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The Relationship Between Types and Duration of Physical Activity and Metabolic Syndrome in Korean Adults

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----------ABSTRACT----------

Purpose

This study aimed to identify the relationship between physical activity and factors associated with metabolic syndrome.

Methods

This study used raw data from the ninth Korea National Health and Nutrition Examination Survey conducted from 2022 to 2024. A total of 16,016 Korean adults with metabolic syndrome were included in the analysis. Data were analyzed using frequencies, percentages, chi-square tests, and multivariable logistic regression analysis, with SPSS version 25.0.

Results

Statistically significant differences in metabolic syndrome were found according to sex (χ^2=325.46, p<.001), age (χ^2=1190.35, p<.001), smoking (χ^2=7.71, p=.020), alcohol consumption (χ^2=247.25, p<.001), walking participation (χ^2=37.62, p<.001), and walking duration (χ^2=46.23, p<.001). Regression analysis showed statistically significant associations with age, alcohol consumption, walking participation, and walking duration. A walking duration of 3 hours to 3 hours and 30 minutes was associated with a lower prevalence of metabolic syndrome.

Conclusion

Walking was identified as an important physical activity for the prevention of metabolic syndrome. Appropriate exercise programs should be developed based on these findings.

Keywords: *Physical activity; Metabolic syndrome*

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I. Introduction

1. Need for the Study

Metabolic syndrome is a cluster of conditions characterized by the simultaneous occurrence of hyperglycemia, hypertension, dyslipidemia, and abdominal obesity. Insulin resistance is known to be a major underlying cause (Reaven, 1988). As a risk factor for cardiovascular disease and diabetes, the prevalence of metabolic syndrome continues to increase (Ko, Park, &Kim, 2008). An analysis of data from the Korea National Health and Nutrition Examination Survey (KNHANES) reported that metabolic syndrome was present in 31.9% of men and 25.6% of women aged 30 years or older in Korea (Hwang, Lee, & Choi, 2014). The major concern regarding metabolic syndrome is that each independent risk factor can cause health problems on its own, but when several factors occur together, the likelihood of secondary and tertiary complications increases (Lee & Choi, 2010).

Research on the relationship between physical activity and metabolic syndrome is currently being actively conducted (Kim, 2015). Physical activity refers to bodily movement that expends energy and includes a wide range of activities, from simple activities of daily living to vigorous exercise. The amount of physical activity is defined as the energy expenditure resulting from the physical activity of the body's skeletal muscles (Sung & Park, 2013). Regular participation in exercise produces positive physiological responses, including psychological and social benefits such as restored confidence; an increase in resting metabolic rate through increased muscle mass (Brehm, 1998); improvement in blood lipids (Hargreaves, 1995); reduction in blood pressure (Kiefer, Kunze, Mitsche,& Kunze, 1998); improvement in insulin resistance (Dwarakanathan, 2006); and increased cardiorespiratory endurance (Wilder, Greene, Winters, Long, Gubler, & Edlich, 2006). Ultimately, exercise has been reported to reduce mortality from coronary artery disease and cardiovascular disease, which are risk factors for metabolic syndrome (Ko et al., 2008).

Gudat, Bungert, Kemmer, and Heinemann (1998) reported that regular moderate-intensity exercise contributes to lower blood pressure, improved blood lipid profiles, better mental health, and a reduced risk of coronary heart disease, suggesting that exercise is effective in preventing and treating metabolic syndrome. In contrast, Kang et al. (2002) reported that high-intensity exercise increased the rate of body-fat reduction and that

exercise and blood pressure showed a positive correlation, indicating that physical activity such as exercise may have a beneficial effect on hypertension. Ko et al. (2008), in an analysis of the proportions of metabolic syndrome indicators between exercise-participating and non-participating groups, found that the proportion of participants without metabolic syndrome indicators was 15.58% higher in the exercise group than in the non-exercise group. In a group that had participated in soccer activities over an extended period, waist circumference and blood pressure—among the metabolic syndrome factors—were lower, whereas fasting blood glucose and triglyceride levels were higher in the exercise group than in the non-exercise group (Kim, Baek, & Lee, 2006). These findings are consistent with those of Lee and Choi (2010), who found that among people with metabolic syndrome, those with regular exercise habits had lower levels of the risk factors diastolic blood pressure and triglycerides, and a different pattern of high-density lipoprotein cholesterol, than those without regular exercise habits.

Seo and Song (2007) also reported that an appropriate amount of physical activity can lower blood pressure in patients with hypertension, reduce waist circumference, increase fat metabolism, improve insulin resistance, lower fasting blood glucose, and reduce the risk of metabolic syndrome. Thus, studies have demonstrated the positive role of exercise in effectively preventing and treating metabolic syndrome. However, previous studies have produced varied findings depending on the type and duration of physical activity associated with metabolic syndrome, and have not reached consistent conclusions. Therefore, this study aims to provide basic data on physical activity for the prevention of metabolic syndrome by investigating the types and duration of physical activity most effective in relation to metabolic syndrome, based on raw data from the ninth KNHANES.

II. Purpose of the Study

This study aimed to identify factors associated with metabolic syndrome according to physical activity in order to provide basic data for the prevention of metabolic syndrome.

The specific objectives were as follows:

1) To identify differences in general characteristics according to the participants' metabolic syndrome status.
2) To identify differences in physical activity according to the participants' metabolic syndrome status.
3) To identify factors influencing metabolic syndrome among the participants.

3. Definition of Terms

1) Metabolic syndrome

Metabolic syndrome refers to a cluster of metabolic dysfunctions involving glucose metabolism, blood pressure, triglycerides, cholesterol, and obesity (Reaven, 1988). In this study, the diagnostic criteria for metabolic syndrome were based on the guidelines presented by the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III, 2001). Metabolic syndrome was defined as the presence of three or more of the following five criteria:

First, blood pressure: systolic blood pressure of 130 mmHg or higher or diastolic blood pressure of 85 mmHg or higher.

Second, hypertriglyceridemia: triglycerides (TG) of 150 mg/dL or higher.

Third, low HDL-C: 40 mg/dL or lower in men and 50 mg/dL or lower in women.

Fourth, abdominal obesity: waist circumference of 90 cm or greater in men and 85 cm or greater in women.

Fifth, fasting blood glucose: hyperglycemia defined as a fasting blood glucose level of 110 mg/dL or higher.

2) Physical activity

Physical activity is defined as bodily movement that occurs as a result of energy expenditure (Sung & Park, 2013). In this study, physical activity was assessed using the physical activity questions included in KNHANES, which were developed on the basis of the International Physical Activity Questionnaire (IPAQ, 2005).

II. Methods

1. Study Design

This study used raw data from the ninth KNHANES, conducted from 2022 to 2024.

2. Participants

The overall survey sample consisted of 31,596 people from 3,254 households selected nationwide through stratified, multistage cluster sampling based on residential area, sex, and age group. Of these, 25,533 participated in the health examination and questionnaire survey, representing a participation rate of 80.8% (Statistics Korea, 2012). This study analyzed 16,016 Korean adults with metabolic syndrome.

3. Research Instruments

This study used data collected through the health examination and health behavior questionnaire of KNHANES. The variables included in the analysis were those available in the KNHANES data and related to

sociodemographic characteristics, health behaviors, and physical activity, which previous studies had reported to be associated with metabolic syndrome.

The variables used in this study included sociodemographic characteristics; health behaviors such as alcohol consumption, smoking, and physical activity; and health examination items related to metabolic syndrome (blood pressure, triglycerides, high-density lipoprotein cholesterol, blood glucose, and waist circumference). Sociodemographic characteristics included sex, age, education level, marital status, and income level. Sex was categorized as male or female. Age was classified as under 30, 30–39, 40–49, 50–59, 60–69, and 70 years or older. Marital status was categorized as living with a spouse (yes) or not living with a spouse (including separation, divorce, or bereavement). Education was classified into four categories: elementary school or less, middle school, high school, and college or higher. Income level was calculated by dividing the average monthly household income by the number of household members and then categorized into quartiles: low, lower-middle, upper-middle, and high.

Smoking status, as a health behavior, was classified as current smoker or non-smoker. Alcohol consumption was categorized according to the amount consumed on a single occasion: 1–2 drinks, 3–4 drinks, 5–6 drinks, 7–9 drinks, and 10 or more drinks. Types of physical activity were classified as participation in vigorous physical activity, moderate physical activity, and walking. The amount of physical activity was measured by the duration (minutes) of vigorous physical activity, moderate physical activity, and walking. Metabolic syndrome was diagnosed when three or more of the following five criteria were met: blood pressure (systolic/diastolic blood pressure ≥130/85 mmHg), triglycerides (≥150 mg/dL), high-density lipoprotein cholesterol (men <40 mg/dL, women <50 mg/dL), fasting blood glucose (≥100 mg/dL), and waist circumference (men ≥90 cm, women ≥80 cm).

4. Data Analysis

Data were analyzed using SPSS version 25.0, with statistical significance set at .05. All individual weights calculated after the stages of design weighting, nonresponse adjustment, post-stratification, and extreme-weight adjustment were applied. Frequencies and percentages were calculated according to participant characteristics. Chi-square tests were used to examine differences in metabolic syndrome according to general characteristics and health behaviors. Multivariable logistic regression analyses accounting for the complex sample design were conducted to examine the associations among the relevant factors, physical activity, and metabolic syndrome.

III. Results

1. General Characteristics of Participants

The participants' general characteristics are presented in Table 1. The characteristics examined included sex, age, spouse status, education level, income level, smoking, and alcohol consumption. Men accounted for 52.8% of the participants and women for 47.2%. Participants ranged in age from 10 to 97 years, with a mean age of 45.86 ± 19.58 years; the largest group was those aged 30 years or younger (22.6%). Participants living with a spouse accounted for 87.2%, which was higher than the proportion without a spouse. Regarding education, 30.3% had completed high school, 29.1% had completed elementary school, 27.2% had a college education or higher, and 13.4% had completed middle school. Current smokers accounted for 50.6%, which was higher than the proportion of non-smokers. The mean amount of alcohol consumed on a single occasion was 4.36 ± 2.87 drinks, and the largest group (27.1%) reported consuming 1–2 drinks per occasion.

2. Differences in Metabolic Syndrome According to General Characteristics and Physical Activity

The analysis of differences in metabolic syndrome according to general characteristics and physical activity is presented in Table 2. Statistically significant differences in metabolic syndrome according to general characteristics were found for sex (χ^2=325.46, p<.001), age (χ^2=1190.35, p<.001), smoking (χ^2=7.71, p=.020), and alcohol consumption (χ^2=247.25, p<.001). Regarding physical activity, statistically significant differences were found in walking participation (χ^2=37.62, p<.001) and walking duration (χ^2=46.23, p<.001).

3. Factors Influencing Metabolic Syndrome

To identify factors influencing metabolic syndrome, logistic regression analysis was performed using seven general characteristics and four physical activity variables as independent variables (Table 3). Among the independent variables entered into the regression model, age and alcohol consumption among general characteristics, and walking participation and walking duration among physical activity variables, were statistically significant. This indicates that the greater the amount of alcohol consumed on a single occasion and the less likely a person is to engage in walking, the higher the likelihood of metabolic syndrome.

An analysis of factors influencing metabolic syndrome using odds ratios showed that participants aged 30 years or younger were 4.14 times more likely not to have metabolic syndrome than those aged 70 years or older.

Participants aged 30–39 years were 1.51 times more likely not to have metabolic syndrome than those aged 70 years or older. Participants consuming 1–2, 3–4, 5–6, and 7–9 drinks on a single occasion were 5.39, 4.19, 3.31, and 1.76 times more likely, respectively, not to have metabolic syndrome than those consuming 10 or more drinks. Those who did not engage in walking were 0.72 times as likely not to have metabolic syndrome as those who did. In other words, people who did not walk were more likely to have metabolic syndrome than those who walked. Participants who walked for 3 hours to 3 hours and 30 minutes were 3.70 times more likely not to have metabolic syndrome than those who walked for more than 3 hours and 30 minutes.

IV. Discussion

This study used raw data from the ninth KNHANES, conducted from 2022 to 2024, to investigate the relationship between physical activity and metabolic syndrome.

According to the results, the prevalence of metabolic syndrome based on participants' general characteristics was higher in men than in women. Participants aged 30 years or younger were 4.14 times more likely not to have metabolic syndrome than those aged 70 years or older, while those aged 30–39 years were 1.51 times more likely not to have metabolic syndrome than those aged 70 years or older. Alcohol consumption also showed a significant difference: the smaller the amount consumed on a single occasion, the lower the likelihood of metabolic syndrome. In other words, the likelihood of metabolic syndrome increased in proportion to the amount of alcohol consumed. This finding is similar to previous research showing that the prevalence of metabolic syndrome increases with greater alcohol consumption (Yoon, Oh, Baik, Park, & Kim, 1998). Alcohol consumption can increase abdominal obesity, a component of metabolic syndrome (Slattery, 1992), raise high-density lipoprotein and triglyceride levels, and increase the risks of hypertension and diabetes (Kao, Puddey, Boland, Watson, & Brancati, 2001; Rimm, Williams, Fosher, Criqui, & Stampfer, 1999). These findings suggest that interventions to regulate alcohol consumption are also needed, particularly among older adults, who are at greater risk of developing metabolic syndrome.

Regarding differences in metabolic syndrome according to physical activity, no significant differences were found in participation in vigorous or moderate physical activity; a significant difference was found only in walking participation. Those who did not walk were 0.72 times as likely not to have metabolic syndrome as those who walked. This finding is consistent with research showing that regular walking has beneficial effects on glucose metabolism, blood pressure, triglycerides, cholesterol, and obesity—risk factors for metabolic syndrome—and that the incidence of metabolic syndrome decreases as regular walking increases (United States Department of Health & Human Services, 1996). Studies involving not only healthy adults but also patients with diabetes and middle-aged women (Kim, Tanabe, Yokoyama, Zempo, & Kuno, 2011; American College of Sports Medicine, 2008) have also found that walking reduces metabolic syndrome. Physical activity such as walking may reduce body fat and obesity, increase insulin sensitivity in the liver, skeletal muscle, and adipose tissue, improve glucose utilization and thereby lower blood glucose levels, and enhance vascular function to reduce hypertension (Kim, Kim, Choi, & Kim, 2014; Isomaa et al., 2001; McNeill et al., 2005; Fuentes et al., 2007). Exercise also positively affects blood lipids by increasing HDL cholesterol, an anti-atherogenic factor, and decreasing LDL cholesterol (McNeill et al., 2005). These findings suggest that physical activity such as walking can reduce the prevalence of metabolic syndrome and the risk of cardiovascular disease, thereby potentially reducing stroke and cardiovascular mortality.

Previous studies have examined the occurrence of metabolic syndrome according to the type of physical activity, and findings regarding the duration of physical activity associated with metabolic syndrome have varied (Kim et al., 2014; Kim, 2015; Ko, Seok, Jung, Kim, Chun, & Kim, 2013). In this study, an analysis of metabolic syndrome according to walking duration, which was statistically significant in relation to metabolic syndrome, showed that participants who walked for 3 hours to 3 hours and 30 minutes were 3.70 times more likely not to have metabolic syndrome than those who walked for more than 3 hours and 30 minutes. In other words, walking for 3 hours to 3 hours and 30 minutes was effective in reducing metabolic syndrome. According to the guidelines of the American College of Sports Medicine (ACSM, 2008) and the American Heart Association (2007), approximately 30 minutes of moderate-intensity aerobic exercise on 5 days per week, or approximately 20 minutes of vigorous-intensity aerobic exercise on 3 days per week, is recommended to reduce the risk of chronic disease and diabetes and to control body weight (American College of Sports Medicine, 2008). In this study, low-intensity walking for approximately 3 hours to 3 hours and 30 minutes per day was associated with a reduction in metabolic syndrome. This may indicate that a relatively long duration of low-intensity walking is required to achieve effects comparable to those of moderate- or high-intensity exercise. Whereas previous studies have examined differences in metabolic syndrome after walking for specified periods (Kim et al., 2014; Kim, 2015; Ko et al., 2013), studies specifically examining walking duration are lacking. Further research is therefore needed to identify the walking duration that affects the reduction of metabolic syndrome.

In this study, no significant relationship was found between metabolic syndrome and participation in moderate or vigorous physical activity. This finding differs from previous studies reporting that the prevalence of metabolic syndrome decreases as physical activity increases (Kim, 2015; Lee, 2012). Further verification through intervention studies that consider external variables, such as individual lifestyle habits and underlying diseases, is considered necessary.

This study has several limitations. First, because the study participants were adults, the findings cannot be generalized to adolescents and children under 20 years of age. Second, although this study examined the relationship between physical activity and metabolic syndrome risk factors, it did not establish a causal relationship; therefore, a clear causal relationship cannot be determined. Despite these limitations, this study is meaningful in that it used a cohort of a large number of people in Korea to investigate the relationship between physical activity and metabolic syndrome risk and, unlike previous studies that focused on the types of physical activity associated with metabolic syndrome, estimated an appropriate duration of walking activity for the prevention of metabolic syndrome. Furthermore, the findings may be used in developing evidence-based educational programs for health promotion and the prevention of diseases such as metabolic syndrome.

V. Conclusion and Recommendations

This study used raw data from the ninth KNHANES, conducted from 2022 to 2024, to investigate the relationship between physical activity and metabolic syndrome. The following conclusions were drawn.

First, participants aged 30 years or younger were 4.14 times more likely not to have metabolic syndrome than those aged 70 years or older, and participants aged 30–39 years were 1.51 times more likely not to have metabolic syndrome than those aged 70 years or older. The likelihood of metabolic syndrome increased as alcohol consumption increased.

Second, people who did not engage in walking were 0.72 times as likely not to have metabolic syndrome as those who walked. Participation in moderate and vigorous physical activity did not have a statistically significant effect on metabolic syndrome.

Third, among people who walked, a walking duration of 3 hours to 3 hours and 30 minutes was found to be effective in reducing the prevalence of metabolic syndrome.

Based on these findings, regular walking should be encouraged to prevent metabolic syndrome, and walking for approximately 3 hours to 3 hours and 30 minutes per day was found to be effective for its prevention. Using the findings of this study as basic data, future research should scientifically establish the effective types, intensities, and durations of exercise for various diseases, considering not only walking and moderate- and vigorous-intensity physical activity but also the duration of each type of exercise. In addition, exercise education should be provided to patients and other target populations as part of evidence-based primary-prevention health programs for the prevention of metabolic syndrome.

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Table 1. General Characteristics of Participants (N = 16,016)

Variable	Category	n (%) / Mean ± SD
Sex	Male	8,455 (52.8%)
	Female	7,561 (47.2%)
Age (years)	≤30	3,617 (22.6%)
	30–39	2,569 (16.0%)
	40–49	2,546 (15.9%)
	50–59	2,705 (16.9%)
	60–69	2,420 (15.1%)
	≥70	2,159 (13.5%)
	Mean ± SD	45.86 ± 19.58
Spouse	Present	10,449 (87.2%)
	Absent	1,539 (12.8%)
Education level	Elementary school	4,539 (29.1%)
	Middle school	2,081 (13.4%)
	High school	4,719 (30.3%)
	College or higher	4,234 (27.2%)
Income level	Low	2,815 (17.8%)
	Lower-middle	4,045 (25.6%)
	Middle	4,451 (28.1%)
	High	4,503 (28.5%)
Smoking	Yes	3,235 (50.6%)
	No	3,152 (49.4%)
Alcohol (drinks per occasion)	1–2	1,238 (21.1%)
	3–4	1,128 (19.2%)
	5–6	1,210 (20.6%)
	7–9	1,713 (29.2%)
	≥10	581 (9.9%)
	Mean ± SD	4.36 ± 2.87

Table 2. Differences in Metabolic Syndrome According to General Characteristics (N = 16,016)

Variable	Category	n (%)	χ^2	p
Sex	Male	8,455 (52.8%)	325.46	<.001
	Female	7,561 (47.2%)		
Age (years)	≤30	3,617 (22.6%)	1190.35	<.001

	30–39	2,569 (16.0%)		
	40–49	2,546 (15.9%)		
	50–59	2,705 (16.9%)		
	60–69	2,420 (15.1%)		
	≥70	2,159 (13.5%)		
Spouse	Present	10,449 (87.2%)	3.40	.127
	Absent	1,539 (12.8%)		
Education level	Elementary school	4,539 (29.1%)	7.06	.234
	Middle school	2,081 (13.4%)		
	High school	4,719 (30.3%)		
	College or higher	4,234 (27.2%)		
Income level	Low	2,815 (17.8%)	8.66	.153
	Lower-middle	4,045 (25.6%)		
	Middle	4,451 (28.1%)		
	High	4,503 (28.5%)		
Smoking	Yes	3,235 (50.6%)	7.71	.020
	No	3,152 (49.4%)		
Alcohol (drinks)	1–2	1,238 (21.1%)	247.25	<.001
	3–4	1,128 (19.2%)		
	5–6	1,210 (20.6%)		
	7–9	1,713 (29.2%)		
	≥10	581 (9.9%)		

Table 3. Differences in Metabolic Syndrome According to Physical Activity Types and Walking Duration (N = 16,016)

Variable	Category	n (%)	χ^2	p
Vigorous physical activity	No	12,101 (85.7%)	1.15	.372
	Yes	2,022 (14.3%)		
Moderate physical activity	No	12,974 (91.9%)	3.24	.163
	Yes	1,150 (8.1%)		
Walking	No	8,679 (61.5%)	37.62	<.001
	Yes	5,432 (38.5%)		
Walking duration (minutes)	<30	2,779 (27.5%)	46.23	<.001
	31–60	3,819 (37.8%)		
	61–90	777 (7.7%)		
	91–120	1,450 (14.4%)		
	121–150	111 (1.1%)		
	151–180	555 (5.5%)		
	181–210	33 (0.3%)		
	≥211	577 (5.7%)		

Table 4. Factors Influencing Metabolic Syndrome (N = 16,016)

Variable	Category	Adjusted OR	95% CI	p
Age (years)	≤30	4.14	2.40–7.13	<.001
	30–39	1.51	—	
	40–49	0.88	—	
	50–59	0.63	—	
	60–69	0.76	—	
	≥70	1.00 (Ref.)	—	
Alcohol (drinks)	1–2	5.39	3.55–8.19	<.001
	3–4	4.19	2.73–6.42	
	5–6	3.31	2.15–5.08	
	7–9	1.76	1.20–2.56	
	≥10	1.00 (Ref.)	—	
Walking	No	0.72	0.54–0.96	.026
	Yes	1.00 (Ref.)	—	
Walking duration (minutes)	<30	1.26	0.78–2.03	<.001
	31–60	1.15	0.76–1.77	
	61–90	1.44	0.85–2.44	
	91–120	1.05	0.66–1.66	
	121–150	0.86	0.29–2.61	
	151–180	0.92	0.49–1.73	
	181–210	3.70	1.51–9.09	
	≥211	1.00 (Ref.)	—	