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**Research Article**

# Associations among Obesity, Eating Speed, and Oral Health

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## Keywords
Dental health · Epidemiology · Metabolic syndrome · Obesity · Overweight

## Abstract
***Objective:*** This study was conducted to understand how eating speed and oral health condition are associated with obesity in Japanese working men. ***Methods:*** We studied a total of 863 men attending an annual medical checkup of the Japanese Maritime Self Defense Force in Sasebo City, Japan. Participants answered a questionnaire about their eating speed, and we examined their anthropometric status in terms of BMI, waist circumference, and oral health condition, especially periodontal disease and number of functional teeth. Multivariate logistic regression analyses adjusting for potential confounding variables were performed. ***Results:*** The multivariate-adjusted odds ratio for waist circumference greater than 90 cm of the 'very fast' group compared to the 'slow, very slow' group was 5.22 (95% confidence interval 1.81–15.06) after adjusting for potential confounding factors. Individuals were more likely to have waist circumference greater than 90 cm if they had a larger 'number of missing functional teeth' (odds ratio 1.14; 95% confidence interval 1.01–1.28) and severe periodontal disease (odds ratio 2.74; 95% confidence interval, 1.46–5.13). ***Conclusion:*** Eating speed, the number of missing functional teeth, and severe periodontal disease are associated independently with larger waist circumference.



## Introduction

The prevalence of obesity has increased worldwide and among Japanese people. According to the World Health Organization report in 2016, around 39% of adults aged 18 years and over were overweight, and 13% of adults aged 18 years and over were obese [1].

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Obesity is known as an important risk factor for various lifestyle diseases such as type 2 diabetes mellitus [2], cardiovascular disease [3], and coronary heart disease [4]. On the other hand, poor oral health condition, especially periodontal disease, has also been reported to be associated with lifestyle-related diseases. It has been suggested to increase the risk of arteriosclerosis [5, 6], type 2 diabetes [7], obesity [8], abdominal obesity [9], and metabolic syndrome [10]. Moreover, metabolic syndrome was shown to possibly play a role in the development or worsening of periodontitis in a longitudinal study [11]. In Japan, the major reasons for tooth extraction are periodontal disease (41.8%), dental caries (32.7%), and resulting dental fractures (10.6%) [12]. A high number of missing functional teeth and severe periodontal diseases may be associated with poor systemic health, since they lead to deterioration in occlusal function resulting in malnutrition.

Recent studies have shown that eating speed plays a role in obesity [13–20] and diabetes [21–23]; therefore, it is recommended that we chew well and eat slowly. A gradual elevation of blood glucose level is recommended in order to prevent overworking the pancreas which can result from continued and rapid insulin secretion [24]. Although teeth function may play an important role in eating speed, this has not been well described. Additionally, periodontal disease [25] and tooth loss [26, 27] are also suggested to increase the risk of obesity. However, it is uncertain whether deteriorated oral health or quick eating enhances obesity, because eating speed and oral health condition have never been analyzed simultaneously until now. We hypothesized that both oral health and eating speed may play a role in obesity. We conducted this investigation to elucidate whether eating speed and oral health condition, indicated by periodontal status and the number of remaining functional teeth, are associated with obesity in Japanese male adults.

## Material and Methods

*Study Population*

Participants in our study were 863 Japanese men belonging to the Maritime Self Defense Force in Sasebo City, Japan. All of them had a military rank ('officer' or 'petty officer'). We conducted the present survey during an annual medical checkup in 2011. The study was approved by the Ethics Committee of Nagasaki University (approval number 1184). We explained the purpose of our study to participants and obtained their informed consent for participation.

*Anthropometric Measurement*

To assess anthropometric status, BMI was calculated from weight in kilograms divided by the square of height in meters. Waist circumference (WC) in centimeters was measured in 824 (95.8%) of 863 subjects. Subjects with a BMI ≥ 25 kg/m$^2$ were defined as 'overweight' and those with a BMI ≥ 30 kg/m$^2$ were defined as 'obese.' Additionally, a WC ≥ 85 cm was defined as 'overweight' based on the Japanese criterion [28], and a WC ≥ 90 cm was defined as 'overweight' based on the Asian criterion [29].

*Questionnaire*

The survey comprised a self-administered questionnaire. In the questionnaire, participants responded by selecting one of five categories – 'very slow,' 'slow,' 'ordinary,' 'fast,' and 'very fast' – to the question: 'How fast is your eating speed compared with others?' This question was referred to previous studies [13, 14]. The validity of the question has been demonstrated by the high level of concordance between self-reported and friend-reported rate of eating [14]. We also asked about participants' lifestyle factors, such as frequency of physical exercise (regularly, sometimes, or other, including former regularly and never), smoking habit (nonsmoker, past smoker, or current smoker), and alcohol intake (yes or no).

*Oral Examination*

One dentist among the authors examined the oral health status of each of the participants. Periodontal status was assessed using the score based on the Community Periodontal Index (CPI) recommended by the

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World Health Organization [30]. All of the teeth were divided into six sextants, and eight designated molars (the first and second molars) and two incisors (upper right and lower left central incisor) were probed as representatives of each sextant. Sextants with fewer than two teeth were excluded. The score for each sextant was simplified in the following way: score 0, CPI code 0 to 2; score 1, CPI code 3 (pocket probing depth 4–5 mm); score 2, CPI code 4 (pocket probing depth ≥ 6 mm). The sum of the scores of all sextants was divided by the total number of existing sextants, and this simplified CPI score was designated the 'severity of periodontitis [31].'

We used two dental status variables: 'number of present teeth,' defined as the sum of the number of sound teeth, treated teeth, and decayed teeth; and 'number of missing functional teeth,' defined as the number of teeth judged to need prosthetic treatment in order to make occlusal pair of opposing teeth; i.e., the sum of the number of teeth lost and the number of teeth so severely decayed that only the root remained. Number of functional teeth was positively associated with chewing ability [32]. Therefore, the greater the number of missing functional teeth you have, the lower your masticatory ability.

*Statistical Analysis*

The two-sample t-test was used to compare the mean of the number of present teeth or the number of missing functional teeth between subjects who were at normal weight or overweight, and with low or high WC according to the Japanese criterion. The Mantel-Haenszel extension of the chi-square test for trends was performed to compare the categorical parameters between subjects who were overweight or had a higher WC by the Japanese criteria. One-way analysis of variance was used to compare the means of BMI or WC among eating speed categories in each age group. Multivariate logistic regression analysis was used to calculate the odds ratios (ORs) of each variable for overweight or obese subjects and also for subjects with higher WC by both criteria.

All statistical analyses were performed using SPSS® Statistics (version 20.0; IBM, Tokyo, Japan). A level of $p < 0.05$ was considered to indicate statistical significance.

## Results

Figure 1A shows the proportions of subjects with BMI values of <25, 25–30, and ≥30 kg/m$^2$ according to eating speed. Figure 1B shows the proportions of subjects with WC of <85, 85–90, and ≥90 cm. The prevalence of overweight or obese individuals increased with increasing speed of eating. Figure 2 shows the mean BMI (A) or WC (B) among subjects with each eating speed according to age group. In all age groups, the mean BMI was 24.0 ± 3.3 (slow, very slow), 24.9 ± 3.8 (ordinary), 26.1 ± 3.8 (fast), and 27.0 ± 3.3 (very fast). The mean WC was 82.4 ± 8.0 (slow, very slow), 85.3 ± 10.1 (ordinary), 87.9 ± 9.9 (fast), and 89.0 ± 8.1 (very fast).

Table 1 shows the mean BMI and WC and the percentage of subjects who were overweight and had high WC using the Japanese criterion according to demographic and behavioral characteristics. BMI and WC increased significantly with increasing 'eating speed' ($p$ for trend < 0.001 for both), 'number of missing functional teeth,' ($p = 0.01$ for both), and 'periodontal status' ($p$ for trend = 0.001 for both). 'Military ranks' were associated with both BMI ($p < 0.001$) and WC ($p = 0.005$).

Table 2 shows multivariate ORs and 95% confidence intervals (95% CI) for subjects who are overweight, obese, and with higher WC by both criteria. The ORs for having a BMI ≥ 25 kg/m$^2$ and having a BMI ≥ 30 kg/m$^2$ were 2.65 (95% CI 1.52–4.65) and 2.66 (95% CI 0.92–7.72), respectively, in the group with 'fast' eating speed compared with 'slow, very slow eating speed'. These figures increased to 5.04 (95% CI 1.95–13.07) or 4.80 (95% CI 1.21–19.09) in the group with 'very fast eating speed'. The ORs of WC ≥ 85 cm and WC ≥ 90 cm were 1.72 (95% CI 0.96–3.11) and 2.34 (95% CI, 1.08–5.05), respectively, in the group with 'ordinary' eating speed compared with 'slow, very slow eating speed'. These figures also increased to 3.13 (95% CI 1.74–5.64) or 3.90 (95% CI, 1.82–8.34) in the group with 'fast', and to 6.59 (95% CI, 2.37–18.48) or 5.22 (95% CI, 1.81–15.06) in the group with 'very fast eating speed'. The

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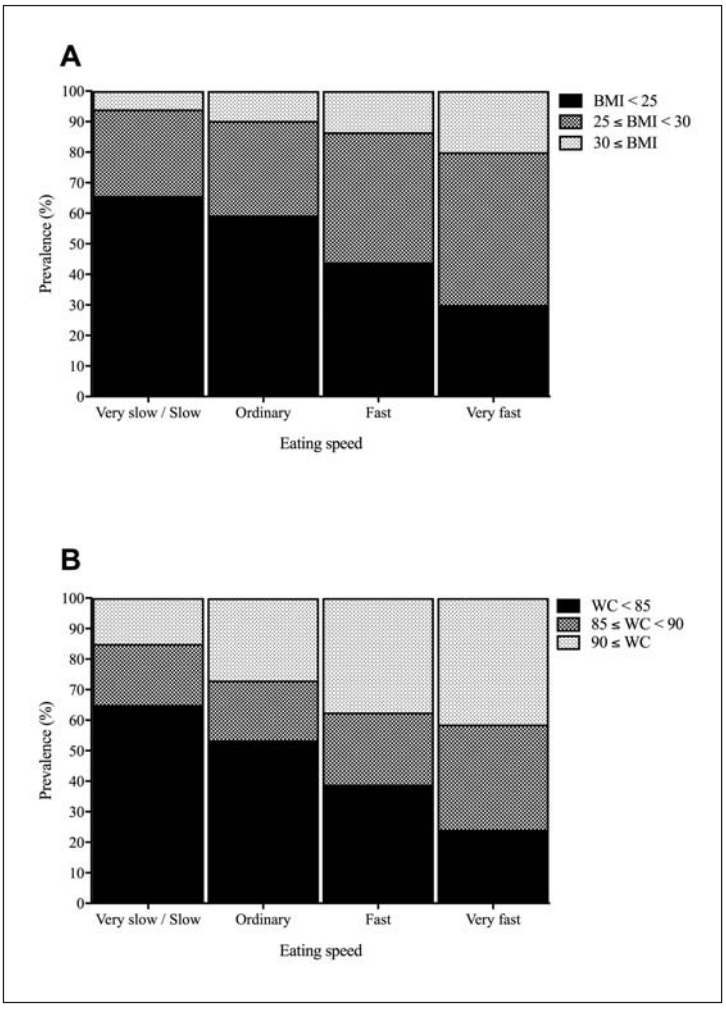


**Fig. 1. A** Proportions of subjects with each BMI of <25, 25–30, and ≥30 kg/m$^2$, by each speed of eating. **B** Proportions of subjects with each WC of <85, 85–90, and ≥90 cm, by each speed of eating.

adjusted ORs of overweight subjects with a WC ≥ 85 cm, and WC ≥ 90 cm for each additional missing functional tooth were 1.14 (95% CI 1.01–1.28), 1.14 (95% CI 1.01–1.29), and 1.14 (95% CI 1.01–1.28). The adjusted ORs of overweight and obese subjects were 2.14 (95% CI 1.45–3.15) and 3.72 (95% CI, 1.63–8.48), respectively, whereas the adjusted ORs of WC ≥ 85 cm and WC ≥ 90 cm were 1.87 (95% CI, 1.27–2.77) and 2.48 (95% CI, 1.56–3.94) respectively, when comparing a 'petty officer' with an 'officer.' Periodontal disease tended to be more severe in overweight and obese subjects and in those with higher WC, and was significantly more prominent in subjects with WC ≥ 90 cm (OR 2.74, 95% CI 1.46–5.13). Subjects with alcohol habit and a BMI ≥ 30 kg/m$^2$ had lower OR of 0.56 (95% CI 0.34–0.93). Subjects who answered 'exercise sometimes' had significantly higher BMI and also WC than subjects who answered 'exercise regularly'. Smoking habit was not significantly related to obesity.

## Discussion

Our study had two major findings. First, eating speed, loss of functional teeth, and severe periodontal disease were independently associated with obesity. Second, a lower ranking in the military was associated with an increased risk of obesity.

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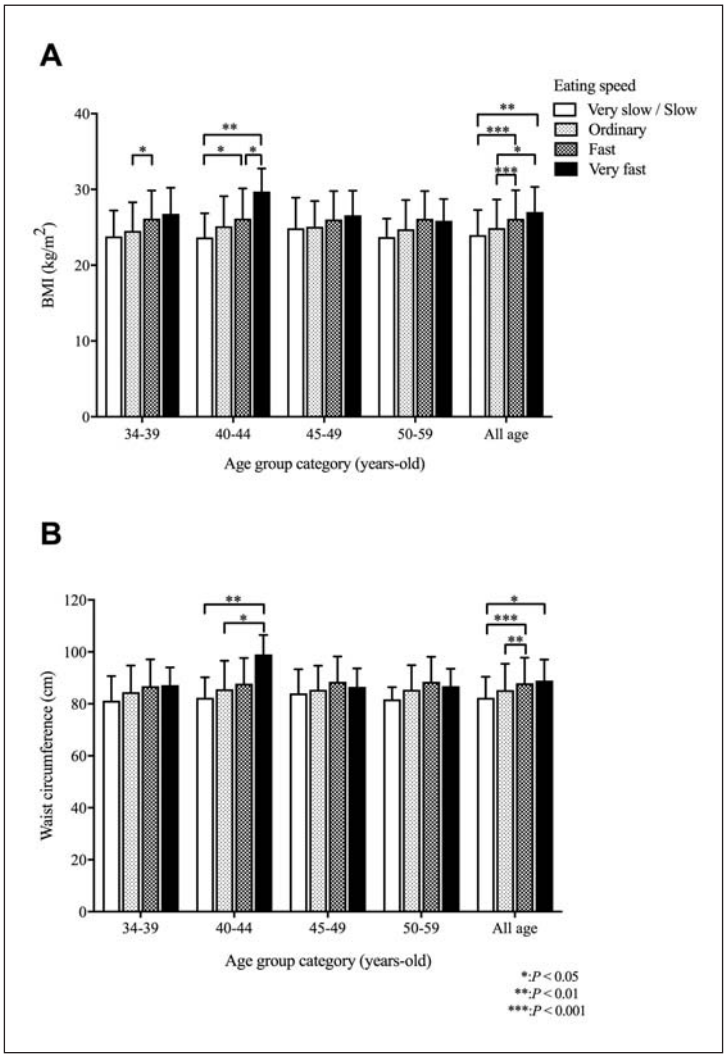


**Fig. 2.** The mean BMI (**A**) or WC (**B**) among subjects with each eating speed according to age group. In the 34- to 39-year-old of panel A, the fast group had significantly higher BMI than the ordinary group (p = 0.02). Additionally, in the 40- to 44-year-old group, the very fast group and the fast group had significantly higher BMI than the very slow/ slow group (p = 0.01 and p = 0.04, respectively). In the 40- to 44-year-old of panel B, the very slow/slow group and the fast group had significantly lower WC than the very fast group (p < 0.01 and p = 0.02, respectively).

Several studies have reported that eating speed has a positive relationship with obesity in almost all age groups and populations [13–18]. This relationship may be explained by the following two aspects: i) Less mastication activates fewer histamine neurons in the brain, leading to delayed sense of stomach fullness and resulting in overeating. The activation of histamine neurons suppresses food intake physiologically by affecting both eating volume and eating speed through H1 receptors in the ventromedial hypothalamus and the hypothalamic paraventricular nucleus, which are known to be satiety centers [33]. ii) Another mechanism is a rapid increase in blood glucose level causing excessive insulin secretion and inducing insulin resistance of a variety of cells. Reduced insulin sensitivity leads to overeating, thus promoting obesity [21].

Although an association between obesity and tooth loss has been reported among adults [26, 27], several studies have found no such associations after adjusting for confounding factors [34]. These previous studies did not consider other oral health conditions such as dental caries and periodontal disease. In our study, we found that functional tooth loss and relatively severe periodontal disease, as well as eating speed, were independently associated with obesity, especially with WC ≥ 90 cm. Recent epidemiological studies have confirmed the

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**Table 1.** Demographic and behavioral characteristics of study participants according to BMI and waist circumference

| Characteristic | BMI < 25 kg/m$^2$ (n = 445/863) | BMI ≥ 25 kg/m$^2$ (n = 418/863) | p value | WC < 85 cm (n = 381/824) | WC ≥ 85 cm (n = 443/824) | p value |
|---|---|---|---|---|---|---|
| Eating speed , n (%) | | | <0.001[a] | | | <0.001[a] |
| Slow, very slow | 44(65.7) | 23(34.3) | | 39(65.0) | 21(35.0) | |
| Ordinary | 213(59.3) | 146(40.7) | | 180(53.4) | 157(46.6) | |
| Fast | 179(44.0) | 228(56.0) | | 155(38.9) | 243(61.1) | |
| Very fast | 9(30.0) | 21(70.0) | | 7(24.1) | 22(75.9) | |
| Number of present teeth, mean (SD) | 26.3(2.7) | 26.2(2.5) | 0.461 | 26.4(2.4) | 26.1(2.8) | 0.087 |
| Number of missing functional teeth, mean (SD) | 0.35(1.08) | 0.57(1.40) | 0.012 | 0.35(1.07) | 0.56(1.41) | 0.014 |
| Periodontal status, n (%) | | | <0.001[a] | | | <0.001[a] |
| 0 | 211(57.8) | 154(42.2) | | 181(52.5) | 164(47.5) | |
| 1 | 211(47.8) | 230(52.2) | | 182(42.8) | 243(57.2) | |
| 2 | 23(40.4) | 34(59.6) | | 18(33.3) | 36(66.7) | |
| Age, n (%) | | | 0.734[a] | | | 0.462[a] |
| <39 years | 113(51.6) | 106(48.4) | | 98(46.4) | 113(53.6) | |
| 40–44 years | 133(50.8) | 129(49.2) | | 109(43.6) | 141(56.4) | |
| 45–49 years | 109(50.9) | 105(49.1) | | 95(46.6) | 109(53.4) | |
| ≥50 years | 90(53.6) | 78(46.4) | | 79(49.7) | 80(50.3) | |
| Military ranks, n (%) | | | <0.001[a] | | | 0.005[a] |
| Petty officers | 338(48.4) | 360(51.6) | | 293(43.9) | 375(56.1) | |
| Officers | 107(64.8) | 58(35.2) | | 88(56.4) | 68(43.6) | |
| Alcohol habit, n (%) | | | 0.220[a] | | | 0.897[a] |
| No | 75(47.2) | 84(52.8) | | 71(46.7) | 81(53.3) | |
| Yes | 370(52.6) | 334(47.4) | | 310(46.1) | 362(53.9) | |
| Smoking habit, n (%) | | | 0.389[a] | | | 0.736[a] |
| Nonsmoker | 118(54.6) | 98(45.4) | | 94(46.3) | 109(53.7) | |
| Past smoker | 126(50.4) | 124(49.6) | | 116(47.7) | 127(52.3) | |
| Current smoker | 201(50.6) | 196(49.4) | | 171(45.2) | 207(54.8) | |
| Exercise, n (%) | | | 0.189[a] | | | 0.103[a] |
| Regularly | 239(54.7) | 198(45.3) | | 210(50.6) | 205(49.4) | |
| Sometimes | 96(46.2) | 112(53.8) | | 77(37.9) | 126(62.1) | |
| Others | 110(50.5) | 108(49.5) | | 94(45.6) | 112(54.4) | |

WC = Waist circumference.
[a]P for trend.

accumulating evidence of the relationship between obesity and periodontal disease [7, 8, 25], and we also recognized the related tendency especially in WC ≥ 90 cm in this study (p = 0.002, table 2). Various oral health problems, such as decayed teeth with cavity sometimes with pain, severe periodontal disease with teeth loosening and tooth losses, deteriorates occlusal function and ability to eat, eventually resulting in an unhealthy dietary lifestyle. We might change our diet to nutrient-dense foods, favoring softer foods rich in higher carbohydrates, sugars, and saturated fats [35, 36], which are not recommended as healthy diet. People

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**Table 2.** Multivariate adjusted odds ratio for subjects with higher BMI (≥25 and ≥30 kg/m$^2$) and waist circumference (≥85 and ≥90 cm)

| | BMI ≥ 25 (n = 418/863) | | BMI ≥ 30 (n = 100/863) | | WC ≥ 85 (n = 443/824) | | WC ≥ 90 (n = 261/824) | |
|---|---|---|---|---|---|---|---|---|
| | OR (95% CI)[a] | p value | OR (95% CI)[a] | p value | OR (95% CI)[a] | p value | OR (95% CI)[a] | p value |
| Eating speed | | <0.001[b] | | 0.066[b] | | <0.001[b] | | <0.001[b] |
| Slow, very slow | reference | | reference | | reference | | reference | |
| Ordinary | 1.40 (0.80–2.46) | 0.240 | 1.86 (0.63–5.51) | 0.259 | 1.72 (0.96–3.11) | 0.070 | 2.34 (1.08–5.05) | 0.031 |
| Fast | 2.65 (1.52–4.65) | <0.001 | 2.66 (0.92–7.72) | 0.072 | 3.13 (1.74–5.64) | <0.001 | 3.90 (1.82–8.34) | <0.001 |
| Very fast | 5.04 (1.95–13.07) | <0.001 | 4.80 (1.21–19.09) | 0.026 | 6.59 (2.37–18.48) | <0.001 | 5.22 (1.81–15.06) | 0.002 |
| Number of missing functional teeth | 1.14 (1.01–1.28) | 0.041 | 1.05 (0.90–1.22) | 0.523 | 1.14 (1.01–1.29) | 0.041 | 1.14 (1.01–1.28) | 0.035 |
| Periodontal status | | 0.083[b] | | 0.143[b] | | 0.069[b] | | 0.007[b] |
| 0 | reference | | reference | | reference | | reference | |
| 1 | 1.32 (0.98–1.77) | 0.067 | 1.10 (0.69–1.75) | 0.704 | 1.32 (0.97–1.78) | 0.073 | 1.26 (0.90–1.75) | 0.176 |
| 2 | 1.72 (0.94–3.15) | 0.078 | 2.21 (0.99–4.95) | 0.053 | 1.87 (0.99–3.53) | 0.055 | 2.74 (1.46–5.13) | 0.002 |
| Age | | 0.716[b] | | 0.896[b] | | 0.350[b] | | 0.081[b] |
| <39 years | reference | | reference | | reference | | reference | |
| 40–44 years | 1.05 (0.72–1.53) | 0.785 | 1.25 (0.70–2.22) | 0.452 | 1.06 (0.72–1.57) | 0.761 | 1.53 (0.99–2.36) | 0.054 |
| 45–49 years | 1.15 (0.77–1.72) | 0.498 | 1.12 (0.60–2.10) | 0.714 | 1.37 (0.90–2.08) | 0.141 | 1.67 (1.06–2.64) | 0.027 |
| ≥50 years | 1.28 (0.82–2.00) | 0.276 | 1.20 (0.60–2.38) | 0.609 | 1.36 (0.86–2.16) | 0.194 | 1.81 (1.09–3.00) | 0.022 |
| Military ranks | | | | | | | | |
| Officers | reference | | reference | | reference | | reference | |
| Petty officers | 2.14 (1.45–3.15) | <0.001 | 3.72 (1.63–8.48) | 0.002 | 1.87 (1.27–2.77) | 0.002 | 2.48 (1.56–3.94) | <0.001 |

*Table 2 continued on next page*

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**Table 2.** Continued

| | BMI ≥ 25 (n = 418/863) | | BMI ≥ 30 (n = 100/863) | | WC ≥ 85 (n = 443/824) | | WC ≥ 90 (n = 261/824) | |
|---|---|---|---|---|---|---|---|---|
| | OR (95% CI)[a] | p value | OR (95% CI)[a] | p value | OR (95% CI)[a] | p value | OR (95% CI)[a] | p value |
| Alcohol habit | | | | | | | | |
| No | reference | | reference | | reference | | reference | |
| Yes | 0.8 (0.55–1.15) | 0.219 | 0.56 (0.34–0.93) | 0.023 | 1.06 (0.73–1.55) | 0.747 | 0.73 (0.49–1.08) | 0.118 |
| Smoking habit | | 0.396[b] | | 0.207[b] | | 0.839[b] | | 0.753[b] |
| Nonsmoker | reference | | reference | | reference | | reference | |
| Past smoker | 1.25 (0.85–1.84) | 0.262 | 0.58 (0.31–1.07) | 0.080 | 0.96 (0.64–1.42) | 0.828 | 0.91 (0.59–1.39) | 0.650 |
| Current smoker | 1.00 (0.70–1.44) | 0.982 | 0.74 (0.44–1.24) | 0.250 | 0.90 (0.62–1.30) | 0.565 | 0.86 (0.58–1.28) | 0.452 |
| Exercise frequency | | 0.114[b] | | 0.015[b] | | 0.010[b] | | 0.007[b] |
| Regularly | reference | | reference | | reference | | reference | |
| Sometimes | 1.44 (1.02–2.03) | 0.040 | 1.85 (1.13–3.04) | 0.015 | 1.73 (1.21–2.47) | 0.003 | 1.82 (1.25–2.64) | 0.002 |
| Others | 1.20 (0.84–1.70) | 0.309 | 0.85 (0.48–1.51) | 0.579 | 1.25 (0.88–1.79) | 0.221 | 1.33 (0.90–1.96) | 0.148 |

[a]Controlled for all variables; eating speed, number of missing functional teeth, periodontal status, age, military ranks, alcohol habit, smoking habit, and exercise frequency.

[b]P for trend.

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develop eating speed and masticatory habits in youth, and it may therefore be more difficult to motivate behavioral change in adulthood. Our finding that the loss of functional teeth was independently associated with obesity indicates that obesity could be prevented by ensuring that people receive proper periodontal and/or prosthetic dental treatment.

The importance of taking lifestyle and socioeconomic status into account is emphasized by our finding that a lower ranking in the military was associated with a high rate of obesity. Military rank is a marker of a person's socioeconomic status. Socioeconomic status has a significant influence on nutrition, physical health, accessibility to medical care, and life expectancy [37, 38]. In western nations, there are many studies about socioeconomic status because data about health inequalities are often available. In Japan, few studies have included socioeconomic status, and disparities are relatively small [39]. In this study, we identified a health inequality in a social group which has small disparities. This finding indicates that different approaches must be considered when providing health education to officers and petty officers.

This study had several limitations. First, the cross-sectional design of this study makes it difficult to draw any conclusions on causal relationships based on the findings. Prospective and/or interventional studies are required to confirm the association between oral health status, eating speed, and obesity. An impact of reducing eating speed and improving oral health status on obesity prevention is to be expected in such studies. Second, we used eating speed determined by self-report for analysis. Though it is not an objective index, several studies have found a positive relationship between subjective eating speed and BMI [13, 40]. Finally, because participants in our study were in a special, uniform group, it may be difficult to generalize these results. Compared with civilians, our study participants work harder physically [41] and eat a larger amount of food and so have a higher energy intake.

In summary, eating speed and the number of missing functional teeth are associated with obesity and high WC. Additionally, military rank also shows an association with these parameters. Thus, eating slowly and maintaining chewing ability through proper periodontal and/or prosthetic dental treatment may lead to better dietary habits, which could help to prevent obesity. Also, military rank should be taken into account in health education about obesity.

## Disclosure Statement

The authors declare no conflict of interest.

## References

1 World Health Organization: Obesity and Overweight Fact Sheet 2018. *www.who.int/mediacentre/factsheets/fs311/en/* (last accessed April 4, 2018).
2 Kopelman PG: Obesity as a medical problem. Nature 2000;404:635–643.
3 Hubert HB, Feinleib M, McNamara PM, Castelli WP: Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. Circulation 1983;67:968–977.
4 Dorn JM, Schisterman EF, Winkelstein W Jr, Trevisan M: Body mass index and mortality in a general population sample of men and women. The Buffalo Health Study. Am J Epidemiol 1997;146:919–931.
5 Pinho MM, Faria-Almeida R, Azevedo E, Manso MC, Martins L: Periodontitis and atherosclerosis: an observational study. J Periodontal Res 2013;48:452–457.
6 Hayashida H, Saito T, Kawasaki K, Kitamura M, Furugen R, Iwasaki T, Hayashida Y, Nakazato M, Sekita T, Takamura N, Maeda T: Association of periodontitis with carotid artery intima-media thickness and arterial stiffness in community-dwelling people in Japan: the Nagasaki Islands study. Atherosclerosis 2013;229:186–191.
7 Saito T, Shimazaki Y: Metabolic disorders related to obesity and periodontal disease. Periodontology 2000 2007;43:254–266.
8 Saito T, Shimazaki Y, Sakamoto M: Obesity and Periodontitis. N Engl J Med 1998;339:482–483.

9 Saito T, Shimazaki Y, Koga T, Tsuzuki M, Ohshima A: Relationship between upper body obesity and periodontitis. J Dental Res 2001;80:1631–1636.
10 Shimazaki Y, Saito T, Yonemoto K, Kiyohara Y, Iida M, Yamashita Y: Relationship of metabolic syndrome to periodontal disease in Japanese women: the Hisayama Study. J Dent Res 2007;86:271–275.
11 Kaye EK, Chen N, Cabral HJ, Vokonas P, Garcia RI: Metabolic syndrome and periodontal disease progression in men. J Dent Res 2016;95:822–828.
12 Aida J, Ando Y, Akhter R, Aoyama H, Masui M, Morita M: Reasons for permanent tooth extractions in Japan. J Epidemiol 2006;16:214–219.
13 Otsuka R, Tamakoshi K, Yatsuya H, Murata C, Sekiya A, Wada K, Zhang HM, Matsushita K, Sugiura K, Takefuji S, OuYang P, Nagasawa N, Kondo T, Sasaki S, Toyoshima H: Eating fast leads to obesity: findings based on self-administered questionnaires among middle-aged Japanese men and women. J Epidemiol 2006;16:117–124.
14 Sasaki S, Katagiri A, Tsuji T, Shimoda T, Amano K: Self-reported rate of eating correlates with body mass index in 18-y-old Japanese women. Int J Obes Relat Metab Disord 2003;27:1405–1410.
15 Leong SL, Madden C, Gray A, Waters D, Horwath C: Faster self-reported speed of eating is related to higher body mass index in a nationwide survey of middle-aged women. J Am Diet Assoc 2011;111:1192–1197.
16 Murakami K, Miyake Y, Sasaki S, Tanaka K, Arakawa M: Self-reported rate of eating and risk of overweight in Japanese children: Ryukyus Child Health Study. J Nutr Sci Vitaminol (Tokyo) 2012;58:247–252.
17 Kimura Y, Nanri A, Matsushita Y, Sasaki S, Mizoue T: Eating behavior in relation to prevalence of overweight among Japanese men. Asia Pac J Clin Nutr 2011;20:29–34.
18 Fukuda H, Saito T, Mizuta M, Moromugi S, Ishimatsu T, Nishikado S, Takagi H, Konomi Y: Chewing number is related to incremental increases in body weight from 20 years of age in Japanese middle-aged adults. Gerodontology 2013;30:214–219.
19 Ohkuma T, Hirakawa Y, Nakamura U, Kiyohara Y, Kitazono T, Ninomiya T: Association between eating rate and obesity: a systematic review and meta-analysis. Int J Obes 2015;39:1589–1596.
20 Lee JS, Mishra G, Hayashi K, Watanabe E, Mori K, Kawakubo K: Combined eating behaviors and overweight: eating quickly, late evening meals, and skipping breakfast. Eat Behav 2016;21:84–88.
21 Otsuka R, Tamakoshi K, Yatsuya H, Wada K, Matsushita K, OuYang P, Hotta Y, Takefuji S, Mitsuhashi H, Sugiura K, Sasaki S, Kral JG, Toyoshima H: Eating fast leads to insulin resistance: findings in middle-aged Japanese men and women. Prev Med 2008;46:154–159.
22 Radzevičienė L, Ostrauskas R: Fast eating and the risk of type 2 diabetes mellitus: a case-control study. Clin Nutr 2013;32:232–235.
23 Sakurai M, Nakamura K, Miura K, Takamura T, Yoshita K, Nagasawa SY, Morikawa Y, Ishizaki M, Kido T, Naruse Y, Suwazono Y, Sasaki S, Nakagawa H: Self-reported speed of eating and 7-year risk of type 2 diabetes mellitus in middle-aged Japanese men. Metabolism 2012;61:1566–1571.
24 Takamura T, Sakurai M, Nakamura M, Shimizu A, Ota T, Misu H, Takeshita Y, Tsuchiyama N, Kurita S, Ando H, Kaneko S: Factors associated with improvement of fasting plasma glucose level by mealtime dosing of a rapid-acting insulin analog in type 2 diabetes. Diabetes Res Clin Pract 2007;75:278–284.
25 Chaffee BW, Weston SJ: Association between chronic periodontal disease and obesity: a systematic review and meta-analysis. J Periodontol 2010;81:1708–1724.
26 Östberg AL, Nyholm M, Gullberg B, Rastam L, Lindblad U: Tooth loss and obesity in a defined Swedish population. Scand J Public Health 2009;37:427–433.
27 Bernardo Cde O, Boing AF, Vasconcelos Fde A, Peres KG, Peres MA: Association between tooth loss and obesity in Brazilian adults: a population-based study. Rev Saude Publica 2012;46:834–842.
28 The Examination Committee of Criteria for 'Obesity Disease' in Japan, Japan Society for the Study of Obesity: New criteria for 'obesity disease' in Japan. Circ J 2002;66:987–992.
29 World Health Organization: Waist Circumference and Waist-Hip Ratio: Report of a WHO Expert Consultation, Geneva, 8–11 December 2008. Geneva, World Health Organization, 2011. *http://www.who.int/nutrition/publications/obesity/WHO_report_waistcircumference_and_waisthip_ratio/en/* (last accessed April 4, 2018).
30 World Health Organization: Oral Health Surveys: Basic Methods, 4thed. Geneva, World Health Organization, 1997.
31 Saito T, Shimazaki Y, Koga T, Tsuzuki M, Ohshima A: Relationship between periodontitis and hepatic condition in Japanese women. J Int Acad Periodontol 2006;8:89–95.
32 Brennan DS, Spencer AAJ, Roberts-Thomson KF: Tooth loss, chewing ability and quality of life. Qual Life Res 2008;17: 227–235.
33 Sakata T, Yoshimatsu H, Masaki T, Tsuda K: Anti-obesity actions of mastication driven by histamine neurons in rats. Exp Biol Med (Maywood) 2003;228:1106–1110.
34 Pilotto LM, Celeste RK, Faerstein E, Slavutzky SM: Association between tooth loss and overweight/obesity among Brazilian adults: the Pro-Saude Study. Braz Oral Res 2014;28:1–6.
35 Ritchie CS, Joshipura K, Hung HC, Douglass CW: Nutrition as a mediator in the relation between oral and systemic disease: associations between specific measures of adult oral health and nutrition outcomes. Crit Rev Oral Biol Med 2002;13:291–300.
36 Touger-Decker R, Mobley C, Academy of N, Dietetics: Position of the Academy of Nutrition and Dietetics: oral health and nutrition. J Acad Nutr Diet 2013;113:693–701.
37 Lynch JW, Kaplan GA, Shema SJ: Cumulative impact of sustained economic hardship on physical, cognitive, psychological, and social functioning. N Engl J Med 1997;337:1889–1895.

Obes Facts 2018;11:165–175
DOI: 10.1159/000488533




38 Aldabe B, Anderson R, Lyly-Yrjänäinen M, Parent-Thirion A, Vermeylen G, Kelleher CC, Niedhammer I: Contribution of material, occupational, and psychosocial factors in the explanation of social inequalities in health in 28 countries in Europe. J Epidemiol Community Health 2011;65:1123–1131.
39 Uchida E, Araki S, Murata K: Socioeconomic factors affecting the longevity of the Japanese population: a study for 1980 and 1985. J Biosoc Sci 1992;24:497–504.
40 Maruyama K, Sato S, Ohira T, Maeda K, Noda H, Kubota Y, Nishimura S, Kitamura A, Kiyama M, Okada T, Imano H, Nakamura M, Ishikawa Y, Kurokawa M, Sasaki S, Iso H: The joint impact on being overweight of self reported behaviours of eating quickly and eating until full: cross sectional survey. BMJ 2008;337:a2002.
41 Okamoto Y, Miyazaki N, Kurumagawa H, Fujino K, Mori K, Shimizu S, Ishikawa K: Relationship between morbidity and body mass index of mariners in the Japan Maritime Self-Defense Force Fleet Escort Force. Mil Med 2001;166:681–684.