Factors Related To Metabolic Syndrome And Oral Health: A National Cross-Sectional Study In Korea

Kyu-Nam Kim[1], Young-Ki Lee[1*], Junghyun Kim[2]

[1]*Department of Public Health, Graduate School of Public Health & Social Welfare, Dankook University, Korea*
[2]*Department of Clinical Laboratory Science, Kyungbok university, Korea*
Correspondence to: Young-Ki Lee
Department of Public Health, Graduate School of Public Health & Social Welfare, Dankook University, Korea
E-mail: pp99pp@dankook.ac.kr

KEYWORDS:	ABSTRACT
Metabolic syndrome, Oral health, Socioeconomic status.	**Objectives**: This study aimed to investigate the association between oral health conditions and metabolic syndrome risk among Korean adults aged 40 years and older. **Methods:** We utilized data from the 2019–2021 Korea National Health and Nutrition Examination Survey (KNHANES). A total of 8,477 adults aged 40 and above were analyzed using complex sample logistic regression analysis to identify factors associated with metabolic syndrome. Metabolic syndrome was defined based on the National Cholesterol Education Program Adult Treatment Panel III (ATP III) criteria. Oral health was evaluated by self-reported chewing difficulty, periodontitis, and speaking difficulty due to oral problems. **Results:** The prevalence of metabolic syndrome was 49.0%. Factors significantly associated with metabolic syndrome included gender, age, residence, marital status, income, education, smoking, physical activity, chewing difficulty, periodontitis, and speaking difficulty due to oral problems. Individuals with severe chewing difficulty, periodontitis, or speaking problems were more likely to have metabolic syndrome. For chewing difficulty, the odds ratio (ORs) for metabolic syndrome risk in moderate and severe, compared to none, were 1.23 (95% confidence interval [CI], 1.03–1.23) and 1.24 (95% CI, 1.03–1.26), respectively. The OR for periodontitis was 1.21 (95% CI, 1.01–1.23) compared to none. The OR for speaking difficulty due to oral problems was 1.29 (95% CI, 1.06–1.33) compared to none. **Conclusion:** Our findings suggest that oral health is closely associated with metabolic syndrome and should be considered in public health management strategies. Interdisciplinary preventive measures are recommended for metabolic syndrome management in aging populations.

INTRODUCTION

South Korea is entering a super-aged society, leading to an increase in the prevalence and mortality rates of chronic diseases [1], which is expected to result in a significant socioeconomic burden on future generations [2]. One of the chronic diseases, metabolic syndrome, arises from unhealthy lifestyle habits and increases the risk of cardiovascular diseases and type 2 diabetes [3]. Oral health has a close relationship with the overall health of adults [4-6], and health inequalities based on individual race, income, and community characteristics have an impact on oral health [7-9]. In previous study, it was found that individuals with a

higher body mass index, lower education levels, pre-existing systemic diseases, smoking habits, and toothless exhibited a significantly higher Decayed, Missing and Filled Teeth (DMFT) Index compared to healthy individuals [10].

Some studies indicate a correlation between metabolic syndrome and oral health, with an increased risk of periodontitis when the body mass index is high and three or more components of metabolic syndrome are present [11-12].   Recent studies have shown that diabetes and smoking are associated with the deterioration of oral health [13], and there are findings suggesting that the number of teeth can increase the risk of metabolic syndrome in the elderly [14]. As the proportion of the elderly population increases, oral health becomes essential for maintaining a healthy life throughout one's lifetime. There is a rising trend of metabolic syndrome and oral diseases among middle-aged and elderly individuals. However, research targeting these age groups is limited, and while some studies have reported correlations with certain periodontal diseases, there are constraints in generalizing findings from large population studies [15]. Therefore, this study aims to utilize raw data from the Korea National Health and Nutrition Examination Survey to elucidate the relationship between key influencing factors related to metabolic syndrome and oral health in middle-aged and elderly populations, providing foundational data for the development of oral health prevention programs.

MATERIALS AND METHODS

Study participants

This study was conducted using statistical data from the National Health and Nutrition Examination Survey (KNHANES), which is annually conducted and published by the Ministry of Health and Welfare and the Korea Disease Control and Prevention Agency. The analysis focused on participants who completed both the health examination and survey for the 2019-2021 years of the 8th National Health and Nutrition Examination Survey. A total of 8,477 adults aged 40 and older, who had complete responses to all items, oral examination content, and all five components of metabolic syndrome, were selected as the final analysis subjects.

Sociodemographic characteristics and health behavior

The demographic characteristics investigated include gender, age, education level, income level, residential area, and marital status. Age was assessed based on the Korean age system, while education level was categorized into 'below elementary school', 'middle school', 'high school', and 'college or higher', with further distinctions made between 'below middle school', 'high school', and 'college'. Income level was classified into four quartiles: 'high', 'upper middle', 'lower middle', and 'low'. Residential area was divided into urban and rural, and marital status was categorized as 'married' and 'unmarried'.

Health behavior characteristics included smoking, drinking, and physical activity. Information on smoking was gathered through the question, "Do you currently smoke cigarettes?" Those who answered 'smoke daily' or 'smoke occasionally' were classified as smokers, while those who had smoked in the past but do not currently smoke were classified as former smokers, and those who did not fall into either category were classified as non-smokers. Information on drinking was obtained by asking, "Have you ever consumed more than one drink in your lifetime?" Those who answered 'yes' were classified as having drinking experience, while those who answered 'no' were classified as having no drinking experience. Physical activity was assessed with the question, "Do you engage in moderate-intensity sports, exercise, or leisure activities that cause you to breathe slightly harder or have a slightly faster heartbeat for at least 10 minutes?" Those who answered 'yes' were classified as exercising, while those who answered 'no' were classified as not exercising.

Oral health assessment

Oral health characteristics were measured using a 5-point Likert scale for chewing function discomfort, periodontal disease, and difficulty speaking due to oral problems using a questionnaire included in the KNHANES.

Metabolic syndrome assessment

The definition of metabolic syndrome, according to the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III), is based on the presence of three or more of the following five criteria: waist circumference (men >90 cm, women >80 cm), blood pressure (>130/85 mmHg), fasting blood glucose (>110 mg/dL), HDL cholesterol (men <40 mg/dL, women <50 mg/dL), and triglycerides (>150 mg/dL).

Statistical Analysis

The independent variables of this study include general characteristics (gender, age, education, income, residence), health behaviors (smoking, alcohol consumption, physical activity), oral health (chewing discomfort, periodontitis, difficulty speaking due to oral problems), and metabolic syndrome along with its five components (hypertension, fasting blood glucose, hypertriglyceridemia, HDL cholesterol, abdominal obesity). Frequency analysis was conducted to describe these variables in terms of frequency and percentage. Differences in demographic characteristics, health behavior characteristics, and oral health characteristics according to the prevalence of metabolic syndrome were analyzed using complex sample cross-tabulation (Rao-Scott chi-square test). Factors related to metabolic syndrome were analyzed using complex sample multiple logistic regression, and odds ratios along with 95% confidence intervals were calculated for each factor. All statistical analyses were performed using SAS version 9.4 (SAS Institute, Inc., Cary, NC, USA), and statistical significance was tested at a significance level of 5%.

RESULTS

1. General characteristics

Table 1 shows the general characteristics of participants according to metabolic syndrome. The demographic characteristics associated with metabolic syndrome showed statistically significant differences based on gender ($p<0.001$), age ($p<0.001$), residential area ($p<0.001$), marital status ($p<0.01$), income level ($p<0.001$), and education level ($p<0.001$). Among the subjects, those who were male, older in age, residing in urban areas, unmarried, and had lower income and education levels exhibited a higher prevalence of metabolic syndrome compared to the normal group.

Health behavior characteristics also showed significant differences, particularly in smoking ($p<0.001$) and physical activity ($p<0.001$). Smokers and alcohol consumers had a higher prevalence of metabolic syndrome. Additionally, oral health characteristics revealed significant differences in periodontitis ($p<0.02$), chewing difficulty ($p<0.02$), and speaking difficulty due to oral problems ($p<0.001$). The presence of periodontitis, along with increased chewing and speaking difficulties, was associated with a higher prevalence of metabolic syndrome compared to the normal group.

Table 1. General characteristics of participants stratified by metabolic syndrome (N=8477)

Variables	Normal group (N=4323)		Metabolic syndrome group (N=4154)		P [a)]
	N	%	N	%	
Gender					
Male	1472	34.1	2169	52.2	<0.001
Female	2851	65.9	1985	47.8	
Age					
40-49	1063	24.6	938	22.6	<0.001
50-64	1765	40.8	1530	36.8	
65 over	1495	34.6	1686	40.6	
Residence					
Urban	3387	78.3	3116	75.0	<0.001

Rural	936	21.7	1038	25.0	
Marital status					
Married	4174	96.6	3964	95.4	0.01
Single	149	3.4	190	4.6	
Income					
Lowest	895	20.7	1030	24.8	<0.001
Middle-low	1054	24.4	1074	25.9	
Middle-high	1156	26.7	1022	24.6	
Highest	1218	28.2	1028	24.7	
Education					
Elementary	945	21.9	1151	27.7	<0.001
Middle	548	12.7	535	12.9	
High	1423	32.9	1274	30.7	
University over	1407	32.5	1194	28.7	
Smoking					
No	2919	67.5	2207	53.1	<0.001
Ex-smoker	903	20.9	1238	29.8	
Current-smoker	501	11.6	709	17.1	
Drinking					
No	634	14.7	560	13.5	0.06
Yes	3689	85.3	3594	86.5	
Physical activity					
No	3225	74.6	3224	77.6	<0.001
Yes	1098	25.4	930	22.4	
Periodontitis					
No	3231	74.7	3049	73.4	0.02
Yes	1092	25.3	1105	26.6	
Chewing difficulty					
None	2562	59.3	2341	56.4	0.02
Moderate	748	17.3	757	18.2	
Severe	1013	23.4	1056	25.4	
Speaking difficulty due to oral problems					
No	3580	82.8	3333	80.2	<0.001
Yes	743	17.2	821	19.8	

Data are presented as N (%).

[a] Calculated using the chi-square test.

2. The metabolic syndrome and its components characteristics of participants

Table 2 illustrates the metabolic syndrome and its components characteristics of participants. The abdominal obesity was prevalent, with 3,210 individuals (37.9%) classified as normal and 5,267 (62.1%) as abnormal. For hypertension, 2,142 participants (25.3%) were normal, while 6,335 (74.7%) were abnormal, indicating a high prevalence of hypertension. Regarding fasting blood glucose levels, 4,128 individuals (48.7%) were normal, and 4,349 (51.3%) were abnormal, reflecting a significant proportion with abnormal fasting glucose. Most participants had normal triglyceride levels, with 7,297 (86.1%) classified as normal and 1,180 (13.9%) as abnormal. The levels of low HDL cholesterol were nearly evenly split, with 4,381 individuals (51.7%)

normal and 4,096 (48.3%) abnormal. Overall, the prevalence of metabolic syndrome was almost equal, with 4,323 participants (51.0%) classified as normal and 4,154 (49.0%) as abnormal.

Table 2. The metabolic syndrome and its components characteristics of participants (N=8477)

Variables	N	%
Abdominal obesity		
Normal	3210	37.9
Abnormal	5267	62.1
High blood pressure		
Normal	2142	25.3
Abnormal	6335	74.7
High fasting glucose		
Normal	4128	48.7
Abnormal	4349	51.3
High triglyceride		
Normal	7297	86.1
Abnormal	1180	13.9
Low HDL cholesterol		
Normal	4381	51.7
Abnormal	4096	48.3
Metabolic syndrome		
Normal	4323	51.0
Abnormal	4154	49.0

Data are presented as N (%).
HDL, high-density lipoprotein.

3. Multivariable logistic regression analysis for the factors associated with metabolic syndrome and oral health

Table 3 depicts the ORs for the factors associated with metabolic syndrome and oral health. Males are approximately 2.09 times more likely to develop metabolic syndrome compared to females (95% CI: 1.91-2.28, p<0.001). Individuals aged 65 and older show a 1.278 times higher risk compared to those aged 40-49 (95% CI: 1.14-1.44, p<0.001). However, the age group of 50-64 did not show a significant difference (OR: 1.01, p=0.93). Rural residents have a 1.15 times higher risk of metabolic syndrome compared to urban residents (95% CI: 1.03-1.27 p<0.001).

Unmarried individuals are 1.34 times more likely to develop metabolic syndrome than married individuals (95% CI: 1.08-1.67, p=0.01).

The lowest income group has a 1.36 times higher risk compared to the highest income group (95% CI: 1.21-1.54, p<0.001), while the lower-middle income group shows a 1.21 times higher risk (95% CI: 1.07-1.36, p<0.001). The middle-high income group did not show a significant difference (OR: 1.05, p=0.44). Individuals with education below elementary school have a 1.61 times higher risk compared to those with a college education or higher (95% CI: 1.38-1.89, p<0.001). Middle school graduates show a 1.20 times higher risk (95% CI: 1.02-1.41, p=0.03), while high school graduates did not show a significant difference (OR: 1.09, p=0.15). In summary, males, older adults, rural residents, unmarried individuals, low-income groups, and those with lower education levels are more vulnerable to metabolic syndrome.

Regarding health behaviors, former smokers have a 1.82 times higher risk, and current smokers have a 1.87 times higher risk of metabolic syndrome compared to non-smokers (p<0.001). Alcohol consumption did not show a significant difference (OR: 1.10, p=0.12). Individuals who do not engage in physical activity have

a 1.180 times higher risk compared to those who do (95% CI: 1.07-1.30, p<0.001). Thus, smoking history and lack of physical activity are strongly associated with metabolic syndrome.

In terms of oral health, the prevalence of periodontal disease is also a significant risk factor (OR: 1.21, p=0.03). Those with severe chewing difficulties have a 1.23 times higher risk, and those with serious chewing difficulties have a 1.24 times higher risk compared to those without (95% CI: 1.03-1.26, p=0.01). Additionally, individuals who experience speech difficulties due to oral problems have a 1.29 times higher risk (95% CI: 1.06-1.33, p <0.001). Individuals with severe chewing difficulty, periodontitis, or speaking problems were more likely to have metabolic syndrome.

Table 3. Multivariable logistic regression analysis for the factors associated with metabolic syndrome

Variables (Reference)	OR	95% CI	P for trend
Gender (Female)			
Male	2.09	1.91-2.28	<0.001
Age (40-49)			
50-64	1.01	0.900-1.13	0.93
65 over	1.28	1.14-1.44	<0.001
Residence (Urban)			
Rural	1.15	1.03-1.27	0.01
Marital status (Married)			
Single	1.34	1.08-1.67	0.01
Income level (Highest)			
Lowest	1.36	1.21-1.54	<0.001
Middle-low	1.21	1.07-1.36	<0.001
Middle-high	1.05	0.93-1.18	0.44
Education level (University over)			
Elementary	1.61	1.38-1.89	<0.001
Middle	1.20	1.02-1.41	0.03
High	1.09	0.97-1.22	0.15
Smoking (No)			
Ex-smoker	1.82	1.64-2.01	<0.001
Current-smoker	1.87	1.65-2.13	<0.001
Drinking (No)			
Yes	1.10	0.98-1.25	0.12
Physical activity (Yes)			
No	1.10	1.07-1.30	<0.001
Periodontitis (No)			
Yes	1.21	1.01-1.23	0.03
Chewing difficulty (None)			
Moderate	1.23	1.03-1.23	0.01
Severe	1.24	1.03-1.26	0.01
Speaking difficulty due to oral problems (No)			
Yes	1.29	1.06-1.33	<0.001

Data are presented as odds ratio (OR) and 95% confidence intervals (CIs)

DISCUSSION

This study analyzed the relationship between metabolic syndrome and oral health among middle-aged and elderly individuals in South Korea. The results indicated that the prevalence of metabolic syndrome was approximately 49%, suggesting that it is a significant health issue in this demographic. The increased risk of metabolic syndrome arises from various interrelated factors. Notably, higher risks were observed in groups such as men, older adults, rural residents, low-income individuals, and those with lower educational levels [16]. A study from Taiwan found that low-income and rural residents had limited access to healthcare services, leading to a higher likelihood of developing metabolic syndrome [17]. Additionally, individuals with lower educational levels tend to have a poorer understanding of health and are less likely to engage in health-promoting behaviors, resulting in a higher prevalence of metabolic syndrome. Specifically, men with lower education levels experience metabolic syndrome more frequently and at an earlier age. These findings align with existing research, indicating that socioeconomic factors play a crucial role in the occurrence of metabolic syndrome [10, 18-19].

In comparing the subjects' metabolic syndrome and health management patterns, the impact of alcohol consumption was found to be minimal; however, smoking and lack of physical activity were identified as risk factors for metabolic syndrome. Therefore, it is necessary to focus on these behavioral changes in health education and prevention programs. Previous studies have also confirmed that smoking increases the risk of metabolic syndrome [20], and for older adults, a lack of physical activity is a significant predictor of metabolic syndrome [21]. Consequently, there is a need for tailored health education targeting low-income and rural residents, emphasizing the creation of an environment that encourages feasible health behaviors.

Study on the correlation between metabolic syndrome and oral health has reported that individuals with metabolic syndrome have a higher risk of developing periodontal disease [22-25]. Additionally, assessments of self-masticatory function have been found to be an indirect indicator of oral health status rather than directly related to metabolic syndrome [26]. In this study, a higher proportion of individuals with metabolic syndrome rated their oral health status as poor, and significant associations were observed between metabolic syndrome and periodontal disease as well as masticatory dysfunction. This suggests that the deterioration of oral health may increase the risk of metabolic syndrome, which holds important implications from a preventive medicine perspective. Considering the impact of the components of metabolic syndrome such as abdominal obesity, hypertension, hyperglycemia, and dyslipidemia on oral health, proper management of oral health may contribute to the prevention of metabolic syndrome [27].

Recent study has emphasized the biological mechanisms linking metabolic syndrome and oral inflammation. Chronic periodontal inflammation may elevate systemic inflammatory markers such as CRP and IL-6, which in turn promote insulin resistance and metabolic dysregulation [28]. Microbiome dysbiosis associated with periodontitis has also been shown to alter lipid metabolism and impair endothelial function, supporting the concept of a shared pathophysiological pathway [29]. Evidence from intervention studies reveals that periodontal treatment can modestly improve glycemic control and lipid profiles, indicating a potential benefit for individuals with metabolic syndrome [30]. Furthermore, nutritional deficiencies associated with tooth loss—such as reduced intake of dietary fiber and antioxidants—may contribute to increased cardiometabolic risk [31].

Sociodemographic variables also appear to modify the relationship between oral health and metabolic syndrome. Regional disparities underscore the role of environmental and community factors [32], while longitudinal studies show that progressive tooth loss correlates with worsening metabolic profiles over time [33]. Hormonal changes in postmenopausal women may exacerbate the impact of periodontitis on metabolic syndrome components, illustrating gender-specific risks [34]. These insights advocate for population-specific health policies. Notably, community-based oral health initiatives have demonstrated effectiveness in mitigating metabolic syndrome risk among older adults [35]. Looking forward, artificial intelligence models are being developed to predict metabolic syndrome using oral health indices, opening new avenues for preventive healthcare [36].

In conclusion, this study confirmed that oral health indicators, such as chewing difficulty, periodontitis, and speaking problems, are significantly associated with metabolic syndrome among Korean adults aged 40 and

over. High-risk groups include male, the elderly, those with lower income and education levels, and individuals with poor oral health. Our findings suggest that oral health is closely associated with metabolic syndrome and should be considered in public health management strategies. Interdisciplinary preventive measures are recommended for metabolic syndrome management in aging populations.

Limitations of this study include its cross-sectional design, which restricts causal inference, and reliance on self-reported data, which may introduce bias. Future research should use longitudinal designs and clinical oral health assessments to further explore these relationships. Practical implications include promoting oral health education and screening as part of metabolic syndrome prevention programs in community settings.

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