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PHYSICAL ACTIVITY AND CARDIORESPIRATORY FITNESS ATTENUATE THE IMPACT OF SARCOPENIC-OBESITY ON CARDIOVASCULAR DISEASE RISK IN KOREAN MEN: A CROSS SECTIONAL STUDY

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ABSTRACT

Background and objective

The role of physical activity (PA) and fitness with respect to the relationship between sarcopenic obesity and cardiovascular disease (CVD) risk in Korean men is poorly understood. This study investigated whether or not PA and cardiorespiratory fitness (CRF) attenuate the synergistic impact of sarcopenic obesity on CVD risk in a sample of Korean men aged 40 years and older.

Material and methods

This study analyzed data (n=3089 men aged 40 years and older) obtained from the KNHANES IV and V. Participants were classified into four groups: the absence of both sarcopenia and obesity called optimal body composition, the presence of sarcopenia only, the presence of obesity only, or the coexistence of sarcopenia and obesity defined as sarcopenic obesity. The 10-year Framingham risk score model was used to estimate CVD risk, which was classified into low (<10%), intermediate (10–20%), and high (>20%) categories. PA was assessed with the Korean version of the International Physical Activity Questionnaire. CRF was estimated using nonexercise-based health indicators such as gender, age, resting heart rate, and PA score.

Results

Logistic regression analyses showed that the odds ratios (ORs) for ≥10% 10-year CVD risk were significantly higher in the order of obesity (OR=1.717, p<0.001), sarcopenia (OR=2.290, p<0.001), and sarcopenic obesity (OR=3.568, p<0.001) compared to optimal (OR=1). The ORs of ≥10% 10-year CVD risk remained statistically significant even after adjustment for age, education, and income but were no longer significant after additional adjustment for PA and CRF.

Conclusion
The current findings suggest that high PA and CRF attenuate the synergistic impact of sarcopenia and obesity on CVD risk in Korean men, implying a clinical importance of interventions targeting low PA and poor CRF for men with sarcopenic obesity.

Key Words: *cardiovascular disease; obesity; physical activity; physical fitness; sarcopenia*

INTRODUCTION

Obesity is a well-established risk factor of cardiovascular disease (CVD).[1] Sarcopenia is another novel risk factor for CVD.[2] Consequently, the coexistence of sarcopenia and obesity, called sarcopenic obesity (SO)[3], is synergistically associated with a number of health outcomes, including functional impairments,[4] increased CVD risk,[5] and increased death risk from CVD[6] and all causes[7] in older men.

Data obtained from the Framingham Heart Study has been used to develop Framingham risk score (FRS) algorithms for estimating 10-year CVD risk. The FRS considers the six coronary risk factors: age, total cholesterol (TC), high-density lipoprotein cholesterol (HDLC), systolic blood pressure (SBP), diabetes, and smoking.[8] However, the FRS algorithms do not consider scores for physical inactivity (PA) and cardiorespiratory fitness (CRF) even though low PA and CRF are independent risk factors for CVD[9] and all-cause mortality.[10,11] Furthermore, findings from both cross-sectional[12] and intervention studies[13] showed that regular PA and/or high CRF had favorable effects on many of the established risk factors of CVD.

With its prevalence on a steady rise, CVD is the second leading cause of death after malignancy and has become both a major economic and public health burden in South Korea.[14] To the best of our knowledge, however, the role of PA and CRF as moderators in determining the association between SO and CVD risk is poorly understood in Korean populations. This cross-sectional study investigated whether PA and CRF attenuate the impact of SO on the risk of CVD in Korean men.

METHODS

Data Source and Study Population

The data used in this study were obtained from the Korea National Health and Nutrition Examination Surveys (KNHANES) IV and V, which were conducted nationwide in the Republic of Korea from 2008 to 2011. A detailed description of the KNHANES is available elsewhere.[15,16] Initially, we selected 3566 men aged 40 years and older from the participants of the KNHANES IV and V. We excluded individuals who had no data available regarding height and weight (n=1), resting heart rate (n=338), blood lipids (n=54), income (n=39), physical activity (n=10), and education (n=35) at baseline. Consequently, a total of 3089 men were included in final data analyses (Figure 1), and their demographics and physical characteristics are described in Table 1.

Observed Phenotypes

Obesity and sarcopenia

Waist circumference (WC) is closely associated with metabolic complications and obesity-related health risks,[17] especially in Asians.[18] More importantly, body mass index (BMI) fails to account for changes in body composition with aging, specifically the age-related decline in muscle mass, strength, and function.[19] In this study, therefore, WC was used to determine obesity in the presence of SO. Specifically, the same Korean-specific WC threshold (≥90 cm in men) for metabolic syndrome was used to determine obesity.[20]

Appendicular skeletal muscle mass (ASM) was defined as the sum of the muscle mass in

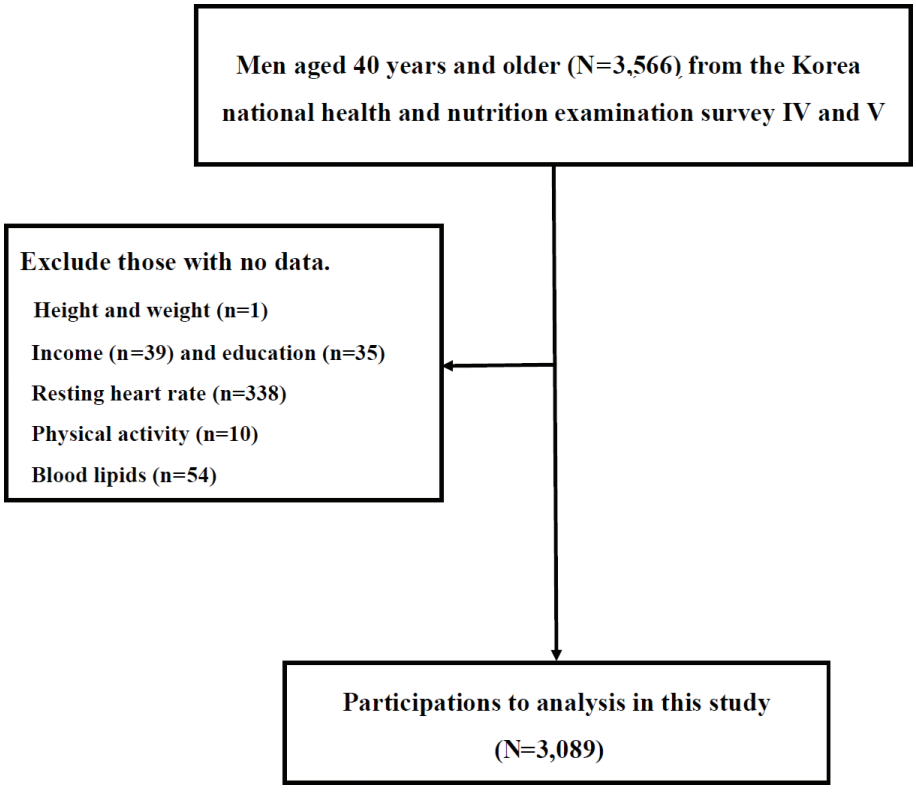

FIG. 1 Flow of eligible study of participants.

the arms and legs as measured by dual energy X-ray absorptiometry (DXA) (DISCOVERY-W fan-beam densitometer, Hologic, Inc., Bedford, MA, USA). Sarcopenic index was calculated as ASM (kg) divided by body weight (kg), and the index values that were <1 standard deviation below the mean of the sex-specific healthy reference group (i.e., aged 20–39 years) from the same KNHANES IV and V database were considered sarcopenic.[16]

Outcomes

Cardiovascular disease risk

The risk of CVD was assessed by estimating 10-year FRS. The 10-year FRS for CVD was calculated with the 1988 Framingham risk factor criteria and men-specific algorithm on the basis of the six risk factors: age, TC, HDLC, SBP, and smoking status.[8] The 10-year FRS percentage for CVD was classified as low (< 10%), intermediate (10 ~ 20%), and high risk (> 20%).[21]

Covariates

Physical activity and cardiorespiratory fitness

The Korean version of the International Physical Activity Questionnaire (IPAQ) short form, of which validity and reliability were previously tested in Korean adults,[22] was used to assess frequency (times/week) and duration (minutes) of physical activity lasting for at least 10 min. This physical activity was classified according to light, moderate, and vigorous intensity and was expressed in METs-minutes/week. Nonexercise-based estimation of CRF (eCRF) was determined as peak volume of oxygen consumption (peak VO_2) using the formula[23]: eCRF (METs) = 2.77

TABLE 1 Description of Study Participants

Parameters	N=3089
Age (years)	58.6±11.7
Income (10,000 won/month)	347.1±770.3
Education, n (%)	
Elementary	809 (26.2)
Middle/high	1466 (47.5)
College	814 (26.4)
Current/past smokers, n (%)	2428 (78.6)
Diabetes, n (%)	401 (13.0)
Hypertension, n (%)	880 (28.5)
BMI (kg/m^2)	23.9±3.0
WC (cm)	84.9±8.7
SMI (%)	33.5±2.9
FBG (mg/dL)	103.7±29.4
TC (mg/dL)	188.6±35.2
HDLC (mg/dL)	43.7±10.3
TG (mg/dL)	150.8±101.8
Insulin (μU/L)	9.7±4.9
SBP (mmHg)	124.0±16.6
DBP (mmHg)	79.3±10.6
PA (METs-min/week)	339±647
eCRF (METs)	10.3±1.9
10-year FRS	19.5±13.8

BMI, body mass index; WC, waist circumference; SMI, skeletal muscle index; FBG, fasting blood glucose; TC, total cholesterol; HDLC, high-density lipoprotein cholesterol; TG,: triglycerides; SBP, systolic blood pressure; DBP, diastolic blood pressure; PA, physical activity; eCRF, estimated cardiorespiratory fitness; FRS, Framingham risk score.

(men=0) – 0.10 (age) – 0.17 (BMI) – 0.03 (resting heart rate) + 1.00 (PA score) + 18.07.

Demographics and laboratory parameters

Smoking status (current smokers or non-smokers), education (i.e., elementary or middle and high school or college), and monthly income were assessed using self-administered questionnaires. Height, weight, WC, and blood pressure (BPs) were assessed by trained persons. Height and weight were measured with a portable stadiometer (seca 225 stadiometer, SECA, CA, USA) and a portable scale (GL-6000-20, Gtechnology, Seoul, Korea), respectively, and body mass index (BMI) was calculated as weight divided by height (kg/m^2). Resting BPs were measured with a sphygmomanometer (Baumanometer® wall unit 33, Baum Co. Inc., NY, USA) with the subjects in seated position, with the arm at heart level and resting on the armrest of a chair. Fasting venous blood sampling was performed after overnight fasting to determine concentrations of glucose, total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDLC), and insulin. A detailed description of the clinical and laboratory measurements is available elsewhere.[15]

Statistics

Descriptive statistics (mean, standard deviation, and frequency) were calculated for all measured parameters. Statistical differences across groups were determined with the general linear model using an appropriate alpha adjustment procedure. Regression analysis was used to test for significant trends in outcome variables across categories of FRS and SO. Odds ratio (OR) and 95% confidence interval (95% CI) for elevated FRS percentage (≥10%) were calculated across categories of SO using multiple logistic regression before and after adjustments for potential covariates. Alpha was set at 0.05. All statistical analyses were performed using the SPSS-PC statistical software (version 23.0, SPSS, Inc.).

RESULTS

Table 2 presents the descriptive statistics of outcome variables according to 10-year FRS categories. Significant linear trends in demographics/body composition (i.e., age, BMI, WC, and SMI), SES (i.e., income and education), health behaviors

TABLE 2 Descriptive Statistics of Outcomes According to Levels of Framingham Risk Score

Parameters	FRS categories			p for trends
	Low (<10)	Intermediate (10–20)	High (>20)	
Age (years)	47.1±6.2	58.4±8.9	68.1±8.4	<0.001
[a]Income (10,000 won/month)	451±689	407±1,050	219±498	<0.001
Education, n (%)				<0.001
Elementary	76 (8.3)	220 (22.7)	513 (42.4)	
Middle/high	446 (48.8)	485 (50.1)	535 (44.3)	
College	392 (42.9)	263 (27.2)	159 (13.2)	
Current smoker (%)	185 (20.2)	287 (29.6)	525 (43.5)	<0.001
Diabetes (%)	25 (2.7)	103 (10.6)	244 (20.2)	<0.001
Hypertension (%)	85 (9.3)	282 (29.1)	512 (42.4)	<0.001
BMI (kg/m^2)	23.7±3.0	24.1±2.9	23.8±3.0	<0.001
WC (cm)	82.7±8.2	85.7±8.6	85.9±8.8	<0.001
SMI (%)	34.6±2.8	33.6±2.7	32.7±2.8	<0.001
FBG (mg/dL)	95.8±18.5	101.7±26.4	110.4±34.2	<0.001
TC (mg/dL)	184.0±31.8	186.9±36.4	191.6±36.1	<0.001
HDLC (mg/dL)	46.5±10.5	44.0±10.2	41.5±9.8	<0.001
[a]TG (mg/dL)	132.4±84.7	146.8±100.3	164.0±109.1	<0.001
Insulin (mU/L)	9.3±4.2	9.5±4.3	10.2±6.1	<0.001
SBP (mmHg)	114.2±12.1	121.8±14.2	133.2±17.1	<0.001
DBP (mmHg)	78.1±10.0	79.7±10.6	79.3±10.9	0.001
[a]PA (METs-min/week)	372±664	332±601	311±651	0.800
eCRF (METs)	11.8±1.4	10.4±1.6	9.2±1.7	<0.001
10-year FRS	6.4±2.1	14.6±2.9	33.1±11.9	<0.001

CVD, cardiovascular disease; BMI, body mass index; WC, waist circumference; SMI, skeletal muscle index; FBG, fasting blood glucose; TC, total cholesterol; HDLC, high-density lipoprotein cholesterol; TG, triglycerides; SBP, systolic blood pressure; DBP, diastolic blood pressure; eCRF, estimated cardiorespiratory fitness; FRS, Framingham risk score. [a]*Log_{10} transformation was performed prior to statistical analyses.*

and conditions (i.e., smoking status, eCRF, diabetes, and hypertension), and blood chemistry and BP profiles (i.e., fasting glucose and insulin, TC, TG, HDLC, SBP, and DBP) were found according to 10-year FRS levels (from low to high). In general, individuals belonging to intermediate and high FRS category were older and had poor body composition (i.e., higher BMI and SW and lower SMI) in conjunction with poor SES (lower income and less education) compared with individuals belonging to the low FRS category. In addition, individuals belonging to the intermediate or high FRS category had high blood pressure, poor blood chemistry profile (higher fasting glucose, TC, and TG in conjunction with lower HDLC), more health conditions (a higher prevalence of smoking, diabetes, and hypertension), and lower eCRF compared with individuals in the

low FRS category. No linear trend in PA was found according to FRS categories.

Table 3 presents the descriptive statistics of outcome variables according to sarcopenia and central obesity-based classifications. With respect to demographics/body composition, individuals with the isolated condition of sarcopenia (defined as sarcopenia) and the coexistence of sarcopenia and obesity (defined as SO) were older and had lower SMI, PA, and eCRF compared to individuals without either sarcopenia or obesity (defined as optimal body composition) and individuals with

TABLE 3 Descriptive Statistics of Outcome Variables According to Sarcopenia and Central Obesity-Based Phenotypes

Parameters	Observed phenotypes				p for trends
	Sarcopenia (-)/ Obesity (-)	Sarcopenia (+)/ Obesity (-)	Sarcopenia (-)/ Obesity (-)	Sarcopenia (+)/ Obesity (+)	
Age (years)	57.4±11.6	62.1±12.1	56.9±10.6	61.4±11.3	<0.001
[a]Income (10,000 won/month)	366±851	300±342	334±523	327±897	0.227
Education, n (%)					0.979
Elementary	479 (26.5)	116 (28.5)	88 (20.5)	126 (28.3)	
Middle/high	852 (47.1)	175 (43.0)	235 (54.8)	204 (45.8)	
College	447 (26.4)	116 (28.5)	106 (24.7)	115 (25.8)	
Current smoker, n (%)	607 (33.6)	121 (29.7)	137 (31.9)	132 (29.7)	0.702
Diabetes, n (%)	141 (7.8)	78 (19.2)	67 (15.6)	86 (19.3)	<0.001
Hypertension, n (%)	385 (21.3)	149 (36.6)	123 (28.7)	222 (49.9)	<0.001
BMI (kg/m^2)	22.6±2.4	23.6±2.2	26.6±2.0	27.0±2.4	0.233
WC (cm)	80.2±6.4	84.0±4.3	93.9±3.7	95.9±5.1	<0.001
SMI (%)	35.1±2.1	30.3±1.4	33.7±1.5	29.8±1.6	<0.001
FBG (mg/dL)	99.5±24.9	107.6±35.9	108.6±30.6	112.6±35.2	<0.001
TC (mg/dL)	186.6±33.9	190.8±37.3	191.6±34.8	191.8±38.3	0.002
HDLC (mg/dL)	45.6±10.8	42.1±9.5	40.4±8.0	40.3±9.3	<0.001
[a]TG (mg/dL)	135.1±100.3	156.8±81.6	172.9±96.3	188.2±114.7	<0.001
Insulin (mU/L)	8.4±3.5	10.4±5.8	11.2±5.4	12.8±6.5	0.001
SBP (mmHg)	122.0±16.6	126.6±16.7	125.0±15.1	128.8±16.8	<0.001
DBP (mmHg)	78.6±10.5	79.1±10.7	81.2±10.1	80.9±10.9	0.002
[a]PA (METs-min/week)	388±696	222±522	353±629	237±529	0.036
eCRF (METs)	9.7±1.8	10.2±1.7	9.2±1.7	10.3±1.9	<0.001
10-year FRS (%)	17.1±12.6	23.7±14.8	19.6±13.1	25.1±15.5	<0.001

BMI, body mass index; WC, waist circumference; SMI, skeletal muscle index; FBG, fasting blood glucose; TC, total cholesterol; HDLC, high-density lipoprotein cholesterol; TG, triglycerides; SBP, systolic blood pressure; DBP, diastolic blood pressure; eCRF, estimated cardiorespiratory fitness; FRS, Framingham risk score. [a]Log_{10} transformation was performed prior to statistical analyses.
Sarcopenia (-)/obesity (-): the absence of both sarcopenia and obesity.
Sarcopenia (+)/obesity (-): the presence of sarcopenia.
Sarcopenia (-)/obesity (+): the presence of obesity.
Sarcopenia (+)/obesity (+): the coexistence of sarcopenia and obesity.

the isolated condition of obesity (defined as obesity). In addition, individuals with sarcopenia and SO had a higher ≥10% 10-year CVD risk value than individuals with optimal body composition and obesity. With respect to blood chemistry and health conditions, individuals with sarcopenia, obesity, and SO had higher values of glucose, insulin, TC, TG, SBP, and DBP and lower HDLC levels in conjunction with higher prevalence of diabetes and hypertension compared with individuals with optimal body composition. No significant differences in income, education, and smoking status were found according to sarcopenia and obesity-based phenotypes.

Table 4 presents ORs and 95% CIs of CVD risk according to sarcopenia- and obesity-based phenotypes. The ORs for ≥10% 10-year CVD risk were significantly higher in the order of obesity (OR=1.717, p<0.001), sarcopenia (OR=2.290, p<0.001), and SO (OR=3.568, p<0.001) compared to optimal body composition (OR=1). Those increased ORs remained statistically significant even after adjustment for age in Model 1 and additionally for income and education in Model 2. However, the ORs of obesity (OR=1.241, p=0.243), sarcopenia (OR=1.367, p=0.115), and SO (OR=1.407, p=0.122) for the 10-year CVD risk were no longer significant after additional adjustment for PA and eCRF in Model 3.

DISCUSSION

In this cross-sectional study, we found that SO was synergistically and significantly associated with increased FRS-based 10-year CVD risk than the isolated condition of sarcopenia or obesity. To the best of our knowledge, this is the first report establishing that high PA and CRF attenuate the impact of SO on the CVD risk in Korean men.

Our findings are in accordance with previous studies reporting a synergistic impact of SO on CVD risk in Western populations. In a prospective

TABLE 4 Odd Ratios and 95% Confidence Intervals of Observed Phenotypes for Cardiovascular Disease Risk

Phenotypes	≥10% 10-year Framingham risk score for cardiovascular disease							
	Model 1	p	Model 2	p	Model 3	p	Model 4	p
Sarcopenia (-)/ Obesity (-)	OR = 1		OR = 1		OR = 1		OR = 1	
Sarcopenia (+)/ Obesity (-)	2.290 (1.765 ~ 2.971)	<0.001	1.878 (1.290 ~ 2.736)	0.010	1.848 (1.264 ~ 2.702)	0.002	1.367 (0.927 ~ 2.017)	0.115
Sarcopenia (-)/ Obesity (+)	1.717 (1.353 ~ 2.179)	<0.001	2.555 (1.861 ~ 3.506)	<0.001	2.546 (1.850 ~ 3.504)	<0.001	1.241 (0.864 ~ 1.783)	0.243
Sarcopenia (+)/ Obesity (+)	3.568 (2.684 ~ 4.745)	<0.001	3.750 (2.590 ~ 5.429)	<0.001	3.523 (2.426 ~ 5.116)	<0.001	1.407 (0.912 ~ 2.170)	0.122

Model 1 = unadjusted.
Mode 2 = adjusted for age.
Model 3 = adjusted for model 2 plus income and education.
Model 4 = adjusted for model 3 plus physical activity and estimated cardiorespiratory fitness.
Sarcopenia (-)/obesity (-): the absence of both sarcopenia and obesity.
Sarcopenia (+)/obesity (-): the presence of sarcopenia.
Sarcopenia (-)/obesity (+): the presence of obesity.
Sarcopenia (+)/obesity (+): the coexistence of sarcopenia and obesity.

cohort study involving 3366 community-dwelling Canadian older adults who were free of CVD at baseline, Stephen and Janssen[5] showed that CVD risk was increased by 23% within the SO group but not in the sarcopenic or obese groups. In another population-based cohort study involving 4252 older men, Atkins et al.[6] found that men with sarcopenia and obesity had a higher risk of all-cause mortality (hazard ratio, HR = 1.41, 95% CI = 1.22–1.63; HR = 1.21, 95% CI = 1.03–1.42, respectively) compared with men with optimal body composition, with the highest risk in individuals with SO (HR = 1.72, 95% CI = 1.35–2.18), after adjustment for lifestyle characteristics. Risk of CVD mortality was significantly higher in men with sarcopenia and obesity but not in men with SO. By analyzing data from the UK Biobank (502,641 men and women aged 40 and 69 years), Farmer et al.[24] also showed that SO was associated with an increased risk of CVD as well as an increased risk of CVD and all-cause mortality.

Similarly, the synergistic impact of SO on CVD risk has been observed in Asian populations. By analyzing data from the KNHANES 2009, Chin et al.[2] showed that sarcopenia was significantly and independently associated with increased CVD risk (OR=1.768; 95% CI=1.075–2.909) in elderly Korean adults. By analyzing data obtained from the KNHANES V in 2010, Kim et al.[14] showed that CVD risk was significantly associated with SO but not the isolated condition of sarcopenia or obesity in Korean adults. Similarly, Byeon et al.[25] by analyzing data (n=3766/57% women) from the KNHANES 2010–2011 showed that SO was associated with a higher FRS for CVD than the isolated condition of sarcopenia or obesity in Korean adults. In addition, the impact of SO on CVD risk was observed in patients with chronic diseases, including type-2 diabetes,[26] hypertension,[27] and peritoneal dialysis.[28]

In addition to the synergistic impact of sarcopenia and obesity on CVD risk, findings from recent studies also showed that aging-related loss of skeletal muscle mass is independently associated with cardiometabolic health. In a pilot study involving overweight or obese men (n=72) and those with normal weight (n=38), Khazem et al.[29] found that regardless of body fat content, individuals with low lean body mass (LBM) had a higher risk of developing cardiometabolic diseases (OR) = 5.46, 95% CI = 1.31–26.39, $p<0.05$) compared with individuals without low LBM. In a population-based cohort study involving 1019 Caucasian adults aged 45 years and older without pre-existing CVD from the Greek general population (485 men), Tyrovolas et al.[30] also showed that skeletal muscle mass (SMM) as baseline was significantly and inversely associated with incident CVD during a 10-year follow-up. In that study, the researchers found that individuals in the highest SMM tertile had 81% lower risk for a CVD event than individuals in the lowest SMM tertile, implying a diagnostic role of the isolated condition of sarcopenia in the prediction of long-term CVD risk, especially among mid-life men. Together, we cannot rule out that the impact of SO on CVD risk observed in the current study may reflect the isolated consequence of aging-related loss of skeletal muscle mass.

The preventive effect of high PA and CRF against the risk of SO for CVD observed in this study may be explained by the relationships of PA and CRF with SO. For example, findings from previous cross-sectional studies showed that the risk of SO was significantly lower in active Korean older adults[31,32] or in fit Spanish older adults.[33,34] In addition, low PA and poor CRF are two modifiable risk factors for CVD. In a cross-sectional analysis of 27,158 apparently healthy US women (mean age, 54.7 years) from the Women's Health Study, Mora et al.[35] showed that lower PA and higher BMI were independently associated with adverse outcomes of blood lipid and inflammatory biomarkers. In a cohort study involving 19,838 women who completed baseline measurements, Farrell et al. [36] examined the relationships of CRF and

adiposity parameters with CVD mortality risk during a follow-up period of 19.2 ± 10.3 years and found that high CRF was significantly associated with a reduced risk of CVD mortality. By conducting a meta-analysis involving 23 gender-specific cohort studies (representing 1,325,004 person-years of follow-ups), Williams[37] investigated the relationships of CHD and CVD with leisure time PA and CRF and found that the risks of CHD and CVD decreased linearly according to incremental PA percentiles, while the reductions in relative risk of the diseases were nearly twice as great for CRF than PA. Together, the findings from previous and current studies suggest that high PA and/or CRF may contribute to the decreases in the adverse health outcomes of SO including CVD risk.

The alleviating effect of high PA and CRF on the impact of SO on CVD risk can be explained. First, high PA and CRF are significantly associated with decreased CVD risk factors[38,39], decreased body fat content, improved lipoprotein-lipids, increased insulin sensitivity, decreased blood pressures, increased endothelial function, anti-inflammatory responses, and others. In addition, accumulating evidence from exercise intervention studies shows that regular PA can have similar beneficial effects on those risk factors of CVD. In particular, exercise interventions have been found to induce positive effects on muscle mass and/or function and body fat[32,33] and to improve CVD risk factors.[32] Last, maintaining or improving CRF also reduces those CVD risk factors.[40]

This study has some limitations. First, the inclusion of nonexercise-based estimates for CRF rather than objective measurements may be one study limitation. The accuracy of eCRF used in the current study remains to be confirmed in a representative sample of Korean adults. Last, the cross-sectional nature of the current study is another limitation, preventing drawing conclusions about causation. Intervention studies will be necessary to elucidate the mechanism(s) by which high PA and CRF attenuate the impact of SO on CVD risk.

CONCLUSION

The findings of the current study suggest that PA and CRF may be important moderators in determining the risk of SO for CVD in Korean men, suggesting that interventions targeted at promoting both PA and CRF would be a useful therapeutic strategy for individuals with SO.

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CONFLICT OF INTEREST

The author has no conflict of interest to disclose.

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