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무증상 성인에서 대사증후군과 관상동맥석회화의 관련성

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Metabolic Syndrome as a Predictor of Coronary Artery Calcification in Asymptomatic Korean Adults

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Introduction: Identification of individuals at high risk for coronary heart disease (CHD) is a challenge, though essential, for the prevention of future events. Thus, early detection of CHD has been a priority in research and practice. We conducted a study to evaluate the relationship between metabolic syndrome (MS) and its components with coronary artery calcium (CAC) as a surrogate of CHD in a large Korean adult population.
Methods: The study subjects (n=14,429) were individuals who visited a health promotion center in Seoul, Korea from Jan. 2010 to Dec. 2010. Personal and family medical histories were collected and smoking status, anthropometric measurements, and laboratory tests were measured. CAC scores were measured by the multi-detector computed tomography.
Results: The study population consisted of 11,884 men (mean age 41.9±6.6 years) and 2,544 women (mean age 42.9±8.0 years). The total prevalence of MS was 19.6%, with 21% in men and 13.2% in women. CAC (CAC>0) was found in 15.0% of men and 5.4% of women. When compared to the non-MS group, the MS group had a higher prevalence of CAC after adjusting for age, smoking, and family history of stroke and CHD in both men (odds ratio [OR], 1.82; 95% confidence interval [CI], 1.62-2.05; *P*<0.001) and women (OR, 2.23; 95% CI, 1.49-3.33; *P*<0.001). All individual components of MS, except high density lipoprotein cholesterol level, were associated with a high risk for CAC presence.
Conclusions: Individuals with MS had a greater prevalence of CAC compared with individuals without this condition.
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Keywords: Calcium, Coronary artery disease, Metabolic syndrome X

Introduction

Coronary heart disease (CHD) is a leading cause of death worldwide. Morbidity and mortality from CHD have rapidly increased in Korea. According to the Korean statistical analysis for cause of deaths in 2010, CHD was the 3rd highest of all registered deaths.[1)] Identification of individuals at high risk for CHD is challenging, though essential, for the prevention of future events. Thus, early detection of CHD has been a priority in research and practice.

One of the best independent predictor for CHD risk is coronary artery calcium (CAC).[2-6)] CAC screening with a CT (computed tomography) scanner is a noninvasive test that looks for the presence of calcium (called calcification) in the walls of coronary arteries. The amount of calcium inside the walls of coronary arteries (calcium score) is a good predictor of future coronary heart events. A normal calcium score is 0 and a very high score is >400.

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Metabolic syndrome (MS) is a cluster of coronary heart disease risk factors including visceral obesity, dyslipidemia, hypertension, and impaired glucose metabolism, which are known to be associated with coronary heart morbidity and mortality.[7-9] The prevalence of MS is increasing worldwide; thus, MS presents a major challenge for public health professionals because of its global, social, and economic burden.[10] The prevalence of MS in South Korea was reported as 27.4% in men and 20.9% in women (24.1% in South Korean adults).[11] A recent meta-analysis reported that the metabolic syndrome is associated with a 2-fold increase in coronary heart outcomes and a 1.5-fold increase in all-cause mortality.[12] The majority of studies that documented the predictive value of MS have been carried out in Caucasian populations, and thus, it is uncertain whether MS plays a similar role in Asians.[13,14] Even in Korea, the relationship of MS and CHD risk of morbidity and mortality has hardly beedn published.[15] We conducted a study involving a large Korean adult population to evaluate the relationship between MS and its components with CAC as a surrogate of CHD.

Methods

1. Study participants

We investigated the clinical characteristics of 15,095 individuals aged 22 to 85 years, who were free of known clinical CHD and stroke. Participants underwent CAC scanning by a Multi-Detector Computed Tomography (MDCT) during health examinations from January to December in 2010 at Samsung Medical Healthcare Centers. Participants who had a history of coronary heart disease and stroke (n=147) or missing self-reported data (n=520) were excluded. The final number of subjects for analysis was 14,428 (men 82.4%, n=11,884). The study protocol was approved by the Institutional Review Board of the Kangbuk Samsung Hospital (IRB No. KBC12019).

2. Questionnaire

Participants were asked to fill out questionnaires, which included demographic factors (age, gender, and family history of stroke and coronary heart disease) and habits including smoking status (nonsmoker, ex-smoker, and current smoker). For those who could not read or write, caregivers or trained nurses assisted with filling out the questionnaires. The trained nurses double-checked the questionnaires for unanswered questions and encouraged participants to complete them.

3. Anthropometric and laboratory measures

Height, weight, and waist circumference (WC) were measured. WC was measured using a non-stretchable tape placed midway between the lowest rib and the iliac crest over the lightly dressed abdomen. Trained nurses measured sitting blood pressure with a mercury sphygmomanometer. Blood samples were taken from the antecubital vein after more than 12 hours of fasting. Serum levels of total cholesterol (TC) and triglycerides (TG) were determined using an enzymatic colorimetric assay while low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) were determined using a homogeneous enzymatic colorimetric assay on an automated analyzer (Modular Analytics D2400; Roche Diagnostics, Tokyo, Japan). Serum fasting blood glucose (FBS) was determined using the hexokinase method on the Cobas Integra 800 (Roche Diagnostics; Rotkreuz, Switzerland).

4. Calculation of CAC scores

All patients underwent MDCT on the LightSpeed VCT XTe (GE, Japan) using rapid acquisition (100 ms) of 30 to 40 contiguous slices 2.5-mm thick. Using electrocardiogram (ECG) triggering, we acquired images at end-diastole during a single breath hold. Scans were interpreted by experienced radiologists. All regions with a density greater than 130 Hounsfield units were identified as potential calcifications. For each calcified focus, a score was calculated according to the Agatston's method.[16] The Agatston calcium score was obtained by multiplying the area by a weighting factor that is dependent on the peak signal anywhere in the lesion. The final Agatston score was derived as the sum score of all lesions identified within the coronary tree (left main, left anterior descending, left circumflex, and right coronary arteries), again, according to the method described by Agatston et al.[16] The presence of CAC was defined by a score >0.

5. Diagnosis of MS

Metabolic syndrome was defined according to the 2001 National Cholesterol Education Program Adult Treatment Panel III (ATP III),[17] except for abdominal obesity by WC, which is not applicable to the relatively lean Asian people, and for high FBS cutoff level, which was lowered (≥100 mg/dL) according to the American Diabetes Association.[18] WC directly reflects abdominal fat mass and has good correlation with other metabolic components.[19] Inoue et al. proposed a WC standard for Asians.[20] MS was defined as having 3 or more components of the following: 1) abdominal obesity, WC ≥90 cm in men and ≥80 cm in women; 2) high TG, ≥150 mg/dL; 3) low HDL-C, <40 mg/dL in men, <50 mg/dL in women; 4) high BP, ≥130/85 mmHg or the use of medication; and 5) high FBS, ≥100 mg/dL or the use of medication.

6. Statistical analysis

All variables are presented as mean±SD or as proportions. Men were significantly different from women in all characteristics including the prevalence of MS and CAC. Men and women were analyzed separately. Continuous variables (age, components of MS) were compared using a *t*-test and categorical variables were compared using Pearson's Chi-square test. Tests for trend were performed by Cochran-Armitage trend test using linear-by-linear association.

We calculated the odds ratio (OR) and 95% confidence interval (CI) of the presence of CAC in the MS group compared to the non-MS group by logistic regression. Multiple logistic regression analysis was performed to adjust significant confounders.

The CAC scores according to the number of MS risk factors in men and women were compared using the Spearman's rank order correlation analysis test. Of all subjects, 51.7% were 40 to 49 years old. Age is strongly related with CAC and MS. To control for the effects of age, subjects were classified as <40, 40-49, and ≥50 years and analyzed to estimate ORs and 95% CI of CAC in the MS-group compared to the non-MS group.

A 2-tailed *P* value of ≤0.05 was considered statistically significant. All analyses were performed using SPSS 18.0 for Windows (SPSS Inc., Chicago, IL, USA, 2009).

RESULTS

1. Baseline characteristics of study subjects

Table 1 shows the characteristics of the MS group compared to the non-MS group. MS was present in 19.6% of all subjects and in 21.0% of men and 13.2% of women. CAC was present (CAC >0) in 15.0% of men and 5.4% of women. Of all subjects, 35.7% were younger than 40 years and 51.7% were 40 to 49 years old.

The MS group had a higher prevalence of CAC and higher mean CAC scores than the non-MS group, for both men and women. The MS group was older and heavier, had higher rates of DM and HTN, had more positive family histories of stroke, and had a higher number of current smokers. This last finding was seen in men but not in women. Family history of CAD was higher in the MS group, but only among women.

2. Risk factors of CAC presence

All outlined metabolic risk factors for the presence of CAC were statistically significant in univariate logistic regression analysis, except for smoking history in women (Table 2). Age showed the highest ORs in both men and women. High BP, history of HTN, history of DM, BMI, and MS all had high ORs in women. High BP, history of HTN, history of DM, and MS had high ORs in men. In univariate anlysis, ORs for the presence of CAC were significantly higher for men with family history of stroke (OR, 1.83; 95% CI, 1.60-2.11) compared to men without such family history, and also higher in women with family history of stroke (OR, 1.63; 95% CI, 1.06-2.51) compared to those without.

According to multivariate logistic regression analysis, there was a statistically significant association between the presence of CAC and MS (OR, 1.82; 95% CI, 1.62-2.05 in men and 2.23; 95% CI, 1.49-3.33 in women). Of the components of MS, low HDL-C was not associated with CAC in women (OR, 1.26; 95% CI, 0.84-1.88) and was borderline significant in men (OR, 1.16; 95% CI, 1.01-1.35). High TG was barely associated with CAC in women (OR, 1.67 [1.08-2.58]). High BP showed the most significant association in all subjects (OR, 1.87; 95% CI, 1.68-2.08 in men and 4.41; 95% CI, 2.99-6.51 in women). Having a his-

Table 1. Basic characteristics of study population according to MS status and gender[a]

Characteristics	Total (n=14,428)	Men (n=11,884) No MS (n=9,391)	Men MS (n=2,493)	Men *P*	Women (n=2,544) No MS (n=2,209)	Women MS (n=335)	Women *P*
Age, y	42.1±6.9	41.7±6.7	43.1±6.4	<0.001[b]	42.2±7.5	47.6±9.3	<0.001[b]
<40	5147 (35.7)	3549 (37.8)	708 (16.6)		836 (37.8)	54 (16.1)	
40-49	7460 (51.7)	4761 (50.7)	1446 (58.0)		1075 (48.7)	178 (53.1)	
≥50	1821 (12.6)	1081 (11.5)	339 (13.6)		298 (13.5)	103 (30.7)	
BMI, kg/m^2	24.5±3.1	24.2±2.6	27.5±2.8	<0.001[b]	22.2±3.0	26.1±3.6	<0.001[b]
<23	4511 (31.2)	2882 (30.7)	108 (4.3)		1469 (66.6)	52 (15.5)	
23≤BMI<25	3934 (27.2)	3108 (33.1)	308 (12.4)		421 (19.1)	97 (29.0)	
25≤BMI<27	3124 (21.6)	2153 (22.9)	713 (28.6)		183 (8.3)	75 (22.4)	
≥27	2850 (19.7)	1243 (13.2)	1362 (54.7)		134 (6.1)	111 (33.1)	
Family history of stroke	1715 (11.9)	1035 (11.0)	324 (13.0)	0.060[c]	301 (13.6)	55 (16.4)	0.173[c]
Family history of CHD	1550 (10.7)	925 (9.8)	262 (10.5)	0.328[c]	296 (13.4)	67 (20.0)	0.012[c]
Smoking status				<0.001[b]			0.23[b]
Non-smoker	6752 (46.8)	3593 (38.3)	719 (28.8)		2122 (96.1)	318 (94.9)	
Ex-smoker	4124 (28.6)	3177 (33.8)	877 (35.2)		57 (2.6)	13 (3.9)	
Current smoker	3552 (24.6)	2621 (27.9)	897 (36.0)		30 (1.4)	4 (1.2)	
WC, cm	84.9±8.3	84.5±6.6	93.1±6.8	<0.001[d]	77.3±7.9	88.2±8.8	<0.001[d]
SBP, mmHg	117.4±12.4	116.9±10.8	126.3±11.8	<0.001[d]	108.5±12.2	121.5±13.6	<0.001[d]
DBP, mmHg	74.9±9.1	74.8±8.0	81.2±9.0	<0.001[d]	68.0±8.4	76.3±9.5	<0.001[d]
HTN diagnosed	1191 (8.2)	466 (5.0)	532 (21.3)	<0.001[d]	93 (4.2)	100 (29.9)	<0.001[d]
TC, mg/dL	204.2±36.0	203.7±34.9	213.13±37.32	<0.001[d]	195.2±36.4	212.2±37.4	<0.001[d]
LDL-C, mg/dL	126.5±32.5	127.8±31.4	131.6±33.9	<0.001[d]	114.2±32.3	132.8±33.9	<0.001[d]
HDL-C, mg/dL	52.8±12.7	52.9±11.4	43.9±9.5	<0.001[d]	63.1±13.5	48.3±11.8	<0.001[d]
TG, mg/dL	139.8±96.3	126.6±73.6	233.9±133.8	<0.001[d]	83.6±38.3	181.9±103.6	<0.001[d]
FBS, mg/dL	96.0±16.4	94.7±12.9	107.5±23.7	<0.001[d]	90.2±9.8	108.0±26.1	<0.001[d]
DM diagnosed	362 (2.5)	161 (1.7)	160 (6.4)	<0.001[d]	18 (0.8)	23 (6.9)	<0.001[d]
CAC scored	17 (5-57)	16 (4-48)	20 (6-67)	<0.001[d]	25 (8-74)	17 (3-115)	0.020[d]
=0	12508 (86.7)	8178 (87.1)	1923 (77.1)	<0.001[c]	2119 (95.9)	288 (86.0)	<0.001[c]
>0	1920 (13.3)	1213 (12.9)	570 (22.9)		90 (4.1)	47 (14.0)	

Abbreviations: MS, metabolic syndrome; BMI, body mass index; CHD, coronary heart disease; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; HTN, hypertension; TC, total cholesterol; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; TG, triglyceride; FBS, fasting blood sugar; DM, diabetes mellitus; CAC, coronary artery calcium.
[a]Values are presented as mean±SD, median (interquartile range), or number (%).
[b]Calculated by Cochran-Armitage trend test.
[c]Calculated by chi-square test.
[d]Calculated by student *t*-test.

tory of hypertension and diabetes showed higher ORs for CAC in both genders (Table 3). Age was the strongest predictor for CAC presence and significantly related with MS in both genders. Thus, we stratified age to evaluate whether age is a significant modifier of the association between MS and CAC and to present the ORs of MS, and its components, and CAC (Table 4). We found that the ORs of MS and CAC were not significantly different in the age groups.

3. CAC presence, relation between CAC score and MS traits

The presence of CAC was observed in 21.8% of the MS group compared to 11.2% of the non-MS group. Table 5 shows our analysis of the distribution of CAC scores according to the number of MS components. CAC scores increased positively with the number of MS components (*P*<0.001 by Spearman's rank order correlation test).

DISCUSSION

We examined the relationships between MS and CAC in asymptomatic Korean population. In our study, MS, defined by the NCEP-ATP III criteria, was associated with the risk for CAC presence after controlling for other established coronary heart risk factors (OR, 1.82; 95% CI, 1.62-2.05 in men, 2.23; 95% CI, 1.49-3.33 in women). This result is similar to a study from Korea, which reported that MS was associated with the risk for incident CHD after controlling for other established coronary heart risk fac-

Table 2. Univariate analysis for the presence of CAC with metabolic syndrome and metabolic risk factors

Characteristics	Men (n=11,884)		Women (n=2,544)	
	OR (95% CI)	P^a	OR (95% CI)	P^a
Age, y	1.14 (1.13-1.15)	<0.001[b]	1.15 (1.13-1.17)	<0.001[b]
<40	1.00		1.00	
40-49	4.28 (3.56-5.01)		8.82 (3.17-24.56)	
≥50	12.41 (10.37-14.84)		59.58 (21.68-163.74)	
BMI, kg/m^2		<0.001[b]		<0.001[b]
<23	1.00		1.00	
23≤ <25	1.26 (1.09-1.47)		2.24 (1.45-3.44)	
25≤ <27	1.66 (1.43-1.93)		2.77 (1.66-4.60)	
≥27	1.77 (1.52-2.05)		3.07 (1.85-5.08)	
Family history of stroke	1.83 (1.60-2.11)	<0.001	1.63 (1.06-2.51)	<0.001
Family history of CHD	1.65 (1.42-1.92)	<0.001	1.75 (1.15-2.66)	<0.001
Smoking status		<0.001		0.638
Non-smoker	1.00		1.00	
Ex-smoker	1.58 (1.40-1.80)		1.06 (0.38-2.95)	
Current smoker	1.58 (1.39-1.79)		0.53 (0.07-3.90)	
Abdominal obesity[c]	1.40 (1.26-1.55)	<0.001	2.58 (1.81-3.67)	<0.001
Raised BP[d]	2.13 (1.92-2.36)	<0.001	9.15 (6.39-13.11)	<0.001
HTN diagnosed	3.40 (3.03-3.82)	<0.001	8.67 (5.99-12.55)	<0.001
Reduced HDL-C[e]	1.22 (1.06-1.40)	<0.001	1.62 (1.12-2.37)	0.010
Raised TG[f]	1.65 (1.49-1.83)	<0.001	2.54 (1.69-3.82)	<0.001
Raised FBS[g]	1.75 (1.58-1.94)	<0.001	2.29 (1.57-3.35)	<0.001
DM diagnosed	4.53 (3.76-5.44)	<0.001	6.11 (3.26-11.46)	<0.001
Number of MS components		<0.001[b]		<0.001[b]
0	1.00		1.00	
1	1.65 (1.42-1.93)		2.87 (1.60-5.14)	
2	2.28 (1.95-2.66)		6.05 (3.42-10.70)	
≥3 (MS)	3.14 (2.70-3.65)		9.62 (5.50-16.82)	

Abbreviations: CAC, coronary artery calcium; OR, odds ratio; CI, confidence interval; BMI, body mass index; CHD, coronary heart disease; BP, blood pressure; HTN, hypertension; HDL-C, high density lipoprotein cholesterol; TG, triglyceride; FBS, fasting blood sugar; DM, diabetes mellitus; MS, metabolic syndrome.
[a]Calculated by univariate logistic regression analysis.
[b]Calculated by Cochran-Armitage trend test.
[c]Defined as waist circumference >90 cm for males and >80 cm for females.
[d]Defined as blood pressure ≥130/85 mmHg for both gender.
[e]Defined as high density lipoprotein cholesterol level <40 mg/dL for males and <50 mg/dL for females.
[f]Defined as triglyceride level ≥150 mg/dL for both gender.
[g]Defined as fasting blood sugar level ≥100 mg/dL for both gender.

tors (OR, 1.98; 95% CI, 1.30-3.03 in men, 4.04; 95% CI, 1.78-9.14 in women) after a follow-up of mean 8.7 years.[15] Of the individual components of MS, every component except low HDL-C had a high risk for CAC presence. Additionally, high BP was most strongly associated with CAC in both men (OR, 1.87; 95% CI, 1.68-2.08) and women (OR, 4.41; 95%CI, 2.99-6.51). This result was consistent with those of other studies looking at CAC. One previous study[21] demonstrated that high blood pressure, and its duration in particular, promotes the presence and overall extent of coronary calcium. The mechanism of the interaction between hypertension and coronary calcification has not been determined, but may be multifactorial. In our study, Patients with history of hypertension had higher OR for CAC than high BP in men (OR 2.56 VS 1.87). HTN was a better predictor for CAC than MS in men. (OR 2.56 VS 1.82) We set the criterion for high FBS as ≥100 mg/dL according to the NCEP/ATP III criteria. However, when we put diabetic patients into High FBS, the OR for CAC was better (OR, 2.92; 95% CI, 2.41-3.54 in men, 3.12; 95% CI, 1.58-6.18 in women) than high FBS (OR, 1.47; 95% CI, 1.32-1.64 in men, 1.68; 95% CI, 1.12-2.52 in women). Wong et al.[22] also reported that the positive relationship between DM and the presence of CAC (OR, 2.3; 95% CI, 1.5-3.3) was stronger than between MS and the presence of CAC (OR, 1.7; 95% CI, 1.3-2.3). The clustering of components was a strong predictor for CAC. The presence of diabetes and hyper-

Table 3. Multivariate analysis for presence of CAC with metabolic syndrome and metabolic risk factors[a]

Characteristics	Men (n=11,884)		Women (n=2,544)	
	OR (95% CI)	P^b	OR (95% CI)	P^b
Abdominal obesity[c]	1.42 (1.27-1.59)	<0.001	1.72 (1.18-2.49)	0.01
Raised BP[d]	1.87 (1.68-2.08)	<0.001	4.41 (2.99-6.51)	<0.001
Reduced HDL-C[e]	1.16 (1.01-1.35)	0.040	1.26 (0.84-1.88)	0.258
Raised TG[f]	1.57 (1.41-1.75)	<0.001	1.67 (1.08-2.58)	0.023
Raised FBS[g]	1.47 (1.32-1.64)	<0.001	1.68 (1.12-2.52)	0.012
HTN diagnosed	2.56 (2.26-2.89)	<0.001	3.91 (2.60-5.88)	<0.001
DM diagnosed	2.92 (2.41-3.54)	<0.001	3.12 (1.58-6.18)	<0.001
Number of MS components		<0.001[h]		<0.001[h]
0	1.00		1.00	
1	1.51 (1.29-1.77)		1.98 (1.09-3.61)	
2	1.90 (1.62-2.24)		3.22 (1.78-5.84)	
≥3	2.63 (2.25-3.08)		4.35 (2.42-7.81)	
Metabolic syndrome	1.82 (1.62-2.05)	<0.001	2.23 (1.49-3.33)	<0.001

Abbreviations: CAC, coronary artery calcium; OR, odds ratio; CI, confidence interval; BP, blood pressure; HDL-C, high density lipoprotein cholesterol; TG, triglyceride; FBS, fasting blood sugar; HTN, hypertension; DM, diabetes mellitus; MS, metabolic syndrome.
[a]Adjusted for age, smoking, and family history of stroke and coronary heart disease.
[b]Calculated by multivariate logistic regression analysis.
[c]Defined as waist circumference >90 cm for males and >80 cm for females.
[d]Defined as blood pressure ≥130/85 mmHg for both gender.
[e]Defined as high density lipoprotein cholesterol level <40 mg/dL for males and <50 mg/dL for females.
[f]Defined as triglyceride level ≥150 mg/dL for both gender.
[g]Defined as fasting blood sugar level ≥100 mg/dL for both gender.
[h]Calculated by likelihood ratio test for trend.

tension are both better predictors of CAC than MS. According to multivariate logistic regression analysis, low HDL-C was not significantly associated with CAC and high TG was weakly associated with CAC in women. According to our estimates, the reason might be that high TG and low HDL-C were considerably influenced by age in women. Nielsen et al.[23] suggested that lipoprotein changes reflecting disturbed TG metabolism could be more pronounced in postmenopausal women. As we stratified age, high TG was significantly related with CAC in the forties for women (OR, 2.99; 95% CI, 1.58-5.65) but not as significant in women older than 50 years, possibly due to the effects of menopause (OR, 1.14; 95% CI, 0.63-2.05) Low HDL-C might be the weakest related factor for CAC, as this showed the lowest OR for men (1.16; 95% CI, 1.01-1.35) among the MS components.

Abdominal obesity was a good predictor of CAC in both genders. Obesity was also a good predictor of CAC. The presence of CAC was associated with the male sex, age, pulse pressure, metabolic syndrome, and obesity among 1653 asymptomatic Koreans (mean age 51±8 years).[24]

Age was the most powerful predictor for the presence of CAC in both genders. In men, the prevalence of CAC was 4.7% for those younger than 40 years, 17.0% for those in their forties, and 37.3% of those older than 50 years. For women, the prevalence of CAC was 0.4%, 3.8%, and 21.2% for the same age intervals. The prevalences seen in our data are quite similar with that of Park et al.[25] They reported the prevalence of CAC as 7.8% in men younger than 40 years and 22.3% in those in their forties. In women, the prevalence was 0.8% and 22.3% for the same age groups.

In the West, there have been many studies on the relationship between MS and CAC. Hunt et al.[26] reported that participants with MS were more likely to have a positive CAC score, similar to our results. Wong et al.[22] reported on a CAC screening study of 1823 people (36% women) aged 20 to 79 years in which people with MS had an increased likelihood of CAC compared to those without (OR, 1.40; 95% CI, 1.05-1.87). Again, these results were similar to our results. There was also a study about the relationship between MS and the progression of CAC over 4 years, as well as, the presence of CAC.[27]

In contrast, there have only been a few studies in Korea on the relationship between MS and CAC. Kim et al.[28] reported on a CAC screening study of 3961 asymptomatic individuals (36% women) aged 25 to 92, that participants

Table 4. Multivariate analysis for presence of CAC with metabolic syndrome and metabolic risk factors by age group[a]

Age<40	Men (n=4,257)		Women (n=890)	
Characteristics	OR (95% CI)	P[b]	OR (95% CI)	P[b]
Abdominal obesity[c]	1.65 (1.22-2.22)	<0.001	2.59 (0.36-18.80)	0.35
Raised BP[d]	2.33 (1.74-3.12)	<0.001	7.67 (0.77-76.36)	0.08
Reduced HDL-C[e]	1.47 (1.01-2.13)	0.039	4.82 (0.67-34.62)	0.121
Raised TG[f]	2.20 (1.64-2.95)	<0.001	0.00	0.989
Raised FBS[g]	1.63 (1.19-2.22)	<0.001	0.00	0.989
Metabolic syndrome	2.54 (1.86-3.47)	<0.001	5.17 (0.51-52.84)	0.17
40≤Age<50	Men (n=6,207)		Women (n=1,253)	
Characteristics	OR (95% CI)	P[a]	OR (95% CI)	P[a]
Abdominal obesity[c]	1.34 (1.16-1.54)	<0.001	1.94 (1.08-3.48)	0.031
Raised BP[d]	1.65 (1.44-1.89)	<0.001	3.18 (1.72-5.89)	<0.001
Reduced HDL-C[e]	1.08 (0.89-1.29)	0.448	0.96 (0.48-1.92)	0.921
Raised TG[f]	1.57 (1.37-1.79)	<0.001	2.99 (1.58-5.65)	<0.001
Raised FBS[g]	1.43 (1.20-1.69)	<0.001	1.92 (1.03-3.60)	0.039
Metabolic syndrome	1.68 (1.45-1.94)	<0.001	2.55 (1.33-4.88)	0.012
Age≥50	Men (n=1,420)		Women (n=401)	
Characteristics	OR (95% CI)	P[a]	OR (95% CI)	P[a]
Abdominal obesity[c]	1.54 (1.21-1.95)	<0.001	1.54 (0.93-2.53)	0.087
Raised BP[d]	2.29 (1.83-2.85)	<0.001	5.59 (3.25-9.63)	<0.001
Reduced HDL-C[e]	1.24 (0.92-1.67)	0.148	1.35 (0.80-2.28)	0.257
Raised TG[f]	1.30 (1.04-1.63)	0.019	1.14 (0.63-2.05)	0.674
Raised FBS[g]	1.67 (1.34-2.08)	<0.001	1.59 (0.93-2.72)	0.189
Metabolic syndrome	1.88 (1.47-2.42)	<0.001	2.00 (1.19-3.36)	0.008

Abbreviations: CAC, coronary artery calcium; OR, odds ratio; CI, confidence interval; BP, blood pressure; HDL-C, high density lipoprotein cholesterol; TG, triglyceride; FBS, fasting blood sugar.
[a]Adjusted for smoking and family history of stroke and coronary heart disease.
[b]Calculated by multivariate logistic regression analysis.
[c]Defined as waist circumference >90 cm for males and >80 cm for females.
[d]Defined as blood pressure ≥130/85 mmHg for both gender.
[e]Defined as high density lipoprotein cholesterol level <40 mg/dL for males and <50 mg/dL for females.
[f]Defined as triglyceride level ≥150 mg/dL for both gender.
[g]Defined as fasting blood sugar level ≥100 mg/dL for both gender.

Table 5. Comparisons of coronary calcium score and components of MS[a,b]

Sex	Number of MS components	CAC score						
		0	0<S<25	25≤S<50	50≤S<75	75≤S<100	≥100	Total
Male	0	3122 (91.4)	184 (5.4)	53 (1.6)	16 (0.5)	8 (0.2)	34 (1.0)	3417
	1	2882 (86.5)	286 (8.6)	60 (1.8)	30 (0.9)	23 (0.7)	51 (1.5)	3332
	2	2174 (82.3)	263 (10.0)	71 (2.3)	43 (1.6)	17 (0.6)	74 (2.8)	2642
	≥3	1923 (77.1)	317 (12.7)	78 (3.1)	46 (1.8)	19 (0.8)	110 (4.4)	2493
	Total	10101	1050	262	135	67	269	11884
Female	0	1061 (98.3)	9 (0.8)	5 (0.5)	1 (0.1)	1 (0.1)	2 (0.2)	1079
	1	678 (95.4)	16 (2.3)	4 (0.6)	5 (0.7)	1 (0.1)	7 (1.0)	711
	2	380 (90.7)	22 (5.3)	5 (1.2)	1 (0.2)	4 (1.0)	7 (1.7)	419
	≥3	288 (86)	25 (7.5)	3 (0.9)	5 (1.5)	2 (0.6)	12 (3.6)	335
	Total	2407	72	17	12	8	28	2544
Total		12508	1122	279	147	75	297	14428

Abbreviations: MS, metabolic syndrome; CAC, coronary artery calcium.
[a]Values are presented as number (%).
[b]Correlation between coronary calcium score and components of metabolic syndrome was significant (*p* value calculated by Spearman's rank order correlation analysis was <0.001).

with MS were more likely to have a positive CAC score compared to those without (OR, 1.73; 95% CI, 1.46-2.04; *P*<0.001). Women, mostly postmenopausal (mean age 057±10 years) showed no relationship between low HDL and high TG with CAC, which was also seen in men. However, family history and smoking status were not considered. Compared with individuals without CAC, individuals with CAC tended to be older and were more likely to be current or past smokers.[29)]

In our study, compared to never smokers, current and past smokers showed significantly higher ORs for CAC in men (crude OR, 1.58; 95% CI, 1.39-1.79 and 1.58; 95% CI, 1.40-1.79, respectively). But smoking status was not associated with the presence of CAC in women. The reason for this might be that fewer women reported ever smoking; 95% reported having never smoked.

CAC is a sensitive noninvasive technique that can detect and quantify coronary calcium, a marker of atherosclerosis.[30)] However, most of the studies have involved US population. These American studies have shown that CAC is a strong independent predictor of CHD in both genders among middle-aged and old age groups, various ethnic groups, and individuals with and without diabetes. An international study comparing subclinical atherosclerosis, including CAC, among Japanese, Japanese-Americans, Koreans, and whites was recently published. It showed that compared to whites, the Japanese had lower levels of atherosclerosis, whereas Japanese-Americans had similar or higher levels.[29)]

The strength of our study is in the large number of our sample size. We investigated other risk factors such as smoking and family history of CHD and stroke, which have not been typically included in other studies with CAC outcome. We had 14,428 asymptomatic individuals, which is a much higher number than any recent related studies. Though most of our participants had a CAC score of zero (86.7%), our sample size was large and the participants with CAC scores above zero included 1,920 adults. This is a meaningful size to evaluate the distribution of CAC and its related factors in a relatively young population.

The limitation of this study is as follows. First, the participants in our study might not represent the typical Korean population. Second, as the participants were relatively young, we may not have had enough CAC cases, especially for age stratification. The majority were under 50 years (87.4%, n=12,607). As the baseline data of CAC, especially in the young population, is rare, our study can serve as a basic source to characterize CAC. Since our study was a retrospective cross-sectional study, we did not identify causalities between MS and CAC. As such, a prospective cohort study would help to clarify the relationship between MS, CAC, and CHD in Korea. Further studies involving the general population are also needed. However, to overcome this limitation, we used subgroup analysis to assess the effect of age on the relationship between CAC and MS by dividing subjects into three age categories. The results of the subgroup analysis offered similar relationships between CAC and MS regardless of age. However, in young-aged (<40 years) participants, MS was somewhat more strongly associated with the presence of CAC than in older subjects. We did not adjust for other metabolic risk factors, such as alcohol consumption and physical activity. Studies including these factors are required in the future to clarifying the independent relationship between MS and CAC.

We evaluated the relationship between MS and its components with CAC as a marker of subclinical CHD in a large Korean adult population. Overall, individuals with MS had a greater prevalence of CAC compared with individuals without. Of the individual components, low-HDL is the only component that did not contribute to CAC.

요 약

연구배경: 심혈관질환은 심각하면서도 예방이 가능하다. 따라서 조기진단을 위한 많은 방법들이 논의되고 있다. 본 연구는 심혈관질환의 예측인자로 관심을 받고 있는 대사증후군과 최근 관상동맥질환의 표지자로 알려진 관상동맥석회화의 관련성을 평가하려는 목적으로 수행되었다.

방법: 서울의 한 검진센터를 방문해서 관동동맥석회화 검사를 수행한 사람을 대상으로 하였다. 2010년 한 해 동안 해당대상자의 과거력, 가족력, 흡연력과 신체측정, 검사실 검사를 분석하였으며 칼슘스코어는 multi-detector computed tomography로 촬영하여 구하였다.

결과: 총 연구대상자는 남자 11,884명(평균나이 41.9±6.6년), 여자 2,544명(평균나이 42.9±8.0년)로 대사증후군의 유병률은 각각 21%, 13.2%이었다. 관동동맥석회화는 남자의 15%, 여자의 5.4%에서 관찰되었다. 대사증후군이 없는 군에 비해 대사증후군이 있는 사람의 관상동맥석회화 유병률이 통계적으로 의미 있게 높았다. 연령, 흡연, 중풍과 관상동맥질환의 가족력을 보정하고 남자에서는 대응비 1.82 (95% 신뢰구간, 1.62-2.05; $P<0.001$), 여자에서는 대응비 2.23 (95% 신뢰구간, 1.49-3.33; $P<0.001$)로 나왔다. 대사증후군의 각 인자는 저 HDL 콜레스테롤 외에는 관상동맥

석회화와 유의한 관련성이 있었다.

결론: 대사증후군을 가진 성인이 없는 사람에 비해 관상동맥석회화 유병률이 높았다.

중심단어: 대사증후군, 관상동맥, 칼슘

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