed excellent agreement.

3.3. Changes in parameters measured in 47 participants over 5 consecutive years

Of 401 participants, 47 underwent annual medical examination between September 2014 and September 2018. Therefore, a subgroup analysis was performed using data that were collected for these 47 participants during the 5 consecutive years. The BMI, TC, PP, TG, HDL-C, LDL-C, ABI (left and right sides), and baPWV (left and right sides) values measured in these 47 participants over the 5-year period are presented in Table 5.

Table 1

Baseline clinical characteristics of the study participants.

Characteristics	25-(OH) D deficiency group (n = 162)	25-(OH) D insufficiency group (n = 162)	25-(OH)D sufficiency group (n = 77)	P
25-(OH)D (ng/mL)	15.32 (2.93–19.88)	25.12 (20.07–29.91)[a]	33.91 (30.23–82.42) [a,b]	<.001*
Age (yr)	68.5 (43–90)	66 (42–91)	64 (43–88)	.096
Sex, male	137 (84.6%)	130 (80.2%)	57 (74.0%)	.150
BMI (kg/m^2)	24.4 (15.1–30.4)	24.25 (16.0–32.5)	23.5 (16.2–31.0)	.264
SBP (mm Hg)	130 (99–180)	130 (90–190)	120 (95–189)[a,b]	.004*
PP (mm Hg)	56 (15–100)	55.5 (26–101)	50 (25–90)[a]	.033*
Left ABI	1.13 (0.92–1.37)	1.12 (0.87–1.35)[a]	1.12 (0.91–1.71)	.024*
Right ABI	1.15 (0.96–1.48)	1.14 (0.78–1.35)	1.14 (0.93–1.31)	.063
TC (mmol/L)	5.15 ± 0.10	5.09 ± 0.96	5.21 ± 0.87	.672
TG (mmol/L)	1.80 (0.43–7.69)	1.88 (0.50–6.50)	1.41 (0.39–5.60)	.048*
HDL-C (mmol/L)	1.35 (0.59–4.00)	1.41 (0.76–4.09)	1.48 (0.93–2.68)[a]	.021*
LDL-C (mmol/L)	3.45 (1.40–5.63)	3.43 (1.44–5.62)	3.56 (1.59–6.10)	.500
Left baPWV (mm/s)	1903 (1018–3740)	1760 (1147–4484)	1660 (968–2874)[a]	.004*
Right baPWV (mm/s)	1878 (2.75–3592)	1748 (1106–4635)	1692 (1080–2998)[a]	.006*

* $P < .05$, Kruskal–Wallis tests.

[a] $P < .05$ vs 25-(OH) D deficiency group.

[b] $P < .05$ vs 25-(OH) D insufficiency group.

Data are presented as median (range), mean ± standard deviation, or n (%).

25-(OH) D levels in 25-(OH) D deficiency group: ≤20 ng/mL; 25-(OH) D insufficiency group: 20 ng/mL <25-hydroxyvitamin D <30 ng/mL; and 25-(OH) D sufficiency group: ≥30 ng/mL.

25-(OH) D = 25-hydroxyvitamin D, ABI = ankle–brachial index, baPWV = brachial–ankle pulse wave velocity, BMI = body mass index, DBP = diastolic blood pressure, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, PP = pulse pressure, SBP = systolic blood pressure, TC = total cholesterol, TG = triglyceride.

Table 2

Univariate linear regression analysis of factors associated with 25-hydroxyvitamin D (n = 401).

Parameters	Beta (slope)	95% CI	*P*
Age (yr)	−0.108	−0.195, −0.021	.015*
Sex (male = 1, female = 0)	−3.033	−5.355, −0.711	.011*
BMI (kg/m^2)	−0.133	−0.447, 0.181	.405
SBP (mm Hg)	−0.050	−0.102, 0.001	.055
DBP (mm Hg)	−0.015	−0.093, 0.063	.703
PP (mm Hg)	−0.064	−0.127, −0.002	.043*
Left ABI	−4.750	−14.474, 4.975	.338
Right ABI	−8.966	−19.067, 1.135	.082
TC (mmol/L)	0.145	−0.819, 1.108	.768
TG (mmol/L)	−1.242	−2.092, −0.392	.004*
HDL-C (mmol/L)	1.388	−0.609, 3.385	.172
LDL-C (mmol/L)	−0.118	−1.221, 0.984	.833
Left baPWV (mm/s)	−0.003	−0.005, −0.002	<.001*
Right baPWV (mm/s)	−0.003	−0.005, −0.001	.001*

* $P < .05$.

ABI = Ankle–brachial index, baPWV = brachial–ankle pulse wave velocity, BMI = body mass index, CI = confidence interval, DBP = diastolic blood pressure, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, PP = pulse pressure, SBP = systolic blood pressure, TC = total cholesterol, TG = triglyceride.

The association between 25-(OH) D levels and baPWV is further analyzed in Figure 1. Although there appeared to be a general trend for baPWV to increase progressively over the 5-year period ($P = .251$ for left; $P = .282$ for right), 25-(OH) D levels showed notable variation over the 5-year period ($P < .001$), making it difficult to draw conclusions regarding its association with baPWV. Nevertheless, increases in 25-(OH) D levels from 1 year to the next were associated with decreases in baPWV over the same period, and vice versa (Fig. 1).

4. Discussion

A notable finding of this study was that SBP, PP, baPWV (left and right sides), ABI (left and right sides), and TG differed significantly among the 3 groups; whereas, age, BMI, DBP, TC, HDL-C, and LDL-C did not show any significant difference. Furthermore, multivariate linear regression demonstrated that TG, left baPWV, and right baPWV were significantly associated with 25-(OH) D levels. Additionally, a 5-year longitudinal analysis in a subgroup of participants suggested that an increase in 25-(OH) D levels from 1 year to the next was associated with a decrease in baPWV over the same period, and vice versa. Taken together, our results indicate that lower 25-(OH) D levels are

Table 3

Multivariate linear regression analysis of factors associated with 25-hydroxyvitamin D (right baPWV excluded from the model; n = 401).

Variables	*B*	SE	*t*	*P*	VIF	95% CI of B
TGs	−1.468	0.426	−3.444	0.001	1.015	−2.306, −0.630
Left baPWV	−0.004	0.001	−4.300	<0.001	1.015	−0.006, −0.002

B = Unstandardized beta (slope), baPWV = brachial–ankle pulse wave velocity, CI = confidence interval, SE = standard error of the unstandardized beta, *t* = *t*-test statistic, TG = triglyceride, VIF = variance inflation factor.

Table 4

Multivariate linear regression analysis of factors associated with 25-hydroxyvitamin D (left baPWV excluded from the model; n = 401).

Variables	*B*	SE	*t*	*P*	VIF	95% CI of B
TGs	−1.428	0.428	−3.336	.001	1.013	−2.269, −0.586
Right baPWV	−0.003	0.001	−3.794	<.001	1.013	−0.005, −0.002

B = Unstandardized beta (slope), baPWV = brachial–ankle pulse wave velocity, CI = confidence interval, SE = standard error of the unstandardized beta, *t* = *t*-test statistic, TG = triglyceride, VIF = variance inflation factor.

Table 5

Changes in parameters measured in 47 participants over 5 consecutive years.

Parameters	2014	2015	2016	2017	2018
BMI (kg/m^2)	24.56 ± 2.88	24.1 ± 2.72	24.20 ± 2.81	24.46 ± 2.96	24.27 ± 2.74
SBP (mmHg)	130.1 ± 18.2	125.8 ± 16.0	129.2 ± 17.0	132.3 ± 19.8	138.5 ± 18.4
DBP (mmHg)	72.0 ± 10.6	69.7 ± 12.3	73.5 ± 9.2	78.4 ± 10.5	80.3 ± 10.7
25-(OH)D (ng/mL)	24.07 ± 9.61	17.79 ± 10.49	25.82 ± 11.04	24.21 ± 7.76	21.10 ± 8.22
Left ABI	1.12 ± 0.10	1.14 ± 0.10	1.12 ± 0.08	1.13 ± 0.08	1.13 ± 0.09
Right ABI	1.12 ± 0.09	1.13 ± 0.09	1.14 ± 0.09	1.16 ± 0.08	1.13 ± 0.10
TC (mmol/L)	5.13 ± 0.88	5.25 ± 0.93	5.28 ± 1.00	5.31 ± 0.91	4.97 ± 1.00
TG (mmol/L)	1.95 ± 1.05	2.02 ± 1.30	1.79 ± 0.94	2.10 ± 1.05	1.84 ± 0.98
HDL-C (mmol/L)	1.47 ± 0.54	1.51 ± 0.53	1.51 ± 0.42	1.59 ± 0.52	1.47 ± 0.42
LDL-C (mmol/L)	3.47 ± 0.61	3.61 ± 0.78	3.68 ± 0.83	3.48 ± 0.77	3.38 ± 1.00
Left baPWV (mm/s)	1917.7 ± 515.4	1951.6 ± 648.4	1962.4 ± 510.5	1997.8 ± 484.7	2007.5 ± 546.6
Right baPWV (mm/s)	1903.8 ± 507.3	1990.0 ± 584.0	1947.7 ± 511.2	1976.9 ± 488.6	1955.9 ± 631.7

25-(OH) D = 25-hydroxyvitamin D, ABI = ankle–brachial index, baPWV = brachial–ankle pulse wave velocity, BMI = body mass index, DBP = diastolic blood pressure, HDL-C = high-density lipoprotein cholesterol, LDL-C = low-density lipoprotein cholesterol, SBP = systolic blood pressure, TC = total cholesterol, TG = triglyceride.

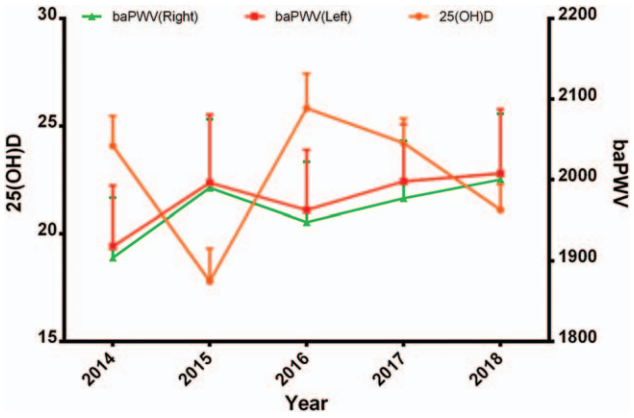

Figure 1. Changes in 25-hydroxyvitamin D levels, left brachial–ankle pulse wave velocity, and right brachial–ankle pulse wave velocity in 47 participants over 5 consecutive years (2014–2018). 25-(OH) D = 25-hydroxyvitamin D, baPWV = brachial–ankle pulse wave velocity.

associated with reduced arterial elasticity, although it is still unclear whether this association is direct or indirect.

In recent years, vitamin D deficiency is prevalent in the general population due to the reduction in outdoor activities and the time and intensity of skin exposure to ultraviolet light. It has been estimated that about a billion people, globally, are in a state of vitamin D insufficiency, consequences of which go far beyond bone health.[19] Numerous studies have demonstrated that vitamin D insufficiency is common throughout the world,[12–14] and data from the US National Health and Nutrition Examination Survey showed that 3 of every 4 US citizens had 25-(OH) D insufficiency.[20] The findings of the present study revealed that vitamin D insufficiency and deficiency was present in 40.4% and 40.4% of the participants, respectively. Our findings are consistent with previous studies describing a high level of vitamin D insufficiency in China.[14,21] Since numerous recent investigations have reported a relationship between vitamin D status and CVD risk, we evaluated the association of 25-(OH) D levels with CVD risk factors in relatively healthy subjects undergoing medical examinations at our hospital.

The findings of this study showed that 25-(OH) D levels were negatively correlated with SBP and PP, but not significantly correlated with DBP. Previous studies have also reported negative association between vitamin D and blood pressure. For example, Forman et al conducted a study with a 4-year follow-up and found a 3 to 6-fold higher risk of developing hypertension in subjects with 25-(OH) D levels <37.5 mmol/L.[22] Furthermore, a meta-analysis performed by Kunutsor et al showed that the incidence of hypertension decreased by 12% for every 10 ng/mL increase in 25-(OH) D levels.[23] Our findings were also consistent with the research demonstrating that oral vitamin D reduces SBP but not DBP in people aged more than 50 years with vitamin D deficiency[24] and in patients with type 2 DM.[25] Nevertheless, it should be noted that other studies have not found an association between vitamin D and BP.[26] Therefore, further research will be needed to establish whether there is an association between vitamin D status and BP.

The correlation between 25-(OH) D levels and blood lipid metabolism has also received attention in recent years. The present study found that vitamin D levels in middle-aged and elderly people were significantly negatively correlated with TG level but not with TC, HDL-C. or LDL-C levels. In agreement with our observations, the findings of the third US National Health and Nutrition Examination Survey suggested that a decreased vitamin D level was significantly associated with an elevated TG level but not with changes in TC or LDL-C levels.[27] However, other investigations have indicated that 25-(OH) D levels may also be related to TC and LDL-C levels. For example, the GARCIA-BAILO study in Canada showed that TG, TC, LDL-C, and TC/HDL-C ratio were significantly negatively correlated with serum 25-(OH) D concentration,[28] while a study of patients with CVD also revealed negative correlations of 25-(OH) D levels with TG, TC, and LDL-C.[29]

Arterial stiffness is an independent predictor of CVD incidence and CVD-related mortality[5] and is the earliest detectable sign of structural and functional vascular wall changes.[4] The evaluation of central arteriosclerosis plays an important role in the early detection and prevention of CVD. In clinical practice, baPWV has been widely used to screen for early atherosclerotic diseases because it is a simple, non-invasive, economic, reliable, and repeatable technique for evaluating sclerosis and stiffness of major arteries.[6–8] Vitamin D is thought to play an important role in maintaining the normal physiological functions of the cardiovascular system, and previous studies have reported an association between serum vitamin D levels and CVD.[30] Vitamin D level is negatively correlated with the carotid–femoral PWV in healthy people.[31] Furthermore, 2 cross-sectional studies reported that 25-(OH) D levels were negatively correlated with baPWV,[32,33] in agreement with our findings. Epidemiological and clinical research conducted during the past 3 decades has suggested that 25-(OH) D deficiency might be associated with an increased incidence of atherosclerosis.[34] With regard to the possible mechanisms underlying an association between vitamin D deficiency and atherosclerosis, it has been reported that vitamin D can inhibit the occurrence and progression of inflammatory responses and the formation of foam cells and atherosclerotic plaques,[35] improve the secretion of insulin and ameliorate insulin resistance,[36] downregulate activation of the renin–angiotensin–aldosterone system,[37,38] delay plaque formation and the progression of vascular stenosis,[39] and regulate the proliferation and development of immune cell subgroups.[40]

This study has several limitations. First, this study was of retrospective nature; therefore, the results may be prone to selection bias or information bias, and the confounding factor causing hypovitaminosis is also a limitation of this retrospective observational study. Second, this study was conducted at a single center that only included people living in the Guiyang region of China. Moreover, the proportion of males and females were also not balanced. Therefore, the findings may not be representative for middle-aged and elderly individuals in China. Third, the sample size of this study was small, so the study may have been underpowered to detect some real differences or correlations; this may have explained the lack of a significant correlation between longitudinal changes in 25-(OH) D levels and baPWV ($P = .06$). Additional studies with larger sample sizes are needed to establish the association between 25-(OH) D levels and CVD risk factors.

In conclusion, 25-(OH) D levels were found to be associated with TG, left baPWV, and right baPWV values. Additionally, a 5-year longitudinal analysis indicated that an increase in 25-(OH) D levels from 1 year to the next was associated with a decrease in baPWV over the same period, and vice versa. Further studies are needed to establish whether the association between 25-(OH) D levels and arterial stiffness is direct or indirect.

Author contributions

Conceptualization: Lan Shi, Qiao Zhang.
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