

■ Original Article

Factors Positively Influencing Health Are Associated with a Lower Risk of Development of Metabolic Syndrome in Korean Men: The 2007–2009 Korean National Health and Nutrition Examination Survey

Shinhye Kim¹, Mi-Ra Cho², Taejong Kim³, Hyoung-Ji Lim³, Jae Woo Lee³, Hee-Taik Kang^{3,*}

¹Department of Family Medicine, Seoul National University Hospital, Seoul, Korea

²Department of Family Medicine, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Korea

³Department of Family Medicine, Chungbuk National University College of Medicine, Cheongju, Korea

Background: The prevalence of metabolic syndrome (MetS) has risen rapidly worldwide, including in South Korea. Factors related to lifestyle are closely associated with the development of MetS. The aim of this study was to investigate the association between MetS and a number of factors positively influencing health, namely non-smoking, low-risk drinking, sufficient sleep, regular exercise, and the habit of reading food labels, among Korean men.

Methods: This cross-sectional study included 3,869 men from the 2007–2009 Korean National Health and Nutrition Examination Survey. Information on five factors positively influencing their health was obtained using a self-reported questionnaire. We categorized subjects into four groups, depending on the number of positive factors reported (group I, 0–1 factor; group II, 2 factors; group III, 3 factors; group IV, 4–5 factors).

Results: Men who reported a greater number of positive health factors had better laboratory and anthropometric values than men who reported fewer positive health factors. The prevalence of MetS was 29.1, 27.2, 20.7, and 14.6% in groups I to IV, respectively. Compared to group I, odds ratios (95% confidence intervals) for MetS were 0.96 (0.78–1.19) in group II, 0.67 (0.52–0.87) in group III, and 0.52 (0.35–0.76) in group IV, after adjusting for confounding factors. Odds ratios for abdominal obesity, glucose intolerance, and hypertriglyceridemia were statistically significant.

Conclusion: A greater number of positive lifestyle factors influencing health were associated with a lower risk of developing MetS, in a nationally representative sample of Korean men.

Keywords: Metabolic Syndrome X; Smoking; Alcohol Drinking; Exercise; Sleep

Received: March 27, 2016, Revised: June 8, 2016, Accepted: July 19, 2016

*Corresponding Author: Hee-Taik Kang Tel: +82-2-2019-3480, Fax: +82-2-3463-3287, E-mail: kanght0818@gmail.com

Copyright © 2017 The Korean Academy of Family Medicine

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0>) which permits unrestricted noncommercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

INTRODUCTION

Metabolic syndrome (MetS) refers to the combination of obesity-related disorders of abdominal obesity, elevated blood pressure, glucose intolerance, and atherogenic dyslipidemia. It is well-known that individuals with MetS are at a higher risk of developing type 2 diabetes or cardiovascular disease. The prevalence of MetS in adults ranges from 20% to 30% depending on age, ethnicity, and how to define MetS, and is rising rapidly worldwide, including in South Korea.¹⁾ This growing prevalence of MetS poses a significant threat to public health.

Factors related to lifestyle, such as tobacco smoking,²⁾ heavy alcohol consumption,³⁾ lack of physical activity,⁴⁾ and insufficient sleep⁵⁾ are closely associated with the development and progression of MetS, although the underlying pathophysiology has not yet been fully elucidated. Moreover, several previous studies have reported that the practice of reading food labels is associated with improved dietary intake.^{6,7)}

In 2010, the Korean Ministry of Health and Welfare reported that men aged 70 years or less had a seven-fold higher risk of developing MetS than women aged 70 years or less. Furthermore, men are likely to engage less than women in activities associated with improving their health in a positive manner, such as non-smoking, low-risk alcohol drinking, and regular exercise.⁸⁾ South Korea has developed rapidly over the past few decades, and this has resulted in more frequent exposure to a convenient but unhealthy lifestyle. An unhealthy lifestyle can contribute to the development of obesity-related disorders such as MetS. Several studies have reported that clustering of modifiable lifestyle factors, rather than an unhealthy lifestyle in itself, is closely associated with the risk of developing MetS.⁹⁾ However, the combined effect of factors that influence health positively is less studied. We hypothesized that individuals with a clustering of such positive factors would have a lower risk of development and progression of MetS.

Our aim in this study was therefore to explore the association between MetS and a number of factors that influence health positively, namely non-smoking, low-risk alcohol drinking, sufficient sleep, regular exercise, and the habit of reading food labels in a weighted, representative sample of Korean men. In addition, we investigated the relationship of each component of MetS to these positive health factors.

METHODS

1. Study Population

This cross-sectional study was based on data obtained from the Korean National Health Examination and Nutrition Survey (KNHANES) 2007–2009, conducted by the Korean Ministry of Health and Welfare. Households were selected as sampling units through a stratified, multistage, probability sampling design that was based on information such as geographic region, sex, and age group, obtained using household registries. Sampling weights, which indicates the probability of being sampled, were allocated to every subject. Thus, results based on sampling weights are representative of the entire Korean population.

During the survey period, all subjects were notified that they were

randomly selected, and agreed voluntarily to participate in this nationally representative survey. Subjects were asked to complete four parts (a health interview survey, a health behavior survey, a health examination survey, and a nutrition survey) of a questionnaire. Subjects had the right to decline participation in this survey based on the National Health Enhancement Act, and submitted informed consent documents prior to participating in the study. In addition, subjects also approved the use of their blood samples for other academic purposes. A variety of information regarding the subjects was collected during the survey, including their medical history, results of physical examinations, health-related behavior, and anthropometric and biochemical data. Trained medical staff conducted physical examinations following standard methods.

Subjects answered questions regarding their lifestyle, including questions about cigarette smoking, alcohol consumption, sleep duration, physical activities, and the use of food labels. Subjects were divided into two categories: non-smokers and smokers. Drinking patterns of the subjects were assessed based on the Alcohol Use Disorders Identification Test (AUDIT) questionnaire that includes 10 points for screening subjects, and is commonly used to identify heavy drinkers.⁸⁾ Sleep duration was assessed by the following self-reported question: "On average, how many hours and minutes do you sleep per night?" To evaluate levels of physical activity, a short form taken from the International Physical Activity Questionnaire was adopted, and was translated into Korean. The survey contains questions as to whether the subjects reads food labels or not, when buying food products. Based on the answers, we classified subjects as 'food label users' or not.

We excluded female subjects, individuals younger than 20 years of age, those without complete anthropometric data and lifestyle behavior data, and those who did not fast overnight prior to blood sampling.

After these exclusions, 3,869 men were included in the final analysis. The institutional review board of the Korea Centers for Disease Control and Prevention approved this study.

2. Anthropometric Measurements and Laboratory Data

Subjects' body weight and height were measured in light indoor clothing without shoes, to the nearest 0.1 kg and 0.1 cm, by trained medical staff. Body mass index was calculated as the ratio of weight (kg)/height (m²). The medical staff measured waist circumference at the narrowest region between the iliac crest and the 12th rib using a non-elastic tape-line. Blood pressure was measured on the subject's right arm using a mercury sphygmomanometer (Baumanometer; Baum, Copiague, NY, USA). Systolic and diastolic blood pressures were measured twice at 5-minute intervals and the average of the two measurements was recorded. After overnight fasting, blood samples were collected from the subjects through an antecubital vein puncture. Levels of glucose, triglycerides, high-density lipoprotein (HDL) cholesterol, and total cholesterol were measured using an ADVIA1650 auto-analyzer (Siemens Medical Solutions Diagnostics, Erlangen, Germany) and a Hitachi Automatic Analyzer 7600 (Hitachi Co., Tokyo, Japan). Data from a food

frequency questionnaire were collected based on the 24-hour recall method. Daily energy intake was calculated using the Can-Pro ver. 2.0 software (Korean Nutrition Society, Busan, Korea), which was developed by the Korean Nutrition Society.

3. Definition of Metabolic Syndrome and Positive Health Factors

According to the 'clinical practice guideline of prevention and treatment for MetS in Korea,⁹⁾ MetS is diagnosed when a subject meets three or more of the following criteria: (1) abdominal obesity, measured using the waist circumference for South Asians/Asians (waist circumference ≥ 90 cm in men); (2) high blood pressure; SBP ≥ 130 mm Hg, DBP ≥ 85 mm Hg, or if the subject is taking medications to treat high blood pressure; (3) high fasting blood sugar (fasting plasma glucose ≥ 100 mg/dL), or if the subject is taking medications to treat high blood sugar; (4) high triglyceride levels (fasting triglycerides ≥ 150 mg/dL), or if the subject is taking medications to treat to high triglycerides; (5) low HDL cholesterol levels (HDL cholesterol < 40 mg/dL), or if the subject is taking medications to treat low HDL cholesterol.

In this study, we defined the following five factors influencing health positively: non-smokers, defined as individuals who had smoked less than 100 cigarettes in their lifetime; low-risk drinkers, defined as individuals with an AUDIT score between 0–14; adequate sleepers, defined as individuals who slept for 6–8 hours a day on average; regular exercisers, defined as individuals who engaged in moderate to vigorous-intensity physical activity three or more days per week; and food label users, defined as individuals who usually read food labels when buying food products.

Finally, we categorized the subjects into four groups according to

the number of positive practices that they engaged in on a daily basis: group I, 0–1 positive practice; group II, 2 positive practices; group III, 3 positive practices; group IV, 4–5 positive practices.

4. Statistical Analysis

For the subjects in the 2007–2009 KNHANES to represent the entire Korean population, we applied sampling weights to take the complex sampling method into account. Mean values of continuous variables such as age, waist circumference, blood pressure, daily energy intake, and other laboratory data were compared among the four groups using general linear models. Chi-square tests were used to compare inter-group differences in categorical variables including the five positive factors (non-smoker, low-risk drinker, adequate sleeper, regular exerciser, and food label user), education level of the subject, and the prevalence of MetS.

All data are presented as mean \pm standard error. Multiple logistic regression analyses were performed to calculate odds ratios (ORs) for MetS and each of its diagnostic components according to the number of factors influencing health positively, after adjusting for confounding variables such as age, socioeconomic status (education status, household income), and daily energy intake. All analyses were conducted using SAS statistical software ver. 9.1 (SAS Institute Inc., Cary, NC, USA). All statistical tests were two-sided and statistical significance was set to a P-value of < 0.05 .

RESULTS

General characteristics of the study population (unweighted number: 3,869 men) and sub-group characteristics, based on the number of

Table 1. Subject characteristics according to the number of positive factors influencing health

	Total	Group I	Group II	Group III	Group IV	P-value
No. of positive health factors		0–1	2	3	4–5	
Unweighted no. of subjects (%)	3,869 (100.0)	866 (22.4)	1,507 (39.0)	1,134 (29.3)	362 (9.3)	
Age (y)	42.7 \pm 0.3	45.0 \pm 0.6	43.3 \pm 0.4	42.5 \pm 0.5	37.1 \pm 0.7	< 0.001
Waist circumference (cm)	84.1 \pm 0.2	85.2 \pm 0.4	84.3 \pm 0.3	83.8 \pm 0.3	82.4 \pm 0.5	< 0.001
Systolic blood pressure (mm Hg)	117.5 \pm 0.3	119.6 \pm 0.6	117.7 \pm 0.5	116.6 \pm 0.6	114.6 \pm 0.6	< 0.001
Diastolic blood pressure (mm Hg)	78.0 \pm 0.2	79.1 \pm 0.5	78.3 \pm 0.4	77.4 \pm 0.4	76.5 \pm 0.6	0.003
Cholesterol (mg/dL)	187.0 \pm 0.7	188.5 \pm 1.3	188.5 \pm 1.1	185.5 \pm 1.3	182.1 \pm 2.2	0.024
Triglycerides (mg/dL)	158.2 \pm 2.4	181.0 \pm 5.3	164.1 \pm 4.1	145.7 \pm 4.2	125.2 \pm 4.7	< 0.001
High-density lipoprotein cholesterol (mg/dL)	45.7 \pm 0.2	46.2 \pm 0.4	45.7 \pm 0.3	45.0 \pm 0.3	46.9 \pm 0.6	0.017
Fasting plasma glucose (mg/dL)	98.0 \pm 0.4	100.5 \pm 1.0	98.3 \pm 0.6	97.2 \pm 0.7	94.0 \pm 0.8	< 0.001
Energy intake (kcal/d)	2,318 \pm 18	2,344 \pm 41	2,330 \pm 29	2,303 \pm 31	2,266 \pm 50	0.579
Monthly household income (USD)*	3,415 \pm 132	2,842 \pm 140	3,505 \pm 252	3,697 \pm 235	3,449 \pm 155	0.001
Education ≥ 12 y	78.2 (0.9)	67.9 (1.8)	77.8 (1.3)	82.1 (1.1)	89.2 (1.6)	< 0.001
Non-smoker	20.5 (0.8)	1.1 (0.3)	7.2 (0.8)	33.0 (1.7)	74.0 (2.6)	< 0.001
Low-risk drinker	71.9 (0.8)	25.9 (1.7)	73.4 (1.3)	93.7 (0.8)	98.2 (0.8)	< 0.001
Adequate sleeper	83.5 (0.7)	54.5 (2.0)	86.8 (1.1)	94.9 (0.8)	97.3 (0.9)	< 0.001
Regular exerciser	37.7 (1.1)	6.0 (0.9)	27.3 (1.4)	57.6 (1.7)	84.6 (2.3)	< 0.001
Food label user	14.9 (0.7)	1.3 (0.5)	5.3 (0.7)	20.8 (1.5)	61.7 (2.8)	< 0.001
Metabolic syndrome	24.4 (0.8)	29.5 (1.7)	27.3 (1.3)	21.6 (1.4)	15.3 (2.3)	0.001

Values are presented as mean \pm SE or frequency % (SE), unless otherwise stated. SE, standard error.

*1 USD (US dollar) = 1,000 Korean won.

factors affecting health positively, are shown in Table 1. The mean age of subjects was 42.7 years and the prevalence of MetS was 24.4%. Individuals with more number of positive health factors tended to have better laboratory markers and socioeconomic status (higher household income and education levels). Men in group IV had the narrowest waist circumference, the lowest levels of blood pressure and triglycerides, and the highest levels of HDL cholesterol. There was no statistically significant difference in the daily energy intake among the four groups. The prevalence of MetS in relation to the number of positive health factors in men was 29.1% in group I, 27.2% in group II, 20.7% in group III, and 14.6% in group IV (P-value=0.001, chi-square tests for trend). This indicates that men who maintained a healthier lifestyle had a lower risk of developing MetS than men who did not maintain as healthy a lifestyle.

We performed weighted multivariate logistic regression analyses to determine whether the number of factors affecting health positively was associated with MetS prevalence (Table 2). In comparison with the men from group I, who reported one or fewer positive health factors, the unadjusted ORs (95% confidence intervals [CIs]) for MetS were 0.64 (0.50–0.81) in the men from group III, who reported three positive health factors and 0.42 (0.29–0.60) in the men from group IV, who reported 4–5 positive health factors. After adjusting for age, education level, daily energy intake, and household income, the adjusted ORs (95% CIs) for MetS were 0.67 (0.52–0.87) in group III and 0.52 (0.35–0.76) in group IV.

We also performed further logistic regression analyses for each diagnostic component of MetS, in relation to the number of factors affecting health positively (Figure 1). These analyses were adjusted for age, education level, daily energy intake, and household income, in addition to the other diagnostic components of MetS. Compared with group I, the ORs for abdominal obesity, glucose intolerance, and hypertriglyceridemia were statistically significant (0.78 [0.62–0.99] in group III and 0.55 [0.38–0.80] in group IV for abdominal obesity, 0.72 [0.57–0.92] in group III and 0.60 [0.43–0.84] in group IV for glucose intolerance, and 0.62 [0.51–0.75] in group III and 0.44 [0.32–0.60] in group IV for hypertriglyceridemia). In addition, prevalence and ORs (95% CIs) for MetS according to each positive factor were presented in Appendices 1, 2.

DISCUSSION

The main findings of this study are that incorporation of a greater

number of healthy practices in daily life (such as non-smoking, low-risk alcohol drinking, adequate sleeping, regular exercise, and the habit of reading food-labels) is significantly associated with a lower risk of developing MetS in Korean men, after controlling for age and other potential confounding factors. In addition, we found that men who incorporated a greater number of healthy practices in their daily lives were at lower risk for developing abdominal obesity, glucose intolerance, and hypertriglyceridemia, which are among the five components used to diagnose MetS, than men who incorporated fewer healthy practices. Numerous studies have demonstrated a significant relationship between the development of MetS and the positive lifestyle factors that we have evaluated in our study, as discussed below.

1. The Effect of Cigarette Smoking on Metabolic Syndrome

Cigarette smoking is the most important preventable cause of death and illness. Prohibiting cigarette smoking or motivating its cessation promotes public health. A number of studies have revealed that cigarette smoking is related to a higher risk of developing MetS in a positive, dose-dependent manner.¹⁰⁾ While cigarette smoking, including second-hand smoking, impairs insulin sensitivity and elevates triglyceride levels and blood pressure,¹¹⁾ cessation of smoking improves insulin sensitivity and lipoprotein profiles, despite a slight gain in weight.¹²⁾

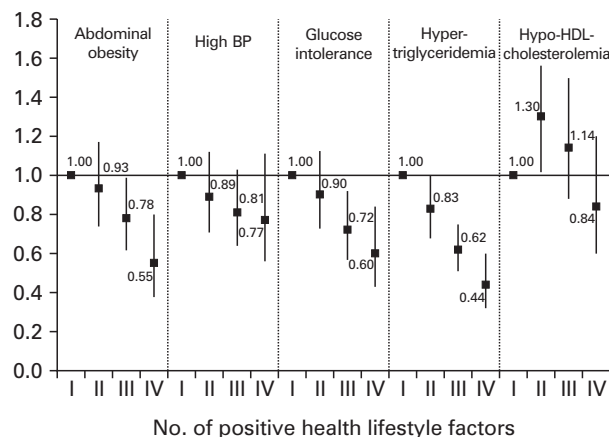


Figure 1. Multivariable logistic regression analysis of each diagnostic component of metabolic syndrome according to the number of positive health factors. Groups were categorized as follows according to the number of positive health factors: group I, 0–1; group II, 2; group III, 3; group IV, 4–5. Each logistic regression analysis was adjusted for age, education level, daily energy intake, household income, and other diagnostic components of metabolic syndrome. BP, blood pressure; HDL, high-density lipoprotein.

Table 2. Odds ratios for metabolic syndrome in relation to the number of positive health factors

	Group I	Group II	Group III	Group IV
No. of positive health factors	0–1	2	3	4–5
Model 1	1	0.91 (0.74–1.12)	0.64 (0.50–0.81)	0.42 (0.29–0.60)
Model 2	1	0.97 (0.79–1.20)	0.70 (0.54–0.89)	0.55 (0.38–0.80)
Model 3	1	0.96 (0.78–1.19)	0.67 (0.52–0.87)	0.52 (0.35–0.76)

Values are presented as odds ratios (95% confidence intervals). Model 1 was unadjusted. Model 2 was adjusted for age. Model 3 was adjusted for age, education level, daily energy intake, and household income.

The effects of cigarette smoking on glucose and lipid metabolism may contribute to the stimulation of cortisol circulation and release of the growth hormone, which have insulin-antagonistic effects.¹³⁾ Even though cessation of cigarette smoking might cause weight gain,¹⁴⁾ the beneficial effects of cessation outweigh its adverse effects.

2. The Effect of Alcohol Consumption on Metabolic Syndrome

Alcohol consumption is very popular in Korea; 81.6% of men and 52.4% of women in Korea have lifestyles that involve alcohol consumption. The amount of alcohol consumed daily per capita is 30.1 g for men and 6.6 g for women. Numerous epidemiological studies have reported a J- or U-shaped association between alcohol-drinking and cardiovascular morbidities/mortality. Heavy alcohol intake can cause metabolic dysfunction and is associated with a higher risk of cardiovascular events, while light to moderate alcohol intake can lower cardiovascular events and elevate HDL cholesterol levels.^{15,16)} However, conflicting results have been reported regarding the relationship between alcohol consumption and MetS.¹⁷⁾ In addition to the total amount of alcohol intake, unhealthy drinking patterns are considered an important risk factor for MetS in men.¹⁸⁾ We categorized subjects as high-risk drinkers or others according to the AUDIT score. Because the AUDIT questionnaire consists of 10 screening questions including frequency of drinking, quantity of drinks consumed, adverse events after drinking, among others, it not only assesses the amount of alcohol consumed, but also identifies heavy drinkers.¹⁹⁾ Drinking alcohol stimulates the appetite through reduction of glycemic levels, and causes obesity-related disorders including dyslipidemia and diabetes mellitus.²⁰⁾ Chrysohoou et al.²¹⁾ reported that chronic alcohol consumption is associated with glycemic levels, triglyceride levels, and arterial blood pressure in a J-shaped manner. Our results are therefore consistent with those reported by previous studies. High-risk drinking patterns may contribute to a higher prevalence of MetS.

3. The Effect of Regular Exercise on Metabolic Syndrome

It is well-known that increased physical activity maintains and promotes health and reduces mortality, regardless of a reduction in body weight.²²⁾ Several studies have confirmed that being physically active is associated with a lower risk of developing MetS, in a dose-responsive manner.²³⁾ Interventions to increase physical activity in individuals with MetS reduced the prevalence of MetS and improved its diagnostic components.^{24,25)} A meta-analysis of seven randomized-controlled trials by Pattyn et al.²⁵⁾ demonstrated that waist circumference and blood pressure were significantly reduced in healthy adults with MetS after endurance exercise, while HDL cholesterol levels were increased. Aerobic exercise training is a useful tool to manage MetS, as well as to decrease abdominal obesity, glucose intolerance, blood pressure, and dyslipidemia.²⁴⁾

4. The Effect of Sleep Duration on Metabolic Syndrome

Although several epidemiological studies have suggested that the du-

ration of sleep plays an important role in the development and progression of MetS, other studies have not observed this association. Some studies report a U-shaped relationship between duration of sleep and the development of MetS. More recently, a positive relationship between a short duration of sleep and the risk of developing MetS was reported, based on findings from a meta-analysis.²⁶⁾ The mechanism linking duration of sleep and the development of MetS is not clear. However, Spiegel et al.²⁷⁾ suggested that sleep deprivation disturbs energy balance and glucose metabolism. In addition, short duration of sleep causes hormonal dysregulation, such as a decrease in leptin levels and increase in ghrelin levels, which result in overeating and weight gain.²⁸⁾ Evidence demonstrating a relationship between long duration of sleep and the development of MetS is mixed. Individuals that sleep for a long time may have less waking hours to incorporate physical activities, resulting in a relatively sedentary lifestyle. For the above-mentioned reasons, sleeping too much or too little are both possible risk factors for the development of MetS.

5. The Effect of Reading Food Labels on Metabolic Syndrome

Disclosure of nutritional information on food products is expected to decrease calorie consumption and fat intake, and have a positive effect on public health;²⁹⁾ however, the effectiveness of food labeling is still unclear.³⁰⁾ Health authorities in various countries have drafted legislatures to ensure that nutrition information is made available on food packaging to promote public health. Kang et al.³¹⁾ reported that food label users drawn from the Korean population had a lower risk of developing MetS. They showed that food label users consumed larger amounts of anti-oxidants such as vitamin A and C. These results appear to be consistent with conclusions from other studies, that the development of MetS is positively associated with oxidative stress and is inversely related to blood anti-oxidant levels.³²⁾

Although the above-mentioned relationships between individual positive health factors and MetS are frequently found, the combined effect of positive factors influencing health, and the underlying mechanisms of these interactions are less well studied. But these positive lifestyle factors are likely to interact with one another and aggregate in clusters.³³⁾ Combinations of health behaviors may have synergistic effects on the risk of developing disease.³⁴⁻³⁶⁾ In this study, we suggest that lifestyle factors should be considered together, rather than in isolation when researching MetS.

There are several limitations to this study. First, it was impossible to establish causality between healthy lifestyle practices and the development of MetS, because this study had a cross-sectional design. However, several prospective studies have indicated that each of the positive factors we examined protects against the development and progression of MetS.³⁾ Furthermore, Banda et al.³⁷⁾ reported that a combination of healthy lifestyle factors reduced new-onset hypertension in men. Second, we could not fully exclude the possibility of misclassification, because this study was based on a self-reported questionnaire. Individuals with unhealthy lifestyles may have been miscategorized

into a healthy lifestyle group because they did not report socially undesirable lifestyle habits such as cigarette smoking or high-risk drinking. Third, we assessed health influencing factors using qualitative rather than quantitative methods. Future studies should assess the dose-response association between health influencing factors and the development of MetS using quantitative methods. Further, each beneficial or health influencing factor was given equal weight in this study. The next study should consider the effect of size for each component.

Despite these potential limitations, this study has several strengths. We conducted all statistical analyses after applying sampling weights to nationwide data that were collected through a multistage probability-based complex sampling approach. Thus, our data are representative of the general Korean male population aged 20 years or older. We performed additional analyses to determine the relationship between positive factors and each component of MetS, after adjusting for age, daily energy intake, socioeconomic status, and other components of MetS. A positive impact of modifying lifestyle practices were seen on abdominal circumference, blood pressure, serum glucose, and triglyceride except HDL cholesterol level.

In conclusion, we found that Korean men who incorporated a greater number of healthy practices in their daily lives were at lower risk of developing MetS than men who incorporated fewer healthy practices, after adjusting for possible confounding factors such as age, education level, daily energy intake, and household income. These findings indicate that individuals should be encouraged to incorporate positive habits into their daily lives to promote their health and prevent the development of MetS, especially in those individuals with abdominal obesity, glucose intolerance, or hypertriglyceridemia. In addition, healthcare provider interventions may be more effective at preventing and treating MetS, if the fact that these factors cluster and interact with one another is taken into consideration.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGMENTS

We appreciate the Korea Centers for Disease Control and Prevention for the provision of the KNHANES data.

REFERENCES

- Lim S, Shin H, Song JH, Kwak SH, Kang SM, Won Yoon J, et al. Increasing prevalence of metabolic syndrome in Korea: the Korean National Health and Nutrition Examination Survey for 1998-2007. *Diabetes Care* 2011;34:1323-8.
- Sun K, Liu J, Ning G. Active smoking and risk of metabolic syndrome: a meta-analysis of prospective studies. *PLoS One* 2012;7:e47791.
- Slagter SN, van Vliet-Ostaptchouk JV, Vonk JM, Boezen HM, Dullaart RP, Kobold AC, et al. Combined effects of smoking and alcohol on metabolic syndrome: the LifeLines cohort study. *PLoS One* 2014;9:e96406.
- Johnson JL, Slentz CA, Houmard JA, Samsa GP, Duscha BD, Aiken LB, et al. Exercise training amount and intensity effects on metabolic syndrome (from Studies of a Targeted Risk Reduction Intervention through Defined Exercise). *Am J Cardiol* 2007;100:1759-66.
- Iftikhar IH, Donley MA, Mindel J, Pleister A, Soriano S, Magalang UJ. Sleep duration and metabolic syndrome: an updated dose-risk meta-analysis. *Ann Am Thorac Soc* 2015;12:1364-72.
- Park MJ, Yun KE, Lee GE, Cho HJ, Park HS. A cross-sectional study of socioeconomic status and the metabolic syndrome in Korean adults. *Ann Epidemiol* 2007;17:320-6.
- Ollberding NJ, Wolf RL, Contento I. Food label use and its relation to dietary intake among US adults. *J Am Diet Assoc* 2010;110:1233-7.
- Kim SY, Nayga RM Jr, Capps O Jr. The effect of food label use on nutrient intakes: an endogenous switching regression analysis. *J Agri Resour Econ* 2000;25:215-31.
- Kang HT, Kim SY, Kim J, Kim J, Kim J, Park HA, et al. Clinical practice guideline of prevention and treatment for metabolic syndrome. *Korean J Fam Pract* 2015;5:375-420.
- Liu L, Nunez AE. Cardiometabolic syndrome and its association with education, smoking, diet, physical activity, and social support: findings from the Pennsylvania 2007 BRFSS Survey. *J Clin Hypertens (Greenwich)* 2010;12:556-64.
- Cena H, Fonte ML, Turconi G. Relationship between smoking and metabolic syndrome. *Nutr Rev* 2011;69:745-53.
- Eliasson B, Attvall S, Taskinen MR, Smith U. Smoking cessation improves insulin sensitivity in healthy middle-aged men. *Eur J Clin Invest* 1997;27:450-6.
- Andersson K, Eneroth P, Arner P. Changes in circulating lipid and carbohydrate metabolites following systemic nicotine treatment in healthy men. *Int J Obes Relat Metab Disord* 1993;17:675-80.
- Tian J, Venn A, Otahal P, Gall S. The association between quitting smoking and weight gain: a systemic review and meta-analysis of prospective cohort studies. *Obes Rev* 2015;16:883-901.
- O'Keefe JH, Bybee KA, Lavie CJ. Alcohol and cardiovascular health: the razor-sharp double-edged sword. *J Am Coll Cardiol* 2007;50:1009-14.
- Ronksley PE, Brien SE, Turner BJ, Mukamal KJ, Ghali WA. Association of alcohol consumption with selected cardiovascular disease outcomes: a systematic review and meta-analysis. *BMJ* 2011;342:d671.
- Alkerwi A, Boutsen M, Vaillant M, Barre J, Lair ML, Albert A, et al. Alcohol consumption and the prevalence of metabolic syndrome: a meta-analysis of observational studies. *Atherosclerosis* 2009;204:624-35.
- Lee KW, Park BJ, Kang HT, Lee YJ. Alcohol-drinking patterns and metabolic syndrome risk: the 2007 Korean National Health and Nutrition Examination Survey. *Alcohol* 2011;45:499-505.
- Skipsey K, Bureson JA, Kranzler HR. Utility of the AUDIT for identification of hazardous or harmful drinking in drug-dependent patients. *Drug Alcohol Depend* 1997;45:157-63.
- Baliunas DO, Taylor BJ, Irving H, Roerecke M, Patra J, Mohapatra S, et al. Alcohol as a risk factor for type 2 diabetes: a systematic review and meta-analysis. *Diabetes Care* 2009;32:2123-32.
- Chrysohoou C, Panagiotakos DB, Pitsavos C, Skoumas J, Toutouza M, Papaioannou I, et al. Effects of chronic alcohol consumption on lipid levels, inflammatory and haemostatic factors in the general popula-

- tion: the 'ATTICA' Study. *Eur J Cardiovasc Prev Rehabil* 2003;10:355-61.
22. Nocon M, Hiemann T, Muller-Riemenschneider F, Thalau F, Roll S, Willich SN. Association of physical activity with all-cause and cardiovascular mortality: a systematic review and meta-analysis. *Eur J Cardiovasc Prev Rehabil* 2008;15:239-46.
 23. Laaksonen DE, Lakka HM, Salonen JT, Niskanen LK, Rauramaa R, Lakka TA. Low levels of leisure-time physical activity and cardiorespiratory fitness predict development of the metabolic syndrome. *Diabetes Care* 2002;25:1612-8.
 24. Katzmarzyk PT, Leon AS, Wilmore JH, Skinner JS, Rao DC, Rankinen T, et al. Targeting the metabolic syndrome with exercise: evidence from the HERITAGE Family Study. *Med Sci Sports Exerc* 2003;35:1703-9.
 25. Pattyn N, Cornelissen VA, Eshghi SR, Vanhees L. The effect of exercise on the cardiovascular risk factors constituting the metabolic syndrome: a meta-analysis of controlled trials. *Sports Med* 2013;43:121-33.
 26. Xi B, He D, Zhang M, Xue J, Zhou D. Short sleep duration predicts risk of metabolic syndrome: a systematic review and meta-analysis. *Sleep Med Rev* 2014;18:293-7.
 27. Spiegel K, Knutson K, Leproult R, Tasali E, van Cauter E. Sleep loss: a novel risk factor for insulin resistance and type 2 diabetes. *J Appl Physiol* (1985) 2005;99:2008-19.
 28. Dashti HS, Scheer FA, Jacques PF, Lamon-Fava S, Ordovas JM. Short sleep duration and dietary intake: epidemiologic evidence, mechanisms, and health implications. *Adv Nutr*. 2015;13:648-59.
 29. Neuhouser ML, Kristal AR, Patterson RE. Use of food nutrition labels is associated with lower fat intake. *J Am Diet Assoc* 1999;99:45-53.
 30. Finkelstein EA, Strombotne KL, Chan NL, Krieger J. Mandatory menu labeling in one fast-food chain in King County, Washington. *Am J Prev Med* 2011;40:122-7.
 31. Kang HT, Shim JY, Lee YJ, Linton JA, Park BJ, Lee HR. Reading nutrition labels is associated with a lower risk of metabolic syndrome in Korean adults: the 2007-2008 Korean NHANES. *Nutr Metab Cardiovasc Dis* 2013;23:876-82.
 32. Czernichow S, Vergnaud AC, Galan P, Arnaud J, Favier A, Faure H, et al. Effects of long-term antioxidant supplementation and association of serum antioxidant concentrations with risk of metabolic syndrome in adults. *Am J Clin Nutr* 2009;90:329-35.
 33. Dodd LJ, Al-Nakeeb Y, Nevill A, Forshaw MJ. Lifestyle risk factors of students: a cluster analytical approach. *Prev Med* 2010;51:73-7.
 34. Schlecht NF, Franco EL, Pintos J, Negassa A, Kowalski LP, Oliveira BV, et al. Interaction between tobacco and alcohol consumption and the risk of cancers of the upper aero-digestive tract in Brazil. *Am J Epidemiol* 1999;150:1129-37.
 35. McLaughlin JK, Gridley G, Block G, Winn DM, Preston-Martin S, Schoenberg JB, et al. Dietary factors in oral and pharyngeal cancer. *J Natl Cancer Inst* 1988;80:1237-43.
 36. Wong ND, Zhao Y, Patel R, Patao C, Malik S, Bertoni AG, et al. Cardiovascular risk factor targets and cardiovascular disease event risk in diabetes: a pooling project of the Atherosclerosis Risk in Communities Study, Multi-Ethnic Study of Atherosclerosis, and Jackson Heart Study. *Diabetes Care* 2016;39:668-76.
 37. Banda JA, Clouston K, Sui X, Hooker SP, Lee CD, Blair SN. Protective health factors and incident hypertension in men. *Am J Hypertens* 2010;23:599-605.

Appendix 1. Prevalence of metabolic syndrome in relation to each positive factor influencing health

Variable	Value
Smoking status	
Non-smoker	17.9±1.5
Smoker	26.6±0.9
Alcohol status	
Low-risk drinker	23.4±0.9
Alcohol drinker	28.5±1.5
Sleep status	
Adequate sleeper	24.8±0.9
Inadequate sleeper	25.0±1.8
Exercise status	
Regular exerciser	21.9±1.3
Irregular exerciser	26.6±1.0
Food label	
Food label user	19.4±2.0
Food label non-user	25.8±0.9

Values are presented as frequency % of metabolic syndrome±standard error.

Appendix 2. Odds ratios for metabolic syndrome in relation to each positive factor influencing health

	Model 1	Model 2
Smoking status (ref: smoker)		
Non-smoker	0.60 (0.48–0.75)	1.04 (1.03–1.04)
Alcohol status (ref: alcohol drinker)		
Low-risk drinker	0.77 (0.65–0.91)	0.73 (0.62–0.87)
Sleep status (ref: inadequate sleeper)		
Adequate sleeper	0.98 (0.80–1.12)	1.21 (0.97–1.50)
Exercise status (ref: irregular exerciser)		
Regular exerciser	0.77 (0.64–0.93)	0.77 (0.64–0.92)
Food label (ref: food label non-user)		
Food label user	0.69 (0.53–0.91)	0.92 (0.69–1.21)

Values are presented as odds ratios (95% confidence intervals). Model 1 was unadjusted. Model 2 was adjusted for age. Ref, reference.