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# Relationship between oral health behaviour and handgrip strength: a cross-sectional study with 7589 Korean adults

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**ABSTRACT**

**Objective:** This cross-sectional study investigated the relationship between handgrip strength and oral health behaviours among Koreans.

**Methods:** The data of 7589 individuals (3384 men and 4205 women) aged ≥19 years who participated in the Korea National Health and Nutrition Examination Survey 2014–2015 were analyzed. Oral health behaviour was assessed based on the number of daily toothbrushing sessions and the use of secondary oral-care products. The association between oral-health behaviour and handgrip strength was investigated adjusting for confounders. Multivariable logistic regression analysis was performed ($\alpha = 0.05$).

**Results:** The proportion of participants diagnosed with sarcopenia was significantly higher in the group with poor oral-health behaviours. After adjusting for confounders including age, the adjusted odds ratios and 95% confidence intervals of female participants with low handgrip strength in groups toothbrushing thrice or more per day, twice per day, and once or less per day were 1 (reference), 1.18 (0.99–1.4), and 1.24 (0.89–1.71), respectively. There were significantly more participants with low handgrip strength in the group that did not use secondary oral products for both sexes.

**Conclusions:** Oral health behaviour is associated with handgrip strength among adults. Poor oral self-care habits may constitute a risk indicator for low muscle strength.

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**KEYWORDS**
Dental care; muscle strength; oral health; oral hygiene; sarcopenia

## Introduction

Maintaining muscle strength is an important factor for a healthy lifestyle [1,2]. Reduced skeletal muscle strength may be associated with frailty, disability, falls, and metabolic syndrome [3–5]. Furthermore, a low level of skeletal muscle mass and strength correlates with an increased risk of morbidity, hospitalization, and mortality in the elderly [6,7]. Handgrip dynamometry, a quick, inexpensive, and easy method to measure grip strength, has been reported to be a valid and reliable method to assess whole body muscle strength [8,9]. As handgrip strength clearly differs among ethnicities and nationalities [10,11], different cut-off values should be applied accordingly. The Asian Working Group for Sarcopenia has defined weak handgrip strength of <26 kg for men and <18 kg for women as indicative of sarcopenia [12].

Oral health behaviours may be related to general health behaviours [13,14]. Specifically, those who regularly use a toothbrush, dental floss, or mouthwash are more likely to care about their general health condition [14,15]. In this respect, oral health behaviour can be an indicator of general health [15]. In addition, several studies have reported that the frequency of toothbrushing and the use of secondary oral products are linked to systemic conditions, such as metabolic syndrome and obesity [16–18]. Lifestyle habits, such as oral health self-care, can be impeded by muscle strength loss. However, whether reduced muscular strength is connected to poor oral self-care or vice versa has not yet been well-studied [19].

In this study, we aimed to investigate the correlation between handgrip strength and oral health behaviours on the basis of nationwide data of the Korean adult population. The null hypothesis of this study was that no significant relationship exists between handgrip strength and oral health behaviours in Korean adults.

## Methods

### *Study participants*

Data from the Korean National Health and Nutrition Examination Survey (KNHANES) 2014–2015 were analyzed in the present study. The KNHANES is conducted annually to monitor the general health and nutritional status of the

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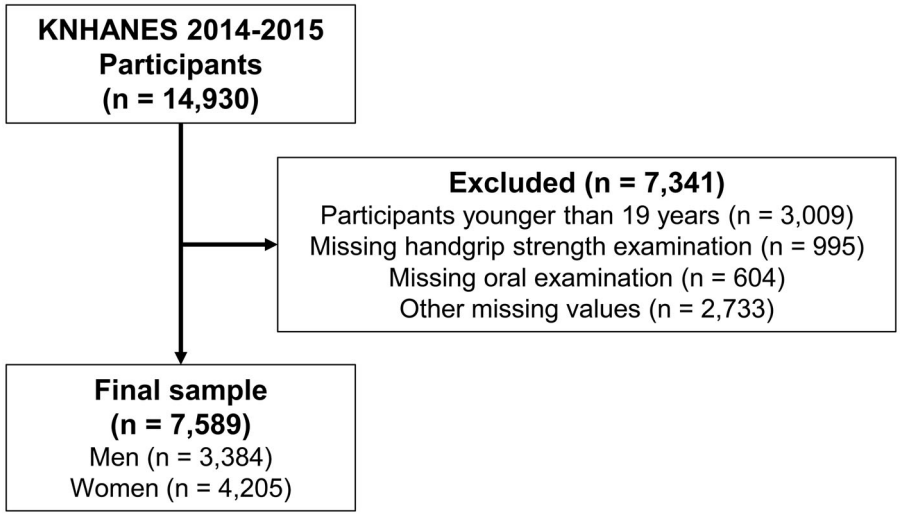


**Figure 1.** Flow chart of the study enrolment process.

South Korean population by the Korean Centres for Disease Control and Prevention (KCDC) and the Korean Ministry of Health and Welfare. The Institutional Review Board (IRB) of the KCDC approved this nationwide study (IRB number: 2013-12EXP-03-5C). All study procedures were carried out in accordance with the Helsinki Declaration. Trained interviewers and examiners recorded the data of the study participants *via* a health interview, health examination, and nutritional survey. This cross-sectional study was compliant with the STROBE guidelines [20].

Initially, a total of 14,930 participants were included in the KNHANES 2014–2015. Informed consent was obtained from all participants involved. In this study, the data of participants aged ≥19 years ($n = 11,921$) were analyzed. Participants who did not participate in the handgrip strength examination ($n = 995$) and oral examination ($n = 604$) were excluded. Those with missing data for confounders ($n = 2733$) were also excluded. Finally, 7589 participants (3384 men and 4205 women) were included (Figure 1).

### Inclusion criteria

- Age ≥19 years
- Participation in handgrip strength examination
- Participation in oral examination
- Presence of data regarding confounders

### Exclusion criteria

- Absence of arms, hands, or fingers
- Presence of hand paralysis
- Presence of hand or finger casting
- Presence of a full hand or wrist bandage
- Had undergone surgical treatment of the hand or wrist within the past three months
- Had experienced pain, prickling, and/or rigidness of the hand or wrist within the past one week

### Oral health behaviours

Participants' oral health behaviours were surveyed through the administration of a questionnaire. The frequency of daily toothbrushing was represented by the number of toothbrushing sessions each day. The toothbrushing frequency was categorized into the following three groups: toothbrushing ≤1, 2, and ≥3 times per day.

The secondary oral products included dental floss, interdental toothbrushes, electric toothbrushes, and mouthwashes. According to their use of secondary oral products, participants were classified into two categories: 'yes' and 'no.'

### Handgrip strength

Participants' handgrip strength was estimated using a digital hand dynamometer (Digital Grip Strength Dynamometer, Takei, Tokyo, Japan). Prior to measuring handgrip strength, the assessment methods were explained in detail to the participant, and accessories on the participant's hand and wrist were removed. Participant grip strength was measured in the standing position, with both arms naturally lowered. The handgrip strength of both hands was then assessed thrice at 1-minute intervals. The maximum holding time of the digital hand dynamometer was limited to within 3 s. The maximum grip strength of the preferred hand was documented in kg and used in the analysis [21]. For further analysis, handgrip strength was categorized according to the Asian Working Group for Sarcopenia as follows: reduced (<26 kg) and normal (≥26 kg) in men; reduced (<18 kg) and normal (≥18 kg) in women [12]. Handgrip strength of <26 kg for men and <18 kg for women was assumed to indicate the presence of sarcopenia. Low handgrip strength below the cut-off value can be utilized as a clinical predictor for limited mobile activity [22,23].

### Potential confounders

All participants were asked to submit a self-reported questionnaire containing data on sociodemographic and lifestyle

features, including age, household income, education level, smoking habits, and alcohol intake. According to their answers to the questionnaires, the smoking habit of participants was categorized as 'yes' (current smoker) or 'no' (non-smoker and ex-smoker). Based on the frequency of alcohol intake during the previous 1 year, the drinking status of the participants was classified as 'yes' (≥2 days per month) or 'no' (≤1 day per month).

The weights, heights, and waist circumferences of the participants were measured to the nearest 0.1 kg, 0.1 cm, and 0.1 cm, respectively, by trained examiners. The body mass index (BMI) was documented by dividing the body weight in kg by the height in $m^2$ ($kg/m^2$). Obesity was assumed as a BMI of ≥25 [24].

A mercury sphygmomanometer (Baumanometer; Baum, Copiague, NY, USA) was used to assess the systolic and diastolic blood pressures. Participants with systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg or who were using medication for hypertension were defined as hypertensive. Venous blood samples were collected from participants who had fasted for >8 h by trained examiners.

Glucose levels were analyzed using the enzymatic method of the Automatic Analyzer 7600 (Hitachi Co., Tokyo, Japan). Participants were defined as diabetic if they had a fasting plasma glucose level of ≥126 mg/dL, were receiving treatment with insulin or anti-diabetic drugs or had been diagnosed with diabetes mellitus by a physician [25].

Specially trained dentists completed the oral health examinations of all participants. The dental prosthesis status of the participants was classified as 'yes' (those with fixed or removable dental prostheses) or 'no' (those without any dental prostheses) [26].

### *Statistical analysis*

SAS version 9.3 for Windows (SAS Institute, Cary, NC, USA) was used to perform all statistical analyses of the KNHANES data. The assessment represents a complicated design of the survey, including stratification, clustering, and weighting. The KNHANES provided the stratified sampling variable and clustering variable. The SAS survey procedure was utilized to account for the complex sampling design and provide the approximations of the entire Korean population.

All analyses were conducted separately for male and female participants due to known differences in handgrip strength between the sexes. The general characteristics of the study population were investigated using the chi-squared test. Grip strength levels in accordance with oral hygiene behaviours were documented as unadjusted and adjusted means and 95% confidence intervals (CIs) using a general linear model. The means were adjusted for potential confounders (age, household income, education level, smoking status, alcohol consumption, obesity, hypertension, diabetes mellitus, and dental prosthesis status). Multivariable logistic regression analyses were conducted to evaluate the relationship between reduced handgrip strength and oral hygiene behaviours. The handgrip strength was dichotomized as low or not low using cut-off scores for conducting the logistic regression. The median handgrip strength value in the present study was used as the cut-off value. Statistical analyses were also performed after adjusting for potential confounders, including age, household income, education level, smoking status, alcohol consumption, obesity, hypertension, diabetes mellitus, and dental prosthesis status (Models 2 and 3). A *p*-value (*p*) of <.05 was considered statistically significant.

## Results

Table 1 presents the general characteristics of the participants according to their oral health behaviours and potential confounders. Most potential confounders had a statistically significant relationship with the frequency of toothbrushing per day. In both men and women, those who were 60 years old or older were the most likely to have brushed once or less per day ($p < .001$ for both sexes).

Table 2 presents the levels of handgrip strength according to the frequency of tooth brushing per day and the use of secondary oral products after adjusting for various confounders. The unadjusted and adjusted means for grip strength revealed a tendency for handgrip strength to increase with the number of toothbrushing sessions per day and secondary oral products used ($p < .05$), with the exception of the male participants' toothbrushing frequency ($p = .29$). However, the men who brushed their teeth twice or more per day (adjusted mean, 40.9 kg; 95% CI, 40.4–41.5) still exhibited stronger handgrip strength than that of those who brushed less than two times per day (adjusted mean, 40.2 kg; 95% CI, 39.4–41).

Figure 2 shows the distribution of grip strength according to oral hygiene behaviour. The weighted percentages of men and women with sarcopenia (<26 kg for men and <18 kg for women according to the Asian Working Group for Sarcopenia [12]) were significantly higher in participants with lower oral hygiene behaviour ($p < .01$ for both sexes).

Table 3 indicates the relationship between handgrip strength and oral hygiene behaviour in the multivariable logistic regression models. After adjusting for potential confounders (Model 3), significantly more participants had lower handgrip strength than the median values (41.3 kg for men and 25.4 kg for women) in both men and women when secondary oral products were not used. The relationship between handgrip strength and the frequency of toothbrushing per day was consistent with the use of secondary oral products, but this relationship disappeared in men in the fully adjusted model ($p = .2$).

## Discussion

The null hypothesis was not supported by the results of the study. In female participants, the risk of low handgrip strength was 1.24-fold higher when less frequency of toothbrushing per day and/or no use of secondary oral products were present. The male participants who did not use secondary oral products also had a 1.36-fold increase in the risk of having low handgrip strength.

**Table 1.** General characteristics of study participants according to the oral health behaviours and potential confounders.

| | Frequency of tooth brushing per day | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Men ($n = 3384$) | | | | Women ($n = 4205$) | | | |
| | ≤1 ($n = 529$) | 2 ($n = 1327$) | ≥3 ($n = 1528$) | *p*-value | ≤1 ($n = 304$) | 2 ($n = 1537$) | ≥3 ($n = 2364$) | *p*-value |
| Age (years) | | | | <.001 | | | | <.001 |
| 20 to 29 | 17 (2.3) | 22.8 (1.5) | 20.3 (1.4) | | 15.8 (2.8) | 16.4 (1.2) | 20.8 (1.2) | |
| 30 to 39 | 14.4 (2.1) | 18.3 (1.3) | 22.2 (1.3) | | 8.9 (1.9) | 16.7 (1.2) | 22.2 (1.1) | |
| 40 to 49 | 16.6 (2.1) | 19.5 (1.2) | 23.3 (1.2) | | 15.7 (2.5) | 17.9 (1.2) | 23.9 (1) | |
| 50 to 59 | 19.8 (2) | 21.3 (1.3) | 19 (1.1) | | 17.4 (2.5) | 20.1 (1.2) | 19.9 (1) | |
| ≥60 | 32.2 (2.3) | 18.1 (1) | 15.3 (0.9) | | 42.2 (3.6) | 28.9 (1.4) | 13.1 (0.8) | |
| Income | | | | <.001 | | | | <.001 |
| Lowest quartile | 22.8 (2.1) | 11.7 (1) | 7.6 (0.8) | | 23.4 (2.1) | 12.1 (1) | 5.2 (0.6) | |
| Lower middle quartile | 32.6 (2.7) | 26.5 (1.6) | 19.3 (1.3) | | 11.4 (1.6) | 9.1 (0.8) | 6.3 (0.7) | |
| Upper middle quartile | 27.3 (2.7) | 32.1 (1.6) | 32.2 (1.6) | | 37.9 (2.8) | 45.1 (1.6) | 37.5 (1.6) | |
| Highest quartile | 17.3 (2.2) | 29.7 (1.7) | 40.8 (1.8) | | 27.3 (2.5) | 33.8 (1.6) | 51.1 (1.7) | |
| Education level | | | | <.001 | | | | <.001 |
| Primary school | 35.1 (3.5) | 17.6 (1.1) | 9.9 (0.9) | | 41.5 (3.4) | 25.6 (1.3) | 10.5 (0.7) | |
| Middle school | 29.3 (3.4) | 26.5 (1.5) | 22 (1.2) | | 11.1 (1.9) | 11.1 (0.9) | 8 (0.7) | |
| High school | 20.1 (2.5) | 29.5 (1.7) | 32.4 (1.4) | | 31.4 (3.3) | 32.7 (1.5) | 39.5 (1.3) | |
| College | 15.5 (2.5) | 26.4 (1.6) | 35.7 (1.6) | | 16 (2.6) | 30.6 (1.6) | 42 (1.3) | |
| Smoking status | | | | <.01 | | | | <.001 |
| No | 58.2 (2.6) | 58.8 (1.6) | 65.2 (1.5) | | 91.4 (2) | 96.2 (0.6) | 95.5 (0.5) | |
| Yes | 41.8 (2.6) | 41.2 (1.6) | 34.8 (1.5) | | 8.6 (2) | 3.8 (0.6) | 4.5 (0.5) | |
| Alcohol consumption | | | | .10 | | | | .01 |
| No | 40.4 (2.6) | 34.1 (1.6) | 34.5 (1.5) | | 80.1 (2.6) | 68.8 (1.4) | 66.2 (1.2) | |
| Yes | 59.6 (2.6) | 65.9 (1.6) | 65.5 (1.5) | | 19.9 (2.6) | 31.2 (1.4) | 33.8 (1.2) | |
| Obesity | | | | .40 | | | | <.001 |
| No | 60.4 (2.4) | 61.2 (1.6) | 63.5 (1.5) | | 63 (3.2) | 68.8 (1.3) | 77.6 (1) | |
| Yes | 39.6 (2.4) | 38.8 (1.6) | 36.5 (1.5) | | 37 (3.2) | 31.2 (1.3) | 22.4 (1) | |
| Hypertension | | | | <.001 | | | | <.001 |
| No | 65.5 (2.5) | 73.9 (1.4) | 76.1 (1.2) | | 67.4 (3.2) | 74 (1.2) | 84.8 (0.8) | |
| Yes | 34.5 (2.5) | 26.1 (1.4) | 23.9 (1.2) | | 32.6 (3.2) | 26 (1.2) | 15.2 (0.8) | |
| Diabetes mellitus | | | | <.01 | | | | <.001 |
| No | 85.6 (1.6) | 89.3 (0.8) | 91.3 (0.8) | | 85.2 (2.4) | 90 (0.9) | 95.5 (0.4) | |
| Yes | 14.4 (1.6) | 10.7 (0.8) | 8.7 (0.8) | | 14.8 (2.4) | 10 (0.9) | 4.5 (0.4) | |
| Dental prosthesis status | | | | .11 | | | | <.001 |
| No | 61.2 (2.6) | 66.4 (1.5) | 67.3 (1.3) | | 53.6 (3.5) | 61.2 (1.5) | 69.3 (1) | |
| Yes | 38.8 (2.6) | 33.6 (1.5) | 32.7 (1.3) | | 46.4 (3.5) | 38.8 (1.5) | 30.7 (1) | |
| Use of secondary oral products | | | | <.001 | | | | <.001 |
| No | 67.5 (2.9) | 57.6 (1.7) | 42.1 (1.5) | | 59.7 (3.2) | 48.7 (1.5) | 34.3 (1.2) | |
| Yes | 32.5 (2.9) | 42.4 (1.7) | 57.9 (1.5) | | 40.3 (3.2) | 51.3 (1.5) | 65.7 (1.2) | |

Data are shown as the weighted percentage (standard error).

**Table 2.** Levels of handgrip strength (kg) according to the oral health behaviour.

| | Frequency of tooth brushing per day | | | | Use of secondary oral products | | |
|---|---|---|---|---|---|---|---|
| Handgrip strength (kg) | ≤1 | 2 | ≥3 | *p* for trend | No | Yes | *p* for trend |
| Men ($n = 3384$) | ($n = 529$) | ($n = 1327$) | ($n = 1528$) | | ($n = 1842$) | ($n = 1542$) | |
| Unadjusted[a] | 40.6 (39.8–41.4) | 42.7 (42.2–43.3) | 43 (42.5–43.5) | <.001 | 41.7 (41.2–42.2) | 43.5 (43–44) | <.001 |
| Adjusted[b] | 40.2 (39.4–41) | 41.1 (40.6–41.6) | 40.9 (40.4–41.5) | .29 | 40.5 (40–41) | 41.4 (40.9–42) | <.01 |
| Women ($n = 4205$) | ($n = 304$) | ($n = 1537$) | ($n = 2364$) | | ($n = 1781$) | ($n = 2424$) | |
| Unadjusted[a] | 24.3 (23.4–25.1) | 25.4 (25.1–25.7) | 26.3 (26.1–26.6) | <.001 | 25.1 (24.8–25.4) | 26.4 (26.1–26.6) | <.001 |
| Adjusted[b] | 24.8 (24.1–25.5) | 25.2 (24.9–25.6) | 25.6 (25.3–25.8) | .02 | 25.1 (24.8–25.4) | 25.6 (25.4–25.9) | <.01 |

CI: confidence interval.
[a]Data are shown as the unadjusted mean (95% CI) by analysis of variance.
[b]Data are shown as the adjusted mean (95% CI) adjusting for age, household income, education level, smoking status, alcohol consumption, obesity, hypertension, diabetes mellitus, and dental prosthesis status by analysis of covariance.

The relationship between oral hygiene behaviours and handgrip strength has not been well studied [19]. Previously, Komulainen et al. [19] studied the association of instrumental activities and handgrip strength with oral health behaviour among elderly persons. The results of their study indicated that the inability to perform daily activities was connected to oral self-care methods, but no significant association was found between handgrip strength and the frequency of toothbrushing. These results are not consistent with those of the present study; however, this may be explained by differences in sample size, age of participants, and categorization (lowest tertile vs. middle and highest tertiles) of the handgrip strength variable. Komulainen et al. [19], for example, studied only 168 participants aged ≥75 years. In contrast, this study included >7000 participants with a wider age range; thus, the statistical power to detect an association between oral health behaviour and handgrip strength was greatly enhanced.

The results of this study can be explained from several perspectives. It is well known that poor oral health

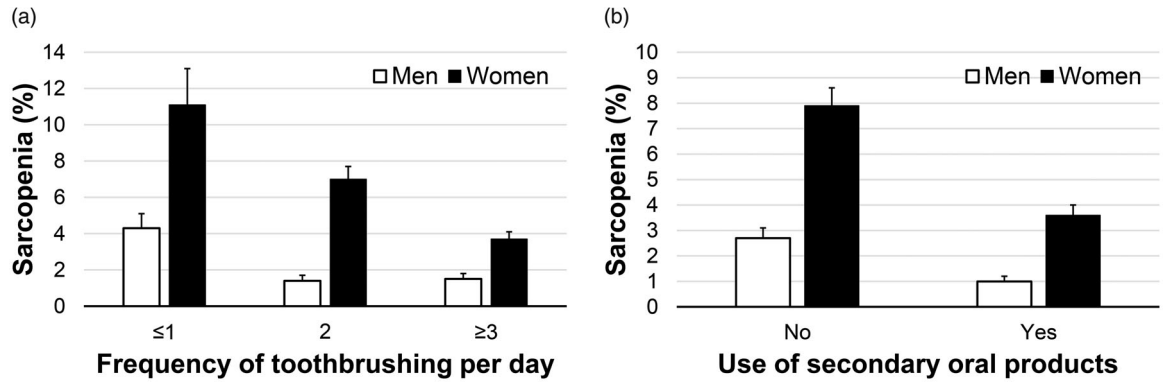


**Figure 2.** Weighted percentage distribution of men and women with sarcopenia according to their oral health behaviours. Sarcopenia was defined with cut-off handgrip strength values of <26 kg in men and <18 kg in women according to the Asian Working Group for Sarcopenia. Data are shown as the weighted percentage (standard error). (a) Distribution of sarcopenia according to the frequency of toothbrushing per day ($p$ for trend <.01 for men and <.001 for women). (b) Distribution of sarcopenia according to the use of secondary oral products ($p$ for trend <.001 for both sexes).

**Table 3.** Adjusted odds ratios for individuals with low handgrip strength according to the oral health behaviour.

| | Men ($n = 3384$) | | | Women ($n = 4205$) | | |
|---|---|---|---|---|---|---|
| Oral health behaviour | Model 1[a] | Model 2[b] | Model 3[c] | Model 1[a] | Model 2[b] | Model 3[c] |
| Frequency of toothbrushing per day | | | | | | |
| ≤1 | 1.72 (1.36–2.18) | 1.45 (1.12–1.88) | 1.23 (0.94–1.6) | 1.86 (1.36–2.52) | 1.47 (1.07–2.01) | 1.24 (0.89–1.71) |
| 2 | 1.13 (0.96–1.35) | 1.12 (0.93–1.34) | 1.03 (0.86–1.24) | 1.42 (1.22–1.66) | 1.25 (1.06–1.47) | 1.18 (0.99–1.4) |
| ≥3 | 1 (ref.) | 1 (ref.) | 1 (ref.) | 1 (ref.) | 1 (ref.) | 1 (ref.) |
| $p$ for trend | <.001 | <.01 | .20 | <.001 | <.01 | .02 |
| Use of secondary oral products (no) | | | | | | |
| No | 1.61 (1.34–1.93) | 1.53 (1.26–1.85) | 1.36 (1.12–1.66) | 1.52 (1.32–1.75) | 1.4 (1.21–1.63) | 1.24 (1.06–1.45) |
| Yes | 1 (ref.) | 1 (ref.) | 1 (ref.) | 1 (ref.) | 1 (ref.) | 1 (ref.) |
| $p$ for trend | <.001 | <.001 | <.01 | <.001 | <.001 | <.01 |

Data are shown as odds ratios (95% confidence interval).
Cut-off values of low handgrip strength: median values for men [<41.3 kg] and women [<25.4 kg].
[a]Crude association.
[b]Adjusted for age.
[c]Adjusted for age, household income, education level, smoking status, alcohol consumption, obesity, hypertension, diabetes mellitus, and dental prosthesis status by multivariable logistic regression.

behaviours, including inadequate plaque removal, result in periodontitis and tooth loss [27]. These dental problems cause difficulties with chewing, and masticatory difficulty is related to handgrip strength [28–30]. Low muscle strength may therefore be caused by malnutrition due to limited masticatory function [31].

In addition, inflammation may be a causative factor. Poor oral health behaviour has been reported to increase inflammation [16,18,32]. Furthermore, poorly controlled oral hygiene status has been correlated with high levels of C-reactive protein and fibrinogen, which are inflammatory markers in the blood [33,34]. As previous studies have demonstrated that high C-reactive protein levels are connected to low handgrip strength [35,36], C-reactive protein may be a link between oral hygiene behaviour and handgrip strength.

Low handgrip strength is correlated with sarcopenia, disability, and limited dexterity [37,38], and previous studies have reported a connection between limited hand function or inadequate hand dexterity and poor oral care ability [39,40]. If a reduction in hand function and dexterity negatively impacts mastication, a vicious cycle may ensue in which handgrip strength is further reduced by malnutrition.

Previously, Shin [30] reported that the number of missing teeth was related to handgrip strength. The results of the present study may serve as a link in explaining the relationship between the number of missing teeth and handgrip strength. Participants with weak muscle strength will be less likely to perform oral hygiene techniques frequently, resulting in loss of teeth. Conversely, a lack of nutrients due to tooth loss may reduce muscle strength and complicate frequently performing oral hygiene procedures.

In this study, the male participants did not display a significant association between the frequency of toothbrushing and handgrip strength in the fully adjusted model. Men are reported to show a greater difference in strength than women depending on whether they are exercising, while women are reported to have a relatively lower handgrip strength compared to the general male population even if they exercise at the level of elite athletes [41]. It is speculated that the difference in muscle strength in men is primarily caused by the effects of strength exercises rather than the impact of systemic health conditions, which is in contrast to that in women. In this study, however, a significant correlation was observed between the use of secondary oral products and handgrip strength in men in the fully adjusted model.

A decline in handgrip strength can adversely affect various physical and mental conditions that are associated with low grip strength [6,37,42,43]. The knowledge of the relationship between oral health behaviour and handgrip strength can be

used as a preventive measure, with multidisciplinary collaboration between physicians and dentists. Dentists should check whether patients who do not practice adequate oral hygiene self-care exhibit symptoms of sarcopenia. It is also necessary to encourage the use of electric toothbrushes for those who do not have sufficient handgrip strength to remove plaque adequately [44]. In addition, medical doctors should check that patients with sarcopenia practice good oral self-care, emphasize the importance of oral health behaviour to such patients, and consider referral to a dentist if necessary.

A significant strength of the current study is the large number of participant data obtained from the nationwide KNHANES that was used for this analysis. Attempts were also made to identify independent correlations by adjusting for various potential confounders. However, this study was not able to analyze several variables. Poor annual dental care visit has been reported to be associated with poor dental health [45]. A relationship between poor tooth brushing frequency and no dental care visits has been also reported [45]. In addition, since muscular strength is known to be associated with activities of daily living (ADLs) in older adults, ADLs should be considered as a covariate in the analyses [19]. However, due to the nature of this study using big data, it was difficult to include such variables in the analysis. This is because the analyzed dataset did not include data of such variables, and analyzing too many variables increase the likelihood of statistical overfitting problems. Furthermore, the cross-sectional design of this study limited the ability to assess the association between cause and outcome. Additional longitudinal studies will be required to elucidate causality.

In conclusion, within the limitations of this cross-sectional study, poor oral health behaviours were significantly associated with low handgrip strength among Korean adults, with the exception of toothbrushing frequency in men. The female participants with less frequency of toothbrushing per day and/or no use of secondary oral products presented a 1.24-fold increase in the risk of low handgrip strength, which remained significant even after adjustment for various confounders. The male participants who did not use secondary oral products also showed a 1.36-fold higher risk of having low handgrip strength. In this regard, poor oral hygiene behaviours may be considered a risk indicator of low muscle strength.

## Disclosure statement

The authors report no conflict of interest.

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## Data availability

The data that support the findings of this study are available in Korean National Health and Nutrition Examination Survey at https://knhanes.cdc.go.kr/knhanes/eng/index.do

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