

## Sleep duration and remaining teeth among older people

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## **Abstract**

**Background:** No studies have examined the associations between the numbers of teeth and sleep disturbance. We examined the associations between the number of teeth and sleep duration in older people, considering the evidence linking fewer teeth and sleep apnoea through changes in jaw position.

**Methods:** We used information from a sample of 23,444 cohort participants, randomly selected from the Japan Gerontological Evaluation Study 2010 (N=169,215) for this study. The outcome variable was self-reported sleep duration (hours/day), and the explanatory variable was self-reported number of teeth (0, 1-9, 10-19,  $\geq 20$ ). We treated age, sex, body mass index, educational attainment, annual equalised household income, depressive symptoms, physical activity, activities of daily living, presence of diabetes and smoking status as covariates. Multinomial logistic regression was used among the 20,548 eligible participants with all necessary information.

**Results:** The mean age was 73.7 (SD=6.13) years. Most participants (28.1%) reported sleep duration of 7 hours, while a small proportion of the participants reported short ( $\leq 4$  hours, 2.7%) or long ( $\geq 10$  hours, 4.7%) sleep duration. The proportion of edentulous participants was 14.7%. Taking the 7-hour sleep duration as the reference category, edentulous participants (relative risk ratio [RRR]=1.43, 95% confidence interval [CI]=1.07-1.90) or 1-9 teeth (RRR=1.29, 95% CI=1.02-1.63) had significantly higher relative risk ratio for short sleep, independent of covariates. They also had higher relative risk ratio for long sleep duration (RRR=1.75, 95% CI=1.40-2.19; RRR=1.48, 95% CI=1.21-1.81, respectively).

**Conclusions:** Compared to people with 20 or more teeth, older adults with fewer than 10 teeth have higher risks for short and long sleep durations.

## **Highlights**

- Our cross-sectional population-based study offers a link between fewer teeth and sleep disturbance.
- The sleep duration of the older adults with less than 10 teeth was either shorter or longer than 7 hours. Sleep disturbances were more severe among edentulous individuals than among the rest of the group.
- As this was a cross-sectional study, further longitudinal or interventional studies on oral health and sleep disturbance are needed.

Key words: Sleep duration, number of teeth, cross-sectional study, JAGES

## **1. Introduction**

Sleep disturbance is an important public health issue in the aging society, given the high prevalence in sleep problems of the adult population aged 60 and over [1], which is expected to reach two billion in 2050 worldwide [2]. Long sleep duration as well as short sleep duration has been linked to increased all-cause mortality among older people. [3, 4] Additionally, laboratory- and epidemiologically-based studies have shown that self-reported short and long sleep durations were associated with increased risks of cardiovascular disease, [5] diabetes mellitus, [6, 7] obesity, [6] poor cognitive performance, [8, 9] and poor self-rated health. [10]

Sleep apnoea is a main cause for inadequate sleep duration. Obstructive sleep apnoea (OSA) is characterised by shorter slow wave sleep and longer apnoea. [11] It is closely linked with retraction of the tongue root [12] or resting tongue position. [13-15] Loss of dental occlusion is known to cause protrusion of jaw position, which leads to retraction of the tongue root, while being edentulous (having no teeth) contributes to the resting tongue position. Therefore, we hypothesised that the number of teeth, especially fewer teeth, may be associated with sleep disturbance. Older adults with fewer teeth are likely to have short sleep duration as well as long sleep duration compared with those who have more teeth.

To the best of our knowledge, no studies have examined the associations between the number of teeth and sleep duration. The aim of this study was to offer an empirical link between the numbers of teeth and sleep duration.

## **2. Methods**

### **2.1 Study Design and Population**

This cross-sectional study used data from the Japan Gerontological Evaluation Study (JAGES) Project. [16, 17] The JAGES Project regularly investigates social, behavioural and

health factors of people aged 65 years and over. The target population of the JAGES Project was restricted to community-dwelling individuals who were not certified for long-term public care (i.e., disabilities) insurance benefits. [18]

In the present study, we used data from surveys conducted from 2010 to 2011 (N=169,215; response rate: 66.3%). One in five randomly selected, participants from a total of 23,444 individuals from the JAGES participants were administered the sleep duration questionnaire. Of these, 20,548 cases with complete information on the sleeping duration were used for our study.

## **2.2 Ethical considerations**

The JAGES protocol was reviewed and approved by the Ethics Committee on Research of Human Subjects of Nihon Fukushi University and Tohoku University. The questionnaire was sent via mail, with a written explanation of the study aim. The people who returned the questionnaire were regarded as having provided consent to participate in the survey. Use of the data was semi-closed, and the authors obtained permission to use the data from the JAGES data management committee.

## **2.3 Measures**

### **2.3.1 Outcome variable**

Sleep duration was assessed using the question: “*How long (in hours) do you usually sleep per day?*”. The participants were asked to write time of sleeping. We classified the time as follows:  $\leq 4$  h, 5 h, 6 h, 7 h, 8 h, 9 h and  $\geq 10$  h. [19] Following a previous study, [20] “short” and “long hours of sleep” were categorized as the duration of  $\leq 4$  and  $\geq 10$  hours/day, respectively.

### 2.3.2 Explanatory variable

The participants were asked to identify number of remaining teeth, which we used as an explanatory variable in this study. We categorised the response as follows: no teeth, 1-9 teeth, 10-19 teeth and  $\geq 20$  teeth.

### 2.3.3 Covariates

The following sociodemographic characteristics, health-related behaviours and health statuses were included in the model as covariates: age, sex, body mass index, educational attainment, annual household income, depressive symptoms, physical activity, activities of daily living (ADL), diabetes (type 1 or 2) and smoking status.

Educational attainment was categorised as follows:  $\leq 9$  years, 10–12 years, and  $\geq 13$  years of education. Annual equalized household income was categorized as follows:  $< \$20,000$  ( $< ¥2,000,000$ ),  $\$20,000$ – $\$29,999$  ( $¥2,000,000$ – $¥2,999,999$ ), and  $\geq \$30,000$  ( $\geq ¥3,000,000$ ) (US\$1 = ¥100). The participants' depressive symptoms were assessed by the 15 items from the Geriatric Depression Scale (GDS-15). Previous studies concluded that a cut-off point of 5 is appropriate for screening depression in community-dwelling older adults in the United States and Japan, [21, 22] which we applied in this study. As a proxy for physical activity, the variable on frequency of getting out from their home was used, and was dichotomized as follows:  $\geq 1$  and  $< 1$  time/week. ADL was evaluated by participants' responses to the question: *“Do you perform the following activities of daily living by yourself: walking, bathing and toilet use?”* The answers were dichotomised as follows: No need for personal assistance, and require some personal assistance. Having diabetes (type 1 or 2) was self-reported (yes/no). Smoking status was categorised as follows: never smokers, former smokers and current smokers.

## **2.4 Statistical analysis**

We calculated the prevalence for respondents with short or long sleep duration according to the categories of remaining teeth mentioned above. Next, multinomial logistic regression analysis was applied to calculate the relative risk ratios (RRRs) and 95% confidence intervals (CIs) of dental status as an associated factor for shorter or longer sleep duration in reference to the 7 hours of sleep duration. We examined hourly category changes, with a duration of 7 hours as the reference value. Estimates were adjusted for age and sex initially, and then adjusted for all covariates (age, sex, BMI, educational attainment, annual household income, diabetes, GDS, ADL, frequency of going out, and smoking status). We used multiple imputation (MI) to minimise bias due to influence of missing information [23]. The original database was created to be imputed by chained equations, and information on the imputation models is shown in Appendix 1. For the sensitivity analysis, analysis without MI, the missing indicator method [23], was also conducted. Analyses were performed using SPSS version 22.0 and Stata MP14.

## **3. Results**

Table 1 shows the distribution of the participants' characteristics before imputation. The majority of participants (28.1%) reported a sleep duration of 7 hours, while small proportions reported short ( $\leq 4$  hours, 2.7%) and long sleep durations ( $\geq 10$  hours, 4.7%). The proportion of edentulous people was 14.7% (n=3,023) (1-9 teeth: 25.8%, 10-19 teeth: 25.7%,  $\geq 20$  teeth: 33.8%). The mean age of the participants was 73.7 (Standard Deviation=6.1) years.

Table 2 shows the associations between dental status and sleep duration. Among the edentulous people, the proportions of short and long sleep durations were 3.3% (n=100) and 9.0% (n=272), respectively. On the other hand, among participants with 20 or more teeth, the corresponding proportions were only 2.3% (n=160) and 2.8% (n=195), respectively. The



distribution of sleep duration by dental status varied (chi-squared  $p$ -value $<0.01$ ).

The results of multinomial logistic regression analyses with imputed cases is shown in Table 3. Compared to people with 20 or more teeth, people with no teeth had higher RRRs for short (RRR=1.43, 95% CI=1.07–1.90) and long sleep durations (RRR=1.75, 95% CI=1.40–2.19) (Table 3). Figure 1 shows the multivariate adjusted RRRs for sleep duration, with a duration of 7 hours as the reference value. A U-shaped association was observed between dental status and sleep duration. A similar, but flatter, U-shaped association was also observed among people with 1-9 teeth: the RRRs for short and long sleep durations were 1.29 (95% CI=1.02–1.63) and 1.48 (95% CI=1.21–1.81) (Table 3), respectively (Figure 2). The sensitivity without MI also showed similar results (Appendices 2 and 3).

#### **4. Discussion**

To the best of our knowledge, the present study is the first to demonstrate significant associations between the number of teeth and sleep duration among older people in Japan. Specifically, the results suggest that having fewer or no teeth was associated with both short and long sleep durations.

We hypothesised that tooth loss is likely to be related with sleep disturbance indicated by sleep duration. OSA disturbs the quality of sleep and has been associated with a number of nocturnal symptoms, as well as with difficulty in daytime functioning secondary to daytime sleepiness, irritability, fatigue and decreased cognitive functioning. [24] The finding that older adults with fewer teeth had both shorter and longer sleep durations indicates that these individuals may be suffering from OSA. The results of this study imply that interventions that promote dental health would support healthy aging among older adults by helping them to maintain adequate sleep.

In our study, included covariates were based on previous evidence on age, [25, 26] sex, [27]

socioeconomic status [28, 29] and depression [30]. Denture use during sleep could be a methodological concern, yet we did not include this in the model since findings associated with denture use during sleep duration were inconsistent, [31, 32] and current dental practices do not recommend it. [33, 34] In relation to the cross-sectional design, further longitudinal studies are needed to determine a temporal relationship.

Our study was cross-sectional in design; therefore, we cannot claim causality. We believe that the number of remaining teeth reflects accumulation of dental health status, which are affected by oral diseases, such as dental caries and periodontal disease throughout the lifetime, while the sleep duration used in the present study was more current than the number of remaining teeth. This means that the number of teeth is likely to be a precedent condition to the state of sleep. Future longitudinal studies will be able to determine temporal changes between dental health status and sleep durations over time.

In our study, we clearly showed the direction of the associations between number of teeth and sleep duration. JAGES sample coverage is not from all municipalities or a representative sample in Japan; still, we confirmed that the sleep duration profile of our analytic sample was similar to the previous study that was based on a representative sample in Japan [20]. In addition, our outcome and explanatory variables were self-reported. The validity of these measures has been well-established with respect to objective measures, [35-38] and thus we believe the result of the analysis was as reliable as one from objective data. Another limitation is that our questionnaire did not include more sophisticated questions on sleep apnoea and greater jaw occlusion, which were more directly related to our hypothesis and mechanism of oral health and sleep. Further study using these measurements is needed.

In conclusion, compared to people with 20 or more teeth, older adults with fewer than 10 teeth have higher risks for both short and long sleep durations.

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## **Conflict of interest**

The authors have no conflicts of interest directly relevant to the content of this article.

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## Tables

Table 1. Demographic characteristics of the participants (N=20,548)

	Number of respondents (%)
Sex	
Male	9,622 (46.8)
Female	10,926 (53.2)
Age (years)	
65-69	6,258 (30.5)
70-74	6,006 (29.2)
75-79	4,440 (21.6)
80-84	2,605 (12.7)
≥85	1,239 (6.0)
Sleep duration (h)	
≤4	557 (2.7)
5	1,954 (9.5)
6	5,008 (24.4)
7	5,767 (28.1)
8	5,111 (24.9)
9	1,188 (5.8)
≥10	963 (4.7)
Number of teeth	
No teeth	3,023 (14.7)
1-9 teeth	5,301 (25.8)
10-19 teeth	5,281 (25.7)
≥20 teeth	6,943 (33.8)
Body mass index (kg/m <sup>2</sup> )	
Underweight (<18.5)	1,408 (6.9)
Normal-weight (18.5-<25)	14,075 (68.5)
Overweight (25-<30)	3,898 (19.0)
Obese (≥30)	420 (2.0)
Education (years)	
≤9	9,514 (46.3)
10-12	7,180 (34.9)
≥13	3,484 (17.0)
Annual household income	
<\$20,000	8,484 (41.3)
\$20,000-29,999	4,077 (19.8)
≥\$30,000	4,569 (22.2)
Diabetes (type 1 or 2)	
Yes	2,614 (12.7)
No	13,015 (63.3)
Depression (GDS score)	

0–4	12,237 (59.6)
≥ 5 (depressed)	4,798 (23.4)
ADL	
No need for personal assistance	411 (2.0)
Require some personal assistance	19,846 (96.6)
Frequency of going out	
≥1 time/week	18,112 (88.1)
<1 time/week	1,552 (7.6)
Smoking status	
Never smoker	11,159 (54.3)
Former smoker	5,525 (26.9)
Current smoker	2,105 (10.2)

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GDS, geriatric depression scale; ADL, activities of daily living.



Table 2. Cross-tabulation on categorised number of teeth by sleep duration (N=20,548)

	Sleep duration							Total (%)
	≤4 h	5 h	6 h	7 h	8 h	9 h	≥10 h	
Number of teeth								
No teeth	100 (3.3%)	257 (8.5%)	573 (19.0%)	692 (22.9%)	862 (28.5%)	267 (8.8%)	272 (9.0%)	3,023 (100.0%)
1-9 teeth	173 (3.3%)	502 (9.5%)	1,209 (22.8%)	1,395 (26.3%)	1,351 (25.5%)	339 (6.4%)	332 (6.3%)	5,301 (100.0%)
10-19 teeth	124 (2.3%)	505 (9.6%)	1,353 (25.6%)	1,566 (29.7%)	1,300 (24.6%)	269 (5.1%)	164 (3.1%)	5,281 (100.0%)
≥20 teeth	160 (2.3%)	690 (9.9%)	1,873 (27.0%)	2,114 (30.4%)	1,598 (23.0%)	313 (4.5%)	195 (2.8%)	6,943 (100.0%)
Total (%)	557 (2.7%)	1954 (9.5%)	5,008 (24.4%)	5,767 (28.1%)	5,111 (24.9%)	1,188 (5.8%)	963 (4.7%)	20,548 (100.0%)

Table 3. Association between sleep duration and dental health with imputed cases by multinomial logistic regression (N = 20,548)

	Relative risk ratios of 7-hour duration respondents					
	Multivariate RRR (95% CI)*					
	≤4 hours	5 hours	6 hours	8 hours	9 hours	≥10 hours
Sex						
Male	0.63 (0.49-0.82)†	0.66 (0.57-0.77)†	0.74 (0.66-0.82)†	1.28 (1.16-1.43)†	1.91 (1.60-2.28)†	2.26 (1.86-2.74)†
Female	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Number of teeth						
No teeth	1.43 (1.07-1.90)†	1.04 (0.87-1.24)	0.97 (0.85-1.11)	1.28 (1.13-1.46)†	1.58 (1.29-1.93)†	1.75 (1.40-2.19)†
1-9 teeth	1.29 (1.02-1.63)†	1.00 (0.87-1.15)	0.98 (0.88-1.09)	1.11 (1.00-1.23)†	1.23 (1.03-1.47)†	1.48 (1.21-1.81)†
10-19 teeth	0.92 (0.72-1.18)	0.93 (0.82-1.07)	0.97(0.88-1.07)	1.03 (0.93-1.14)	1.02 (0.86-1.22)	0.90 (0.72-1.12)
≥20 teeth	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Education (years)						
≤9	1.33 (1.00-1.76)†	1.20 (1.03-1.41)†	0.96 (0.86-1.07)	1.22 (1.10-1.37)†	2.03 (1.66-2.50)†	2.15 (1.69-2.72)†
10–12	1.09 (0.81-1.45)	1.03 (0.88-1.20)	0.98 (0.88-1.09)	1.01 (0.91-1.13)	1.36 (1.10-1.69)†	1.23 (0.95-1.59)
≥13	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Annual household income						
<\$20,000	1.69 (1.27-2.23)†	1.20 (1.05-1.38)†	1.03 (0.93-1.14)	1.12 (1.01-1.24)†	1.11 (0.92-1.32)	1.21 (0.98-1.48)
\$20,000–29,999	1.02 (0.72-1.45)	1.08 (0.92-1.28)	0.98 (0.88-1.09)	1.07 (0.95-1.20)	1.01 (0.81-1.24)	1.00 (0.79-1.27)
≥\$30,000	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Diabetes (type 1 or 2)						
Yes	1.01 (0.78-1.33)	1.01 (0.86-1.18)	1.03 (0.92-1.16)	1.19 (1.06-1.33)†	1.23 (1.01-1.49)†	1.23 (1.02-1.50)†
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Depression (GDS score)						
0–4	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
≥ 5(depressed)	2.68 (2.17-3.31)†	1.82 (1.60-2.07)†	1.27 (1.15-1.40)†	1.04 (0.94-1.16)	1.19 (1.02-1.40)†	1.57 (1.34-1.85)†
ADL						
No need for personal assistance	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)

Require some personal assistance	2.25 (1.31-3.85)†	1.73 (1.14-2.62)†	1.34 (0.93-1.93)	2.01 (1.44-2.79)†	1.64 (1.03-2.63)†	4.32 (2.98-6.27)†
Frequency of going out						
≥1 time/week	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
<1 time/week	1.21 (0.89-1.64)	0.99 (0.80-1.23)	0.95 (0.80-1.12)	1.13 (0.97-1.32)	1.36 (1.08-1.70)†	1.81 (1.45-2.24)†
Age (years)						
65-69	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
70-74	0.94 (0.75-1.19)	0.96 (0.84-1.09)	0.96 (0.87-1.05)	1.09 (0.99-1.20)	1.22 (1.01-1.46)†	1.64 (1.28-2.10)†
75-79	1.01 (0.79-1.30)	0.90 (0.78-1.05)	0.90 (0.80-1.00)	1.33 (1.19-1.49)†	1.45 (1.19-1.76)†	2.86 (2.25-3.65)†
80-84	0.75 (0.54-1.04)	0.87 (0.72-1.05)	0.86 (0.75-0.99)†	1.55 (1.36-1.77)†	2.21 (1.78-2.73)†	4.07 (3.14-5.28)†
≥85	1.01 (0.67-1.52)	0.67 (0.50-0.90)†	0.70 (0.57-0.87)†	1.81 (1.50-2.17)†	3.30 (2.54-4.29)†	7.78 (5.81-10.42)†
Smoking status						
Never smoker	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Former smoker	1.23 (0.93-1.63)	1.12 (0.95-1.32)	1.11 (0.98-1.25)	1.07 (0.95-1.20)	1.11 (0.92-1.33)	0.96 (0.78-1.19)
Current smoker	0.91 (0.64-1.31)	0.89 (0.72-1.09)	0.92 (0.79-1.07)	1.08 (0.93-1.24)	1.07 (0.84-1.35)	1.03 (0.79-1.33)
Body mass index (kg/m <sup>2</sup> )						
Underweight (<18.5)	1.21 (0.88-1.66)	1.21 (0.99-1.48)	1.01 (0.86-1.18)	0.97 (0.83-1.13)	1.13 (0.89-1.44)	1.00 (0.77-1.31)
Normal-weight (18.5-<25)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Overweight (25-<30)	0.93 (0.74-1.18)	1.02 (0.90-1.17)	1.08 (0.98-1.19)	0.96 (0.87-1.07)	1.11 (0.94-1.30)	1.12 (0.93-1.35)
Obese (≥30)	1.23 (0.69-2.18)	1.50 (1.08-2.09)†	0.93 (0.70-1.24)	1.26 (0.96-1.65)	1.00 (0.61-1.65)	1.56 (0.96-2.53)

\* Adjusted for age, sex, educational attainment, household-annual income, all diabetes, depression (Geriatric Depression Scale), ADL, Frequency of going out, smoking status

† p-value<0.05

### **Figure legends**

Figure 1. Relative risk ratios (RRRs; with 95% confidence intervals) of various sleep durations in patients with no teeth, as compared to those with 20 or more teeth (reference: 7 hours) (N=20,548). \*p<0.05.

Figure 2. Relative risk ratios (RRRs; with 95% confidence intervals) of various sleep durations in patients with 1-9 teeth, as compared to those with 20 or more teeth (reference: 7 hours) (N=20,548). \*p<0.05.

