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A Study on Predicting the Risk of Metabolic Syndrome according to Lifestyle through Big Data Analysis

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ABSTRACT

The purpose of this study is to examine the impact of subjects' lifestyle habits on the risk of metabolic syndrome. The primary data used are the statistics from the 2022 Korea National Health & Nutrition Examination Survey (KNHANES), as published by the Korea Disease Control and Prevention Agency, with the survey period remaining consistent. The sampling method of KNHANES involves a two-stage stratified cluster sampling, where survey districts and households serve as the primary and secondary sampling units, respectively. In order to predict the explanatory variables with health characteristics as the dependent variable, the study conducted a median correlation analysis or canonical correlation analysis using the Quantification Method II. Looking at general characteristics, the age distribution was highest in the 34 years and younger group at 29.6%, followed by those 65 years and older at 26.6%, 50~64 years old at 24.0%, and the 35~49 years old group at 19.8%, the lowest distribution. As a result of canonical correlation analysis of the health characteristics, general characteristics, lifestyle characteristics, and metabolic syndrome indicator characteristics of the men among the study subjects, 13 canonical functions were derived. Among them, four canonical functions were found to be statistically significant ($p<0.05$, $p<0.001$). As a result of canonical correlation analysis of women's health characteristics, general characteristics, lifestyle characteristics, and metabolic syndrome indicator characteristics, 13 canonical functions were derived. Among them, four canonical functions were found to be statistically significant ($p<0.05$, $p<0.001$). The study results show that metabolic syndrome can be prevented and managed through a comprehensive approach that includes a balanced diet, regular exercise, strengthening public policies, and personal health management.

1. Introduction

Big Data analysis is being used in a variety of fields because it can better predict the future, reduce potential losses in various fields, and increase management efficiency. The healthcare field

is a representative big data production field along with finance and communications due to its high data volume, variety, and complexity. In addition, healthcare is a field where Big Data analysis is very important and necessary because even a small improvement in efficiency can lead to significant cost savings and the resulting non-economic ripple effects are also large (Choi et al., 2017; Park, 2024).

Healthcare Big Data is divided into six categories, which are Clinical Data that doctors naturally produce in the process of treating patients; Genomic Data that is cellular-level DNA and RNA data obtained through the development of high-speed genome analysis technology; Claim Data that is produced for the purpose of billing between hospitals and insurance companies; Research Data that is obtained from the results of experiments in individual laboratories or observations of clinical trials; Patient-Generated Health Data that is collected through smart devices; and Social Determinants of Health that is data about the patient's environment (Yu et al., 2018; Yu et al., 2024). Among lifestyle habits, sleep duration is known to affect abdominal obesity in adolescents, but the results of previous studies were inconsistent. One study on sleep duration in European children and adolescents reported that sleep duration was negatively related to abdominal obesity, while another study on American adolescents reported that variability in sleep duration, rather than sleep duration, was positively related to abdominal obesity (He et al., 2015; Lee, 2023).

Metabolic syndrome refers to a condition in which risk factors that increase the risk of cardiovascular disease and diabetes, such as elevated blood pressure, hyperglycemia, abnormal blood lipid levels, and obesity, overlap. Metabolic syndrome has also been reported to increase the prevalence rate of various chronic diseases. Lifestyle habits known to affect metabolic syndrome include weight, smoking, drinking, aerobic exercise, and eating habits. As the prevalence rate of metabolic syndrome increases, the prevalence rate of various diseases increases, so the government is trying to prevent metabolic syndrome to reduce social costs and improve national health (Park et al., 2023; Park et al., 2024).

Physical activity and dietary control are representative activities for preventing obesity. Previous studies have shown that adolescents with higher levels of physical activity have a lower probability of abdominal obesity, and that they have a lower probability of abdominal obesity as adults(Garcez et al., 2015), suggesting that physical activity during this period can reduce the probability of abdominal obesity during adolescence and adulthood (Kim, 2023). The prevalence rate of metabolic syndrome is also on the rise internationally. A study by Hirode G et al. (2020) found that in the United States, the overall increase in the prevalence rate of metabolic syndrome among American adults from 2011~2012 to 2015~2016 did not meet statistical significance, but a significant increase was observed among young adults(Hirode et al., 2020). The study found that prevalence rate rates remained high among people aged 60 and older, while rates were rapidly increasing among younger adults and Hispanic and Asian individuals. Yao F et al. (2017) reported that the prevalence rate of metabolic syndrome is increasing among Chinese residents aged 20 years or older, especially among women, those aged 45 years or older, and urban residents (Yao F et al., 2017). It is emphasized that preventive efforts such as quitting smoking and engaging in physical activity are necessary to reduce the risk of metabolic syndrome. A study by Dang AK et al. (2022) investigated the prevalence rate of metabolic syndrome in a Vietnamese adult population (Dang AK et al., 2022). Metabolic syndrome

was common among the Vietnamese population, with higher prevalence observed in women, urban residents, and individuals with obesity. According to a study by Alkhulaifi F et al. (2022), meal timing and frequency play an important role in preventing and managing metabolic syndrome, and maintaining a regular breakfast, appropriate meal frequency, and consistent meal patterns can help improve metabolic health (Alkhulaifi F et al., 2022). Myers J et al. (2019) found in their study that physical activity and cardiorespiratory fitness are important factors in the prevention and management of metabolic syndrome. Regular exercise and maintaining high cardiorespiratory fitness are effective in improving metabolic health and reducing the risk of metabolic syndrome, which may in turn reduce the risk of cardiovascular disease and diabetes, suggesting that this may be the case (Myers J et al., 2019).

Metabolic syndrome is a disease that requires correction of wrong lifestyle habits along with medical treatment. The third US cholesterol management guidelines (NCEP-ATP III, 2001), which newly defined metabolic syndrome and presented clinical guidelines, also emphasized that strong lifestyle improvement would be a strategy for preventing and managing primary and secondary diseases in the preventive management of metabolic syndrome, and mentioned that this is the most important and cost-effective method for reducing the incidence of complications in the subjects (An et al., 2023; Chong et al., 2023).

Previous studies have primarily focused on the correlation between metabolic syndrome, physical activity, and diet. However, since prevalence rates are influenced by multiple factors, they must be able to include a variety of variables that reflect changes in society. In addition, the prevalence rate of metabolic syndrome has been mainly studied by age, including adolescents, adults, middle-aged, and elderly people, but detailed group-by-group analyses have not been conducted. In addition, since lifestyle habits and work patterns vary by occupational group, customized analysis of factors influencing the prevalence of metabolic syndrome by occupational group should be conducted. Furthermore, most of the research data was conducted based on the KNHANES, but there are limitations in generalizing the results since the research data was analyzed from 2 to 3 years, or at most 5 years.

The study aimed to identify the influence of subjects' lifestyle habits on the risk of developing metabolic syndrome and the specific purpose is to find risk factors for metabolic syndrome according to lifestyle habits through big data analysis.

2. Study Methods and Contents

2.1 Investigation period

The study used the 2022 KNHANES statistics published by the Korea Disease Control and Prevention Agency as raw data, and the survey period was the same (KCDC, 2022). The sampling method of the KNHANES is a two-stage stratified cluster sampling method with survey areas and households as the first and second sampling units.

2.2 Investigation method

The investigation method is based on data extracted from the 2022 KNHANES, and seven items were used as general characteristics, which are gender, age, income level, region, type of health insurance, marital status, education level, generation type, and average weekly working hours. The lifestyle characteristics included eight items, which are current smoking status, lifetime drinking status, drinking frequency, number of days of strength training, number of days of flexibility training, daily walking time, average daily sleep time, and time spent sitting per day. Metabolic syndrome characteristics included nine items, which are body mass index, fasting blood sugar, total cholesterol, HDL cholesterol, triglycerides, LDL cholesterol (direct method), AST (SGOT), and ALT (SGPT). The nutritional characteristics included 10 items: cholesterol intake (mg), carbohydrate intake (g), dietary fiber intake (g), calcium intake (mg), phosphorus intake (mg), sodium intake (mg), potassium intake (mg), magnesium intake (mg), iron intake (mg), zinc intake (mg), and vitamin D intake (μ g). Health characteristics consisted of 4 items, which are subjective health perception, current hypertension, current dyslipidemia, and current diabetes (Table 1).

2.3 Analysis method

Statistical analysis of the data was performed using SPSS (ver 25). Based on general characteristics, significance tests for lifestyle characteristics, metabolic syndrome indicators, nutritional characteristics, and health characteristics were conducted using cross-validation and t-tests. In addition, in order to predict explanatory variables using health characteristics as dependent variables, median correlation analysis or canonical correlation analysis using quantification method II was performed in the study.

3. Analysis Results

3.1 General characteristics of the investigation subjects

Looking at the general characteristics of the investigation subjects, the age distribution was highest in the 34 years and younger group at 29.6%, followed by those aged 65 and older at 26.6%, those aged 50 to 64 at 24.0%, and those aged 35 to 49 at 19.8%, the lowest distribution. Looking at income levels, the distribution was similar across lower, lower middle, upper middle, and upper levels. Looking at marital status, married people accounted for 69.1%, which was higher than single people's 30.9%. Looking at the average working hours per week, the average was 35.41 hours, with men working 38.80 hours and women working 17.55 hours, showing that men worked longer hours than women (Table 1).

Table 1. General characteristics of the investigation subjects

	Male	Female	Total
Age			
~34 years old or younger	895(32.0)	960(27.7)	1,855(29.6)
35~49 years old	520(18.6)	722(20.8)	1,242(19.8)
50~64 years old	637(22.8)	865(24.9)	1,502(24.0)
65 years old or older	745(26.6)	921(26.6)	1,666(26.6)
Income Level			
Low	702(25.1)	869(25.1)	1,571(25.1)
Lower middle	696(24.9)	865(24.9)	1,561(24.9)
Upper middle	703(25.1)	868(25.0)	1,571(25.1)
High	696(24.9)	866(25.0)	1,562(24.9)
Martial Status			
Married	1,800(64.4)	2,526(72.8)	4,326(69.1)
Single	997(35.6)	942(27.2)	1,939(30.9)
Total			
Average working hours per week	38.80 15.84	17.55±32.24	35.41±16.37

3.2 Life Characteristics of the investigation subjects

Looking at the current smoking status, non-smokers were higher at 87.4% and smokers at 12.6%, and smoking rates by gender were higher at 23.4% for men and 3.9% for women, showing a statistically significant difference ($p<0.001$). Looking at lifetime drinking, 76.1% were drinkers and 23.9% were non-drinkers, showing a high distribution of drinking, and by gender, both men and women showed a higher distribution of drinking than non-drinkers ($p<0.001$). Looking at the number of days of muscle-strengthening exercise (per week), the average was 0.90 days, and by gender, men were higher at 1.31 days and women at 0.58 days ($p<0.001$). Looking at the daily walking time, the average was 0.67 hours, and by gender, men were higher at 0.74 hours and women at 0.63 hours ($p<0.001$). Looking at the average daily sleep time, the average was 6.76 hours, and by gender, men and women had similar sleep times (Table 2).

Table 2. Life Characteristics of the Investigation Subjects

	Male	Female	Total	p-value
Current Smoking Status				0.001
Smoking	655(23.4)	136(3.9)	791(12.6)	
Non-smoking	2,142(76.6)	3,332(96.1)	5,474(87.4)	
Lifetime Drinking Stuats				0.001
Drinking	2,244(80.2)	2,521(72.7)	4,765(76.1)	
Non-drinking	553(19.8)	947(27.3)	1,500(23.9)	
Days of Strength Exercise (weekly)	1.31±1.89	0.58±1.35	0.90±1.65	0.001
Walking time per day	0.74±1.01	0.63±0.84	0.67±0.92	0.001
Average sleeping time per day	6.80±1.23	6.72±1.33	6.76±1.29	

3.3 Indicator characteristics of metabolic syndrome

Looking at the body mass index, the average was 23.34 kg/m^2, and by gender, men and women had similar body mass indices. Looking at fasting blood sugar levels, the average was 100.62 mg/dL, and by gender, men had a higher level (103.44 mg/dL) than women (98.39 mg/dL), showing a statistically significant difference ($p<0.001$). Looking at total cholesterol, the average was 186.88 mg/dL, and by gender, it was 182.91 mg/dL for men and 190.03 mg/dL for women, showing a higher level in women, and there was a statistically significant difference ($p<0.001$). Looking at HDL cholesterol, the average was 57.29, and by gender, it was 51.84 for men and 61.61 for women, showing a higher value in women, and there was a statistically significant difference ($p<0.001$). Looking at neutral fat, the average was 125.47, and by gender, men were 144.64 and women were 110.30, showing a higher male score, and there was a statistically significant difference ($p<0.001$).Looking at LDL-cholesterol (direct method), the average was 113.34, and there was a similar trend between men and women. Looking at AST (SGOT), the average was 22.45, with men at 24.28 and women at 21.01, showing a higher value in men and a statistically significant difference ($p<0.001$). Looking at ALT (SGPT), the average was 21.44, with men at 25.84 and women at 17.96, showing a higher value in women, and there was a statistically significant difference ($p<0.001$) (Table 3).

Table 3. Indicator characteristics of metabolic syndrome

	Male	Female	Total	p-value
Body Mass Index (kg/m^2)	23.85±4.24	22.92±4.19	23.34±0.61	0.001
Fasting Blood Sugar (mg/dL)	103.44±24.34	98.39±19.12	100.62±0.55	0.001
Total Cholesterol (mg/dL)	182.91±40.41	190.03±39.84	186.88±40.24	0.001
HDL-Cholesterol	51.84±13.22	61.61±15.26	57.29±15.19	0.001
Neutral Fat	144.64±111.53	110.30±67.93	125.47±91.46	0.001
LDL-cholesterol (Direct method)	112.00±36.69	114.39±36.16	113.34±36.41	0.015
AST (SGOT)	24.28±15.68	21.01±10.39	22.45±13.09	0.001
ALT (SGPT)	25.84±21.98	17.96±17.70	21.44±20.09	0.001

3.4 Nutritional characteristics

Looking at cholesterol intake, the average was 248.23 mg, and by gender, men had a higher intake at 281.66 mg and women had a higher intake at 221.23 mg, showing a statistically significant difference ($p<0.001$). Looking at carbohydrate intake, the average was 254.31g, and by gender, men had a higher intake at 289.73g and women had a higher intake at 225.69g, showing a statistically significant difference ($p<0.001$). Looking at dietary fiber intake, the average was 28.81g, and by gender, men had a higher intake (26.16g) than women (21.90g), showing a statistically significant difference ($p<0.001$). Looking at calcium intake, the average was 490.81 mg, and by gender, men had a higher intake (538.11 mg) than women (451.61 mg), showing a statistically significant

difference (p<0.001). Looking at the phosphorus intake, the average was 1003.38 mg, and by gender, men were higher at 1139.26 mg and women at 893.62 mg, showing a statistically significant difference (p<0.001).

Looking at sodium intake, the average was 3009.14mg, and by gender, men had a higher intake at 3552.12mg and women had a higher intake at 2570.55mg, showing a statistically significant difference (p<0.001). Looking at potassium intake, the average was 2567.91mg, and by gender, men had a higher intake at 2833.34mg and women had a higher intake at 2353.51mg, showing a statistically significant difference (p<0.001). Looking at the magnesium intake, the average was 285.35 mg, and by gender, men had a higher intake at 321.32 mg and women had a higher intake at 256.29 mg, showing a statistically significant difference (p<0.001). Looking at iron intake, the average was 9.01 mg, and by gender, men had a higher intake (10.32 mg) and women had a higher intake (7.92 mg), showing a statistically significant difference (p<0.001). Looking at zinc intake, the average was 9.71 mg, and by gender, men had a higher intake (11.29 mg) and women had a higher intake (8.43 mg), showing a statistically significant difference (p<0.001). Looking at vitamin D intake, the average was 2.87 μg, and by gender, men had a higher intake (3.24 μg) and women had a higher intake (2.57 μg), showing a statistically significant difference (p<0.001) (Table 4).

Table 4. Nutritional characteristics

	Male	Female	Total	p-value
Cholesterol intake (mg)	281.66±216.21	221.23±170.89	248.23±194.78	0.001
Carbohydrate intake (g)	289.73±112.54	225.69±92.55	254.31±106.81	0.001
Dietary fiber intake (g)	26.16±14.14	21.90±12.57	23.81±13.46	0.001
Calcium intake (mg)	538.11±317.54	452.61±267.07	490.81±293.77	0.001
Phosphorus intake (mg)	1139.26±470.61	893.62±375.68	1003.38±438.08	0.001
Sodium intake (mg)	3552.12±1928.90	2570.55±1471.12	3009.14±1759.92	0.001
Potassium intake (mg)	2833.34±1334.72	2353.51±1154.41	2567.91±1260.89	0.001
Magnesium intake (mg)	321.32±147.50	256.29±119.66	285.35±136.69	0.001
Iron intake (mg)	10.32±7.51	7.95±5.16	9.01±6.43	0.001
Zinc intake (mg)	11.29±5.50	8.43±4.18	9.71±5.02	0.001
Vitamin D intake (μg)	3.24±5.09	2.57±4.40	2.87±4.73	0.001

3.5 Health characteristics

Looking at the subjective health evaluation, average was the highest at 39.6%, followed by good at 28.0%, bad at 13.5%, and very bad at 3.0%, the lowest. A similar distribution was also observed by gender (Table 5).

Table 5. Health characteristics

	Male	Female	Total	p-value
Subjective Health Evaluation				0.001
Very Good	304(4.9)	259(4.1)	563(9.0)	
Good	852(13.6)	900(14.4)	1,752(28.0)	
Average	1,054(16.8)	1,426(22.8)	2,480(39.6)	
Bad	329(5.3)	513(8.2)	842(13.5)	
Very Bad	51(0.8)	138(2.2)	189(3.0)	
Unknown	200(3.2)	231(3.7)	431(6.9)	
Total	2,790(44.6)	3,467(55.4)	6,257(100.0)	

3.6 General characteristics, lifestyle characteristics, and metabolic syndrome indicators that affect men's health characteristics

As a result of canonical correlation analysis of the health characteristics, general characteristics, lifestyle characteristics, and metabolic syndrome indicator characteristics of the men among the study subjects, 13 canonical functions were derived. Among them, four canonical functions were found to be statistically significant ($p<0.05$, $p<0.001$). In canonical function 1, it was statistically significant when the degrees of freedom were 14,478 ($p<0.001$). Looking at the standard canonical coefficients of canonical function 1, when the health characteristic is good, the ages are 35 to 49, 50 to 64, 65 or older, income level = 4, non-smoker, and in terms of metabolic syndrome indicator characteristics, there was a correlation in fasting blood sugar, LDL-cholesterol (direct method), AST (SGOT), and ALT (SGPT). In canonical function 2, the canonical function was found to be statistically significant when the degrees of freedom were 13,388 ($p<0.001$). Looking at the standard normal coefficients, it was found that there was a correlation between the health characteristic and good, the general characteristic and age of 35-49 and 65 or older, the lifestyle characteristic and the number of days of strength exercise (per week), and the metabolic syndrome indicator characteristics of neutral fat, LDL-cholesterol (direct method), AST (SGOT), and ALT (SGPT).

In canonical function 3, the canonical function was found to be statistically significant when the degrees of freedom were 1,298 ($p<0.001$). Looking at the standard normal coefficients, the health characteristics were correlated with good and bad, the general characteristics were correlated with age 35-49, age 50-64, income level = 4, the lifestyle characteristics were correlated with the number of days of strength training (per week), and the metabolic syndrome indicator characteristics were correlated with body mass index, fasting blood sugar, neutral fat, LDL-cholesterol (direct method), and ALT (SGPT). In canonical function 4, the canonical function was found to be statistically significant when the degrees of freedom were 11,209 ($p<0.05$). Looking at the standard normal coefficients, the health characteristic was found to be correlated when good, the general characteristics were 35-49 years old, 65 years old or older, income level = 2, income level = 3, income level = 4, the lifestyle characteristics were non-smoking, daily walking time, and the metabolic syndrome indicator characteristics were fasting blood sugar, neutral fat, HDL cholesterol, neutral fat, LDL cholesterol (direct method), AST (SGOT), and ALT (SGPT) (Table 6).

Table 6. General characteristics, lifestyle characteristics, and metabolic syndrome indicators affecting men's health characteristics

Classification		Standard Canonical Coefficient				Canonical Loadage				Canonical Cross Loadage			
		1	2	3	4	1	2	3	4	1	2	3	4
Health Characteristics	Very Good	-0.184	-0.230	0.181	0.125	-0.146	-0.252	0.111	-0.061	-0.068	-0.094	0.028	-0.011
	Good	-0.352 †	-0.354 †	0.389 †	0.360 †	-0.366	-0.288	0.456	0.116	-0.171	-0.107	0.113	0.021
	Average	-0.042	-0.055	0.056	0.288	0.261	0.249	-0.087	0.099	0.122	0.093	-0.021	0.018
	Bad	0.047	0.108	-0.339 †	-0.038	0.195	0.223	-0.517	-0.205	0.091	0.083	-0.128	-0.038
	Very Bad	0.082	0.019	-0.197	-0.159	0.143	0.018	-0.244	-0.177	0.067	0.007	-0.060	-0.033
General Characteristics	35~49 years old	0.406 †	0.466 †	0.581 †	0.694 †	-0.258	0.669	0.089	0.497	-0.121	0.249	0.022	0.091
	50~64 years old	0.979 †	0.075	0.850 †	0.142	0.477	0.119	0.522	-0.356	0.223	0.044	0.129	-0.065
	65 years old and above	0.937 †	-0.454 †	0.241	0.417 †	0.453	-0.609	-0.228	0.024	0.212	-0.227	-0.057	0.004
	Lower middle(income level)	-0.090	0.149	0.133	-0.612 †	0.104	0.094	-0.053	-0.038	0.049	0.035	-0.013	-0.007
	Middle(income level)	-0.235	0.128	0.060	-0.826 †	-0.040	0.018	-0.146	-0.289	-0.019	0.007	-0.036	-0.053
	Upper middle(income level)	-0.330 †	0.108	0.411 †	-0.869 †	-0.209	-0.041	0.404	-0.341	-0.098	-0.015	0.100	-0.063
	Martial status_Single	0.044	-0.228	0.069	0.225	-0.533	-0.210	-0.279	0.117	-0.249	-0.078	-0.069	0.021
	Average working hours per week	0.071	0.297	-0.177	-0.118	0.028	0.580	-0.072	-0.103	0.013	0.216	-0.018	-0.019
Life Characteristics	Smoking Status_Non-smoking	-0.449 †	-0.266	-0.076	0.136	-0.554	-0.364	-0.085	0.146	-0.259	-0.136	-0.021	0.027
	Lifetime drinking status_Non-drinking	0.112	-0.136	-0.122	0.475 †	0.091	-0.210	-0.136	0.483	0.042	-0.078	-0.034	0.089
	Days of strength exercise(per week)	-0.285	-0.409 †	0.347 †	-0.236	-0.335	-0.503	0.405	-0.161	-0.157	-0.187	0.100	-0.030
	Walking time per day	0.155	0.038	-0.295	0.424 †	0.241	0.066	-0.344	0.436	0.113	0.025	-0.085	0.080
	Average daily sleep time	-0.056	-0.238	-0.119	0.121	-0.027	-0.275	-0.114	0.132	-0.013	-0.103	-0.028	0.024
Metabolic Syndrome Indicator Characteristics	Body Mass Index	-0.064	0.275	-0.386 †	-0.069	-0.094	0.470	-0.367	-0.228	-0.044	0.175	-0.091	-0.042
	Fasting blood sugar	0.512 †	-0.044	0.426 †	-0.343 †	0.595	0.090	0.312	-0.342	0.278	0.034	0.077	-0.063
	Total cholesterol	0.296	-0.255	0.091	-0.166	-0.340	0.549	0.578	0.362	-0.159	0.205	0.143	0.066
	HDL-cholesterol	-0.230	0.283	0.266	0.366 †	-0.148	-0.206	0.300	0.225	-0.069	-0.077	0.074	0.041
	Neutral fat	-0.186	0.552 †	0.294	0.485 †	0.134	0.521	0.151	0.167	0.062	0.194	0.037	0.031
	LDL-cholesterol(Direct method)	-0.488 †	0.582 †	0.482 †	0.504 †	-0.401	0.435	0.457	0.239	-0.187	0.162	0.113	0.044
	AST(SGOT)	0.550 †	-0.408 †	0.228	0.637 †	0.049	0.055	-0.026	0.060	0.023	0.021	-0.006	0.011
	ALT(SGPT)	-0.715 †	0.437 †	-0.331 †	-0.673 †	-0.231	0.359	-0.166	-0.175	-0.108	0.134	-0.041	-0.032
			1			2			3			4	
Canonical Correlation			0.467			0.372			0.248			0.184	
Wilk's Lamda			0.584			0.747			0.867			0.923	
df			14478.627			13388.162			1298.339			11209.654	
p-value			0.000***			0.000***			0.000***			0.043*	

*p<0.05, ***p<0.001

†: The standard normal coefficient is 0.3 or higher, indicating explanation power.

3.7 General characteristics, lifestyle characteristics, and metabolic syndrome indicators that affect women's health characteristics

As a result of canonical correlation analysis of the health characteristics, general characteristics, lifestyle characteristics, and metabolic syndrome indicator characteristics of women among the study subjects, 13 canonical functions were derived. Among them, four canonical functions were found to be statistically significant ($p<0.05$, $p<0.001$). In canonical function 1, it was statistically significant when the degrees of freedom were 15,432 ($p<0.001$). Looking at the standard canonical coefficients of canonical function 1, general characteristics were found to be correlated with age of 50-64 years, 65 years or older, lifestyle characteristics were found to be correlated with non-drinking, and metabolic syndrome indicator characteristics were found to be correlated with fasting blood sugar, total cholesterol, HDL cholesterol, neutral fat, LDL cholesterol (direct method), AST (SGOT), and ALT (SGPT). In canonical function 2, the canonical function was found to be statistically significant when the degrees of freedom were 14,269 ($p<0.001$). Looking at the standard normal coefficients, the health characteristic was found to be correlated with bad, the general characteristics were 65 years of age or older, unmarried, the lifestyle characteristics were non-drinking, number of days of strength exercise (per week), and the metabolic syndrome indicator characteristics were total cholesterol, LDL-cholesterol (direct method), and ALT (SGPT).

In canonical function 3, the canonical function was found to be statistically significant when the degrees of freedom were 13,107 ($p<0.001$). Looking at the standard normal coefficients, the health characteristics were found to be correlated with bad and very bad, the general characteristics were 50-64 years old, income level = 4, average weekly working hours, the lifestyle characteristics were non-smoking, and the metabolic syndrome indicator characteristics were body mass index and total cholesterol. In canonical function 4, the canonical function was found to be statistically significant when the degrees of freedom were 11,947 ($p<0.05$). Looking at the standard canonical coefficients, the health characteristics were found to be correlated when very good and average, the general characteristics were 35-49 years old, 50-64 years old, 65 years old or older, income level = 4, unmarried, the lifestyle characteristics were non-smoking, number of days of strength exercise (per week), and the metabolic syndrome indicator characteristics were total cholesterol, HDL cholesterol, neutral fat, and LDL cholesterol (direct method).

Table 7. General characteristics, lifestyle characteristics, and metabolic syndrome indicators affecting women's health characteristics

Classification		Standard Canonical Coefficient				Canonical Loadage				Canonical Cross Loadage			
		1	2	3	4	1	2	3	4	1	2	3	4
Health Characteristics	Very Good	-0.023	-0.260	0.042	-0.470 †	-0.023	-0.260	0.042	-0.470	-0.064	-0.108	0.019	-0.085
	Good	-0.016	-0.130	0.133	0.012	-0.016	-0.130	0.133	0.012	-0.164	-0.079	0.087	-0.014
	Average	0.097	0.102	-0.207	0.400 †	0.097	0.102	-0.207	0.400	0.035	0.027	0.006	0.087
	Bad	0.185	0.413 †	-0.449 †	-0.048	0.185	0.413	-0.449	-0.048	0.129	0.106	-0.081	-0.019
	Very Bad	0.140	0.244	-0.480 †	-0.398 †	0.140	0.244	-0.480	-0.398	0.126	0.039	-0.093	-0.065
General Characteristics	35~49 years old	0.155	0.145	0.205	-0.309 †	0.155	0.145	0.205	-0.309	-0.228	0.061	-0.011	0.030
	50~64 years old	0.646 †	0.287	0.665 †	-0.752 †	0.646	0.287	0.665	-0.752	0.174	0.163	0.114	-0.039
	65 years old or older	0.959 †	-0.512 †	0.065	-0.355 †	0.959	-0.512	0.065	-0.355	0.439	-0.157	-0.043	0.016
	65 years old or older	-0.042	-0.071	0.123	-0.036	-0.042	-0.071	0.123	-0.036	0.028	-0.022	-0.034	0.012
	Middle (income level)	-0.045	0.063	0.272	-0.073	-0.045	0.063	0.272	-0.073	0.025	0.017	0.017	0.014
	Upper middle (income level)	-0.112	-0.019	0.401 †	-0.328 †	-0.112	-0.019	0.401	-0.328	-0.077	-0.011	0.066	-0.047
	Marital status_Single	-0.055	-0.337 †	-0.126	-0.597 †	-0.055	-0.337	-0.126	-0.597	-0.312	-0.107	-0.075	-0.038
	Average working hours per week	-0.024	0.224	-0.318 †	-0.201	-0.024	0.224	-0.318	-0.201	-0.107	0.107	-0.041	-0.036
Life Characteristics	Smoking Status _Non-smoking	0.157	-0.177	0.590 †	0.361 †	0.157	-0.177	0.590	0.361	0.133	-0.074	0.130	0.046
	Lifetime drinking status_Non-drinking	0.414 †	-0.418 †	-0.032	-0.097	0.414	-0.418	-0.032	-0.097	0.329	-0.124	-0.009	-0.003
	Days of strength exercise (per week)	-0.038	-0.441 †	0.119	-0.659 †	-0.038	-0.441	0.119	-0.659	-0.054	-0.136	0.044	-0.108
	Walking time per day	0.157	-0.032	-0.198	0.073	0.157	-0.032	-0.198	0.073	0.147	0.006	-0.055	0.016
	Average daily sleep time	-0.174	-0.243	0.150	0.225	-0.174	-0.243	0.150	0.225	-0.139	-0.072	0.034	0.035
Metabolic Syndrome Indicator Characteristics	Body Mass Index	0.182	0.285	-0.362 †	-0.291	0.182	0.285	-0.362	-0.291	0.220	0.129	-0.074	-0.027
	Fasting Blood Sugar	0.388 †	0.119	0.162	0.192	0.388	0.119	0.162	0.192	0.324	0.063	0.015	0.033
	Total cholesterol	1.512 †	1.066 †	0.902 †	-1.973 †	1.512	1.066	0.902	-1.973	-0.035	0.160	0.132	-0.050
	HDL-cholesterol	-0.746 †	-0.243	-0.065	0.581 †	-0.746	-0.243	-0.065	0.581	-0.217	-0.023	0.045	-0.038
	Neutral fat	-0.411 †	-0.128	0.023	0.795 †	-0.411	-0.128	0.023	0.795	0.165	0.107	0.030	0.032
	LDL-cholesterol (direct method)	-1.358 †	-0.519 †	-0.291	1.455 †	-1.358	-0.519	-0.291	1.455	-0.017	0.151	0.116	-0.044
	AST(SGOT)	0.728 †	-0.206	0.111	-0.251	0.728	-0.206	0.111	-0.251	0.306	0.035	0.021	-0.038
	ALT(SGPT)	-0.425 †	0.334 †	-0.045	-0.014	-0.425	0.334	-0.045	-0.014	0.201	0.092	0.009	-0.032

	1	2	3	4
Canonical Correlation	0.573	0.293	0.212	0.159
Wilk's Lamda	0.543	0.808	0.884	0.926
df	15432.458	14269.748	13107.787	11947.105
p-value	0.000***	0.000***	0.000***	0.029*

*p<0.05, ***p<0.001

†: The standard normal coefficient is 0.3 or higher, indicating explanation power.

4. Study Review

In Korea, research on metabolic syndrome has been actively conducted using national statistical survey data called the KNHANES. Most previous studies were also conducted based on these statistical data. The 2019 KNHANES found that metabolic syndrome increased with age in men more than in women. This is the same result as the KNHANES conducted in 2016-2017 (Park et al., 2020), and in particular, the study by Jeong Min-young and Han In-hwa (2022) showed that the rate of metabolic syndrome increased as the amount of smoking and drinking frequency increased.

A previous study investigating the association between metabolic syndrome and physical activity found that high levels of moderate-intensity and high-intensity physical activity reduced the risk of metabolic syndrome (Seo et al., 2022). In addition, the prevalence rate of metabolic syndrome-related diseases increased with irregular physical activity (Kwak et al., 2022), and the inactive group had higher metabolic syndrome indicators than the high-intensity physical activity group (Kim et al., 2022).

A paper comparing the association between eating habits and metabolic syndrome found that eating alone in adult women under 65 years of age affected the risk of metabolic syndrome due to the recent increase in single-person households (Lee et al., 2022). A study by Choi Han-kyo et al. (2021) showed that the health behavior of postmenopausal women who eat alone increases the risk of metabolic syndrome. However, a study by Song Ji-young et al. (2021) found that it was difficult to confirm a causal relationship between dietary rules and metabolic syndrome. In addition, as we go through the global health crisis of COVID-19 infection, studies on changes in the prevalence rate of metabolic syndrome during the pandemic have also been conducted. Kwon Min et al. (2022) studied the changes in the prevalence and risk factors of metabolic syndrome in adolescents before and after the COVID-19 pandemic, and Kwon Ji-young et al. (2021) studied the changes in body mass index and prevalence of metabolic syndrome during the lockdown period due to COVID-19 infection.

A study on the prevalence of metabolic syndrome by gender and age is the paper by Chae Hyeon-ju and Kim Mi-jong (2023) targeting postmenopausal adult women. A study by Lee Do-young and Kim Jong-sik (2021) targeting obese middle-aged women found that a combined exercise program was effective in preventing metabolic syndrome. In a study by Jeong Dae-in and Ko Dae-sik (2023), it was found that in middle-aged adults, lower subjective health status and lower physical activity were significantly related to the prevalence of metabolic syndrome and in a study by Park Joo-ah and Nam Mi-ra (2022), it was found that in middle-aged men, drinking, smoking, physical activity, and subjective health status affected the severity of metabolic syndrome; however, in the case of middle-aged women, smoking and drinking did not have an effect, which was similar to the difference in influencing factors by gender.

Previous studies on the prevalence of metabolic syndrome by occupation have shown that customized health management exercise programs targeting office workers have a positive effect on body composition and cardiovascular indicators (Bae et al., 2024), and a study targeting shift workers found that the prevalence of metabolic syndrome significantly increased as working hours increased and the average weekly working hours exceeded 52 hours (Jeong et al., 2022). A study that attempted

to identify the correlation between disease and metabolic syndrome included the results of Lim Mi-young (2021) that investigated the impact of adult depression on metabolic syndrome, and the results of a study by Park Yun-jin (2022) that identified the correlation between hyperuricemia and metabolic syndrome.

If existing studies on the prevalence rate of metabolic syndrome were divided by age and gender, additional studies are needed to identify the factors causing the prevalence of metabolic syndrome by group by segmenting household characteristics and living environment. If the prevalence factors of metabolic syndrome are identified through group-specific characteristics analysis in the study, detailed policies can be established in the future. In addition, it is necessary to implement health (prevention) education for patients diagnosed with metabolic syndrome and evaluate its effectiveness. It is important to recognize the severity of metabolic syndrome through domestic and international situations, analyze the problems, and seek ways to improve. Metabolic syndrome can be prevented and managed comprehensively through a balanced diet, regular exercise, strengthening public policies, and personal health management.

Notes

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Conflicts of Interest

No author has any other conflict of interest to declare.

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