Masticatory function loss and frailty risk in community-dwelling older people in the State of São Paulo

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Abstract

Objective: To verify if the loss of masticatory function increases the risk of frailty in community-dwelling older people in the state of São Paulo. *Methods:* A prospective cohort design was adopted based on the FIBRA study database (Fragility in Brazilian Elderly), with a baseline performed in 2008-2009 and follow-up in 2016-2018, elapsed on average 100.2 ± 9.2 months. The outcome variable was the incidence of frailty. The exposure variable was masticatory function according to edentulism and self-reported chewing difficulty. Adjustment variables were sociodemographic, behavioral, and general health conditions. A Poisson regression model with robust variance was used to estimate the relative risk. *Results:* the cumulative incidence of frailty over eight years was 30 cases per 100 edentulous participants with chewing difficulties, who had a higher risk of developing frailty (RR: 1.75 95% CI 1.09-2.81) than the dentate elderly without chewing difficulties, regardless of smoking (RR: 1.71 95% CI 1.07-2.73) and socioeconomic status (RR: 1.72 95% CI 1.13-2.62). *Conclusion:* Loss of masticatory function increases the risk of frailty in older people. Future research should study whether the rehabilitation of oral function reduces this risk.

Keywords: Oral health. Frail elderly. Longitudinal studies.

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Funding: CAPES/PROCAD. Nº do processo: 2972/2014-01 (Projeto nº 88881.068447/ 2014-01). APESP Nº do processo: 2016/00084-8. CNPq Nº do processo: 424789/2016-7.

The authors declare that there is no conflict in the conception of this work.

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Received: November 22, 2021
Approved: May 31, 2022

http://dx.doi.org/10.1590/1981-22562022025.210234.en

INTRODUCTION

Frailty is recognized as one of the main health problems associated with aging[1-3]. It can be defined as a geriatric syndrome which develops as a consequence of a progressive decline in multiple physiological systems, impairing an individual´s capacity to cope with stressors and rendering them vulnerable to adverse outcomes such as hospitalization, dependency, disability and death[4]. Progression of the condition spans 3 possibilities along a spectrum of frailty: robust or non-frail; pre-frail (or at high risk of developing frailty); and frail[4]. Frailty can be reversed, and therefore efforts to provide early detection and treatment of symptoms are need to restore robustness[5].

A relationship between oral health problems and frailty has been established[6]. A potential mechanism underlying this link lies in the association between poor oral status and disability, muscle weakness, lower intake of nutrients and weight loss, factors related with the pathogenesis of frailty[6]. Cross-sectional studies have shown an association between frailty and number of teeth, denture use, negative self-rating of oral health and low use of dental services[7, 8]. A systematic review of longitudinal studies with 3-5 year follow-ups found that poor oral health status was a strong predictor of frailty[9, 10]. Conversely, retaining a higher number of teeth[11] and the presence functional dentition[12] were associated with a lower risk of developing frailty.

Although not universal in aging, deterioration of oral health and frailty are chronic, progressive and cumulative conditions which promote morbidity, disability, pain, discomfort and impairment in social life and overall quality of life[10].Therefore, it is crucial that primary care services adopt early regular diagnostic and treatment measures throughout adult life and into old age, particularly more advanced age.

If deterioration in oral health can serve as a valid marker of the onset of frailty, and given that 50% of community-dwelling older adults are at risk of developing frailty [13], then it is important to explore this relationship because oral status can be used to allow timely identification of individuals at risk. Additionally, the prevalence of both frailty and oral health problems are higher in low-to-middle income countries[13, 14], as is the case in Brazil.Therefore, the objective of this study was to determine whether loss of masticatory function increases the risk of frailty in community-dwelling older people from São Paulo state.

METHODS

A prospective cohort study drawing on data from the Frailty in Brazilian Adults (FIBRA) study was conducted. The FIBRA study is a population-based survey carried out in 2008-2009 to investigate associations between frailty syndrome and sociodemographic, health, functionality and psychosocial variables[15]. Although the original FIBRA study was cross-sectional in design and covered 7 Brazilian cities, each with a different Human Development Index (HDI), the present study involved a sample of 1284 older adults aged ≥65 years, comprising 900 participants from Campinas and 384 from Ermelino Matarazzo, a subdistrict of São Paulo city, Brazil.These are the only cities for which baseline data was collected on oral health of participants and where a complete follow-up of all variables was performed between 2016 and 2018.

For this study, a non-probabilistic consecutive sample was created, where the baseline sample involved simple random sampling of urban census sectors, according to the calculation of the target number of older adults recruited and number of urban census sectors. As a result, 90 census sectors were surveyed by recruiters in Campinas, and 62 in Ermelino Matarazzo. Quotas of men and women were estimated observing the proportions of the distribution of the older population according to different age groups: 65-69, 70-74, 75-79 and ≥80 years.The minimum sample size was estimated at 601 older adults for Campinas with a total population of over 1 million people, allowing for a sampling error of 4%. For Ermelino Matarazzo, with a total population of under 1 million people, a minimum sample of 384 older adults was estimated, allowing for a sampling error of 5%.

During recruitment, a sequence was marked out on a map used by pairs of trained interviewers to cover

the streets. The interviewers visited all households, checking door-to-door for the presence of older adults who met the selection criteria. Inclusion criteria were the older adult agreeing to take part in the study, understanding the instructions, being aged ≥65 years, and a being permanent resident at the address and within the census sector. Older adults who presented problems suggestive of cognitive impairment or advanced Parkinson´s disease, severe hearing or vision loss, stroke complications, permanent or temporary walking disability (except for use of walking aids) and individuals at terminal stage of illness were excluded.

In the 2016-2018 follow-up, conducted at a mean time elapsed since baseline of 100.2 ± 9.2 months, a second wave of data collection was carried out via home visits, during which participants were invited to take part again. After agreeing to participate, respondents were interviewed by pairs of researchers who collected information on the same variables using the same instruments.As a strategy to reduce losses, when the older adult exhibited cognitive impairment, as confirmed by the Mini-Mental State Examination (MMSE), validated for use in Brazil [16], a family member or otreliable informant was asked to answer the self-report questionnaire on their behalf.

For this study, older adults who were frail at baseline and remained frail at the follow-up were excluded. Likewise, individuals who did not participate in the follow-up, whether due to death, not found, refusal, exclusion, drop out, perceived risk to interviewers in vicinity of residence, or missing data for the variables of interest, were also excluded.

The dependent variable was frailty incidence. Frailty was rated using Fried´s phenotype model[4] derived from data from 2 population-based studies: the Cardiovascular Health Study and the Women and Health Study. According to these studies, frailty increases the risk for morbidity, disabilities, falls, hospitalization, institutionalization and death within 2-3 years[4]. The components indicating frailty are as follows:(1) unintentional weight loss in the past year of ≥4.5kg or 5% of body weight; (2) low physical activity level (as indicated by energy expenditure on the Minnesota Leisure Time Activities Questionnaire[17], adjusted for gender; (3) Fatigue/exhaustion (response to statements "strength and vitality for carrying out activities of daily living" and/or "I could not get going"; 4) Low hand-grip strength measured in Kgf by hand-held Jamar type dynamometer, for 3 consecutive attempts, adjusted by sex and Body Mass Index (BMI); and (5) slow walking speed as indicated by mean time in seconds taken to walk 4.6m with usual gait 3 consecutive times, adjusted for sex and weight. Scores below the 20th percentile of the sample for hand-grip strength and physical activity; and above the 80th percentile for gait speed, indicated frailty. Details on the cut-off points used for each criterion have been published elsewhere[18]. Briefly, cut-off scores for physical inactivity (sedentarism) were weekly expenditure < 383kcal for men and expenditure < 270kcal for women; for hand-grip strength, men were defined as frail at strength values < 29 kgf (BMI < 24), < 30 kgf (BMI 24.1–28) and < 32 kgf (BMI > 28), while women were deemed frail at values < 17 kgf (BMI < 23), < 17.3 kgf (BMI 23.1–26), < 18 kgf (BMI 26.1–29) and < 21 kgf (BMI >29); while for gait speed,men were defined as frail for time taken >7 seconds (< 173cm) or 6 seconds (< 173cm), while women were deemed frail for time >7 seconds (< 159cm) or 6 seconds (>160cm). Individuals scoring for ≥3 criteria were classified as "frail"; 1-2 criteria as "pre-frail"; and with no score for all 5 criteria as "robust". Individual frailty incidence was determined over a mean period of 8 years, according to the transition from robust to frail status or from pre-frail to frail status, between baseline and follow-up. Individuals who were frail at baseline and remained so at follow-up were excluded from the sample (n=20).

The exposure of interest was oral health status. Edentulism (defined as total absence of teeth) status and perceived difficulty chewing were determined by self-report. On the basis of this data, the variable "masticatory function" was created, categorized into 4 levels: dentate without chewing difficulty, dentate with chewing difficulty, edentulous without chewing difficulty, and edentulous with chewing difficulty. Also, respondents were probed about their perceived oral health, with responses dichotomized into positive (excellent/good) and negative (fair/poor).

Using baseline data, the following sociodemographic information was analyzed: age, sex, education (years), marital status, family income, living arrangement and homeowner status. Education was stratified into ≤4 years and ≥5 years. Marital status was dichotomized into single/widowed/separated/without partner and married/with partner. Family income was measured according to number of minimum wages (MWs) in 2008 (R$415/US$231) at baseline and in 2017 (R$937/US$288) at follow-up, dichotomized into 0-3 MWs and ≥4 MWs.The variable living arrangement was dichotomized into "alone" and "with others". Results of measures of behavioral variables were also collected, namely: frequency of alcohol consumption (0 and ≥1 times per month), smoking (yes or no) and use of dental services in the past year (yes or no).

With regard to general health variables, BMI was calculated as a proxy of nutritional status and used to classify participants as obese (≥ 30 kg/m^2), overweight (28-29.9 kg/m^2), normal weight (23-27.9 kg/m^2) or underweight (17-22.9 kg/m^2). Multimorbidity was defined as yes (presence of ≥2 disease) or no (≤1 disease), including conditions such as cardiovascular diseases (angina and myocardial infraction), hypertension, stroke, diabetes mellitus, cancer, arthritis, respiratory disorders (bronchitis and emphysema), depression and osteoporosis.

All participants signed an Free and Informed Consent Form, and all procedures were previously approved by the local Research Ethics Committee (CEP) of UNICAMP under permit no. N° 4541075, on 15/02/2021.

The characteristics of participants were treated using descriptive statistics. Pearson´s chi-square test was used, adopting a p-value <0.05 as statistically significant. The strength of associations between oral status (baseline data) and frailty incidence as the outcome (baseline and follow-up data) was estimated by calculating relative risks (RRs) using the Poisson regression model with robust variance. The model was controlled for the covariates outlined previously (obtained from baseline data), considered confounding factors.A bivariate analysis was first performed in which variables with p<0.20, or those documented as important in relation to frailty, were entered in the multivariate analysis.The final model yielded RRs with their respective 95% confidence intervals (CI), adopting a value of p<0.05 to indicate statistical significance.

RESULTS

Of the 1284 original participants in the 2008-2009 wave of the FIBRA study, 549 (42.8%) remained in the 2016-2018 follow-up, with full data available for 428 subjects.In the second wave assessment, participants had a mean age of 80±4 (range 72-102) years, and were predominantly female (69%) and homeowners (85%).The overall incidence of frailty was 21.7% (n=103) (Table 1).

With regard to the reasons for losses to follow-up, 192 (14.9%) participants died and 543 (42.3%) were lost due to not being found, refusal, exclusion, drop-out or risk to interviewers.

The cumulative frailty incidence of participants by masticatory function category is depicted in Figure 1. There were 30 cases of frailty per 100 edentulous participants with chewing difficulty after an average 8 year follow-up period.

The variables associated in the bivariate analysis and final model are shown in Table 2. Individuals who were edentulous with chewing difficulties had a 1.75 times higher risk of developing frailty (RR:1.75 95%CI 1.09-2.81) compared to those who were dentate without chewing difficulties, irrespective of smoking effect (RR:1.71 95%CI 1.07-2.73) and socioeconomic position (RR:1.72 95%CI 1.13-2.62).

Table 1. Characteristics of participants at baseline and at follow-up. *FIBRA Study, Older adults, Campinas and Ermelino Matarazzo, São Paulo state, Brazil, 2008-2009 and 2016-2018.*

Variables	Participants n (%)*	
	2008-2009	2016-2017
Sociodemographic		
Gender		
Male	147 (31)	147 (31)
Female	327 (69)	327 (69)
Education		
0-4 years	363 (76.7)	354 (74.7)
≥ 5 years	110 (23.3)	120 (25.3)
Family income		
0-3 minimum wages	208 (49.6)	270 (63.4)
≥ 4 minimum wages	211 (50.4)	156 (36.6)
Marital status		
single/widowed/separated/without partner	218 (46.2)	259 (55)
married/with partner	254 (53.8)	212 (45)
Living arrangement (alone)		
Yes	69 (14.6)	83 (22.1)
No	404 (85.4)	293 (77.9)
Homeowner		
Yes	398 (84.1)	385 (83.3)
No	75 (15.9)	77 (16.7)
Behavioral variables		
Smoking		
Yes	39 (9)	11 (3.2)
No	395 (91)	334 (96.8)
Alcohol use		
Yes	144 (33.5)	125 (35.3)
No	286 (66.5)	229 (64.7)
Dental visit in past year		
Yes	205 (48)	163 (46.4)
No	222 (52)	188 (53.6)
General health variables		
BMI		
Underweight	66 (14)	93 (19.7)
Normal weight	204 (43.3)	205 (43.5)
Overweight	76 (16.1)	53 (11.3)
Obese	125 (26.6)	120 (25.5)
Multimorbidity		
Yes	297 (68.6)	311 (68.2)
No	136 (31.4)	145 (31.8)

to be continued

Continuation of Table 1

Variables	Participants n (%)*	
	2008-2009	2016-2017
Frailty		
Non-frail	169 (35.7)	98 (20.7)
Pre-frail	277 (58.4)	273 (57.6)
Frail	28 (5.9)	103 (21.7)
Oral health status		
Perceived oral health		
Positive (excellent/good)	66 (15.5)	230 (65.3)
Negative (fair/poor)	359 (84.5)	122 (34.7)
Swallowing difficulties		
Yes	146 (33.9)	147 (37.5)
No	285 (66.1)	245 (62.5)
Edentulous		
Yes	209 (48.6)	187 (54.4)
No	221 (51.4)	157 (45.6)
Masticatory function		
Dentate with chewing difficulty	63 (14.7)	47 (13.7)
Edentulous with chewing difficulty	83 (19.3)	79 (23.1)
Edentulous without chewing difficulty	126 (29.4)	108 (31.6)
Dentate without chewing difficulty	157 (36.6)	108 (31.6)

BMI:body mass index

*20 individuals were frail at baseline and remained so at follow-up and therefore excluded from the sample.

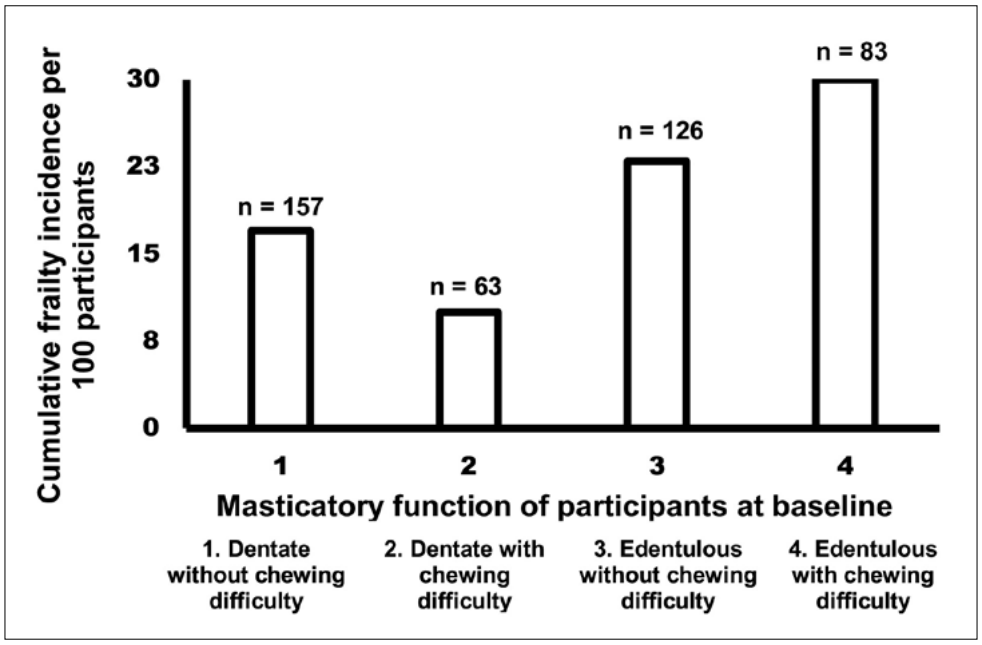

Figure 1. Cumulative frailty incidence according to masticatory function over mean period of 8 years FIBRA Study, Older adults, Campinas and Ermelino Matarazzo, São Paulo state, Brazil, 2008-2009 and 2016-2018.

Table 2. Association of loss of masticatory function with frailty incidence over mean period of 8 years. *FIBRA Study, Older adults, Campinas and Ermelino Matarazzo, São Paulo state, Brazil, 2008-2009 and 2016-2018.*

Variable (baseline)	Frailty incidence	
	Category	Crude RR (95%CI)
Sociodemographic		
Living arrangement	Alone	1.50 (1.0 -2.25)
	With others	1
Education	0-4 years	1.43 (0.90-2.27)
	≥5 years	1
Homeowner	No	1.61 (1.10-2.37)**
	Yes	1
Family income	0-3 MWs	1.60 (1.08-2.36)
	≥ 4 MWs	1
Marital status	Single	1.44 (1.02-2.04)
	married/with partner	1
Behavioral		
Dental visit	No	1.75 (1.16-2.63)*
	Yes	1
Monthly frequency of alcohol use	≥1	0.68 (0.44-1.06)
	0	1
Smoking	Yes	1.80 (1.10-2.94)*
	No	1
General health		
BMI	Obese	1.15 (0.73-1.80)
	Overweight	1.52 (0.96-2.43)
	Normal weight	1
	Underweight	1.59 (0.98-2.56)
Multimorbidity	Yes	1.39 (0.91-2.12)*
	No	1
Oral health status		
Perceived oral health	Negative	0.84 (0.53-1.32)
	Positive	1
Masticatory function	Dentate with chewing difficulty	0.57 (0.25-1.33)
	Edentulous with chewing difficulty	1.82 (1.12-2.94)*
	Edentulous without chewing difficulty	1.39 (0.86-2.23)
	Dentate without chewing difficulty	1

*p-value <0.20. **p-value <0.05. RR:relative risk; CI:confidence interval; MW:minimum wage;BMI (body mass index).

Table 3. Final regression model for variables associated with frailty incidence over mean period of 8 years (n=428). *FIBRA Study, Older adults, Campinas and Ermelino Matarazzo, São Paulo state, Brazil, 2008-2009 and 2016-2018.*

Variable	Category	Frailty incidence RR (95%CI)
Homeowner	No	1.72 (1.13-2.62)*
	Yes	1
Smoking	Yes	1.71 (1.07-2.73)*
	No	1
Masticatory function	Dentate with chewing difficulty	0.62 (0.27-1.42)
	Edentulous with chewing difficulty	1.75 (1.09-2.81)*
	Edentulous without chewing difficulty	1.36 (0.84-2.18)
	Dentate without chewing difficulty	1

*p-value <0.05. RR:relative risk; CI:confidence interval

DISCUSSION

In this study, loss of masticatory function was found to increase the risk of frailty. Masticatory function loss can lead to malnutrition and, in turn, to frailty[19]. This relationship is also consistent with other evidence in the literature, even when different approaches were used to measure loss of masticatory function. A previous longitudinal study estimated this parameter, defining functional mastication as the presence of 20 or more teeth in the oral cavity, and confirmed this marker as a protective factor for frailty[12]. Based on the same rationale, another study with a 3-year follow-up, found that, for each additional tooth present in the oral cavity, there was a 5% lower risk of frailty[11]. However, measuring masticatory function goes beyond counting the teeth present. It is also important to take account of the number of pairs of teeth in occlusion and, in cases of dental losses, to perform prosthetic rehabilitation which restores the function of lost teeth[20].

In the present study, masticatory function loss was determined according to edentulism, together with self-reported chewing difficulty.Using this approach, edentulous individuals without masticatory difficulty were shown to be at no higher risk of frailty. This finding suggests two possible explanations: the simplest may be that older individuals adapted to loss of masticatory function based on the belief that tooth loss is a normal part of aging[21] and modified their diet reducing intake of fiber and protein by overcooking foods or cutting out fresh products from the diet to avoid chewing problems[20]. Indeed, if nutrition had been affected, an effect on frailty would have been evident. Another possible explanation is that these individuals used some kind of denture.The literature suggests that, irrespective of number of remaining teeth, if functional dentures are used, frailty risk does not increase[22]. However, older women living in the community that used dentures, but had chewing or swallowing difficulties, effectively had greater malnutrition, frailty and mortality risk[23]. Congruent with the present study results, these data support the relationship between masticatory dysfunction and frailty. The present study highlights the importance and validity of examining this relationship, investigating older men and women using two separate measures over an average follow-up of 8 years.

The functions of the masticatory system have two distinct aspects: physical function observed clinically; and masticatory function reported by the patient. Although physical functioning can be measured objectively by masticatory efficiency, older individuals do not always perceive its negative impact[24]. This makes subject assessment of masticatory capacity vital. A longitudinal study found that both impaired ability to form food bolus and subjective mastication capacity were associated with progression to frailty[25]. Thus, it is plausible that, in the present study, an association with frailty also occurred, even though masticatory function was measured by self-report.

The mechanisms through which poor oral health can lead to frailty include deteriorating nutritional status due to the inability to consume an adequate diet[26,27], psychosocial effects, such as lack of self-esteem, isolation, reduced quality of life and the chronic inflammation typical of oral diseases, which alters the metabolism of other key organs[28]. These mechanisms are, in turn, associated with socioeconomic position[29] and smoking[30], factors which this study found to contribute to higher risk of frailty. Nevertheless, despite the confounding effect which socioeconomic and smoking status may have had on the relationship studied, an effect on increased incidence of frailty was found among participants with loss of masticatory function.

Regarding the limitations of this study, the difference in proportion of older adults estimated and effectively observed may constitute one such limitation. These disparities may have influenced by the results obtained.Future studies should be conducted to confirm the proportion of older adults who refused to the participate, perhaps because they had deteriorated oral health status, given that the current findings may have been underestimated, albeit without affecting the power of the relationship found.

Although the data collected on masticatory function did not include factors such as partial edentulism, its extent , and use of dentures or otherwise, the lack of this data is unlikely to have made a meaningful difference to the results obtained. The majority of the participants reported using dentures, and most individuals (66%) reported no chewing difficulty.

The use of assessments of oral health status by self-report is advantageous in situations where clinical evaluation is not cost-effective. A previous study involving participants of the FIBRA study Campinas, in the same group of older adults, showed high sensitivity and specificity for self-reported edentulism and use of removable dentures[31]. Both the clinical and subjective assessment of masticatory function proved sensitive for showing that both indicators were associated with frailty[25]. Another strength of the present study is the long follow-up period, being the first study of oral health and frailty to have been conducted after an average period of 8 years from baseline assessment, especially for developing countries such as Brazil.The study findings are particularly timely because projections of edentulism in Brazil indicate the condition is increasing and set to continue rising among older people up until 2040[32].

CONCLUSION

The relevance of this study to the geriatric and gerontology area lies in the finding that loss of masticatory function increased the incidence of frailty over an average period of 8 years. Masticatory function should be incorporated into frailty assessments because edentulism and chewing difficulties can lead to a greater risk of the condition. Future studies investigating whether rehabilitation of masticatory function helps reduce this risk are warranted.

Edited by: Maria Helena Rodrigues Galvão

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