

Effects of Oral Health Behavior and Mental Health on Metabolic Syndrome in Korean Adults

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Background: Integrated management of general, mental, and oral health is necessary to improve an individual's quality of life. This study aimed to identify the effects of mental and oral health behaviors on metabolic syndrome.

Methods: A total of 4,227 Korean adults aged 20 years or older were selected as study subjects using raw data from the first year (2019) of the 8th period of the Korea National Health and Nutrition Examination Survey (KNHANES). A complex sample chi-square test and a complex sample logistic regression analysis were performed using the PASW Statistics ver. 18.0 program.

Results: The effect on metabolic syndrome was significantly higher in male than in 1.833 times in male, 2.914 times in 30~49 years old, and 3.855 times in 50~64 years old, and 3.929 times in people over 65 years old compared to 20~29 years old, and compared to those with a college degree or higher, those with a middle school degree or lower are 2.116 times, those with lower income levels are 1.507 times higher, those with middle-lower are 1.359 times higher, those with middle-high are 1.401 times. Compared to non-smokers, smokers were 1.570 times higher than non-smokers and compared to those without speech problem and chewing difficulty, they were 1.717 times and 1.397 times higher, respectively and 1.973 times higher in those with 0~1 brushing times per day. Mental health did not affect prevalence of metabolic syndrome.

Conclusion: It is necessary to improve maintain a healthy lifestyle to lower the risk of metabolic syndrome. It is necessary to establish effective dental hygiene customized education and an efficient health management system at the national level that can induce improvement of oral health behavior for the prevention and management of metabolic syndrome.

Key Words: Adult, Korean, Mental health, Metabolic syndrome, Oral health

Introduction

The prevalence of metabolic syndrome in South Korea has increased sharply due to aging, a westernized lifestyles, and rapid socioeconomic growth¹⁾. According to a 12-year prevalence survey of metabolic syndrome conducted among Korean adults in 2018, the prevalence increased continuously from 21.6% in 2007 to 23% in 2018, with 27.7% in those aged ≥ 30 years and 45.3% in those aged ≥ 65 years²⁾. Metabolic syndrome comprises a group of diseases in which cardiovascular risk factors, such as abdominal obesity,

hypertension, triglycerides, and abnormal glucose metabolism, occur in a cluster and progress to increase the risk of developing chronic diseases³⁾.

Depression and stress causes insulin resistance and abdominal obesity because cortisol secretion is increased on excessive stimulation of the hypothalamic-pituitary-adrenal axis, increasing the risk of metabolic syndrome⁴⁾. Poor lifestyles and depression have been shown to increase the risk of metabolic syndrome and cardiovascular disease in depressed patients with increased heart rate, reduced heart rate variability, and autonomic nervous

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system changes⁵). Stress also reduces the ability to appropriately respond to emotional and physical threats, and if such maladaptation processes persist, serious and negative phenomena appear in the body⁶). The risk of developing metabolic syndrome appears to be significantly higher in high stress⁷), and it is necessary to study the relationship between mental health and metabolic syndrome⁸). Oral health is an essential health management element responsible for nutrition and digestion⁹). It is also associated with general health and quality of life, including age-related problems such as tooth loss, oral pain, respiratory infections, cardiovascular diseases, stroke, diabetes and malnutrition¹⁰). Poor general health leads to decreased preservation of teeth and decrease mastication ability¹¹). Further, it has been reported that the risk of developing metabolic syndrome is high when the frequency of brushing is less¹²). When floss is not used and the frequency of brushing teeth is less than three times, there is a high risk of developing metabolic syndrome¹³). Therefore, integrated and comprehensive management of mental and oral health is necessary to prevent metabolic syndrome.

Utilizing the 2019 raw data surveyed by the Disease Control Headquarters, we aimed to understand the effects of oral health behavior and mental health of Korean adults on metabolic syndrome.

Materials and Methods

1. Study subjects

In this study, we used the raw data¹⁴) from the eighth Korea National Health and Nutrition Examination Survey (KNHANES VIII-1) of the Ministry of Health and Human Services.

The subjects included in the study were 6,542 adults aged ≥ 20 years who responded to the survey, after excluding 1,568 people of ≤ 19 years age out of 8,110 individuals with raw data from the 8th term of KNHANES. Among the selected 6,542 subjects, 356 people diagnosed with cancer, 34 who patients had been sick for more than 15 days, and 1,925 people with missing data were excluded; 4,227 people who answered all the questions were selected as the final subjects.

2. Study method

In this study, the variables of the health survey and oral examination data from the KNHANES VIII-1 were converted and used. The dependent variable was metabolic syndrome and the independent variables were general traits, oral health behavior, and mental health.

1) Diagnosis of metabolic syndrome

Metabolic syndrome was diagnosed according to the modified National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III) diagnostic criteria and the criteria of the Korean Obesity Society^{15,16}): abdominal obesity (male waist circumference ≥ 90 cm, female ≥ 85 cm), hypertriglyceridemia (blood triglyceride ≥ 150 mg/dl or taking therapeutic agents), low high-density lipoprotein cholesterol (male < 40 mg/dl, female < 50 mg/dl), high blood pressure (systolic blood pressure ≥ 130 mmHg or diastolic blood pressure ≥ 85 mmHg or taking therapeutic drugs), and fasting glycemic disorder (fasting blood glucose ≥ 100 mg/dl or currently taking therapeutic drugs). When three or more criteria were present, metabolic syndrome was diagnosed. Metabolic syndrome was classified as either normal or abnormal.

2) General characteristics

The general characteristics recorded included patient sex, age, education level, income level, smoking status, and drinking status. Sex was classified as male and female, and the subjects were classified into the following age groups: 20~29 years, 30~49 years, 50~64 years, and ≥ 65 years based on the statistics agency life cycle classification¹⁷). The subjects' education level was reclassified into junior high school graduates and below, high school graduates, and college graduates and above, and their income level was divided into lower, middle-lower, middle-upper, and upper-income quartile individuals. The smoking status was recorded as 'yes' for those who smoked less than five packs (100 cigarettes) and more than five packs (100 cigarettes) over their lifetime and 'no' for those who had never smoked. The drinking status was recorded as 'yes' for subjects who consumed alcohol more than once a month for one year and 'no' for those who consumed alcohol less than once a month.

3) Oral health behavior

The oral health behavior variables included perceived oral health, speech problems, chewing difficulty, experience of toothache, and frequency of brushing teeth per day. The perceived oral health was classified as good, moderate, or poor, and speech and chewing difficulties were reclassified as yes, neutral, or no. The occurrence of toothache in the preceding year was recorded as ‘yes’ or ‘no.’ The number of times of teeth brushing per day was classified as 1 or less, 2 to 3 times, and 4 times or more.

4) Mental health

The mental health variables included depression and stress. The presence or absence of depression for more than two weeks in a row was recorded as ‘yes’ or ‘no,’ respectively, and stress was classified into severe, moderate, and no feeling based on the usual stress perception level.

3. Data analysis

The collected data were analyzed using PASW Statistics ver. 18.0 (IBM Corp., Armonk, NY, USA). Complex sample analysis was performed after generating a planning file considering the weights of the variance estimation layer, survey district, health survey, and screening survey. A frequency analysis was performed to examine the general characteristics of the study participants, and a complex sample cross-analysis was performed to examine the differences in metabolic syndrome due to general characteristics, mental health, and oral health behaviors. To investigate the effects on metabolic syndrome, complex sample logistic regression analysis was performed with general characteristics, mental health, and oral health behavior as independent variables. The statistical significance level was $p < 0.05$.

Results

1. Characteristics of the study subjects

Analysis of the participant characteristics revealed that 52.9% were male, 40.5% were 30~49 years old, and 64.9% had drunk experience. Regarding the participants’ mental health, 90.0% did not feel depressed, and the degree of stress was moderate (58.2%). The most common

perceived oral health status was ‘moderate’ at 50.8%, and 88.0% and 68.9% participants did not feel any discomfort during speaking and chewing, respectively. Further, 77.7% participants had no experience of toothache in the past year, and the most commonly reported frequency of tooth brushing per day was 2~3 times by 77.1% participants, followed by 4 times reported by 16.5% participants. The prevalence of metabolic syndrome was 82.1% in the

Table 1. Characteristics of the Study Subjects (n=4,227)

| Variable | Division | Value |
|--------------------------------|----------------|--------------|
| Sex | Male | 2,021 (52.9) |
| | Female | 2,206 (47.1) |
| Age (y) | 20~29 | 555 (18.8) |
| | 30~49 | 1,581 (40.5) |
| | 50~64 | 1,235 (27.2) |
| | ≥65 | 856 (13.5) |
| Education | ≤Middle school | 986 (16.9) |
| | High school | 1,434 (35.5) |
| | ≥College | 1,807 (47.7) |
| Income | Low | 998 (22.7) |
| | Middle-low | 1,045 (24.9) |
| | Middle-high | 1,105 (26.5) |
| | High | 1,079 (25.9) |
| Smoking | Yes | 1,857 (46.5) |
| | No | 2,370 (53.5) |
| Alcohol intake | Yes | 2,615 (64.9) |
| | No | 1,612 (35.1) |
| Depression | Yes | 423 (10.0) |
| | No | 3,804 (90.0) |
| Stress | Severe | 1,157 (29.4) |
| | Moderate | 2,491 (58.2) |
| | None | 579 (12.5) |
| Perceived oral health | Poor | 1,561 (35.9) |
| | Moderate | 2,107 (50.8) |
| | Good | 559 (13.3) |
| Speech problem | Yes | 226 (4.4) |
| | Neutral | 368 (7.6) |
| | No | 3,633 (88.0) |
| Chewing difficulty | Yes | 772 (16.0) |
| | Neutral | 671 (15.1) |
| | No | 2,784 (68.9) |
| Toothache experience | Yes | 992 (22.3) |
| | No | 3,235 (77.7) |
| Frequency of toothbrushing/day | 0~1 | 291 (6.5) |
| | 2~3 | 3,242 (77.1) |
| | ≥4 | 694 (16.5) |
| Metabolic syndrome | Normal | 3,445 (82.1) |
| | Abnormal | 782 (17.9) |

Values are presented as unweighted count (weighted %).

normal group and 17.9% in the high-risk group (Table 1).

2. Metabolic syndrome according to general characteristics and mental health

The proportion of male was 21.9% and that of female was 13.3% in the metabolic syndrome risk group ($p < 0.001$), and by age group, those aged 65 years or older was the most common at 22.9% ($p < 0.001$). In the metabolic syndrome risk group, the education level was 27.1% ($p < 0.001$) for those with a middle school education or less, and the income level was 20.1% ($p < 0.05$) for those with a lower income. and 21.4% were smokers ($p < 0.001$) (Table 2).

3. Metabolic syndrome according to oral health behaviors

In the metabolic syndrome risk group, 20.2% ($p < 0.05$) participants perceived that their oral health was not good, 26.3% had speech disorders ($p < 0.01$), and 21.8% had difficulty in chewing 21.8% ($p < 0.05$). The frequency of

brushing per day was high for 28.3% ($p < 0.001$) (Table 3).

4. The effects on metabolic syndrome

On analyzing the effect of the general characteristics on metabolic syndrome, 1.833 times that of males compared to females, and based on the 20~29 years old, 2.914 times in 30~49 years old, and 3.855 times in 50~64 years old, and 3.929 times in 65 years and older ($p < 0.001$). Depending on the level of education, the effect on metabolic syndrome was based on college graduates or higher, 2.116 times ($p < 0.001$) for those who were middle school graduates and below. Depending on the level of income, the effect on metabolic syndrome was based on high income, 1.507 times ($p < 0.01$) for lower income levels, and 1.359 times ($p < 0.05$) for middle-lower income level, it appeared as high as 1.401 times ($p < 0.05$) for middle-high. Based on non-smokers, the effects of metabolic syndrome were 1.570 times ($p < 0.001$) higher in smokers. In oral health behaviors, based on the absence

Table 2. Metabolic Syndrome according to General Characteristics and Mental Health

| Variable | Division | Metabolic syndrome | | $\chi^2(p)$ |
|----------------|--------------|--------------------|------------|-----------------|
| | | Normal | Abnormal | |
| Sex | Male | 1,573 (78.1) | 448 (21.9) | 53.578 (<0.001) |
| | Female | 1,872 (86.7) | 334 (13.3) | |
| Age (y) | 20~29 | 517 (93.0) | 38 (7.0) | 90.617 (<0.001) |
| | 30~49 | 1,318 (82.0) | 263 (18.0) | |
| | 50~64 | 952 (77.5) | 283 (22.5) | |
| | ≥65 | 658 (77.1) | 198 (22.9) | |
| | Education | ≤Middle school | 730 (72.9) | |
| High school | 1,178 (82.7) | 256 (17.3) | | |
| ≥College | 1,537 (85.0) | 270 (15.0) | | |
| Income | Low | 784 (79.9) | 214 (20.1) | 13.877 (0.039) |
| | Middle-low | 859 (81.6) | 186 (18.4) | |
| | Middle-high | 895 (81.1) | 210 (18.9) | |
| | High | 907 (85.7) | 172 (14.3) | |
| Smoking | Yes | 1,454 (78.6) | 403 (21.4) | 31.398 (<0.001) |
| | No | 1,991 (85.2) | 379 (14.8) | |
| Alcohol intake | Yes | 2,136 (82.4) | 479 (17.6) | 0.326 (0.582) |
| | No | 1,309 (81.7) | 303 (18.3) | |
| Depression | Yes | 341 (82.2) | 82 (17.8) | 0.000 (0.991) |
| | No | 3,104 (82.1) | 700 (17.9) | |
| Stress | Severe | 928 (79.9) | 229 (20.1) | 7.171 (0.059) |
| | Moderate | 2,048 (83.4) | 443 (16.6) | |
| | None | 469 (81.6) | 110 (18.4) | |

Values are presented as unweighted count (weighted %).

χ^2 : chi-square test.

Table 3. Metabolic Syndrome according to Oral Health Behaviors

| Variable | Division | Metabolic syndrome | | χ^2 (p) |
|--------------------------------|---------------|--------------------|------------|-----------------|
| | | Normal | Abnormal | |
| Perceived oral health | Poor | 1,237 (79.8) | 324 (20.2) | 9.240 (0.041) |
| | Moderate | 1,738 (83.3) | 369 (16.7) | |
| | Good | 470 (84.0) | 89 (16.0) | |
| Speech problem | Uncomfortable | 163 (73.7) | 63 (26.3) | 11.165 (0.008) |
| | Neutral | 289 (79.8) | 79 (20.2) | |
| | No | 2,993 (82.8) | 640 (17.2) | |
| Chewing difficulty | Uncomfortable | 590 (78.2) | 182 (21.8) | 10.995 (0.023) |
| | Neutral | 543 (80.8) | 128 (19.2) | |
| | No | 2,312 (83.4) | 472 (16.6) | |
| Toothache experience | Yes | 794 (81.7) | 198 (18.3) | 0.178 (0.697) |
| | No | 2,651 (82.3) | 584 (17.7) | |
| Frequency of toothbrushing/day | 0~1 | 209 (71.7) | 82 (28.3) | 21.858 (<0.001) |
| | 2~3 | 2,661 (82.8) | 581 (17.2) | |
| | ≥4 | 575 (83.3) | 119 (16.7) | |

Values are presented as unweighted count (weighted %).
 χ^2 : chi-square test.

Table 4. The Effects on Metabolic Syndrome

| Variable | Division | OR | 95% CI | p-value |
|--------------------------------|-----------------|-------|---------------|---------|
| Sex | Female | 1 | | |
| | Male | 1.833 | 1.538 ~ 2.184 | <0.001 |
| Age (y) | 20~29 | 1 | | |
| | 30~49 | 2.914 | 2.030 ~ 4.184 | <0.001 |
| | 50~64 | 3.855 | 2.632 ~ 5.649 | <0.001 |
| | ≥65 | 3.929 | 2.695 ~ 5.729 | <0.001 |
| Education | ≤ Middle school | 2.116 | 1.702 ~ 2.631 | <0.001 |
| | High school | 1.192 | 0.977 ~ 1.453 | 0.082 |
| | ≥ College | 1 | | |
| Income | Low | 1.507 | 1.123 ~ 2.022 | 0.007 |
| | Middle-low | 1.359 | 1.014 ~ 1.822 | 0.040 |
| | Middle-high | 1.401 | 1.024 ~ 1.918 | 0.035 |
| Smoking | High | 1 | | |
| | No | 1 | | |
| | Yes | 1.570 | 1.297 ~ 1.900 | <0.001 |
| Perceived oral health | No | 1 | | |
| | Poor | 1.330 | 0.983 ~ 1.800 | 0.064 |
| Speech problem | Moderate | 1.048 | 0.778 ~ 1.413 | 0.755 |
| | Good | 1 | | |
| Chewing difficulty | Neutral | 1.213 | 0.909 ~ 1.619 | 0.189 |
| | Yes | 1.717 | 1.170 ~ 2.519 | 0.006 |
| | No | 1 | | |
| Frequency of toothbrushing/day | Neutral | 1.194 | 0.910 ~ 1.567 | 0.199 |
| | Yes | 1.397 | 1.100 ~ 1.775 | 0.006 |
| | 0~1 | 1.973 | 1.409 ~ 2.761 | <0.001 |
| Frequency of toothbrushing/day | 2~3 | 1.041 | 0.799 ~ 1.355 | 0.766 |
| | ≥4 | 1 | | |

OR: odds ratio, CI: confidence interval.
 By complex sample logistic regression analysis.

of speech problems and chewing problems, the effects of metabolic syndrome in the presence of discomfort were 1.717 times higher in the case of speech problems and 1.397 times higher ($p < 0.01$) in the case of chewing difficulties. Based on those who brush their teeth four or more times a day, the metabolic syndrome was found to have a 1.973 times effect in those who brushed 0~1 times a day ($p < 0.001$) (Table 4).

Discussion

In this study, we investigated the differences in metabolic syndrome due to oral health behavior and mental health, which is a psychological factor, in adults over 20 years old, using KNHANES data. The prevalence of metabolic syndrome is increasing due to an increase in the obese population due to a change in eating habits and a lack of activity in recent years¹⁸). Depression and stress are common social problems and chronic diseases in which psychological problems are interrelated⁷), with excessive caloric intake, smoking, drinking, and lack of physical activity aggravate health behaviors, increasing the risk of metabolic syndrome¹⁹) and affecting life satisfaction. Therefore, it is necessary to consider not only general health but also the relationship between mental and oral health, which are the main components of general health, and this was reflected in this study.

Shim and Kang²⁰), who studied data from the 5th term of KNHANES (2010~2012), reported a prevalence of metabolic syndrome among 26.7% of male and 21.6% of female. Kim et al.²¹), who studied data from the 6th term (2013~2015), reported a prevalence among 26.4% of male and 19.1% of female. Analysis using data from the KNHANES VIII-1 (2019) revealed that the prevalence of the metabolic syndrome decreased slightly, to 21.9% in male and that 13.3% in female. Overall, the higher prevalence in male than in female is a result of a similar, but the reduction in prevalence is due to differences in the study sample. Therefore, an in-depth study considering that the onset of metabolic syndrome may be influenced by social, economic, and environmental factors rather than simple sex-based differences is needed. To create a health management system and healthy lifestyle at the national

level and increase interest in metabolic syndrome, each individual must become healthy.

Among the general characteristics evaluated in this study, the higher the age, the lower the education level, and the lower the income level, the higher was the risk of metabolic syndrome among smokers ($p < 0.05$). This was in line with the study by Im et al.²²) who studied lifestyle factors and metabolic syndrome. Metabolic syndrome is that in which cardiovascular risk factors, such as obesity, abnormal glucose metabolism, hypertension, and hyperlipidemia, appear in combination, and studies have reported on factors that affect smoking²³), and it is thought to be the result of exposure to smoking. As this can lead to various complications, such as stroke or cardiovascular disease, various interventions are required based on the relationship between metabolic syndrome and systemic disease and the social environment of the subjects.

The analysis of mental health and metabolic syndrome revealed that stress and depression were not significantly associated with metabolic syndrome. These results were similar to those of Im²⁴) and Shim and Kang²⁰), who found it unlikely to be an independent effect of stress. In addition, in a study by Lee et al.²⁵) targeting adults in the community, there was no significant difference in the prevalence of depression and metabolic syndrome, which is similar to the results of this study. However, as shown in the study by Im et al.²²), subjects with metabolic syndrome have a low perception of stress, and patients with metabolic syndrome may have low cognition of stress despite stress. In-depth research and development of tools with validity and reliability for mental health are needed.

Analysis of oral health behavior and metabolic syndrome revealed that metabolic syndrome was significantly higher in the case of poor perceived oral health, discomfort in speech problems, chewing difficulty, and a lower frequency of brushing per day ($p < 0.01$). This is in line with the study by Khader et al.²⁶) who reported that individuals with metabolic syndrome had worse periodontal conditions, and Kushiya et al.²⁷) reported that the higher the number of risk factors for metabolic syndrome, the higher the dental plaque index and more severe the periodontal disease. Therefore, it is necessary to develop health education programs linked to oral health management

with systematic and concentrated support.

The effect on metabolic syndrome was significantly higher in male; old age, low education and income levels, and smokers showed significantly higher effects ($p < 0.001$, $p < 0.05$). This was similar to Bang's study²⁸⁾, which showed that the group with metabolic syndrome at a higher age had a lower education level, a low income per household, and a greater frequency of smoking compared to the normal group. Regarding the prevalence of metabolic syndrome, there was no difference between past and current smoking, but it was consistent with a study²⁹⁾ according to which smokers were more likely to have metabolic syndrome than non-smokers. In this study, there were no related factors in metabolic syndrome and drinking, but proper drinking (drink a day) was considered to lower the risk of metabolic syndrome³⁰⁾; therefore, follow-up studies should be conducted using blood counts or interviews to measure the amount and frequency of drinking.

In addition, looking at the factors effecting on metabolic syndrome, oral health behavior factors were significantly higher in the case of speech and chewing difficulties, and a frequency of tooth brushing of less than once per day ($p < 0.001$, $p < 0.01$, $p < 0.05$) showed the highest correlation with the frequency of daily toothbrushing. If periodontal disease occurs because of an insufficient frequency of toothbrushing and inadequate dental plaque control, it has a negative impact on both oral function and systemic health. Looking at the studies on metabolic syndrome and decline in oral function, which are increasing worldwide, have been confirmed a relationship between periodontal disease and, metabolic syndrome³¹⁻³³⁾ and between tooth loss and metabolic syndrome³⁴⁾. However, there are limitations in comparing and discussing the results of this study because there are no prior studies on speech problems and chewing difficulties. Therefore, through an oral health approach, strategies must be developed to effectively manage and prevent health problems by mediating the risk factors for metabolic syndrome.

Although this study is representative of Korea as it is a cross-sectional survey conducted using a sample representative of the Korean population, it is not a longitudinal study; therefore, it has limitations in that it does not reveal

the causal relationship between oral health behavior and mental health and metabolic syndrome. Despite these limitations, it is important to investigate the effects of the KNHANES on oral health behaviors, mental health, and metabolic syndrome. In addition, the effects of lifestyle factors and oral health on metabolic syndrome in Korean adults obtained in this study were confirmed, and it provides the basic data for the development of an intervention program for effective health and oral health management education combining lifestyle factors and oral health factors to prevent metabolic syndrome.

Notes

Conflict of interest

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

Ethical approval

The Research Ethics Committee of the Korea Disease Control and Prevention Agency approved the study (approval no. 2018-01-03-C-A), and the present study design was approved by the Howon University Bioethics Review Committee (1041585-202202-HR-001-01).

Author contributions

Concept and design: Jin-Ah Jung and Hye-Won Cheon. Data collection: Jin-Ah Jung, Hye-Won Cheon, Sang-Eun Moon, and Sun-Hwa Hong. Analysis and interpretation: Jin-Ah Jung, Hye-Won Cheon, Sang-Eun Moon, and Sun-Hwa Hong. Writing the article: Jin-Ah Jung, Hye-Won Cheon, Sang-Eun Moon, and Sun-Hwa Hong. Revision and Editing: Jin-Ah Jung, Hye-Won Cheon, Sang-Eun Moon, and Sun-Hwa Hong. Overall responsibility: Jin-Ah Jung.

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