Relation Between Components of Oral Health and Sarcopenia in Older Adults: a Narrative Review

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SUMMARY

Introduction. With the growing population of older adults, a spike in the problems related to aging is expected, with sarcopenia being the foremost. Among the plethora of factors contributing to the development of sarcopenia, oral hypofunction is one among them and there is a growing number of findings on the link between oral health and sarcopenia. However, the strength of this relationship specifically in the older adult population is poorly understood.

Objective. To determine the relationship between oral health and sarcopenia among older adults.

Materials and methods. Systematic literature search was conducted in the five electronic databases like PubMed, Scopus, Embase, CINAHL and Web of Science, the identified records were exported to Rayyan software, duplicates were removed, and screening of title and abstracts was done. Details about the relationship were extracted from the full text records.

Results. Twenty studies were included in this review, and nineteen are cross-sectional and one cohort design, carried out in South-East Asian nations. The usage of full dentures, masticatory function, tongue pressure, jaw opening force, and the number of surviving teeth have all been demonstrated to significantly correlate with grip strength. Skeletal muscle mass and tongue pressure is found to have a strong association. Gait speed and tongue pressure have a weak association and those who have a loss of at least 10 teeth have been found to walk with less pace.

Conclusions. There exists a relationship between sarcopenia and various components of oral health and oral function among older adults.

KEY WORDS
Aging; older adults; oral health; oral function; sarcopenia.

INTRODUCTION

Sarcopenia a term coined in the last decade of 20th century is characterized by a triad of decrease in muscle mass, muscle strength and physical performance respectively (1–3). The prevalence of sarcopenia ranged from 10% to 27% in the older adults (4). The European Working Group on Sarcopenia in Older People (EWGSOP) and Asian Working Group for Sarcopenia (AWGS) have come up with the diagnostic criteria for sarcopenia among older adults, which consid-

ers muscle mass, muscle strength, and physical performance parameters with slight variations in the cut-off values (2, 3). A plethora of factors contribute to the development of sarcopenia among older adults, including reduced dietary protein intake, increase in muscle protein breakdown, endocrine dysfunction and sedentary lifestyle (5, 6).

The World Dental Federation General Assembly in 2016 come up with the definition of oral health which states "Oral health is multifaceted and includes the ability to speak,

smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expressions with confidence and without pain, discomfort, and disease of the craniofacial complex" (7). Poor oral health and oral health problems are highly prevalent among older adults (8). Moreover, oral health conditions have links with chronic diseases (9) and with physical functions among older adults (10). A study has reported the prevalence of sarcopenia to be 30.8% in older adults visiting the dental outpatient department (11).
Despite of the findings on the link between oral health and sarcopenia (12), the strength of this relationship specifically in older adults population are still poorly understood. Thus, this review aimed to find out the relationship between oral health and sarcopenia among older adults, along with summarizing different components of oral health evaluated in the literature and their association with sarcopenia.

METHODS

Eligibility criteria

The studies were included if they met the criteria: 1) original study, 2) on older adults aged ≥ 60 years, 3) diagnosed with sarcopenia, 4) evaluated different components of oral health, 5) study design like cross sectional study, longitudinal study, case-control, cohort design and 6) study settings like community dwelling, dental clinic, hospital, long term care settings. The studies were excluded if they fail to meet the inclusion criteria and/or: 1) full text not available, 2) language other than English, 3) the studies providing no extractable data.

Data sources and search strategy

The systematic literature search was undertaken in May 2022 using the following electronic databases: PubMed, Scopus, Embase, Cumulated Index to Nursing and Allied Health Literature (CINAHL) and Web of Science. Relevant MeSH terms and Boolean phases were used for the search: like "sarcopenia" OR "reduced skeletal muscle mass" OR "muscle mass loss" OR "muscle atrophy" OR "hand grip strength" OR "quality of life" AND "oral health" OR "dental health" OR "oral hygiene" OR "mastication" OR "occlusal force" OR "Gerodontology" AND "aged" OR "elderly" OR "older adults" OR "older people" AND "residential care facilities" OR "long term care facilities" OR "old age homes" without time restrictions and no filters were applied. The complete search strategy for each database can be requested from the corresponding author.

Data extraction and Quality assessment

Two reviewers, PK and SV independently searched the literature. The identified studies were imported to Rayyan

(Ref. # abcdef) software. After resolving the duplicates, two reviewers conducted title and abstract screening separately. Any conflict regarding the article selection was resolved by discussion with the third reviewer GN. Full-text reading of the identified articles was done by PK, and relevant studies were included in this review matching our inclusion criteria. The data charting form was drafted by PK and it was finalized after a consensus discussion with all the authors. Quality evaluation was performed using the Jonna Brigs Institute appraisal checklist for analytical cross-sectional studies (13).

RESULTS

A total of 5,907 studies were identified through databases searches. After removing duplicate studies, the titles and abstracts of 3,671 studies were screened. A review of the titles and abstracts yielded 150 relevant studies for full-text screening. Finally, 20 studies met all inclusion criteria and were included in this review. A Preferred Reporting Items for Systematic Review and Meta-analysis 2020 (PRISMA 2020) (14) flowchart of the literature search is demonstrated in **figure 1**.
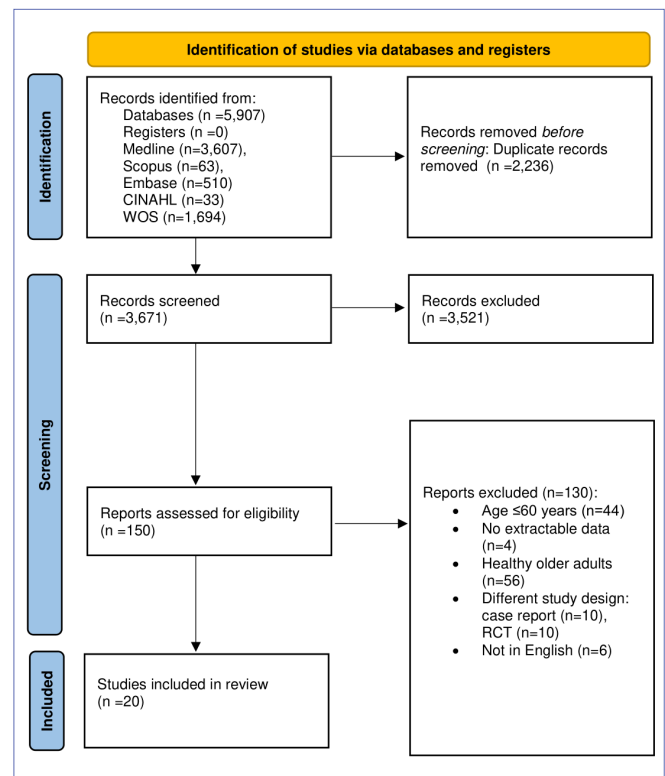
Figure 1. Preferred reporting system of systematic review and Meta-Analysis (PRISMA 2020).

The characteristics and findings from the selected studies are summarized in **table I**. The results of the reviewed studies suggest that the components assessed as part of oral function assessment varied among the studies. Oral hygiene, oral dryness, occlusal force, tongue lip motor function, tongue pressure, masticatory function and swallowing function are the components of oral function reported among studies. Number of teeth, jaw opening force, denture, lip strength, oral health related quality of life, oral health assessment tool, masseter and genohyoid muscle thickness were the components of oral health reported.

Regarding the quality of the studies, all the included studies have clearly defined the criteria for inclusion. Sixteen (n = 16) studies have described the study subjects and the settings in detail (11, 15–24, 24–29), while three (n = 3) studies have not described it in detail (30–32) and it was unclear in one (n = 1) of the study (33). The exposure measured is valid and reliable in six (n = 6) studies (15, 18, 20, 26, 30, 33), while four (n = 4) studies (19, 27, 29, 34) have not measured exposure in a valid and reliable way and it is unclear in ten (n = 10) studies (11, 16, 17, 21–25, 31, 32). Seventeen (n = 17) studies have used the standard criteria for the measurement of the condition (11, 15–21, 23, 25–27, 29–33), while three (n = 3) studies have not used the standard criteria (22, 24, 34). The confounding factors have been identified in ten (n = 10) studies (11, 15–18, 20, 22, 26, 33, 34), seven (n = 7) studies have not identified confounding factors (19, 23, 24, 27, 29, 30, 32), while it was unclear in three (n = 3) studies (21, 25, 31). Nine studies (n = 9) have applied the strategies to deal with the confounding factors (11, 15, 17, 18, 20, 22, 26, 33, 34), in three (n = 3) of the studies it was unclear (16, 21 ,25), and in eight (n = 8) studies it was not stated (19, 23, 24, 27, 29–32). All studies included in this review have measured the outcomes in a valid and reliable way and have used appropriate statistical analysis. The full detail of the critical appraisal assessment tool for analytical study can be found in the **appendix 1**.

Oral hygiene is assessed using tongue coating index in two studies (15, 30), oral dryness is assessed using oral moisture meter using (Mucus Life Co Ltd., Saitama, Japan) in two studies (15, 30), occlusal force assessed in three studies (15, 29, 30), tongue lip motor function assessed in four studies (15, 19, 30, 31), tongue pressure is assessed in ten studies (15, 19, 23–25, 27, 28, 30–32), masticatory function is assessed in seven studies (15, 18, 20, 21, 26, 29, 30), and swallowing function is assessed in three studies (15, 30, 31).

Number of teeth were assessed in eight studies (16–18, 23, 26, 29, 30, 33). Two studies had evaluated the jaw opening force as part of oral health assessment (24, 27). Three studies had included the assessment of denture as part of oral examination (17, 26, 33). Lip strength (23), masseter muscle thickness (22) and cross-sectional area of Genohyoid muscle (19) has been assessed as per the objectives of the studies. One study have assessed oral health related quality of life (11) and two studies have evaluated the oral health using oral health assessment index (11, 16).

Sarcopenia

Four studies have used Asian working group for Sarcopenia (AWGS 2019) criteria (15, 16, 18, 30), one study has used Asian working group for Sarcopenia (AWGS 2016) criteria (11), seven studies have used Asian Working Group for Sarcopenia (AWGS 2014) criteria (17, 19, 20, 23, 26, 27, 31), four studies have used European working group on Sarcopenia in older people (EWGSOP 2010) criteria (25, 28, 29, 32) to diagnose the sarcopenia among the included participants. One study has only considered grip strength component to include participants (33), one study has used SARC-F questionnaire as a screening tool for sarcopenia (21), one study have utilized only appendicular skeletal muscle index component for screening for sarcopenia (22). One study has used grip strength and walking speed components of sarcopenia criteria (24).

Number of teeth

Total of eight studies investigated the association between number of teeth and sarcopenia. Elderly patient with < 20 number of remaining natural teeth were more likely to have diagnosed sarcopenia (OR 5.55) (16, 26). There was no association found between number of tooth loss with muscle mass and with sarcopenia, however, grip strength and walking speed was lower in those who had lost at least 10 teeth compared to those 9 or less (17). A study suggests that less number of teeth was associated with decline in grip strength (18, 33) and possible sarcopenia (33).

Tongue pressure

Ten studies investigated the association between tongue pressure and sarcopenia. Tongue pressure was evaluated with the device disposable oral balloon probe (JMS tongue pressure measuring instrument, Hiroshima, Japan). All are cross-sectional studies, findings suggest significant correlation between tongue pressure and muscle mass (25), tongue pressure and grip strength (24, 25), tongue pressure is independently associated with the presence of nutrition related sarcopenia (23), weak correlation was found between gait speed and tongue pressure (19, 24). Multivariate linear regression analysis showed tongue pressure was significantly associated with the presence of sarcopenia (15, 27, 30, 31, 34).

Table 1. Characteristics and findings from the selected studies.

Author, Year & Country	Title & Design	Study population & Setting	Aim of the study	Oral health component(s) evaluated, and instrument used	Criteria used to diagnose sarcopenia	Statistical method(s) used	Finding(s)
Shirahase et al., 2022 (Japan)	A Cross-Sectional Study on the Relationship between Oral Function and Sarcopenia in Japanese Patients with Regular Dental Maintenance (Cross-sectional study)	269 patients (133 men, 136 women) Aged ≥ 65 years (mean age 74.9 ± 6.50 years) (Dental Clinic)	To clarify the relationship between oral function assessment for oral hypofunction and sarcopenia in patients who had completed treatment for organic denta problems	**Oral Hygiene:** Tongue coating index. **Oral dryness:** Oral mucosal wetness at center of the tongue using oral moisture meter (Mucus, Life, Saitama, Japan). **Occlusal force:** According to number of remaining teeth. **Tongue lip motor function (pa) (times/sec), (ta) (times/sec), (ka) (times/sec):** using automatic measuring device (Kenko-kun Handy, Takei Kiki Kogyo, Niigata, Japan). **Tongue pressure (KPa):** (JMS Tongue Pressure Measuring Device, JMS, Hiroshima, Japan). **Masticatory function (mg/dL):** gummy jelly (Glucolum, G.C., Tokyo, Japan). **Swallowing function (%):** Seirei dysphagia screening questionnaire	Asian Working Group for Sarcopenia 2019 (AWGS 2019). **Grip strength (Kg):** Smedley Hand Held Dynamometer. **Physical performance (m/s):** 6-meter walk. **Appendicular skeletal muscle mass (SMI, Kg/m2):** Body composition analyzer InBody 470	Two Poisson regression models were constructed: Model 1- univariate models Model 2- multivariate model	In univariate analyses, there was a significant association between sarcopenia and the number of remaining teeth (PRR = 0.97, P-value 0.017), tongue-lip motor function [pa] (PRR = 0.69, P-value < 0.001), [ta] (PRR= 0.68, P-value < 0.001), [ka] (PRR = 0.64, P-value < 0.001) , tongue pressure (PRR = 0.93, P-value < 0.001), masticatory function (PRR=1.00, P-value 0.027), and the number of oral hypofunction items (PRR = 1.57, P-value < 0.001). In multivariate analysis, tongue-lip motor function [pa] (PRR = 0.80, P-value < 0.035) [ka] (PRR=0.76, P-value 0.029), tongue pressure (PRR=0.95, P-value 0.003) were significantly associated with sarcopenia
Cao et al., 2022 (China)	Correlation between nutrition, oral health, and different sarcopenia groups among elderly outpatients of community hospitals: a cross-sectional study of 1505 participants in China (Cross-sectional study)	n = 1505 participants, Non sarcopenic n = 1139 (74.47 ± 6.23), Possible sarcopenic n = 88 (78.26 ± 6.74 years), Diagnosed sarcopenic n = 142 (77.02 ± 6.82 years), and Severe sarcopenic n = 136 (85.99 ± 5.83 years) (Hospital)	To characterize the oral health status, prevalence of sarcopenia, and risk factors in different sarcopenia groups of elderly outpatients of community hospitals. Furthermore, to determine the correlation among nutrition, oral health, and different sarcopenia groups.	**Number of remaining natural teeth (NRT)**. **Oral health assessment index of elderly patients** (General Oral Health Assessment Index [GOHAI])	AWGS 2019. **Grip strength (Kg):** Electronic hand dynamometer (CAMRY; China). **Physical performance (m/sec):** 6-meter walk. **Appendicular skeletal muscle mass (Kg/m2):** Bioimpedance analysis (BIA) (InBody 720)	Multinominal logistic regression multivariate analysis	The GOHAI score was associated with the diagnosed sarcopenia group (OR = 5.55, 95% CI = 3.80–8.12) and severe sarcopenia (OR = 6.66, 95% CI = 4.13–10.78). In the regression model, elderly patients with less than 20 NRT were more likely to have diagnosed sarcopenia (OR = 5.55, 95% CI = 3.80–8.12) or severe sarcopenia (OR = 6.66, 95% CI = 4.13–10.76)

Author, Year & Country	Title & Design	Study population & Setting	Aim of the study	Oral health component(s) evaluated, and instrument used	Criteria used to diagnose sarcopenia	Statistical method(s) used	Finding(s)
Wang et al., 2022 (China)	Relationship between tooth loss and sarcopenia in suburban community-dwelling older adults in Shanghai and Tianjin of China (Cross-sectional study)	The subjects were n = 1494 people over 60 years of age (40.7% men; aged 71.64 ± 5.97 years) (Community dwelling)	To investigate potential relationships between tooth loss and sarcopenia and its components in suburban community-dwelling older adults of Shanghai and Tianjin, China	**Number of tooth loss** 0-9 and ≥10. **Brushing frequency:** ≥ 2 times/day, < 2 times/day **Brushing time:** < 2 min, ≥ 2 min **Gingival bleeding:** yes/no **Denture status:** yes/no	AWGS 2014 **ASM/Ht2 (Kg/m2):** Bioelectrical impedance analyzer (Inbody720; Bio space Co., Ltd, Seoul, Korea) **Grip strength (Kg):** Dynamometer (Grip-D; Takei Ltd, Niigata, Japan) **Walk speed (m/sec):** 4-m walk	Binary logistic regression models Multivariate linear regression models	A binary logistic regression model did not identify a statistical relationship between tooth loss and sarcopenia In Multivariate linear regression model muscle mass was not associated with tooth loss in either sex group In men, grip strength was 1.577 kg lower in those with at least 10 teeth lost as compared with those with nine or fewer teeth lost (p = 0.023) Among women, participants who had lost at least 10 teeth had an average walking speed that was 0.059 m/s slower than that of participants with nine or fewer teeth lost (p < 0.001)
Abe et al., 2021 (Japan)	Number of teeth and masticatory function are associated with sarcopenia and diabetes mellitus status among community-dwelling older adults: A Shimane CoHRE study (Cross-Sectional Study)	n = 635 older adults, men n=280, women n = 385participated with mean age 67.3 ± 7.7 (Community dwelling)	To examine the number of teeth and masticatory function as oral health indices and clarify their roles in the pathogenesis of sarcopenia and diabetes mellitus in community-dwelling older adults	The **number of remaining teeth** (excluding third molars and missing teeth) was counted Objective **Masticatory function** was assessed using a gummy jelly	AWGS 2019 **Handgrip strength** **Skeletal muscle index:** Bioimpedance methodology (MC-780A; Tanita Corporation, Tokyo, Japan) **Calf circumference**	Logistic regression analysis	Logistic regression analysis showed that less number of teeth was associated with a decline in handgrip strength (odds ratio [OR], 0.961; 95% confidence interval [CI], 0.932–0.992) and possible sarcopenia (OR, 0.949; 95% CI, 0.907–0.992) Low level of Masticatory function was significantly associated with a decline in handgrip strength (OR, 0.965; 95% CI, 0.941–0.990) and possible sarcopenia (OR, 0.941; 95% CI, 0.904–0.979)

Author, Year & Country	Title & Design	Study population & Setting	Aim of the study	Oral health component(s) evaluated, and instrument used	Criteria used to diagnose sarcopenia	Statistical method(s) used	Finding(s)
Kugimiya et al., 2021 (Tokyo, Japan)	Relationship between Oral Hypofunction and Sarcopenia in Community Dwelling Older Adults: The Otassha Study (Cross-Sectional study)	n = 878 adults (n= 268 men and n= 610 women, Mean age: 76.5 ± 8.3 years) (Community dwelling)	To clarify the relationship between oral hypofunction and sarcopenia among community-dwelling older adults.	**Number of teeth:** Via intra-oral examination **Poor Oral Hygiene (%):**Tongue coating index (TCI) **Oral Dryness:** Oral moisture checker (Mucus, Life Co., Ltd., Saitama, Japan) **Reduced Occlusal Force (N):** sensitive sheet (Dental Prescale 50H Type-R, Fuji Film Co, Tokyo, Japan) **Decreased Tongue–Lip Motor Function (times/sec):** Automatic counter (KENKOU-KUN handy, Takei Scientific Instruments Co., Ltd., Niigata, Japan) **Decreased Tongue Pressure:** JMS tongue pressure device TPM-01, JMS Co., Ltd., Hiroshima, Japan **Decreased Masticatory Function:** Gummy jelly (test gummy jelly, UHA Mikakuto Co., Ltd., Osaka, Japan) **Deterioration of Swallowing Function:** 10-item Eating Assessment Tool	AWGS 2019 **Low muscle strength:** Smedley-type hand dynamometer (Grip-A, Takei Scientific Instruments Co., Ltd., Niigata, Japan) **Low physical performance:** Gait speed to cover 5-m distance **Low Appendicular skeletal muscle mass:** Measured using bio-electrical impedance analysis (InBody 770, InBody Inc., Seoul, Korea)	Logistic regression analysis	Sarcopenia occurred at an increased frequency in patients diagnosed with oral hypofunction (odds ratio:1.59, 95% confidence interval: 1.02–2.47); accordingly, oral hypofunction appears to be significantly associated with sarcopenia

Author, Year & Country	Title & Design	Study population & Setting	Aim of the study	Oral health component(s) evaluated, and instrument used	Criteria used to diagnose sarcopenia	Statistical method(s) used	Finding(s)
Yun and Lee, 2020 (South Korea)	Association between oral health status and handgrip strength in older Korean adult	Total women n =3671, and men n = 2766 (Community dwelling)	Investigated the relationship oral health status and grip strength in older adults living in the community	**Dental prosthesis status:** Full Denture Partial Denture Fixed Prosthesis **Number of remaining teeth:** 0-9 , 10-19, 20-32	**Handgrip strength:** Digital dynamometer (Takei Digital Grip Strength Dynamometer, Model TK)	Chi-square test Logistic regression analysis	In the crude model of logistic regression analysis, both men and women had an association between full denture use and low grip strength compared to high grip strength After controlling for covariates, the use of full dentures was also associated with low grip strength compared to high grip strength in men (OR = 1.47, 95% CI = 1.09–1.98). No significant associations were found in women In the crude model of logistic regression analysis, both men and women had an association between number of teeth and low grip strength compared to high grip strength After controlling for covariates, the 0–9 teeth was associated with low grip strength compared to high grip strength in men [odds ratio (OR) =1.39, 95% confidence interval (CI) = 1.03–1.88] No significant associations were found in women
Kobuchi *et al.*, 2020 (Japan)	The relationship between sarcopenia and oral sarcopenia in elderly people	n = 54 participants (n= 16 men and n= 38 women), mean age of 78.8 ± 7.1 years (Dental hospital and nursing homes)	To clarify the relationship between generalised sarcopenia and oral sarcopenia in the elderly in order to facilitate the establishment of a method for assessing oral sarcopenia	**Cross-sectional area of the Genohyoid muscle (CSG) (mm2):** ultrasonic diagnostic system **Tongue pressure (TP) (KPa):** tongue measuring instrument (JMS) **Oral diadochokinesis (ODK) (times/sec):** calculator method	AWGS 2014 **Skeletal muscle mass index (SMI) (Kg/m2):** Bioelectrical impedance analysis (BIA) using In Body S10 (In Body Japan, Tokyo, Japan) **Grip strength (GS) (Kg):** Digital grip strength tester (Takei Scientific Instruments Co., Ltd.) **Walking speed (WS) (m/sec):** walking 9 m	Pearson's correlation coefficient. Multiple regression analysis	Moderate correlation between CSG and SMI r = .48, p = .00) Weak correlation between GS and TP (r = .29, p = .03) Moderate correlation between WS and ODK (R = .50, p = .00) By multiple regression analysis, SMI (β = .39, p = .003) and TP (β = .27, p = .04) were significantly associated with CSG ODK (β = .39, p = .003) and CSG (β = .29, p = .024) were significantly associated with TP WS (β = .42, p = .001) and SMI (β = .32, p = .009) were significantly associated with ODK

Author, Year & Country	Title & Design	Study population & Setting	Aim of the study	Oral health component(s) evaluated, and instrument used	Criteria used to diagnose sarcopenia	Statistical method(s) used	Finding(s)
Senoo et al., 2020 (Japan)	Combined effect of poor appetite and low masticatory function on sarcopenia in community-dwelling Japanese adults aged ≥ 75 years: A 3-year cohort study (Cohort study)	n = 173 community-dwelling Japanese adults aged ≥ 75 years (Community dwelling)	To investigate the longitudinal association of the combination of poor appetite (PA) and low masticatory function (LMF) with sarcopenia in community-dwelling older adults	Masticatory function assessment using spectrophotometric measurement of differences in gum colour before and after masticating colour-changeable chewing gum were performed at baseline	AWGS 2014 Skeletal muscle mass: Bioelectrical impedance analysis method using the body composition analyser InBody S10 (Biospace, Seoul, Korea) Handgrip strength: Dynamometer (TKK5401; Takei Scientific Instruments Co., Ltd, Niigata, Japan) Usual gait speed: 4-m walking test	Cox proportional hazards regression models	After adjusting for covariates, the adjusted OR for sarcopenia in participants with both PA and LMF was 4.4 (95% confidence interval = 1.6-12.2) compared with those without PA or LMF PA or LMF alone was not significantly associated with sarcopenia development.
Woo et al., 2018 (Hong-Kong, China)	Chewing Difficulty Should be Included as a Geriatric Syndrome	Total n = 2259 men and women chewing difficulty age 60-69 years (Community dwelling)	To test the hypothesis that chewing difficulties form part of the geriatric syndrome	Chewing difficulty: The presence or absence of chewing difficulty was based on answering 'yes' or 'no' to the question. If yes, reason/s for chewing difficulty based on the following: 'Problems with dentures', 'no strength to chew', 'loose teeth or no teeth', 'painful gums or teeth' or 'dry mouth	Strength, Assistance in walking, Rise from chair, Climb stairs, and Falls (SARC-F) questionnaire Sarcopenic (SARC-F ≥ 4)	Binary logistic regressions (Model 1) Binary multivariate logistic regression (Model 2)	Odds ratio with chewing difficulty with model 1: 3.11 (95% CI: 2.44–3.97) Odds ratio with chewing difficulty with model 2: 1.52 (95% CI: 1.13–2.06) The findings of this study support the proposal that chewing difficulties should be included as a geriatric syndrome
Takahashi et al., 2018 (Japan)	Prevalence of sarcopenia and association with oral health-related quality of life and oral health status in older dental clinic outpatients	This study involved n = 279 patients (n = 173 women, n = 106 men) with a mean age of 76 ± 7.5 years (Dental OPD)	To clarify the prevalence of sarcopenia in older dental clinic outpatients and its relationship with OHRQoL and oral health status	Oral Health Impact Profile-14 (OHIP-14) for Oral Health related Quality of Life (OralHRQoL) Oral Health status using Oral Health Assessment Tool (OHAT) that contains eight items assessing various aspects of oral health status, namely, lips, tongue, gums and tissues, saliva, natural teeth, dentures, oral cleanliness, and dental pain, each to be rated using one of three grades: 0 (healthy), 1 (changes) and2 (unhealthy)	AWGS 2016 Grip strength: Jamar-type digital hand dynamometer (MG- 4800, Morito, Aichi, Japan). Usual Gait speed (m/sec) using 6-m walk test Skeletal muscle mass: calf circumference (cm)	Two multivariable linear regression analyses were carried out to identify variables independently associated with OHIP-14 and OHAT scores	Participants with sarcopenia have lower number of teeth (p < 0.001), poorer OHRQoL (p < 0.001), poor oral health status (p < 0.001) Sarcopenia was an independent explanatory factor of OHIP-14 (β = 0.138, p = 0.025) and OHAT scores (β = 0.199, p < 0.001)

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Suzuki *et al.*, 2018 (Japan)	Relationship between characteristics of skeletal muscle and oral function in community-dwelling older women (Cross-Sectional study)	n = 245 participants with median age 81 years (Community dwelling)	To examine the relationship between oral function and sarcopenia staging, including dynapenia and presarcopenia, in community-dwelling older adults	**Maximum tongue pressure (KPa):** JMS tongue pressure measurement instrument; GC, Tokyo, Japan **Oral diadochokinesis "pa", "ta" and "ka" (times/sec):** digital counter (TKK 3350 Digital Counter, Takei Scientific Instruments) **Subjective swallowing difficulties** using the Eating Assessment Tool (EAT-10)	AWGS 2014 **Muscle mass:** Appendicular muscle mass (SMI: Kg/m²) via bioelectrical impedance analysis measurements (MC-780A; TANITA Co., Ltd., Tokyo, Japan) **Hang grip strength (Kg)** using a handgrip dynamometer (TKK 5401; Takei Scientific Instruments, Tokyo, Japan) **Muscle performance:** 5-m walking speed (m/sec)	Multivariate general linear model Post hoc analysis was performed using the Bonferroni test	With respect to oral function, significant differences were observed for maximum tongue pressure, which was significantly lower in the sarcopenia group ($p < 0.01$) than in normal group ($p < 0.01$) Significant differences were observed for oral diadochokinesis which was significantly lower in the sarcopenia group ($p < 0.01$) than in normal group ($p < 0.05$) Significant differences were not observed for EAT-10, the sarcopenia groups tended to show more subjective swallowing difficulties than normal group ($p < 0.050$)
Umeki *et al.*, 2018 (Japan)	The relationship between masseter muscle thickness and appendicular skeletal muscle mass in Japanese community-dwelling elders: A cross-sectional study (Cross-sectional study)	Total participants n = 774 (Mean Age 73.5 ± 5.6) (Community dwelling)	This study examined the association of the MMT, which is associated with masticatory function, with the skeletal muscle index (SMI), a diagnostic criterion for sarcopenia, in community-dwelling elders	**Masseter muscle thickness (MMT) (mm):** measured using an ultrasonography device (Miru-Cube; Global-health, Kanagawa, Japan)	**Skeletal Muscle Index (SMI):** Body composition analyzer (InBody®720; InBody, Seoul, Korea) using the bioelectric impedance method.	Pearson's correlation coefficient Multiple regression analysis	The correlation coefficient between MMT and SMI was r = 0.266, indicating a significant correlation between MMT and SMI The multiple regression analysis indicated that SMI was significantly associated with a decrease in MMT (β = 0.310, $p < 0.001$), Adjusted $R^2 = 0.103$)

Author, Year & Country	Title & Design	Study population & Setting	Aim of the study	Oral health component(s) evaluated, and instrument used	Criteria used to diagnose sarcopenia	Statistical method(s) used	Finding(s)
Sakai, Nakayama, Tohara, Kodama et al., 2017 (Japan)	Relationship between tongue strength, lip strength, and nutrition-related sarcopenia in older rehabilitation inpatients: a cross-sectional study (Cross-sectional study)	A total of n= 201 participants (n= 70 men and n= 131 women) median age 84 years (Inpatient)	To clarify the relationship between tongue strength, lip strength, and nutrition-related sarcopenia (NRS)	Tongue strength: Balloon-type disposable oral probe on one end (JMS, Hiroshima, Japan)(kPa) Lip strength: Lip closure strength indicator Lip De Cum (Cosmo Instruments Co., Ltd., Tokyo, Japan) Remaining teeth	AWGS 2014 Grip strength: Digital grip strength dynamometer (TKK 5401; Takei Scientific Instruments, Tokyo, Japan) (Kg)	Univariable and multivariable logistic regression analyses	All variables except age were significantly associated with NRS in the univariable logistic regression analysis like Tongue strength OR: 0.87, 95% CI:0.83–0.92, P-value < 0.001, Lip strength OR:0.73, 95% CI: 0.65-0.82, P-value < 0.001 Tongue strength and lip strength were independently associated with the presence of NRS (tongue strength: OR = 0.93, 95% CI 0.87–0.98, P=0.012; lip strength: OR = 0.76, 95% CI 0.66–0.88, P= 0.001) in the multivariable logistic regression analysis (R²= 0.51)
Wakasugi et al., 2017 (Japan)	Can grip strength and/ or walking speed be simple indicators of the deterioration in tongue pressure and jaw opening force in older individuals?	n = 197 elderly individuals (n = 97 men; n = 100 women) (Day care)	This study investigates the relationships between decreased whole-body strength, which is easily evaluated, and swallowing-related muscle strength	Tongue pressure: JMS measurement apparatus (JMS, Hiroshima, Japan) Jaw opening force: opening strength trainer (Livet Inc., Tokyo, Japan)	Grip strength: Digital grip dynamometer (TTM Inc., Tokyo, Japan) Walking speed: 4-metre point of an 8-metre walk	Partial correlation analyses	Among men, tongue pressure was correlated with grip strength (r = .60; p < .01, effect size = 0.77) and walking speed (r = .37; p < .01, effect size = 0.61) Jaw opening force was correlated with grip strength (r = .39; p < .01, effect size = 0.62) but not walking speed (p =.07, effect size = 0.43) Among women, neither tongue pressure nor jaw opening force was correlated with either grip strength (0.40, 0.33) or walking speed (0.17, 0.17)
Sakai, Nakayama, Tohara, Maeda et al., 2017 (Japan)	Tongue Strength is Associated with Grip Strength and Nutritional Status in Older Adult Inpatients of a Rehabilitation Hospital (Cross-Sectional study)	174 patients (64 men, 110 women) median age 84 years (Hospital)	To investigate whether tongue strength observed in older adult inpatients of a rehabilitation hospital is associated with muscle function, nutritional status, and dysphagia	Tongue strength: Tongue pressure measuring instrument (JMS, Hiroshima, Japan) fitted with a balloon-type disposable oral probe on one end.	European Working Group on Sarcopenia in Older People 2010 (EWGSOP 2010) Grip strength: Digital grip strength dynamometer (Model T.K.K. 5401, Takei, Japan) Muscle mass: Calf circumference (CC) Arm muscle area (AMA) was also measured as an additional index of muscle mass	Bivariate correlation analysis Multivariate linear regression analysis	Significant correlations were found between maximal tongue pressure and age (r =-0.19, p = 0.012), muscle mass (CC, r = 0.45, p < 0.001; AMA, r = 0.38, p < 0.001), grip strength (r = 0.46, p < 0.001) Multivariate linear regression analysis in all patients and patients 80 years and older revealed that MTP was significantly associated with grip strength in all patients (coefficient = 0.33, 95 % confidence interval (CI) 0.12–0.54, p = 0.002) but not patients 80 years and older (coefficient = 0.25, 95 % CI -0.01 to 0.52, p = 0.061)

Author, Year & Country	Title & Design	Study population & Setting	Aim of the study	Oral health component(s) evaluated, and instrument used	Criteria used to diagnose sarcopenia	Statistical method(s) used	Finding(s)
Iwasaki *et al.*, 2017 (Japan)	The association between dentition status and sarcopenia in Japanese adults aged ≥75 years (Cross-sectional study)	n = 272 participants (n=92 men and n=180 women). The median age was 82 years (Community dwelling)	We investigated whether dentition status is associated with sarcopenia in community-dwelling older Japanese adult	The **number of natural teeth** and **occluding pairs of natural teeth** was counted. In **denture wearers**, the dentures were examined for stability and retention. **Chewing ability** was assessed using the questionnaire.	AWGS 2014 **Skeletal muscle mass (SMM):** Bioelectrical impedance analysis method using the body composition analyser InBody S10 **Handgrip Strength:** Dynamometer (T.K.K.5401) **Usual gait speed:** 4-m walking test.	Logistic regression models. Three regression models were developed. Model 1: included only the dentition status as an exposure (crude model) Model 2: further included age and sex. Model 3: further included covariates shown by univariable analyses	**Number of natural teeth** Model 1: Compared to the individuals with ≥ 20 teeth, those with 1–9 teeth (5.18 (2.24–11.97) and no teeth (2.88 (1.31–6.34) had a significantly higher risk of having sarcopenia Associations were attenuated and became non-significant after adjustment for covariates (Models 2 and 3) **Number of occluding pairs of natural teeth** Model 1: Individuals with ≥10 occluding pairs of natural teeth, those with no occluding pairs of natural teeth had a significantly higher risk of having sarcopenia (crude odds ratio [OR], 6_28; 95% confidence interval [CI], 2_35–16_80) Model 2: Statistically significant association between occluding pairs of natural teeth and sarcopenia remained, although attenuated, after adjustment for other health-related characteristics 3.46 (1.21–9.87) Model 3: Compared to individuals with ≥10 occluding pairs of natural teeth, those with no occluding pairs of natural teeth had significantly higher risk of having sarcopenia (adjusted odds ratio, 3.37; 95% confidence interval, 1.07–10.61) **Denture fit** Model 1: 3.81 (1.59–9.16) Model 2: 5_11 (1.80–14.47) Model 3: Compared to individuals with well-fitting dentures, those with ill-fitting dentures had significantly higher risk of having sarcopenia ((adjusted odds ratio, 5.07; 95% confidence interval, 1.59–16.19)

Author, Year & Country	Title & Design	Study population & Setting	Aim of the study	Oral health component(s) evaluated, and instrument used	Criteria used to diagnose sarcopenia	Statistical method(s) used	Finding(s)
Machida et al., 2017 (Japan)	Effects of aging and sarcopenia on tongue pressure and jaw-opening force	n = 97 older adults (n= 97 men, mean age 78.5 ± 6.6 years; n =100 women, mean age 77.8 ± 6.2 years (Community dwelling)	Aging and sarcopenia reduce not only body strength, but also the strength of swallowing muscles. We examined how aging and sarcopenia affect tongue pressure and jaw-opening force	**Tongue pressure (KPa):** JMS tongue pressure device (JMS, Hiroshima, Japan) **Jaw-opening force (Kg):** jaw-opening sthenometer	AWGS 2014 **Skeletal muscle:** Bioelectrical impedance data (InBody430; InBody Japan, Tokyo, Japan) **The gait speed:** Mean Gait speed of the intermediate 4 m of the 8-m path **Handgrip strength:** Handgrip dynamometer (TTM, Tokyo, Japan)	Multivariate linear regression analysis	**Tongue pressure:** In the multivariate linear regression analysis, sarcopenia were significant independent variables in men (OR: −5.469, 95% CI: −8.248 to −2.690, P-value < 0.001) as well as in women (OR: −3.979, 95% CI: −7.164 to −0.793, P-value 0.015) **Jaw opening force:** In the multivariate linear regression analysis, sarcopenia was a significant independent variable in men (OR: −1.222, 95% CI: −1.900 to −0.544, P-value 0.001), but not in case of women (OR: −0.327, 95% CI: −0.924 to 0.269, P-value 0.279)
Maeda and Akagi, 2015 (Japan)	Decreased tongue pressure is associated with sarcopenia and sarcopenic dysphagia in the elderly	n =104 patient (n = 36 men and n = 68 women), mean age 84.1 ± 5.6 years (Hospital)	To clarify the association between tongue pressure and factors related to sarcopenia such as aging, activities of daily living, nutritional state, and dysphagia	**Tongue pressure measurement (KPa)**: Maximal tongue pressure (MTP) was measured by a device consisting of a disposable oral balloon probe (JMS tongue pressure measuring instrument, JMS, Hiroshima, Japan).	EWGSOP 2010 Sarcopenia was diagnosed by both **skeletal muscle loss** and **low handgrip strength**, which is one of the criteria according to the consensus report	Multivariate regression analysis	Maximum tongue pressure was significantly associated with presence of sarcopenia (OR: -0.207, 95% CI: -10.834 to -0.174, p = 0.043)

Author, Year & Country	Title & Design	Study population & Setting	Aim of the study	Oral health component(s) evaluated, and instrument used	Criteria used to diagnose sarcopenia	Statistical method(s) used	Finding(s)
Murakami *et al.*, 2015 (Japan)	Relationship between chewing ability and sarcopenia in Japanese community-dwelling older adults (Cross-Sectional study)	n = 761 participants (average age 73.0 ± 5.1 years) (Community dwelling)	The present study investigated the relationship between chewing ability and sarcopenia in addition to known sarcopenia-related factors	**Chewing ability:** A color-changeable chewing gum (masticatory performance evaluating gum Xylitol; Lotte, Saitama, Japan) was used to examine chewing ability **Number of existing teeth:** The number of existing intraoral erupted teeth was counted, excluding the residual roots **Number of functional teeth:** The number of prosthetic treatment bridges, plate dentures (removal dentures), implants (artificial roots) of defect sites and the number of existing teeth were counted **Occlusal force:** An occlusal force measurement system film was used, Dental Prescale 50H Type R (Fuji Photo Film, Tokyo, Japan) and an Occuluser (Fuji Photo Film)	EWGSOP 2010 **Skeletal muscle mass index:** Body composition was measured with BIA using an InBody720 (Bio Space, Seoul, Korea) **Grip strength:** Smedley dynamometer (As one, Osaka, Japan) **Usual walking speed:** Participants walked along a walking path with a 3-m acceleration zone, a 5-m measurement zone and a 3-m deceleration zone	Logistic regression analysis	There were significant correlations of sarcopenia with chewing ability (odds ratio 2.18, 95% confidence interval 1.21–3.93)
Buehring *et al.*, 2013 (USA)	Tongue strength is associated with jumping mechanography performance and handgrip strength but not with classic functional tests in older adults (Cross-Sectional study)	n = 97 Caucasian volunteers (n = 49 women, n = 48 men), mean age was 80.7 (range 70–95) (Community dwelling)	To determine whether classic muscle function tests and jumping mechanography (JM) are related to tongue strength	**Isometric tongue strength assessment:** The Iowa Oral Performance Instrument (IOPI) was used to determine anterior and posterior isometric tongue strength (kPa)	EWGSOP 2010 **Muscle function and strength assessment:** SPPB **Grip strength:** hand-held dynamometer (Jamar, Bolingbrook, IL) (Kg) **Appendicular lean mass:** ALM/height²	Linear regression analyses	Anterior maximum tongue pressure was positively correlated (p = .003) with maximal grip strength. r value not reported

Note: AWGS: Asian Working Group for Sarcopenia; EWGSOP: European Working Group on Sarcopenia in Older People; ASM: Appendicular skeletal muscle; PRR: Prevalence rate ratio; OR: Odds ratio; ALM: Appendicular lean mass; HGS: Hand grip strength; GS: Gait speed; IOPI: Iowa oral performance instrument; SPPB: Short physical performance battery; JM: Jumping mechanography; MTP: Maximal tongue pressure; TP: Tongue pressure; SMM: Skeletal muscle mass; NRS: Nutrition related sarcopenia; EAT-10: Eating assessment tool-10; OHIP-14: Oral health impact profile-14; OHAT: Oral health assessment tool; SARC-F: Strength, Assistance in walking, Rise from chair, Climb stairs, and Falls; PA: Poor appetite; LMF: Low masticatory function; CSG: Cross-sectional area of Genohyoid muscle; ODK: Oral diadochokinesis; WS: Walking speed; GOHAI: General Oral Health Assessment Index; TCI: Tongue Coating index; NRT: Number of remaining teeth; m/s: meter per second; Kg: Kilograms; Kg/m²: Kilogram per meter square

Swallowing function

Three studies investigated the association between swallowing and sarcopenia. Swallowing function was assessed using Seirei dysphagia screening questionnaire (15), 10-Item Eating Assessment tool (30, 31). Although significant differences were not observed for EAT-10 (p < 0.05) but still sarcopenic group tended to show more subjective swallowing difficulties than normal group (31). As part of oral hypofunction assessment component, sarcopenia occur at increased risk in patient diagnosed with oral hypofunction (OR = 1.59) (30).

Masticatory function

Seven studies investigated the association between the masticatory function and sarcopenia. In univariate analysis significant association found between sarcopenia and masticatory function (15). A cross sectional study, reported low level of masticatory function was significantly associated with a decline in hand grip strength (OR = 0.96) and possible sarcopenia (OR = 0.90) (18). As part of oral hypofunction assessment, it has been found that sarcopenia occurred at an increased frequency in patient diagnosed with oral hypofunction (30). One of the studies suggested that low masticatory function alone is not associated with sarcopenia but when present alongside poor appetite it is associated with sarcopenia with hazard ratio value of 4.4 (20). Chewing difficulty should be included in geriatric assessment as the OR of 3.11 for sarcopenia in those with chewing difficulty has been found (21). A study using logistic regression analysis have found significant correlation of sarcopenia with chewing ability (OR 2.18) (29).

Tongue lip motor function

Total of four studies have investigated the association between the tongue lip motor function and sarcopenia. Tongue lip motor function has been assessed using digital counter (TKK 3350 Digital counter, Takei scientific instrument) (31), using calculator method (19), Automatic counter (KENKOU-KUN hand, Takei scientific instrument Co. Ltd., Niigata, Japan) (15, 30). In univariate analysis, significant association was found between sarcopenia and decrease tongue lip motor function pa, ta, ka (15, 30). Moderate correlation was found between walking speed and oral diadochokinesis (tongue lip motor function) with r = 0.50 (19). Sarcopenic group showed a significant lower tongue lip motor function (p < 0.01) (31).

Occlusal force

Three studies have investigated the relationship between occlusal force and sarcopenia. Occlusal force was evaluated by number of remaining teeth (15), sensitive sheet (Dental Prescale 50H Type-R, Fuji Film Co., Tokyo, Japan) (29, 30). There exist significant association between the occlusal force assessed according to number of teeth and sarcopenia (15). Occlusal force as part of oral hypofunction assessment component found significant association with the sarcopenia (30). Oral hygiene and oral dryness as part of oral hypofunction assessment found to significantly associated with the sarcopenia (15, 30). Two studies have examined jaw opening force with one using opening strength trainer (Livet Inc., Tokyo, Japan) (24) and other using jaw opening sthenometer (27) to assess it. Jaw opening force correlated with grip strength (r = 0.39) not with walking speed in men (24) as well in multivariate linear regression analysis sarcopenia was a significant independent variable with OR -1.222 for jar opening force. Considering the denture status, an association between the full denture use and low grip strength in both men and women in crude model but after adjusting for covariate no significant association were found in women (33). One of the study findings suggest that the individual with ill-fitting dentures have significantly higher risk of having sarcopenia (OR 5.07) (26). Significant association both in univariate regression and multivariable logistic regression has been found between nutrition related sarcopenia and lip strength (23). There exists a significant correlation r = 0.266 between masseter muscle thickness and skeletal muscle index (22). One of the studies reported moderate correlation between cross-sectional area of Genohyoid muscle and skeletal muscle index have been found (19). In a study, it was found that participants with sarcopenia have poor health related quality of life (p < 0.001) which was assessed using Oral Health Impact Profile-14 (OHIP-14) and sarcopenia was an independent explanatory factor of OHIP-14 (β = 0.138, p = 0.025) (11). Two studies which have assessed oral health assessment index using oral health assessment tool (11, 16). Findings suggest that oral health assessment index score was associated with the diagnosed sarcopenia group (OR = 5.55, 95% CI = 3.80–8.12) and severe sarcopenia (OR = 6.66, 95% CI = 4.13–10.78) (16) and also it has been found that participants with sarcopenia have poor oral health status (p < 0.001) and sarcopenia was an independent explanatory factor of OHAT scores (β = 0.199, p < 0.001) (11).

DISCUSSION

To our knowledge this the first review to investigate the relationship between oral health and sarcopenia restricting to the elderly population. Out of the 20 studies included in this review, 19 records are showing a relationship between oral health and sarcopenia in older adults.
Considering updated sarcopenia assessment as given by consensus groups like European working group on sarcopenia in older

people 2019 (2) as well as Asian working group for sarcopenia 2019 (3) with slight variation in cut-offs, three components are assessed muscle mass, grip strength and gait speed. In two studies, grip strength has been found to have significant correlation with masticatory function (18), tongue pressure (24, 25), jaw opening force (24), full denture use (33), and number of remaining teeth (16–18, 26). Significant correlation found between skeletal muscle mass and tongue pressure (24, 25). Among two studies included in the review, moderate to significant correlation has been found between Genohyoid muscle and masseter muscle thickness (19, 22). Taking walking speed into account, weak correlation found with tongue pressure (24) while not with jaw opening force (24). Walking speed have been found to be lower in those who have lost at least 10 teeth (17). There could be various plausible explanation to link sarcopenia and oral health. According to several research, poor dental health has a negative impact on food intake and lower consumption of a variety of nutrients, such as protein, calcium, and vitamins A, D, and E (35–37). The reduction in muscle mass, muscle strength, and physical performance may be significantly influenced by dietary shortages (38–40). Through neurological pathways, balance and exercise can be linked to oral health. According to certain studies, dental occlusion affected postural stability (41, 42). The periodontal ligament's proprioceptive feeling may be crucial in regulating how the body balances. Additionally, according to some research, the trigeminal nerve's orofacial sensory input may affect balance and muscle strength (43, 44). It is plausible that peripheral orofacial sensory input affects motoneuronal control of the exertion of muscle power in other sections of the body given that prior research have shown a correlation between limb and orofacial motor control mechanisms. Loss of muscle strength may result from periodontal disease-induced inflammation. In gingival tissue, periodontitis raises interleukin-6 and TNF- levels (45).

It's likely that sarcopenia causes a decline in oral function and, conversely, that muscle loss decreases muscle strength. In actuality, hand grip strength, muscle mass, and sarcopenia have all been connected to occlusal force, mastication, tongue pressure, and swallowing (46–48). 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. Also, models exist which predict the risk of sarcopenia among older adults (49). However, the use of oral health status as one of the factor in the prediction models is not taken into consideration, which could be used in future research. Studies that evaluated the oral health of institutionalised older persons have shown that the elderly residing in residential facilities have poor oral health (50, 51). However, there is a lack of research on the oral health of sarcopenic elderly

people living in long-term care facilities. Similar trends can be observed in this review, where twelve investigations were done on sarcopenic older persons living in communities from the twenty studies that were included with no single study in institutionalised sarcopenic older adults. It has been reported that residents of old age homes have a much lower quality of life than people who live in the community (52). Oral conditions also impact quality of life of older adults (53) and their general health and diet (37) which may deteriorate sarcopenia status of the older adult. Additionally, as people age, their capacity to care for their oral health may diminish and taking too many medications may cause dry mouth (54). Nearly half of all residents of care homes have their own natural teeth (55), yet they have substantially worse oral health than their contemporaries who live in the community (*e.g.*, caries prevalence was 73% *vs* 40%) (56).

This study have few limitations as well. First, all the studies of this review are observational studies with cross-sectional and cohort study design, the cause and effect relationship between the oral health and sarcopenia cannot be established. Second, most of the included studies are restricted geographically to Asian region making the generalizability of the association difficult. Lastly, grey literature, conference abstract and proceedings were not accessed.

Significance of the review

The cross-sectional and cohort design of the studies included in this review suggest the relationship exist between the oral health and sarcopenia, however the cause effect relation cannot be commented. Considering the objective of the review the findings would help the dentist as well as physiotherapist to work in tandem to provide holistic care to the older adults there by improving their quality of life. However, other professionals could be involved like nutritionist to say a few in a team to provide a comprehensive care to older adult.

Future recommendations

To the best of our knowledge, no studies have been conducted explicitly in institutionalised sarcopenic older adults. Future research could compare the oral health characteristics of institutionalised sarcopenic older persons with those of institutionalised non-sarcopenic older adults in a case-control study. Also, to look at the cause and effect relationship between the oral health and sarcopenia longitudinal cohort study could be considered for future research.

CONCLUSIONS

There exists a relationship between sarcopenia various components of oral health and oral function among older

adults. This review would help the practitioners and researchers in selecting oral health and function components in the prediction model as well as to include in the management.

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DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

PK, SV AND GN: conceptualization, searching methodology, database searching. PK, SV: duplicate removal, title and abstract screening, data extraction, synthesis of data. PK, GN: data chart preparation, writing. GN: conflict resolution.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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SUPPLEMENTS

Appendix 1. JBI critical appraisal checklist for analytical cross-sectional study.

1) Title: A Cross-Sectional Study on the Relationship between Oral Function and Sarcopenia in Japanese Patients with Regular Dental Maintenance
Author: Shirahase *et al.*
Year: 2022

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?	■			
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?	■			
Were strategies to deal with confounding factors stated?	■			
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

2) Title: Correlation between nutrition, oral health, and different sarcopenia groups among elderly outpatients of community hospitals: a cross-sectional study of 1505 participants in China
Author: Cao *et al.*
Year: 2022

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?			■	
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?	■			
Were strategies to deal with confounding factors stated?			■	
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

3) Title: Relationship between tooth loss and sarcopenia in suburban community-dwelling older adults in Shanghai and Tianjin of China
Author: Wang *et al.*
Year: 2022

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?			■	
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?	■			
Were strategies to deal with confounding factors stated?	■			
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

4) Title: Number of teeth and masticatory function are associated with sarcopenia and diabetes mellitus status among community-dwelling older adults: A Shimane CoHRE study
Author: Abe *et al.*
Year: 2021

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?	■			
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?	■			
Were strategies to deal with confounding factors stated?	■			
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

5) Title: Relationship between Oral Hypofunction and Sarcopenia in Community Dwelling Older Adults: The Otassha Study
Author: Kugimiya *et al.*
Year: 2021

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?		■		
Was the exposure measured in a valid and reliable way?	■			
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?		■		
Were strategies to deal with confounding factors stated?		■		
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

6) Title: Association between oral health status and handgrip strength in older Korean adult
Author: Yun and Lee
Year: 2020

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?			■	
Was the exposure measured in a valid and reliable way?	■			
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?	■			
Were strategies to deal with confounding factors stated?	■			
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

7) Title: The relationship between sarcopenia and oral sarcopenia in elderly people
Author: Kobuchi *et al.*
Year: 2020

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?		■		
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?		■		
Were strategies to deal with confounding factors stated?		■		
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

8) Title: Combined effect of poor appetite and low masticatory function on sarcopenia in community-dwelling Japanese adults aged ≥ 75 years: A 3-year cohort study
Author: Senoo *et al.*
Year: 2020

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?	■			
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?	■			
Were strategies to deal with confounding factors stated?	■			
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

9) Title: Chewing Difficulty Should be Included as a Geriatric Syndrome
Author: Woo, Tong, Yu
Year: 2018

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?			■	
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?			■	
Were strategies to deal with confounding factors stated?			■	
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

10) Title: Prevalence of sarcopenia and association with oral health-related quality of life and oral health status in older dental clinic outpatients
Author: Takahashi, Maeda and Wakabayashi
Year: 2018

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?			■	
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?	■			
Were strategies to deal with confounding factors stated?	■			
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

11) Title: Relationship between characteristics of skeletal muscle and oral function in community-dwelling older women
Author: Suzuki *et al.*
Year: 2018

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?		■		
Was the exposure measured in a valid and reliable way?			■	
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?			■	
Were strategies to deal with confounding factors stated?		■		
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

12) Title: The relationship between masseter muscle thickness and appendicular skeletal muscle mass in Japanese community-dwelling elders: A cross-sectional study
Author: Umeki *et al.*
Year: 2018

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?			■	
Were objective, standard criteria used for measurement of the condition?		■		
Were confounding factors identified?	■			
Were strategies to deal with confounding factors stated?	■			
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

13) Title: Relationship between tongue strength, lip strength, and nutrition-related sarcopenia in older rehabilitation inpatients: a cross-sectional study
Author: Sakai *et al.*
Year: 2017 3rd August

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?			■	
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?		■		
Were strategies to deal with confounding factors stated?		■		
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

14) Title: Can grip strength and/or walking speed be simple indicators of the deterioration in tongue pressure and jaw opening force in older individuals?
Author: Wakasugi *et al.*
Year: 2017

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?			■	
Were objective, standard criteria used for measurement of the condition?		■		
Were confounding factors identified?		■		
Were strategies to deal with confounding factors stated?		■		
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

15) Title: Tongue Strength is Associated with Grip Strength and Nutritional Status in Older Adult Inpatients of a Rehabilitation Hospital
Author: Sakai, Nakayama, Tohara, Maeda *et al.*
Year: 2017

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?			■	
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?			■	
Were strategies to deal with confounding factors stated?			■	
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

16) Title: The association between dentition status and sarcopenia in Japanese adults aged ≥75 years
Author: Iwasaki *et al.*
Year: 2017

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?	■			
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?	■			
Were strategies to deal with confounding factors stated?	■			
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

17) Title: Effects of aging and sarcopenia on tongue pressure and jaw-opening force
Author: Machida *et al.*
Year: 2017

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?		■		
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?		■		
Were strategies to deal with confounding factors stated?		■		
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

18) Title: Decreased tongue pressure is associated with sarcopenia and sarcopenic dysphagia in the elderly
Author: Maeda and Akagi
Year: 2015

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?		■		
Were objective, standard criteria used for measurement of the condition?		■		
Were confounding factors identified?	■			
Were strategies to deal with confounding factors stated?	■			
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

19) Title: Relationship between chewing ability and sarcopenia in Japanese community-dwelling older adults
Author: Murakami *et al.*
Year: 2015

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?	■			
Was the exposure measured in a valid and reliable way?		■		
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?		■		
Were strategies to deal with confounding factors stated?		■		
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			

20) Title: Tongue strength is associated with jumping mechanography performance and handgrip strength but not with classic functional tests in older adults
Author: Buehring *et al.*
Year: 2013

	Yes	No	Unclear	Not applicable
Were the criteria for inclusion in the sample clearly defined?	■			
Were the study subjects and the setting described in detail?		■		
Was the exposure measured in a valid and reliable way?			■	
Were objective, standard criteria used for measurement of the condition?	■			
Were confounding factors identified?		■		
Were strategies to deal with confounding factors stated?		■		
Were the outcomes measured in a valid and reliable way?	■			
Was appropriate statistical analysis used?	■			