PATTERNS OF PHYSICAL ACTIVITY AND METABOLIC SYNDROME AMONG ADULT KOREANS: A CROSS SECTIONAL STUDY

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Abstract. The purpose of this study was to determine whether leisure time physical activity (PA) affects risk for developing metabolic syndrome (MetS) among Korean adults. We studied 1,728 Korean adults over age 20 years who visited a public health promotion center in Seoul, Korea. All subjects completed an International Physical Activity Questionnaire, and were examined for MetS criteria as defined by National Cholesterol Education Program's Adult Treatment Panel III criteria. The association between PA and MetS was assessed using multivariate logistic regression analysis. The odds ratios (95% confidence interval) for having MetS and engaging in vigorous PA, moderate PA or light PA (walking) compared with having MetS and not engaging in vigorous PA, moderate PA or light PA (walking) were 0.482 (0.322-0.721, $p < 0.001$), 0.547 (0.370-0.810, $p = 0.003$) and 0.482 (0.318-0.731, $p < 0.001$) for PA once a week; 0.763 (0.468-1.243, $p = 0.277$), 0.697 (0.419-1.160, $p = 0.165$) and 0.674 (0.403-1.128, $p = 0.134$) for PA twice a week; 0.449 (0.248-0.815, $p = 0.008$), 0.568 (0.338-0.954, $p = 0.033$) and 0.451 (0.260-0.780, $p = 0.004$) for PA 3 times a week; 0.321 (0.123-0.835, $p = 0.020$), 0.737 (0.362-1.502, $p = 0.401$) and 0.411 (0.185-0.916, $p = 0.030$) for PA 4 times a week; and 0.216 (0.064-0.727, $p = 0.013$), 0.390 (0.166-0.915, $p = 0.031$) and 0.318 (0.181-0.558, $p < 0.001$) for PA 5 or more times a week, respectively. These findings indicate vigorous PA, moderate PA and light PA may reduce the risk of MetS among Korean adults.

Keywords: physical activity, metabolic syndrome, Korean adults

INTRODUCTION

According to the Korea National Health Insurance Corporation (2012), the prevalence of metabolic syndrome (MetS) among Korean adults aged >30 years is 31.4% for men and 18.4% for women and the prevalence of MetS has been steadily increasing yearly. MetS is a public health problem in Korea.

MetS is associated with unhealthy dietary habits and a sedentary lifestyle (Eckel *et al*, 2005). MetS is a risk factor for a variety of chronic diseases and some health conditions (Ford, 2005; Wilson *et al*, 2005). The National Cholesterol Education Program's Adult Treatment Panel III, defines MetS as having 3 or more of the following criteria: a low high density

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lipoprotein cholesterol level (HDL-C <50 mg/dl for women and <40 mg/dl for men), a high triglyceride (TG) level (≥150 mg/dl), an elevated blood pressure (≥130/80 mmHg), an elevated fasting blood glucose level (≥100 mg/dl), and a large waist circumference (≥88 cm for women and ≥102 cm for men) (NCEP, 2002).

Prevention and management of MetS consists of losing weight or maintaining a healthy weight and increasing physical activity (PA) (Strasser, 2013). Previous studies have found lack of PA as a risk factor for developing MetS, independent of weight loss or reduction in percent body fat (Lakka and Laaksonen, 2007; Camarillo-Romero *et al*, 2012; Wang *et al*, 2012). One epidemiological study reported improvement in MetS criteria with PA (Broekhuizen *et al*, 2011).

However, few studies have examined the association between PA and MetS among Korean adults. A search for "physical activity and metabolic syndrome in Korea" in PubMed on December 31, 2012 revealed only 4 studies (Cho *et al*, 2009; Hong *et al*, 2009; Park *et al*, 2007; You and Son, 2012), 3 of which were limited to sample groups of adolescents or children. The single study among adults did not evaluate the frequency or intensity of PA. Therefore, we studied the frequency and intensity of PA as it relates to MetS among Korean adults.

MATERIALS AND METHODS

Subjects

We studied 1,728 adults (men = 590; women = 1,138), aged >20 years who had visited a public health promotion center in Seoul, Korea during 2010-2011. They completed an International Physical Activity Questionnaire (IPAQ) (Craig *et al*, 2003). Each subject was examined for TG level, HDL-C level, blood pressure, fasting blood glucose and waist circumference. All study procedures were approved by the Human Care and Use Committee of the S-gu Community Health Center and all subjects provided written consent before participating in the study.

Independent variables

PA was evaluated for each subject using three questions from the self-administered IPAQ (Craig *et al*, 2003). The first question asked subjects to report their frequency of vigorous PA (such as aerobics, running, fast bicycling, or fast swimming) performed for at least 10 minutes per session during the previous week; possible responses were: none, once, twice, 3 times, 4 times and ≥5 times a week. The second question asked subjects to report their frequency of moderate physical activity (such as bicycling at a regular pace, swimming at a regular pace, or doubles tennis) performed during leisure time for at least 10 minutes per session during the previous week; possible responses were: none, once, twice, 3 times, 4 times and ≥5 times a week. The third question asked subjects to report their frequency of physical activity in the form of walking for at least 10 minutes per session during the previous week; possible responses were: none, once, twice, 3 times, 4 times and ≥5 times a week.

Dependent variables

The National Cholesterol Education Program's Adult Treatment Panel III defines people with fewer than 2 MetS criteria as healthy and people with 3 or more criteria as having MetS (NCEP, 2002).

An ADVIA 1650 automated analyzer (Bayer HealthCare, Tarrytown, NY) was used to measure TG, HDL-C and glucose levels. A Pureauto S TG-N (Daiichi, Japan), Cholestest N-HDL (Daiichi, Japan) and Hexokinase (Daiichi, Japan) were also

used to determine the levels of TG, HDL and glucose, respectively.

After completing the IPAQ and having their blood drawn, subjects stood with their feet 25-30 cm apart and had their waist circumferences measured at the region of the trunk midway between the lower costal margin (bottom of the lower rib) and the iliac crest (top of the pelvic bone). The individual performing the measurement stood beside the subject and wrapped the tape carefully around the subject's trunk, without compressing the underlying soft tissue. The waist circumference was measured to the nearest 0.5 cm at the end of a normal exhalation (WHO, 1999).

Subjects were asked to rest in a sitting position for at least 10 minutes prior to obtaining their blood pressure. Their systolic and diastolic blood pressures were measured in the right arm by a nurse using a mercury sphygmomanometer (Alpk, Japan). Blood pressures were measured 3 times at 2 minutes intervals, then the average blood pressure was determined (Lynn and Peter, 2009).

Variables

The variables examinied were : 1) sex (male or female); 2) self reported age; 3) history of smoking (never smoked, former smoker, current smoker); 4) history of alcohol consumption (non-drinker, once a month, 2-3 times a month, ≥4 times a month); 5) amount of sleep (<5 hr/day, 6 hr/day, 7 hr/day, ≥8 hr/day); 6) level of mental stress (very low, low, high, very high); 7) education level (elementary or lower, middle school, high school, college or higher); 8) economic status (very poor, poor, wealthy, very wealthy).

Statistical analysis

The results are presented as means ± standard deviations. Multivariate logistic regression analyses were conducted to determine whether frequency and intensity of PA were related to obesity after adjusting for age, sex, sleep duration, mental stress, education level, economic status and frequencies of drinking and smoking. Statistical significance was set at $p < 0.05$. All analyses were performed using SPSS version 18.0 (SPSS, Chicago, IL).

RESULTS

Subject characteristics are shown in Table 1. The results of multivariate logistic regression analysis of the association between PA and MetS among adult Korean adults is shown in Table 2.

The odds ratios (95% confidence interval) for having MetS and engaging in vigorous PA, moderate PA or light PA (walking) compared with having MetS and not engaging in vigorous PA, moderate PA or light PA (walking) were 0.482 (0.322-0.721, $p < 0.001$), 0.547 (0.370-0.810, $p = 0.003$) and 0.482 (0.318-0.731, $p < 0.001$) for PA once a week; 0.763 (0.468-1.243, $p = 0.277$), 0.697 (0.419-1.160, $p = 0.165$) and 0.674 (0.403-1.128, $p = 0.134$) for PA twice a week; 0.449 (0.248-0.815, $p = 0.008$), 0.568 (0.338-0.954, $p = 0.033$) and 0.451 (0.260-0.780, $p = 0.004$) for PA 3 times a week; 0.321 (0.123-0.835, $p = 0.020$), 0.737 (0.362-1.502, $p = 0.401$) and 0.411 (0.185-0.916, $p = 0.030$) for PA 4 times a week; and 0.216 (0.064-0.727, $p = 0.013$), 0.390 (0.166-0.915, $p = 0.031$) and 0.318 (0.181-0.558, $p < 0.001$) for PA 5 or more times a week, respectively. These results indicate vigorous PA, moderate PA and light PA are all associated with the risk for developing MetS among Korean adults.

DISCUSSION

The primary aim of this study was to examine the association between PA and

Table 1
Subject characteristics.

Variable	Male (n = 590)	Female (n = 1,138)	Total (n = 1,728)
Age (years)	51.07 ± 11.89	51.28 ± 10.61	51.21 ± 11.06
Height (cm)	169.99 ± 5.74	157.48 ± 5.29	161.51 ± 7.99
Weight (kg)	71.44 ± 9.26	57.19 ± 7.58	61.79 ± 10.53
BMI (kg/m^2)	24.70 ± 2.78	23.08 ± 2.98	23.60 ± 3.01
Presence of metabolic syndrome, n (%)			
Yes	169 (28.6)	254 (22.3)	423 (24.5)
No	421 (71.4)	884 (77.7)	1,305 (75.5)
History of smoking, n (%)			
Non-smoker	499 (84.6)	1,126 (98.9)	1,625 (94.0)
Former smoker	52 (8.8)	3 (0.3)	55 (3.2)
Current smoker	39 (6.6)	9 (0.8)	48 (2.8)
Frequency of drinking, n (%)			
Non-drinker	494 (83.8)	979 (86.1)	1,473 (85.2)
Once a month	22 (3.7)	105 (9.2)	127 (7.3)
2-3 times a month	39 (6.6)	39 (3.4)	78 (4.5)
More than 4 times a month	35 (5.9)	15 (1.3)	50 (2.9)
Sleep duration, n (%)			
<5 hours/day	13 (2.2)	51 (4.5)	64 (3.7)
6 hours/day	31 (5.3)	97 (8.5)	128 (7.4)
7 hours/day	22 (3.7)	80 (7.0)	102 (5.9)
≥8 hours/day	524 (88.8)	910 (80.0)	1,434 (83.0)
Mental stress, n (%)			
Very low	506 (85.7)	873 (76.7)	1,379 (79.8)
Low	10 (1.7)	19 (1.7)	29 (1.7)
High	43 (7.3)	171 (15.0)	214 (12.4)
Very high	31 (5.3)	75 (6.6)	106 (6.1)
Education level, n (%)			
Elementary school or lower	41 (6.9)	85 (7.5)	126 (7.3)
Middle school	20 (3.4)	107 (9.4)	127 (7.3)
High school	146 (24.7)	317 (27.9)	463 (26.8)
College or higher	383 (65.0)	629 (55.2)	1,012 (58.6)
Economic status, n (%)			
Very poor	117 (19.8)	302 (26.6)	419 (24.2)
Poor	67 (11.4)	137 (12.0)	204 (11.8)
Wealthy	385 (65.2)	615 (54.0)	1,000 (57.9)
Very wealthy	21 (3.6)	84 (7.4)	105 (6.1)

Data are presented as mean ± standard deviation or n (%).
BMI, body mass index.

Table 2
The results of multivariate logistic regression analyses of physical activity for normal. Korean adults and Korean adults with metabolic syndrome (n = 1,728).

Variables	Case	β	SE	OR	95% CI	p-value
Vigorous physical activity						
None	1,164	Reference				
Once a week	215	-0.730	0.205	0.482	0.322-0.721	<0.001[c]
Twice a week	121	-0.271	0.249	0.763	0.468-1.243	0.277
Thrice a week	118	-0.800	0.304	0.449	0.248-0.815	0.008[b]
4 times a week	59	-1.137	0.488	0.321	0.123-0.835	0.020[a]
≥5 times a week	51	-1.531	0.619	0.216	0.064-0.727	0.013[a]
Moderate physical activity						
None	1,118	Reference				
Once a week	214	-0.602	0.200	0.547	0.370-0.810	0.003[b]
Twice a week	120	-0.360	0.259	0.697	0.419-1.160	0.165
Thrice a week	134	-0.566	0.265	0.568	0.338-0.954	0.033[a]
4 times a week	62	-0.305	0.363	0.737	0.362-1.502	0.401
≥5 times a week	80	-0.941	0.435	0.390	0.166-0.915	0.031[a]
Light physical activity						
None	999	Reference				
Once a week	182	-0.730	0.212	0.482	0.318-0.731	<0.001[c]
Twice a week	109	-0.394	0.263	0.674	0.403-1.128	0.134
Thrice a week	134	-0.797	0.280	0.451	0.260-0.780	0.004[b]
4 times a week	58	-0.889	0.409	0.411	0.185-0.916	0.030[a]
≥5 times a week	246	-1.145	0.287	0.318	0.181-0.558	<0.001[c]

SE, standard error; OR, odds ratio; CI, confidence interval.
[a]$p < 0.05$; [b]$p < 0.01$; [c]$p < 0.001$.

MetS among a sample of Korean adults. The present study found PA was negatively associated with MetS.

Previous studies have found a strong association between PA and abdominal fat, a criterion for MetS (Hill and Wyatt, 2005; Wareham *et al*, 2005). Many studies have found increased PA may prevent and treat MetS (Lakka and Laaksonen, 2007; Kim *et al*, 2011; Stabelini Neto *et al*, 2011; Camarillo-Romero *et al*, 2012; Wang *et al*, 2012). The results of the present study reveal increased PA is associated with decreased risk for developing MetS among the sampled Korean adults. All 3 intensities of PA (vigorous, moderate and light) were associated with lower risk of developing MetS after adjusting for age, sex, sleep duration, mental stress, education level, economic status, and frequencies of drinking and smoking. The authors conclude any intensity of PA can be used to reduce the risk of developing MetS among Koreans.

The present study had several limitations. First, this investigation was based on a cross sectional retrospective study. For this reason, causality between variables could not be proven; however, the relationship between PA and MetS was explored. Second, although we used a reliable and validated self-administered

IPAQ (Craig *et al*, 2003), PA was self-reported; therefore, subject to recall bias. Third, this study did not evaluate food consumed by subjects, a lifestyle factor that can affect MetS. Fourth, because subjects in the present study were recruited from one public health promotion center in Seoul, Korea, they do not represent the general Korean population. Further well-designed studies should be conducted to confirm our results. Two strengths of this study were the large number of subjects (n = 1,728) and the focus on Korean adults.

In conclusion, the findings of this study suggest PA can reduce the risk of developing MetS among Korean adults independent of age, sex, sleep duration, mental stress, education level, economic status or the frequencies of drinking or smoking.

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