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Review

Association between oral health and sarcopenia: A literature review

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Abstract

Purpose: Sarcopenia has recently been attracting attention as an early sign of the need for nursing care in older adults. Some studies have reported that oral health is related to sarcopenia and its diagnostic factors (hand grip strength, walking speed, and skeletal muscle mass). However, the relationship between oral health and sarcopenia remains poorly investigated and no review to date has compiled the available research on this relationship. The aim of this review was to summarize the current evidence describing the association between oral health and sarcopenia.

Study selection: The internet database PubMed was searched using various combinations of related and synonymous keywords for “oral” or “dental” or “oral health” or “oral function” and “sarcopenia” or “walking speed” or “hand grip strength” or “skeletal muscle mass.” A total of 27 studies found to be eligible were critically evaluated and their key findings were summarized.

Results: Most of the studies were cross-sectional and conducted in Japan. A wide range of oral factors, including number of teeth, occlusal support, periodontal state, occlusal force, mastication, tongue pressure, and swallowing, were covered. The overall findings were that oral health indices could be significantly associated with sarcopenia and its diagnostic factors.

Conclusions: Relationships may exist between aspects of oral health and sarcopenia or its diagnostic factors. However, reports showing associations between oral health and sarcopenia are scarce, and definitive conclusions could not be drawn. Further longitudinal studies are necessary to confirm these relationships.

Keywords: Oral health, Sarcopenia, Review, Gerodontology

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1. Introduction

The older adult population is rapidly growing in developed and developing regions alike, and prolonging healthy longevity is a global goal [1]. To achieve healthy longevity, it is important to avoid functional disability. Sarcopenia has been attracting attention in recent years as one of the early stages in the decline toward the need for nursing care. In 1989, Rosenberg addressed the importance of sarcopenia when observing the decrease in skeletal muscle mass that occurred with aging [2]. In 2010, the European Working Group on Sarcopenia in Older People (EWGSOP) proposed the following clinical definition and diagnosis of sarcopenia: “Sarcopenia is a syndrome characterized by a progressive and generalized loss of skeletal muscle mass and strength, with a risk of adverse outcomes, such as physical disability, poor quality of life and death” [3]. In 2014, the Asian Working Group for Sarcopenia (AWGS) proposed diagnostic criteria for sarcopenia for Asians, taking racial, environmental, and cultural differences into consideration [4]. In 2018, the EWGSOP revised their

diagnostic criteria for sarcopenia [5] and in 2019, the AWGS followed suit [6].

Recently, much attention has been focused on the relationship between oral health and sarcopenia. The Japanese Society of Gerodontology has proposed the concept of oral hypofunction, and it is assumed that impaired oral health leads to sarcopenia [7]. The Japanese Society of Dysphagia Rehabilitation, Japanese Association of Rehabilitation Nutrition, Japanese Association on Sarcopenia and Frailty, and Society of Swallowing and Dysphagia of Japan proposed the concept of sarcopenic dysphagia. The potential for dysphagia secondary to sarcopenia was discussed in that position paper [8].

Some reports have shown relationships between oral health and hand grip strength [9–24], walking speed [19–21, 24–26], and skeletal muscle mass [13, 19, 22, 24, 27, 28, 29], which are measurements used in the diagnosis of sarcopenia. Despite the increasing number of reports that have appeared about the association between oral health and sarcopenia [27, 30–35], the details of this relationship remain poorly discussed. In this review, focusing on oral health factors such as oral condition, occlusal force, mastication, tongue pressure, and swallowing, we describe and summarize current evidence pertaining to the association between oral health and sarcopenia. This comprehensive review will contribute to the knowledge base for researchers and clinicians in the field of gerontology. Additionally, we discuss weaknesses in current evidence and make recommendations for future research.

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2. Material and Methods

2.1. Search strategy

A manual search and an electronic search using the internet database PubMed were conducted using the following oral health terms: “oral” or “dental” or “oral health” or “oral function.” The following sarcopenia terms were also searched: “sarcopenia” or “hand grip strength” or “walking speed” or “skeletal muscle mass.” These searches were conducted to identify studies exploring the association between oral health and sarcopenia.

2.2. Inclusion and exclusion criteria

The following specific inclusion criteria were applied:

- (1) Primary research on persons aged 65 and older
- (2) Studies published after 2000
- (3) Studies published in English

The following specific exclusion criteria were applied:

- (1) Reviews
- (2) Articles in any language other than English
- (3) Observational studies that did not describe analytical methods, or that did not consider participants' background factors

The search and selection processes, independently carried out by two of the authors of this review, ended on July 18, 2019. After the titles and abstracts were screened, the full texts of all reviewed articles were obtained and carefully read. Following discussion between the authors on the basis of the reported inclusion and exclusion criteria, 27 studies were selected for the present literature review. Figure 1 shows the flowchart for document retrieval.

3. Results

The characteristics and findings from the selected studies are summarized in Tables 1 and 2. The results of the reviewed studies were categorized into five parts: (1) oral conditions; (2) occlusal force (including masseter tension and thickness); (3) mastication; (4) tongue pressure; and (5) swallowing.

3.1. Oral conditions

Nine studies investigated the association between oral conditions and sarcopenia, as well as oral conditions and sarcopenia diagnostic factors. Oral conditions were evaluated by number of teeth [11, 30, 33], occlusal support [9, 12, 15, 26, 32], and periodontal state [10].

Among the cross-sectional studies, number of teeth was not significantly associated with hand grip strength [11] or sarcopenia [30]. Occlusal support was not significantly associated with grip strength [9, 12, 15]; however, it was significantly associated with sarcopenia [32].

Among the longitudinal studies, Hamalainen et al. reported that periodontitis was related to a decrease in hand grip strength [10]. Hatta et al. reported that a loss of posterior occlusal support was associated with reduced walking speed [26]. Tanaka et al. found that the number of teeth influenced sarcopenia onset [33].

3.2. Occlusal force

Eight studies investigated the association between occlusal force and sarcopenia, as well as occlusal force and the diagnostic factors of sarcopenia. Occlusal force was evaluated by a dental bite force meter [14] or pressure sensitive sheets [23–25, 30, 33]. Masseter muscle thickness and tension were evaluated by ultrasonography and palpation [17, 21, 29].

Fig. 1. Description of included records in the review.

Among the cross-sectional studies, four examined the association between occlusal force and hand grip strength. While two of these studies found a significant association [17, 23], the other two found that the association was only significant in men [14, 21]. Two studies examined the association between occlusal force and walking speed, and a significant association was found in one study [25] but not the other [21]. One study reported a significant association between occlusal force and skeletal muscle mass [29]. One study indicated a significant association between occlusal force and sarcopenia [30].

Among the longitudinal studies, Horibe et al. reported that walking speed was significantly associated with decreasing occlusal force, but that hand grip strength and skeletal muscle index (SMI) were not significantly associated with decreasing occlusal force [24]. Tanaka et al. found no significant association between occlusal force and the onset of sarcopenia [33].

3.3. Mastication

Eleven studies investigated the association between mastication and sarcopenia or its diagnostic factors. Mastication was evaluated by subjective or objective methods. Subjective masticatory ability was evaluated by questions about chewable food [12, 13, 16, 19, 20, 24] or by asking participants to state how many of the 15 listed foods were chewable [11, 15]. Objective masticatory performance was evaluated by assessing participants' ability to chew a piece of colored chewing gum [19, 24, 30] or a gummy jelly [23, 33].

Of the cross-sectional studies assessing subjective masticatory ability, six examined the association between mastication and hand grip strength. Three studies found a significant association between them [12, 13, 16], while the other three did not [11, 15, 19]. One study examined the association between mastication and walking speed; however, no significant association was found [19]. One study examined the association between mastication and skeletal muscle mass, but no significant association was found [13].

Of the cross-sectional studies that conducted objective assessments of masticatory performance, three examined the association between mastication and hand grip strength. One study found a significant association between them [23], but the other two did not [15, 19]. One study examined the association between mastication and walking speed; however, no significant association was found [19]. Two studies examining the association between mastication and skeletal muscle mass found a significant association between them [19, 24]. One study found a significant association between mastication and sarcopenia [30].

Among the longitudinal studies, Kamdem et al. reported that low hand grip strength was not significantly associated with impaired subjective masticatory ability; however, low walking speed was associated with impaired subjective masticatory ability [20]. Horibe et

Table 1. Characteristics and findings from the selected studies (cross-sectional studies).

Authors Year of publication	Sample size Age Country	Oral function	Sarcopenia or sarcopenia diagnostic items	Covariates	Statistical method Main result
Yamaga et al. 2002[9]	749 community- dwelling adults70 and 80 yearsJapan	Occlusal support	Hand grip strength	Age, Gender, Education, Height, Weight, Smoking, Medical history, Hypertension, Albumin, Lower back pain, Marriage	• Logistic regression analysisOcclusal support was not significantly associated with hand grip strength.
Takata et al. 2004[11]	697 community- dwelling adults80 yearsJapan	Number of teeth Mastication	Hand grip strength	Gender, Height, Weight, Smoking, Drinking, SBP, FSG, Albumin, Exercise, Medical care, Back pain, Marriage	• Logistic regression analysisNumber of teeth and subjective masticatory ability were not significantly associated with grip strength.
Moriya et al. 2009[12]	821 community- dwelling adults65–84 yearsJapan	Occlusal support Mastication	Hand grip strength	Age, Gender, Education, Social interaction, BMI, Employment, Systemic disease, Albumin	• Linear regression analysisSubjective masticatory ability was related to hand grip strength ($\beta = -2.3$, $p < 0.01$) only in elderly aged 65–74.
Moriya et al. 2011[13]	354 community- dwelling adults67–74 yearsJapan	Mastication	Hand grip strength Skeletal muscle mass (BIA)	Age, Gender, Education, Social interaction, Employment, Height, Weight, Smoking, Drinking, Type of household, Chronic disease, Pattern of occlusal contact	• Ordinal regression analysisHand grip strength ($\beta = 0.10$, $p < 0.01$) was associated with subjective masticatory ability.
Iinuma et al. 2012[14]	489 community- dwelling adults85–102 yearsJapan	Occlusal force	Hand grip strength	Age, Education, BMI, Smoking, MMSE, Ischemic stroke, CAD, Diabetes, Hypertension, Albumin, C-reactive protein	• Logistic regression analysisOcclusal force was significantly associated with handgrip strength (quartile [highest]: reference category, OR = 2.3, $p < 0.05$) only in men.
Moriya et al. 2014[15]	210 edentulous adults65–86 yearsJapan	Occlusal support Mastication	Hand grip strength	Age, Education, Social interaction, Employment, Height, Weight, Chronic medical disease, Living alone	• Linear regression analysisOcclusal support and masticatory ability were not significantly associated with grip strength.
Moriya et al. 2014[16]	501 community- dwelling adults65–74 yearsJapan	Mastication	Hand grip strength	Age, BMI	• Structural equation modelingSubjective masticatory ability was significantly related to hand grip strength.
Gaszynska et al. 2014[17]	259 community- dwelling adults65–99 yearsPoland	Masseter muscle tension	Hand grip strength	Age, Gender, Education, BMI, Number of teeth	• Logistic regression analysisHigher hand grip strength (OR = 1.4, $p < 0.01$) had a higher masseter muscle tension.
Okada et al. 2015[25]	1284 community- dwelling adults69–71 and 79–81 yearsJapan	Occlusal force	Walking speed	Age, Gender, Education, Economic status, BMI, Cardiovascular disease, Stroke, Malignant tumor, Hand grip strength, Protein intake	• Logistic regression analysisLower occlusal force (quartile [highest]: reference category, OR = 1.57, $p < 0.01$) was associated with slower walking speed.
Murakami et al., 2015[30]	761 community- dwelling adults65–85 yearsJapan	Number of teeth Occlusal force Mastication	Sarcopenia (cut- off value using the criteria of AWGS)	Age, BMI	• Logistic regression analysisOcclusal force (OR = 1.00, $p < 0.01$) and objective masticatory performance (OR = 2.2, $p = 0.01$) showed a significant correlation with sarcopenia.
Maeda et al. 2015[31]	104 hospitalized patients ≥ 65 yearsJapan	Tongue pressure Swallowing (FOIS)	Sarcopenia (cut- off value using the criteria of AWGS)	Age, Gender, BMI, Albumin, MNA-SF, BI, Dentures, CONUT	• Linear regression analysis Sarcopenia (OR = - 0.21, $p = 0.04$) was significantly associated with tongue pressure. • Logistic regression analysisSarcopenia (OR = 10.4, $p = 0.04$) was significantly associated with dysphagia.
Maeda et al. 2016[27]	224 community- dwelling adults ≥ 65 Japan	Swallowing (FOIS)	Skeletal muscle mass (BIA) Sarcopenia (cut-off value using the criteria of AWGS)	Age, Gender, MNA-SF, BI	• Logistic regression analysisSMI (OR = 0.48, $p < 0.01$) and presence of sarcopenia (OR = 5.9, $p < 0.01$) was significantly associated with the prevalence of dysphagia.
Iwasaki et al. 2017[32]	272 community- dwelling adults ≥ 75 yearsJapan	Occlusal support	Sarcopenia(cut- off value using the criteria of AWGS)	Age, Gender, BMI, IADL, Cognitive impairment, Exercise	• Logistic regression analysisCompared to individuals with ≥ 10 occluding pairs, those with no occluding pairs had higher rate of sarcopenia (OR = 3.4, $p < 0.05$).
Sakai et al. 2017[18]	174 inpatients ≥ 65 yearsJapan	Tongue pressure Swallowing (FOIS)	Hand grip strength	Age, Gender, BMI, BI, MNA-SF, Albumin, CONUT, CC, AMA, Grip strength, Complete denture, Number of teeth, Eichner index	• Linear regression analysisHand grip strength ($\beta = 0.33$, $p < 0.01$) was significantly associated with tongue pressure.
Takagi et al.2017[19]	487 community- dwelling adults ≥ 65 yearsJapan	Mastication	Hand grip strength Walking speed Skeletal muscle mass(BIA)	Age, Gender, TMIG-IC, Grip strength, Gait speed, GDS, MMSE, Number of functional teeth, Number of teeth, Occlusal force, Mouth dryness	• Logistic regression analysisSMI (OR = 0.52, $p < 0.05$) was significantly correlated with objective masticatory performance.
Umeki et al. 2018[29]	774 community- dwelling adults ≥ 65 yearsJapan	Masseter muscle thickness	Skeletal muscle mass(BIA)	Age, Gender, Quadriceps thickness, Occlusal force, Gum score, Eichner index	SMI ($\beta = 0.31$, $p < 0.01$) was significantly associated with masseter muscle thickness.
Yamaguchi et al. 2018[21]	97 community- dwelling adults ≥ 65 yearsJapan	Masseter muscle thickness	Hand grip strength Walking speed	Age, Weight, SMI ,Tooth loss	• Linear regression analysisIn men, hand grip strength was significantly associated with muscle thickness at rest ($\beta = 0.33$, $p = 0.03$) and during contraction ($\beta = 0.32$, $p = 0.03$).

Table 1. (Continued)

Authors Year of publication	Sample size Age Country	Oral function	Sarcopenia or sarcopenia diagnostic items	Covariates	Statistical method Main result
Yoshimura et al. 2018[22]	637 hospitalized patients ≥ 65 years Japan	Swallowing (FILS)	Hand grip strength Skeletal muscle mass (BIA)	Age, Gender, Time from onset, CCI, FMI, Premorbid mRS, Brain infarction, Brain hemorrhage, Subarachnoid hemorrhage, Hip fracture, Vertebral fracture, Total knee arthroplasty, HAD-pneumonia	• Linear regression analysis FILS scores were significantly associated with hand grip strength ($\beta = 0.41$, $p < 0.01$) and skeletal muscle mass ($\beta = 0.23$, $p < 0.01$).
Suzuki et al. 2018[34]	248 community- dwelling women ≥ 65 years Japan	Tongue pressure	Sarcopenia (cut- off value using the criteria of AWGS)	Age	• Linear regression analysis Tongue pressure was found to be significantly lower in the sarcopenia groups than in the normal group.
Mihara et al. 2018[23]	809 community- dwelling adults 82–84 years Japan	Occlusal force Mastication Tongue pressure Swallowing (RRST)	Hand grip strength	Gender, BMI, IADL, Number of teeth, Use of removable denture, Periodontal condition	• Linear regression analysis Hand grip strength was significantly associated with occlusal force ($\beta = 0.18$, $p < 0.01$) and tongue pressure ($\beta = 0.29$, $p < 0.01$). • Logistic regression analysis Hand grip strength was significantly associated with objective masticatory performance (OR = 1.1, $p = 0.02$) and swallowing (OR = 1.1, $p < 0.01$).
Cha et al. 2019[35]	197 community- dwelling adults ≥ 65 years Korea	Swallowing (SSA)	Sarcopenia (cut- off value using the criteria of AWGS)	Age, Gender, Drinking, G-QOL, Albumin, LDL-C	• Logistic regression analysis Sarcopenia (OR = 2.7, $p = 0.02$) had a significantly higher rate of dysphagia.

SBP: Systolic blood pressure, FSG: Fasting serum glucose, BMI: Body mass index, MMSE: Mini-mental state examination, CAD: Coronary artery disease, AWGS: Asian Working Group for Sarcopenia, OR: Odds ratio, FOIS: Functional oral index scale, MNA-SF: Mini nutritional assessment – short form, BI: Barthel index, IADL: Instrumental activities of daily living, CONUT: Controlling nutritional status, BIA: Bioelectrical impedance analysis, SMI: Skeletal muscle index, CC: Calf circumference, AMA: Arm muscle area, TMIG-IC: Tokyo Metropolitan Institute of Gerontology Index of Competence, GDS: Geriatric depression scale, FILS: Food intake level scale, CCI: Charlson's comorbidity, FMI: Fat mass index, mRS: Modified Rankin scale, HAD: Hospital-associated deconditioning, SSA: Standardized swallowing assessment, G-QOL: Geriatric quality of life scale, LDL-C: Low-density lipoprotein cholesterol

Table 2. Characteristics and findings from the selected studies (longitudinal studies).

Authors Year of publication	Sample size Age Country	Oral function	Sarcopenia or sarcopenia diagnostic items	Covariates	Statistical method Main result
Hamalainen et al. 2004[10]	79 community- dwelling adults 80 years Finland	Periodontitis	Hand grip strength	Gender, Height, Weight, Number of chronic conditions, Physical activity	• Linear regression analysis Decline in hand grip strength was more than two-fold greater among those with periodontitis than among those with a healthy periodontium ($p = 0.02$).
Kamdern et al. 2017[20]	992 community- dwelling adults 73–77 years Switzerland	Mastication	Hand grip strength Walking speed	Age, Gender, Education, Financial problem, Smoking, Drinking, Number of chronic diseases, Weight loss, Lack of endurance, Low physical activity, MMSE	• Logistic regression analysis Low walking speed (OR = 3.1, $p < 0.01$) was significantly associated with impaired masticatory ability.
Maeda et al. 2017[28]	95 hospitalized patients ≥ 65 years Japan	Swallowing (FOIS)	Skeletal muscle mass (BIA)	BMI, MNA-SF, BI, Grip strength, Premorbid FOIS, MMSE, Energy intake, Duration of restricted oral intake	• Logistic regression analysis SMI (OR = 24.0, $p < 0.01$) was significantly correlated with decreased swallowing function.
Tanaka T et al. 2018[33]	2011 community- dwelling adults ≥ 65 years Japan	Number of teeth Occlusal force Mastication Tongue pressure	Sarcopenia (Di- agnostic flow of the AWGS)	Age, Gender, BMI, Smoking, Chronic conditions, Cognitive function, Depressive symptoms, Living arrangement, Yearly income	• Cox proportional hazard model Tongue pressure ($p = 0.04$) and subjective masticatory ability ($p < 0.01$) were significantly associated with sarcopenia.
Horibe et al. 2018[24]	491 community- dwelling adults Japan	Occlusal force- Mastication	Walking speed Hand grip strength Skeletal muscle mass	Age, Gender, MMSE, SDS	• Logistic regression analysis Walking speed was significantly associated with occlusal force (OR = 4.3, $p < 0.01$) and subjective masticatory ability (OR = 4.6, $p = 0.02$).
Hatta et al. 2019[26]	353 community- dwelling adults 79–81 years Japan	Occlusal support	Walking speed	Gender, Education, Economic status, Height, Weight, Smoking, History of stroke, C-reactive protein, Grip strength, MoCA-J	• Conditional logistic regression analysis Loss of posterior occlusal support (OR = 1.9, $p = 0.04$) was significantly associated with reduced walking speed.

MMSE: Mini-mental state examination, OR: Odds ratio, FOIS: Functional oral index scale, BIA: Bioelectrical impedance analysis, BMI: Body mass index, MNA-SF: Mini nutritional assessment – short form, BI: Barthel index, SMI: Skeletal muscle index, AWGS: Asian Working Group for Sarcopenia, SDS: Self-rating depression scale, MoCA-J: Japanese version of Montreal cognitive assessment.

al. reported that walking speed was significantly associated with decreasing subjective masticatory ability, but not with decreasing objective masticatory performance. Furthermore, hand grip strength and SMI were not significantly associated with decreasing subjective or objective masticatory ability [24]. Tanaka et al. reported that

subjective masticatory ability significantly influenced the onset of sarcopenia. However, objective masticatory performance did not significantly influence the onset of sarcopenia [33].

3.4. Tongue pressure

Five studies investigated the association between tongue pressure and sarcopenia or its diagnostic factors. Tongue pressure was evaluated with a device consisting of a disposable oral balloon probe.

Among the cross-sectional studies, two examined the association between tongue pressure and hand grip strength and found a significant association [18, 23]. Two studies examined the association between tongue pressure and sarcopenia. Both studies reported a significant association [31, 34].

In a longitudinal study, Tanaka et al. reported that tongue pressure significantly influenced the onset of sarcopenia [33].

3.5. Swallowing

Six studies investigated the association between swallowing and sarcopenia or its diagnostic factors. Swallowing was evaluated by a Repetitive Saliva-Swallowing Test [23], the Functional Oral Intake Scale [18, 27, 28, 31], the Food Intake Level Scale [22], or the Standardized Swallowing Assessment [35].

Among the cross-sectional studies, two examined the association between swallowing and hand grip strength. One study found a significant association [22], but the other did not [18]. Two studies that examined the association between swallowing and skeletal muscle mass found a significant association between them [22, 27]. Three studies that examined the association between swallowing and sarcopenia found a significant association between them [27, 31, 35].

In a longitudinal study, Maeda et al. reported that SMI was correlated with decreased swallowing function [28].

4. Discussion

To our knowledge, this is the first review to investigate the relationship between oral health and sarcopenia, as well as oral health and diagnostic factors for sarcopenia such as hand grip strength, walking speed, and muscle mass.

In 2018, the EWGSOP revised the diagnostic criteria for sarcopenia. Diagnosis of sarcopenia no longer includes a walking speed test, and the restriction on patients under 65 years of age has been removed [5]. In 2019, the AWGS also revised the diagnostic criteria for sarcopenia. The cut-off values for walking speed and male grip strength have been changed [6]. All diagnoses of sarcopenia in the studies we reviewed were the previous criteria. All reviewed studies used the previous AWGS criteria. In future studies, the diagnosis of sarcopenia must be made accurately and carefully based on the latest knowledge.

In some of the studies extracted in this review, it was found that oral conditions, occlusal force, and mastication were associated with sarcopenia and its diagnostic factors; however, other studies found no significant associations. In this review, we could not clarify these relationships. Almost all studies showed that tongue pressure and swallowing were related to sarcopenia and its diagnostic factors, and it is likely that tongue pressure and swallowing are bidirectionally related to sarcopenia. However, most of the studies that investigated the relationship between sarcopenia and oral health were cross-sectional. Therefore, well-designed cohort studies should be conducted over longer periods to allow for a more comprehensive understanding of this relationship.

Previous research suggests three plausible mechanisms through which oral health is related to sarcopenia. First is the nutritional pathway. Some studies reported that poor oral health adversely affects dietary intake and results in lower intake levels of multiple nutrients including protein, calcium, and vitamins A, D, and E [36–38]. Shortages of these nutrients may play an important role in the decline in muscle mass, muscle strength, and physical performance [39–41]. Second, oral health can be related to balance and exercise through neural mechanisms. Some studies found that dental occlusion influenced postural stability [42, 43]. The proprioceptive sensation of the

periodontal ligament may play an important role in controlling body balance. Furthermore, some studies reported that orofacial sensory input from the trigeminal nerve may influence muscle strength and balance [44–49]. Given that previous studies have demonstrated an association between limb and orofacial motor control mechanisms, it is possible that peripheral orofacial sensory input influences motoneuronal control of the exertion of muscle strength in other parts of the body. Third, inflammation caused by periodontal disease may lead to a loss of muscle strength. Periodontitis increases the levels of interleukin-6 and TNF- α in gingival tissue [50]. The role of cytokines has recently attracted growing interest in studies on sarcopenia and strength loss [51, 52].

In the reverse direction, there is a possibility that loss of muscle mass decreases muscle strength, and that sarcopenia causes a decline in oral function. In fact, it has been reported that hand grip strength, muscle mass, and sarcopenia are related to occlusal force, mastication, tongue pressure, and swallowing [20, 24, 28]. Sarcopenia can also weaken the oral muscles. Although sarcopenia is likely to be closely related to oral health, the available studies do not adequately describe the mechanism of this association. Recently, sarcopenic dysphagia has been defined as dysphagia caused by sarcopenia. Dysphagia caused by sarcopenia is present in both generalized skeletal muscles and swallowing-related muscles, and this diagnosis is excluded if sarcopenia of the body is absent [8, 53]. The mechanisms of dysphagia caused by sarcopenia may be secondary sarcopenia in generalized skeletal muscles and the muscles related to swallowing after inactivity, malnutrition, and disease [53, 54].

Therefore, impaired oral health can lead to sarcopenia, which can, in turn, cause dysphagia, resulting in a negative cycle that worsens the patient's general condition. This process indicates that oral health is likely to be closely related to sarcopenia. However, there is still limited evidence linking sarcopenia and oral health. In order to confirm this relationship, it would be necessary to accumulate evidence through a well-designed large-scale cohort study.

5. Conclusion

Most studies in the literature have reported a relationship between oral health and sarcopenia or its diagnostic factors (such as hand grip strength, walking speed, and muscle mass). However, reports showing an association between sarcopenia and oral health are still few in number and inconsistent; therefore, definitive conclusions cannot be drawn. Further longitudinal studies and reviews are necessary to evaluate these relationships.

Conflict of interest statement

There are no conflicts of interest with regard to this study.

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