Original Article

Ideal Cardiovascular Health Metrics and Coronary Artery Calcification in Northern Chinese Population: A Cross-sectional Study*

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Abstract

Objective Coronary artery calcification (CAC) is a well-established risk predictor of coronary heart disease events and is recognized as an indicator of subclinical atherosclerosis.

Methods A cross-sectional study consisting of 2999 participants aged ≥40 years from the Jidong community of Tangshan City, an industrial and modern city of China, was conducted between 2013 and 2014 to examine the association between the ideal cardiovascular health (CVH) metrics and CAC. The ideal CVH metrics were determined based on the definition of the American Heart Association (AHA). The participants were then grouped into 4 categories according to the quartiles of their CVH metric scores as follows: first quartile (0-2), second quartile (3), third quartile (4), and fourth quartile (5-7). CAC was assessed by using high-pitch dual-source CT, and patients were identified based on thresholds of 0, 10, 100, or 400 Agatston units, as per common practice.

Results The prevalence of subclinical atherosclerosis was 15.92%, 13.85%, 6.76%, and 1.93%, determined by using the CAC scores at thresholds of 0, 10, 100, and 400 Agatston units, respectively. Compared with the group in the first quartile, the other three CVH groups had a lower odds ratio of CAC >0 after adjusting for age, sex, income level, education level, and alcohol use in the logistic regression analysis. The odds ratios in these groups were 0.86 [95% confidence interval (CI), 0.63-1.17; P<0.05], 0.75 (95% CI, 0.55-1.02; P<0.05), and 0.49 (95% CI, 0.35-0.69; P<0.05), respectively. These associations of CAC with the CVH metrics were consistent when different CAC cutoff scores were used (0, 10, 100, or 400).

Conclusion The participants with more-ideal cardiovascular metrics had a lower prevalence of subclinical atherosclerosis determined according to CAC score. Maintaining an ideal cardiovascular health may be valuable in the prevention of atherosclerosis in the general population.

Key words: Ideal cardiovascular health; Coronary artery calcification; Atherosclerosis

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INTRODUCTION

Coronary heart disease (CHD) is the single largest cause of death in developed countries and is one of the leading causes of disease burden in developing countries, accounting for 7.3 million deaths and 58 million disability-adjusted life years (DALYs) worldwide in 2011[1-2]. Inappropriate lifestyle factors increase the risk of CHD[3-5], including smoking, poor quality diet,

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physical inactivity, excessive alcohol consumption, and obesity, which are major preventable causes of CHD and mortality[3-5]. Epidemiological studies have showed the correlation between healthy lifestyle factors and reduced risks of myocardial infarction (MI) and CHD mortality[6-9].

Coronary artery calcification (CAC), a marker of subclinical atherosclerosis, is well established as a risk predictor of CHD events[10-12] and all-cause mortality[13-14] in asymptomatic adults, and provides incremental prognostic information beyond that of traditional risk factors [14-15]. Previous studies showed that normal body mass index (BMI)[16], lipids[17-19], blood pressure[20], fasting blood glucose[21], active physical activity[22], and nonsmoking status were correlated with lower CAC scores[23]. Noninvasive imaging detects CAC in minute amounts and thus is a valuable indicator of preclinical diseases in their early stages. However, limited evidence is available about the association between ideal cardiovascular health behavioral factors and subclinical atherosclerosis assessed based on CAC score, especially in China.

The American Heart Association (AHA) defined seven behaviors and risk factors (smoking status, BMI, physical activity, healthy dietary score, total cholesterol level, blood pressure, and fasting blood glucose level) as health metrics and created three stages for each metric to reflect poor, intermediate, and ideal cardiovascular health status[24]. Identifying health behaviors and risk factors that are correlated with the maintenance of subjects' health is an important strategy for the prevention of CHD.

We hypothesized that ideal cardiovascular metrics would be a protective factor of subclinical cardiovascular disease (assessed based on CAC score)[25]. Therefore, we conducted a cross-sectional study to investigate the association between ideal cardiovascular metrics and CAC in a Chinese population.

METHODS

Study Design and Participants

In the present investigation, we conducted a cross-sectional analysis of baseline data of the target population. This is a community-based, ongoing observational study aimed to investigate the progression of atherosclerosis in Chinese adults[26]. Briefly, from July 2013 to August 2014, 9078 subjects aged ≥18 years who were residents in a community in Jidong were recruited. Jidong is located in Tangshan City, which is a large and littoral modern city located in the southeast of Beijing. All data were handled and managed by using the Ruichi Precision Medical Record System (RPMRS), which was developed to standardize, integrate, manage, and analyze precision medical data.

The study included 2999 participants aged ≥40 years who had complete information on results of examinations for coronary artery calcification and peripheral arterial atherosclerosis. We excluded 204 participants with a history of stroke, myocardial infarction, heart failure, and cancer. A total of 2795 participants (1401 men and 1394 women) remained in the last analysis. During baseline survey, physical examinations and surveys were conducted by trained medical professionals from the Jidong Oilfield Corporation Medical Center. The study was conducted according to the guidelines of the Declaration of Helsinki. Ethical approval for the research protocol was obtained and written informed consents were approved by the ethics committee of Jidong Oilfield Corporation Medical Center prior to the study initiation. Written informed consents were obtained from all the participants.

Assessment of Cardiovascular Health Metrics

According to the guidelines by the American Heart Association, we defined the seven CVH metrics in three levels as follows: 'ideal,' 'intermediate,' and 'poor,'[24]. Based on the score for healthy-diet behaviors, the dietary intake metric was classified as ideal (4 or 5 components), intermediate (2 or 3 components), or poor (0 or 1 component). The smoking metric was classified as ideal (never- or quit-smoking for >12 months), intermediate (former-smoking for ≤12 months), or poor (current smoking). Physical activity was classified as ideal (≥150 min/week of moderate intensity or ≥75 min/week of vigorous intensity), intermediate (1-149 min/week of moderate intensity or 1-74 min/week of vigorous intensity), or poor (none). BMI was classified as ideal (<25 kg/m^2), intermediate (25-29.9 kg/m^2), or poor (≥30 kg/m^2). Blood pressure was classified as ideal [systolic blood pressure (SBP) of <120 mmHg, diastolic blood pressure (DBP) of <80 mmHg, and untreated], intermediate (SBP of 120-139 mmHg, DBP of 80-90 mmHg, and treated to goal), or poor (SBP of ≥140 mmHg or DBP of ≥90 mmHg). Fasting blood glucose level was classified as ideal (<100 mg/dL and untreated), intermediate (100-125 mg/dL and treated to goal), or poor (0-125 dL). Total cholesterol status was classified as ideal (<200 mg/dL and untreated), intermediate (200-239 mg/dL or treated to goal), or poor (≥240 mg/dL).

Information on smoking, physical activity, and dietary intake was collected by using questionnaires. Smoking status was classified as 'never', 'former', or 'current' according to self-reported information. Physical activity was evaluated based on the responses to questions on the type and frequency of physical activities at work and during leisure time. Dietary intake was assessed by using a brief semiquantitative food frequency questionnaire[27] included in the above-mentioned questionnaires. All the participants were asked regarding the amount and frequency of their consumption of the following 10 major food groups/items during the past 12 months: vegetable, fruits, fiber-rich whole grains, eggs, red meat (beef/lamb/pork), fish/sea food, milk and dairy products, soybean products, nuts, sugar-sweetened beverage, and tea. Salt intake was self-reported as grams per day. Healthy dietary-intake components were defined as follows: ≥4.5 servings per day of fruits and vegetables; ≥2 servings per week of fish or shellfish; ≥3 servings per day of fiber-rich whole grains; sugary drinks once a week or less; and salt intake of <6 g/day.

BMI was defined based on measured height (accurate to 0.1 cm) and weight (accurate to 0.1 kg), and calculated as the body weight (kg) divided by the square of height (m^2). Blood pressure was measured by using a mercury sphygmomanometer with a cuff of appropriate size. Two SBP and DBP readings were taken at 5 min intervals, after the participants had rested in a chair for at least 5 min. The average of the two readings was used for the current data analyses. If the two measurements differed by more than 5 mmHg, an additional reading was taken, and the average of the three readings was used.

Blood samples were drawn by trained phlebotomists from the subjects after overnight fasting. The venous blood samples in tubes containing trisodium ethylenediaminetetraacetic acid were immediately stored at 4 °C after antecubital venipuncture. Blood samples were then centrifuged for 10 min at 3000 rotations per minute at 25 °C. After separation, plasma samples were used within 4 h. All biochemical indexes, including total cholesterol and fasting blood glucose levels, were measured by using an autoanalyzer (AU400, Olympus, Japan) at the laboratory of the Jidong Oilfield Corporation Medical Center.

Assessment of Potential Covariates

Information on demographic and clinical characteristics (age, sex, marital status, alcohol use, personal monthly income, education, and history of diseases) was collected by using questionnaires. Marital status was divided into 'married' and 'unmarried' (including single, divorced, or widowed). Alcohol drinking was defined as a daily intake of liquor of at least 100 mL (equivalent to 240 mL of wine or 720 mL of beer) for >1 year. Physical activity was evaluated based on responses to the questions on the type and frequency of physical activities at work and during leisure time. History of disease, including myocardial infarction, heart failure, stroke, and cancer, was based on a self-report. The use of antihypertensive, cholesterol-lowering, and glucose-lowering medications within the past 2 weeks before the baseline interview was also self-reported. Average monthly income was categorized as '≤¥3000', '¥3001-5000', and '≥¥5001'. Educational attainment was categorized as 'illiteracy or primary', 'middle school', and 'college or university'.

Coronary Artery Calcification

CAC was assessed by using high-pitch dual-source CT (Siemens, Germany). CAC scores were calculated by using the equation introduced by Agatston et al.[28], which uses the weighted method, multiplying the calcific volume by a range of coefficients that are dependent on peak density [coefficient 2, 201-300 Hounsfield units (HU); coefficient 3, 301-400 HU; coefficient 4, >400 HU]. The same assessment software was used, and the same chief technician and supervising physician directed the high-pitch dual-source CT for the duration of this study. No defined diagnostic criteria for CAC have been established; thus, we used several commonly used thresholds in clinical practice to identify patients with high CAC (0, 10, 100, and 400 Agatston units)[29-31]. To demonstrate that our findings were not sensitive to which threshold is used, we present results based on the analyses for all 4 cutoff points. The proportion of individuals in each of these CAC score groups was calculated for each CVH metric level.

Statistical Analysis

Continuous variables were described as mean values [standard deviation (SD)] and compared by using analysis of variance. Categorical variables were described as percentages and compared by using the chi-square test. Multivariable logistic regression was used to estimate odds ratios for CAC as the dependent variable. Separate models were constructed for the following CAC scores: >0 versus 0, ≥10 versus <10, ≥100 versus <100, and ≥400 versus <400, and all models adjusted for age, sex, marital status, alcohol use, income level, and education level.

To assess the cumulative impact of ideal CVH metrics on coronary artery calcium (CAC), the total score of the ideal CVH metrics for each individual was calculated as the sum of the scores in the seven CVH metrics. In the logistic regression models for estimating the association between the total score and coronary artery calcium (CAC), the summary ideal CVH metrics were entered in the models as quartiles, with the lowest quartile as the reference. All the statistical tests were two-sided with the significant level set at 0.05. All the analyses were performed by using SAS 9.4 (SAS Institute, Cary, North Carolina, USA).

RESULTS

The characteristics of the participants regarding the quartile of the ideal CVH metric score are described in Table 1. Those with a relatively higher ideal CVH metric scores were more likely to be women, younger, have higher educational level and income, and have less alcohol intake. Significant linear trends of each factor and behavior were detected across the ideal CVH metric score categories, with the exception of age and income. The participants with ideal CVH metric scores in a higher quartile had lower baseline BMI values, total cholesterol levels, fasting plasma glucose levels, blood pressures, and CAC scores (*P*<0.001). With respect to healthy behaviors, those with ideal CVH metric scores in a higher quartile had higher baseline physical activity levels and healthy diets than those with lower ideal CVH metric (first quartile) scores and prevalence of smoking (*P*<0.001).

The most common CVH metric score per individual was 4 (26.64%). Among the study participants, 0.64% had zero ideal CVH metrics, whereas only 8.85% had 6 ideal CVH metrics, and 2.35% had 7 ideal CVH metrics (Figure S1). The prevalence rates of subclinical atherosclerosis were 15.92%, 13.85%, 6.76%, and 1.93%, determined based on CAC score by using thresholds of 0, 10, 100, and 400 Agatston units, respectively (Table 2). The prevalence of subclinical atherosclerosis differed in the first, second, third, and fourth quartiles of CVH (*P* for trend <0.001).

Table 3 shows the association between each component of the ideal CVH metrics and the prevalence of CAC. After adjusting for age, sex, education level, income level, and alcohol use, we found that the ideal fasting blood glucose and smoking metrics were significantly correlated with the low risk of having a higher CAC score. In addition, the trends were consistent among different comparisons that used different CAC cutoff scores. The ideal total cholesterol metric was also significantly correlated with the low risk of having a higher CAC score when using 0 and 10 as CAC cutoffs. However, statistical significance was lost when 100 and 400 were used as CAC cutoff values.

Table 4 shows the odds ratios (ORs) for CAC presence after adjusting for age and sex, education level, income level, and alcohol intake. For the participants with ideal CVH metric scores in the highest quartile, the ORs of CAC scores >0 were less than half of those for the participants with ideal CVH metric scores in the first quartile [OR 0.49, 95% confidence interval (CI), 0.35-0.69]. In the highest quartile group, similar patterns were evident in the participants with CAC scores of ≥10 (OR 0.50, 95% CI, 0.35-0.71) and ≥100 (OR 0.42, 95% CI, 0.26-0.69). When a CAC score of ≥400 was the considered outcome, a significant reduction in the odds of developing CAC was also observed in those with ideal CVH metric scores in the highest quartile (OR 0.33, 95% CI, 0.14-0.78).

DISCUSSION

After the AHA defined a set of ideal cardiovascular health metrics to measure the progress toward the 2020 Impact Goal, several studies have attempted to estimate the prevalence of ideal cardiovascular health metrics in the United States[5,32-33]. These studies reported that the prevalence of all the seven ideal cardiovascular health metrics in the US adult population was nearly 1%, which indicated that only few adults achieved ideal cardiovascular health. Studies from China also showed that only 0.1%-0.5% of participants met all the seven ideal cardiovascular health behaviors and factors[34-36]. Our study reported that 58 participants (2.35%) had ideal levels of all the seven health metrics in a Chinese population and was the first to demonstrate that participants with higher ideal cardiovascular health metric scores had a lower prevalence of subclinical atherosclerosis as estimated

Table 1. Baseline Characteristics of Participants for All 7 Ideal Cardiovascular Health Metrics Grouped by the Number of Metrics in the Ideal Range

Characteristic	Number of Ideal Cardiovascular Health Metrics				$P^{\#}$
	Quartile 1 (0-2)	Quartile 2 (3)	Quartile 3 (4)	Quartile 4 (5-7)	
n	571	667	738	819	
Age(years)	55.41±7.45	56.50±7.73	56.08±7.72	53.74±7.81	<0.001
Men(%)	396 (69.35%)	381 (57.12%)	357 (48.37%)	267 (32.60%)	<0.001
Income, ¥/month					0.0465
≤3000	314 (55.87%)	372 (56.79%)	404 (55.04%)	412 (50.99%)	
3001-5000	226 (40.21%)	239 (36.49%)	297 (40.46%)	353 (43.69%)	
≥5001	22 (3.91%)	44 (6.72%)	33 (4.50%)	43 (5.32%)	
Education level					0.0002
Illiteracy/primary	52 (9.11%)	62 (9.30%)	75 (10.16%)	51 (6.23%)	
Middle school	381 (66.73%)	412 (61.77%)	433 (58.67%)	482 (58.85%)	
College/University	138 (24.17%)	193 (28.94%)	230 (31.17%)	286 (34.92%)	
Alcohol use (yes)	258 (45.18%)	231 (34.63%)	208 (28.18%)	156 (19.05%)	<0.001
Smoking					<0.001
Poor	297 (52.01%)	194 (29.09%)	147 (19.92%)	52 (6.35%)	
Intermediate	14 (2.45%)	7 (1.05%)	3 (0.41%)	3 (0.37%)	
Ideal	260 (45.53%)	466 (69.87%)	588 (79.67%)	764 (93.28%)	
BMI					<0.001
Poor	102 (17.86%)	69 (10.34%)	37 (5.01%)	4 (0.49%)	
Intermediate	392 (68.65%)	386 (57.87%)	267 (36.18%)	101 (12.33%)	
Ideal	77 (13.49%)	212 (31.78%)	434 (58.81%)	714 (87.18%)	
Physical activity					<0.001
Poor	296 (51.84%)	220 (32.98%)	203 (27.51%)	100 (12.21%)	
Intermediate	62 (10.86%)	56 (8.40%)	45 (6.10%)	27 (3.30%)	
Ideal	213 (37.30%)	391 (58.62%)	490 (66.40%)	692 (84.49%)	
Diet					<0.001
Poor	131 (22.94%)	120 (17.99%)	121 (16.40%)	72 (8.79%)	
Intermediate	401 (70.23%)	415 (62.22%)	423 (57.32%)	333 (40.66%)	
Ideal	39 (6.83%)	132 (19.79%)	194 (26.29%)	414 (50.55%)	
Total cholesterol					<0.001
Poor	88 (15.41%)	59 (8.85%)	46 (6.23%)	20 (2.44%)	
Intermediate	296 (51.84%)	228 (34.18%)	184 (24.93%)	93 (11.36%)	
Ideal	187 (32.75%)	380 (56.97%)	508 (68.83%)	706 (86.20%)	
Blood pressure					<0.001
Poor	219 (38.35%)	175 (26.24%)	147 (19.92%)	80 (9.77%)	
Intermediate	337 (59.02%)	445 (66.72%)	433 (58.67%)	346 (42.25%)	
Ideal	15 (2.63%)	47 (7.05%)	158 (21.41%)	393 (47.99%)	
Fasting blood glucose					<0.001
Poor	123 (21.54%)	80 (11.99%)	40 (5.42%)	7 (0.85%)	
Intermediate	271 (47.46%)	214 (32.08%)	118 (15.99%)	49 (5.98%)	
Ideal	177 (31.00%)	373 (55.92%)	580 (78.59%)	763 (93.16%)	
CAC score					<0.001
0	446 (78.11%)	541 (81.11%)	613 (83.06%)	750 (91.58%)	
0-10	15 (2.63%)	17 (2.55%)	17 (2.30%)	9 (1.10%)	
10-100	49 (8.58%)	56 (8.40%)	60 (8.13%)	33 (4.03%)	
100-400	39 (6.83%)	41 (6.15%)	38 (5.15%)	17 (2.08%)	
>400	22 (3.85%)	12 (1.80%)	10 (1.36%)	10 (1.22%)	

Note. Data are presented in mean±SD or Number (percentage). $^{\#}P$ for trends or *P* in analysis of variances. BMI: Body mass index; CAC: Coronary artery calcification.

Table 2. The Prevalence of Subclinical Atherosclerosis Determined by CAC Using Different Thresholds, Representing as Percentage (95% CI)

Thresholds of CAC Score (Agatston units)	Total	Quartile 1	Quartile 2	Quartile 3	Quartile 4	*P* for Trend
0	15.92 (14.56-17.28)	21.89 (18.50-25.29)	18.89 (15.92-21.86)	16.94 (14.23-19.65)	8.42 (6.52-10.33)	<0.0001
10	13.85 (12.56-15.13)	19.26 (16.03-22.50)	16.34 (13.53-19.15)	14.63 (12.08-17.19)	7.33 (5.54-9.11)	<0.0001
100	6.76 (5.83-7.69)	10.68 (8.15-13.22)	7.95 (5.89-10.00)	6.50 (4.72-8.28)	3.30 (2.07-4.52)	<0.0001
400	1.93 (1.42-2.44)	3.85 (2.27-5.43)	1.80 (0.79-2.81)	1.36 (0.52-2.19)	1.22 (0.47-1.97)	0.0008

Table 3. Odds Ratios (95% CI) for Coronary Artery Calcification for Different Categories of Health Metrics*

Metrics	0*	10*	100*	400*
Smoking				
Poor	1#	1	1	1
Intermediate	1.53 (0.62-3.82)	1.84 (0.74-4.62)	1.85 (0.63-5.42)	0.78 (0.10-6.34)
Ideal	**0.74 (0.56-0.97)**	**0.72 (0.53-0.96)**	**0.58 (0.40-0.85)**	**0.34 (0.18-0.66)**
Physical activity				
Poor	1	1	1	1
Intermediate	0.79 (0.45-1.38)	1.00 (0.57-1.77)	1.58 (0.78-3.23)	0.83 (0.18-3.72)
Ideal	1.06 (0.83-1.35)	1.11 (0.86-1.44)	1.07 (0.75-1.52)	0.83 (0.46-1.52)
Diet				
Poor	1	1	1	1
Intermediate	1.09 (0.80-1.47)	1.12 (0.81-1.54)	0.86 (0.57-1.30)	0.64 (0.32-1.28)
Ideal	0.91 (0.64-1.28)	0.94 (0.65-1.36)	0.96 (0.60-1.55)	0.65 (0.29-1.47)
BMI				
Poor	1	1	1	1
Intermediate	0.93 (0.62-1.39)	0.92 (0.60-1.41)	0.81 (0.46-1.41)	0.38 (0.17-0.86)
Ideal	0.78 (0.52-1.17)	0.79 (0.51-1.21)	0.68 (0.39-1.19)	0.37 (0.16-0.84)
Total cholesterol				
Poor	1	1	1	1
Intermediate	0.80 (0.54-1.19)	0.90 (0.59-1.37)	0.87 (0.48-1.58)	1.01 (0.33-3.09)
Ideal	**0.47 (0.32-0.69)**	**0.54 (0.36-0.81)**	0.62 (0.35-1.10)	0.67 (0.23-2.00)
Blood pressure				
Poor	1	1	1	1
Intermediate	0.84 (0.65-1.08)	0.81 (0.62-1.06)	0.79 (0.55-1.12)	1.34 (0.69-2.61)
Ideal	0.77 (0.55-1.09)	0.75 (0.52-1.07)	0.70 (0.43-1.16)	1.04 (0.40-2.69)
Fasting blood glucose				
Poor	1	1	1	1
Intermediate	0.94 (0.65-1.35)	0.97 (0.66-1.42)	0.95 (0.59-1.53)	0.68 (0.31-1.49)
Ideal	**0.60 (0.43-0.84)**	**0.60 (0.42-0.86)**	**0.50 (0.31-0.79)**	**0.40 (0.19-0.85)**

Note. *Thresholds of CAC score (Agatston units). #The reference group includes patients with poor metric of cardiovascular health. The following potential confounders were adjusted for each OR: age, sex, income level, education level, alcohol use. Bold ORs indicating to P<0.05.

Table 4. Associations of Coronary Artery Calcification with Number of Ideal Cardiovascular Health Metrics (CVH), Adjusted OR (95% CI)*

Item	0*	10*	100*	400*
Quartile 1	1#	1	1	1
Quartile 2	0.86 (0.63-1.17)	0.73 (0.54-1.01)	0.66 (0.44-0.99)	0.40 (0.19-0.84)
Quartile 3	0.75 (0.55-1.02)	0.70 (0.51-0.95)	0.55 (0.36-0.84)	0.31 (0.14-0.68)
Quartile 4	0.49 (0.35-0.69)	0.50 (0.35-0.71)	0.42 (0.26-0.69)	0.33 (0.14-0.78)

Note. *Thresholds of CAC score (Agatston units). #The reference group includes patients with poor metric of cardiovascular health. The following potential confounders were adjusted for each OR: age, sex, income level, education level, alcohol use.

based on CAC scores in the Chinese population.

Our study showed that the ideal smoking metric was associated with a lower risk of having CAC. This is consistent with results from other studies in populations other than the Chinese population. A study consisting of 32,481 individuals aged 30 to 90 years found that the ideal smoking metric was negatively correlated with CAC[18]. Likewise, a US cross-sectional study with 9341 asymptomatic participants found that CAC was associated with poor smoking metrics[17]. Health behaviors of smokers may play an important role in mediating the relationship between subclinical atherosclerosis and risk of cardiovascular events.

Other cardiovascular health behaviors, including ideal diet intake, and being physically active were reported to be associated with a reduced likelihood of having subclinical atherosclerosis assessed based on CAC score[22,37]. However, Taylor et al.[38] found no significant relationship between physical activity, particularly high-intensity physical activity, diets, and CAC severity. Consistently with the results of the study by Taylor et al.[38], our study results showed that ideal diet and physical activity were not associated with lower CAC scores. The difference among the three studies might have arisen from the difference in ethnicity of the study participants. Our study included mainly Han-ethnic Chinese, who probably had different physique and lifestyles from the other ethnic populations.

We also analyzed the association between CAC and the biomarker indicators of ideal cardiovascular health. The results of this study repeated the negative correlations of blood pressure[20], diabetes[21], and BMI[16] with CAC in a Chinese population. Different from the previously reported finding that total cholesterol level was not associated with CAC[19], our finding indicated that the ideal total cholesterol metric was also significantly correlated with the low risk of having a higher CAC score when 0 and 10 were used as CAC cutoff scores. However, statistical significance was lost when 100 and 400 were used as CAC cutoff scores. In addition, consistent to several reports[39-40], we also found an association between fasting blood glucose level and CAC. The Rancho Bernardo Study showed that fasting blood glucose level (>100 mg/dL) was an independent predictor of CAC progression in participants aged <65 years[39]. Another study reported that fasting blood glucose level in the upper normal range appears to be associated with the presence of CAC in apparently non-diabetic Brazilian men[40]. This association suggested that all levels of dysglycemia, even those well below the current American Diabetic Association diagnostic levels for diabetes mellitus, are associated with increased CHD risk.

We further investigated the cumulative impact of ideal CVH metrics on CAC. Remarkably, the increased total scores of the ideal CVH metrics were associated with low CAC scores, consistent with the results of previous studies that evaluated the association between individual health risk factors or health behaviors and CAC[41]. The negative association between the total scores of the ideal CVH metrics and CAC was found at the clinical CAC cutoff scores of >0 versus 0, ≥10 versus <10, ≥100 versus <100, and ≥400 versus <400. A previous study also showed that more favorable CVH categories were associated with lower risk of CAC[41]. Identifying and reducing the earliest damage before developing risk factors in generally healthy individuals would seem to provide a clear advantage of preventing the progression of coronary atherosclerosis.

Although our study included a large sample size and adjusted for various potential confounders, several limitations should be noted. First, dietary intake was defined based on a questionnaire survey modified from the established food frequency questionnaire, which might have influenced the magnitude of this association. Second, we did not take into account the statins used to treat atherosclerosis. Cholesterol-lowering statin medications play a central role in the development of endothelial inflammation and decreased atherosclerosis[42-44]. In this study, the CVH categories (blood pressure, fasting blood glucose level, and total cholesterol level) that included medical factors such as blood pressure were classified as ideal (SBP of <120 mmHg, DBP of <80 mmHg, and untreated), intermediate (SBP of 120-139 mmHg, DBP of 80-90 mmHg, and treated to goal), or poor (SBP of ≥140 mmHg or DBP of ≥90 mmHg). Thus, whether taking statins into account would affect the magnitude but not the direction of the association is unclear. Third, this was a cross-sectional study, which limited our ability to conclude a cause-and-effect relationship between the ideal cardiovascular metrics and CAC. The causal relationship between the ideal cardiovascular metrics and CAC needs be justified in a further study.

CONCLUSION

In brief, we showed that the ideal cardiovascular metrics were associated with a lower prevalence of subclinical atherosclerosis determined based on CAC score in our Chinese population. Maintaining ideal cardiovascular health may be valuable in the prevention of atherosclerosis in the general population.

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CONTRIBUTORS

LUO Tai Yang and DONG Jian Zeng wrote the manuscript and interpreted the data. DAI Tian Yi and LUO Tai Yang analyzed the data. LIU Xiao Hui and DONG Jian Zeng critically reviewed the manuscript. LIU Xin Min reviewed/edited the manuscript. ZHANG Qian contributed to the discussion and reviewed/edited the manuscript.

Conflict of Interest Disclosures None.

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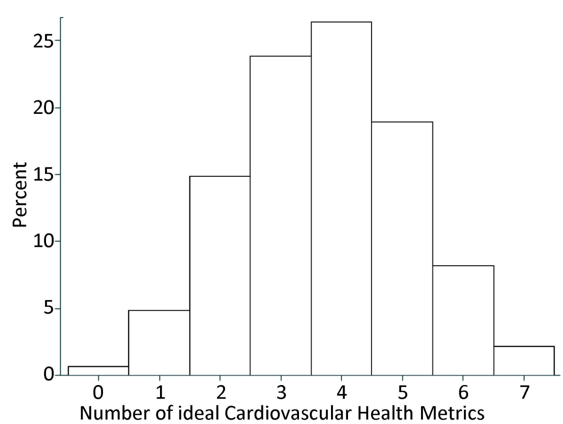

Figure S1. Distribution of cardiovascular healthmetric numbers in participants.