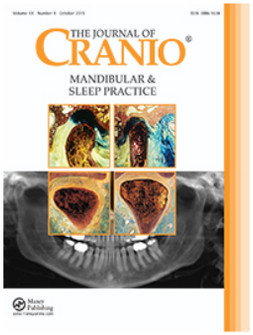

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SLEEP

Association between sleeping time and temporomandibular disorders in a sample of the South Korean population

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ABSTRACT

Objective: This study investigated the relationship between sleeping time and temporomandibular disorders (TMDs).

Methods: This study used data from the Fifth Korea National Health and Nutrition Examination Survey from 2010 to 2011. The final sample size consisted of 11,782 adults aged ≥19 years. Logistic regression analysis was performed to assess the relationship between sleeping time and TMD.

Results: The adjusted odds ratios of the TMD group were 1.421 (1.067, 1.892) (Model 1), 1.388 (1.028, 1.873) (Model 2), and 1.360 (1.012, 1.826) (Model 3) for subjects with sleeping time ≤5 hours ($p < 0.05$) and 1.317 (0.992, 1.748) (Model 1), 1.358 (1.01, 1.827) (Model 2), and 1.352 (0.977, 1.872) (Model 3) for subjects with sleeping time ≥9 hours ($p < 0.05$).

Conclusion: Sleeping time ≤5 hours and ≥9 hours were associated with an increased rate of TMD.

KEYWORDS

Long sleeping time; short sleeping time; temporomandibular disorders; stress; logistic regression analysis; cross-sectional study; national survey; epidemiology

Introduction

Good sleep is necessary for good physical and psychological health. Many studies about the relationships between sleep and systemic diseases have been performed. Disturbance of sleeping time has been identified as a risk factor of lifestyle diseases [1]. Long, as well as short, sleep duration was associated with diabetes, hypertension, and cardiovascular disease [1]. However, most studies reported that decreased sleep quantity and quality were related to increased prevalence of metabolic and cardiovascular diseases [2–4]. Some authors reported that deprivation of sleeping time was related to increased pain sensitivity [5–7]. Patients with chronic pain were more likely to complain of decreased sleeping time and sleep quality [8,9]. Osteoarthritic patients with pain showed sleep disturbance, but the patients without pain did not show sleep disturbance [10].

Poor sleep quality itself is also associated with temporomandibular disorders (TMDs). Previous studies also reported that the subjects with poor sleep quality were more susceptible to TMD [11–14]. The prevalence of TMD was twice as high in patients with poor sleep quality [14]. TMD-free adults whose subjective sleep quality deteriorated progressively developed TMD signs and symptoms eventually [14]. Sleep was a more important risk indicator in the development of TMD than depression [13]. Recent studies have reported that patients with TMD show symptoms and signs related to psychological depression, anxiety, and enhanced pain sensitivity [15,16]. The enhanced pain sensitivity of patients with TMD may be related to sleep disturbance [11–14]. These studies used some indices or questionnaires to measure the patients' sleep disorders. However, these authors focused on sleep quality and sleep disorders such as sleep apnea of TMD patients [11,13,14]. They did not differentiate between sleep quality and quantity (length of sleeping time), despite there being no correlation between sleep quality and sleep quantity [17]. The effect of sleeping time on TMD has not been characterized in detail because the previous studies were only concerned about the effect of sleep quality on TMD.

For this reason, the authors developed a hypothesis that short sleeping time may be associated with an increased prevalence of TMD. This hypothesis was tested using multiple regression models in the present study. The aim of this study was to investigate the association

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between sleeping time and TMD in a nationally representative sample of the South Korean population.

Materials and methods

Study population

Data were obtained from the Fifth Korea National Health and Nutrition Examination Survey (KNHANES V) from 2010 to 2011. The KNHANES is a nationwide survey of a representative sample of the South Korean population and is conducted by the Korean Center for Disease Control and Prevention. This survey was approved by the Institutional Review Board (IRB) for Human Subjects of the Korea Center for Disease Control and Prevention. Before the survey, each participant signed an informed consent form. All data used in this study are available in public files provided by the Korea Centers for Disease Control and Prevention and the Ministry of Health and Welfare of Korea (https://knhanes.cdc.go.kr/knhanes/sub03/sub03_06_02.do). Because of the use of national data, individual IRBs for this study were not needed.

A total of 17,476 subjects participated in this survey. The participant rates were 81.9% in 2010 and 80.4% in 2011. Exclusion criteria of the present study were as follows: (1) those aged <19 years (13,306 participants) and (2) those with missing values in the health assessments or questionnaires (11,782 participants). The final sample size for this study was 11,782.

Data collection and measurements

The participants' demographic, socioeconomic, and health data were collected by experienced, trained interviewers and examiners. Demographic and socioeconomic variables were age, sex, alcohol consumption, education, and income levels. Higher education level was defined when respondents had completed at least high school. Individuals with household incomes <25% of the total equivalized income were classified in the low-income group. The alcohol consumption level was classified as mild to moderate if the individuals consumed <30.0 g alcohol/day. "Ever-smoker" was defined as respondents having smoked at least five packs of cigarettes in their whole lives. Regular exercise was defined as an intense physical activity performed for at least 20 minutes at a time at least three times a week.

Health variables were metabolic syndrome, diabetes, hypertension, waist circumference, and body mass index (BMI). BMI was calculated as weight in kg divided by height in m^2. Metabolic syndrome was diagnosed when three or more of the following criteria were met: (1) waist circumference ≥90 cm in males or ≥80 cm in females; (2) fasting triglyceride ≥150 mg/dL or using lipid-lowering medication; (3) high-density lipoprotein-C <40 mg/dL in males or <50 mg/dL in females or using cholesterol-lowering medication; (4) blood pressure ≥130/85 mm Hg or using anti-hypertensive medication; and (5) fasting blood glucose ≥100 mg/dL or using blood glucose-lowering medication according to the American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement criteria for Asians [18].

Psychological variables included subjective mental stress recognition level, depressive mood for at least two weeks, and suicidal thoughts. Subjective mental stress recognition level was assessed by the questionnaires using a 4-point Likert scale, ranging from 1 (very severe) to 4 (almost never). Subjective mental stress level was classified into high (Likert scale 1, 2) and low (Likert scale 3, 4). Depressive mood and suicidal thoughts were assessed by the "yes/no" question.

Sleeping time each night was evaluated through a self-reported questionnaire. The participants recorded their sleeping hours in Arabic numbers. Sleeping time was classified into short (≤5), adequate (6 ≥ ≤ 8), and long (≥9) groups, according to previous studies [3,19,20].

TMD was assessed by the questionnaires and clinical examination, performed by qualified dentists. The clinical criteria of TMD were based on the World Health Organization (WHO) guidelines [21]: (1) clicking of one or both temporomandibular joints (TMJs), (2) tenderness of the temporalis and/or masseter muscles on one or both sides, and (3) reduced jaw mobility. Clicking was assessed by an audible or palpable TMJ sound. Tenderness was assessed by the pressure of two fingers and measured twice at the thickest muscle area. Reduced jaw mobility was defined as <30 mm or less than the width of three fingers of interincisal distance. TMD was defined as at least one of the above signs or symptoms within one year.

Statistical analysis

All survey analyses included the sampling weights, strata, and clusters because KNHANES is a stratified multistage clustered probability design. All data are expressed as mean ± standard error or percentage. The authors used logistic regression analyses to assess odds ratios (ORs) and 95% confidence intervals (CIs), which were used to determine the association between sleeping time and TMD. Regression analyses were performed in accordance with KNHANES statistical guidelines. ORs and CIs were estimated after adjustment for potential confounders. Three multiple regression models were used. Model 1 was adjusted for age

and sex. Model 2 was adjusted for the variables adjusted in Model 1 and alcohol consumption level, regular exercise, income, and education level. Model 3 was adjusted for the variables adjusted in Model 2 and BMI and mental stress recognition level.

SAS software version 9.2 for Windows (SAS Institute Inc., Cary, NC, USA) was used to analyze these data. Results were considered significantly different when $p < 0.05$.

Results

The subjects with TMD were found to have lower age, lower BMI, lower waist circumference, and lower rates of metabolic syndrome compared with the subjects without TMD. The TMD group showed higher income, higher education level, and higher rate of regular exercise. The rates of suicidal thoughts and depressive mood lasting at least two weeks were not significantly different between the two groups. However, mental stress recognition level was higher in the TMD group (Table 1).

Some association was observed for sleeping time and TMD. The short and long sleep groups showed a higher prevalence rate of TMD compared with the adequate sleep group. The adjusted ORs at 95% CI level after adjusting with age and sex were 1.421 (1.067, 1.892) in the short sleep group and 1.317 (0.992, 1.748) in the long sleep group (p= 0.0144). After adjusting with age, sex, smoking, alcohol consumption level, regular exercise, income, and education level, the adjusted ORs at 95% CI level were 1.388 (1.028, 1.873) in the short sleep group and 1.358 (1.01, 1.827) in the long sleep group (p= 0.0225). The adjusted ORs at 95% CI level after adjusting with age, sex, smoking, alcohol consumption level, regular exercise, income, education level, BMI, and mental stress recognition level were 1.360 (1.012, 1.826) in the short sleep group and 1.352 (0.977, 1.872) in the long sleep group (p= 0.0396) (Table 2).

Discussion

The present study assessed the relationship between sleeping time and TMD in a nationally representative

Table 1. Baseline characteristics of the study population.

	TMD[1] (n = 813)	No TMD (n = 10,969)	p
Age (years)	35.8 ± 0.5	46 ± 0.3	<0.0001*
Sex (% of male)	43 (2)	50 (0.5)	0.0009*
Low income (bottom quarter, %)	11.1 (1.5)	17 (0.6)	0.0005*
Education (high school graduate or higher, %)	85.8 (1.4)	69.2 (0.9)	<0.0001*
Ever-smoker (five or more packs of cigarettes in life, %)	34 (2.1)	38.8 (0.7)	0.037*
Alcohol consumption (<30 g alcohol/day, %)	12.1 (1.5)	10.5 (0.4)	0.2728
BMI[2] (mean, kg/m^2)	22.88 ± 0.17	23.7 ± 0.05	<0.0001*
Waist circumference (mean, cm)	78.2 ± 0.5	81.3 ± 0.2	<0.0001*
Metabolic syndrome (yes, %)	14.2 (1.5)	26.5 (0.5)	<0.0001*
Regular exercise within a week (yes, %)	22.1 (2)	20.7 (0.6)	0.4684
Subjective mental stress rate (high, %)	38 (2.1)	27.1 (0.6)	<0.0001*
Depressive mood at least two weeks (yes, %)	15.1 (1.6)	12.9 (0.4)	0.1529
Sleeping time (hours per day)			0.0941
≤5	13.5 (1.6)	13.9 (0.4)	
6	24.4 (1.8)	26.9 (0.6)	
7	28.8 (2)	28.9 (0.6)	
8	22.5 (1.9)	22.7 (0.5)	
≥9	10.9 (1.3)	7.6 (0.4)	

[1] TMD: temporomandibular disorders; BMI: body mass index.
[2] Values are presented as the mean ± standard error for continuous variables or as the proportion (standard error) for categorical variables.
*p< 0.05.

Table 2. Adjusted odds ratios (ORs) of temporomandibular disorders (TMD) according to sleeping time.

		TMD		
		Model 1	Model 2	Model 3
Sleeping time				
	≤5	1.421 (1.067, 1.892)	1.388 (1.028, 1.873)	1.360 (1.012, 1.826)
	6 ≥ ≤ 8	1	1	1
	≥9	1.317 (0.992, 1.748)	1.358 (1.01, 1.827)	1.352 (0.977, 1.872)
p		0.0144*	0.0225*	0.0396*

Model 1 was adjusted for age and sex.
Model 2 was adjusted for age, sex, smoking, alcohol consumption, regular exercise, income, and education level.
Model 3 was adjusted for age, sex, smoking, alcohol consumption, regular exercise, income, education, body mass index (BMI), and subjective mental stress level.
*p< 0.05.

sample of the South Korean population. The results suggest that sleeping time is associated with TMD. TMD tended to be more prevalent in the short and long sleep groups. To the best of the authors' knowledge, this is the first study to examine the relationship between sleeping time and TMD in the general population.

Many studies have reported the association between sleep quality and TMD [12–14]. Patients with myofascial pain or TMD have been reported to have higher Pittsburgh sleep quality indices than subjects without these disorders [12,22]. The sleep scores from the Sleep Assessment Questionnaire were reported as a more important risk indicator in the development of TMD than depression [13]. Poor sleep quality increased serum estrogen and inflammatory cytokines, including interleukin (IL)-1β, IL-6, cyclooxygenase-2, and tumor necrosis factor (TNF)-α in the synovial membrane of the TMJ [23].

Short sleep duration is also associated with an increased risk for inflammatory conditions [23–25]. IL-1β, IL-6, and TNF-α, pro-inflammatory cytokines of TMD, are elevated during sleep deprivation or reduced sleep time [24–26]. After a night's sleep loss, females showed increases in the expression of TNF-α and IL-6 as compared to decreases in men [25]. Sleep deprivation induces changes in the myosin heavy chain isoforms of the masseter muscle and upregulates matrix metalloproteinase (MMP)-1, MMP-3, and MMP-13 in the TMJ, all of which contribute to the pathogenesis of TMD [27,28]. These reports are consistent with the authors' findings. The present study showed the short sleep group showed a higher prevalence of TMD.

Another interesting finding of this study is that the long sleep group also showed higher rates of TMD. The potential associations between long sleeping time and TMD have not been investigated previously. However, many studies have suggested that long sleeping time is also associated with increased mortality and systemic disease [29–31]. Some studies have proposed that longer sleeping time may be associated with reduced sleep quality. The postmenopausal women who slept 9 hours tended to wake up earlier and found it difficult to sleep again [32]. The subjects who slept for more than 9 hours complained of difficulty getting to sleep and unrefreshed awakening, compared with 7- and 8-hour sleepers [33]. These results suggested that long sleep exerts negative effects on sleep quality. A cross-cultural comparison study showed that long sleepers had poorer health status irrespective of countries [34]. The authors suggested the unrecognized diseases of long sleepers have a negative effect on their mortality rate and physical conditions. According to a longitudinal family-based cohort study, longer sleep duration was associated with stimulation of the IL-6/C-reactive protein (CRP) inflammatory pathway [35]. A higher level of CRP was observed in women, but not in men [36]. Gender differences between sleep duration and inflammatory markers may be associated with gender differences in TMD prevalence.

The authors fully understand that a more cautious approach to the interpretation of these results should be taken because this study has some limitations:

(1) This survey was conducted in only one Asian country. Therefore, these results may not be generalizable to other populations.
(2) Sleeping time was measured by a self-reported questionnaire instead of objective sleeping time. However, it would not have affected the outcome of this study because self-reported sleeping time is an effective method to estimate health problems [5,37].
(3) Subjective and objective sleep quality was not examined in this survey. Therefore, the data do not permit an examination of the association of sleep quality with TMD.
(4) The subgroup analysis according to TMD symptoms (clicking, tenderness, and reduced jaw mobility) was not performed. Therefore, it is difficult to explain the association between sleeping time and each symptom of TMD.
(5) TMJ structures and disc position were not diagnosed by radiographs such as magnetic resonance images (MRI) because national survey data were used in the present study. However, clinical examination alone is not likely to be a major problem because clinical diagnostic criteria for pain-related TMD and one intra-articular TMD show adequate validity (sensitivity ≥0.80, specificity ≥0.97) [38].
(6) As in other cross-sectional studies, it is not possible to infer a cause-and-effect relationship between sleeping time and TMD.

Despite these limitations, the main strength of the present study is that it used data from a nationally representative sample and that it was sufficiently powered to investigate relevant questions about sleep quantity (sleeping time) and TMD. Some studies have reported that patients with TMD suffer from poor sleep quality [12,13,22]. However, these studies examined only a patient group with TMD. The results in the

present study provide epidemiological evidence for an association between sleeping time and TMD.

Conclusion

The results showed that TMD tended to be more prevalent in the short and long sleeping time in South Korea. Both short and long sleeping time may be considered risk factors of TMD. However, well-controlled prospective studies are needed to precisely investigate the causal relationships between sleep quantity, especially long sleeping time, and TMD.

Disclosure of interest

The authors report no conflicts of interest.

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