UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ODONTOLOGIA DE PIRACICABA

MARIANA MARINHO DAVINO DE MEDEIROS

FUNÇÕES ORAIS, MORTALIDADE E ESTADOS FÍSICO E NUTRICIONAL EM IDOSOS RESIDENTES EM INSTITUIÇÕES DE LONGA PERMANÊNCIA

ORAL FUNCTIONS, MORTALITY AND PHYSICAL AND NUTRITIONAL STATUS AMONG OLDER ADULTS LIVING IN LONG-TERM CARE FACILITIES

Piracicaba
2024

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Tese apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do título de Doutora em Clínica Odontológica, na Área de Prótese Dental.

Thesis presented to the Piracicaba Dental School of the University of Campinas in partial fulfillment of the requirements for the degree of Doctor in Dental Clinic, in Prosthodontics area.

Orientadora: Profª. Dra. Renata Cunha Matheus Rodrigues Garcia

Este trabalho corresponde à versão final da tese defendida pela aluna Mariana Marinho Davino de Medeiros, e orientada pela Profª. Dra. Renata Cunha Matheus Rodrigues Garcia

Piracicaba

2024

Ficha catalográfica
Universidade Estadual de Campinas (UNICAMP)
Biblioteca da Faculdade de Odontologia de Piracicaba
Marilene Girello - CRB 8/6159

M467f

Medeiros, Mariana Marinho Davino de, 1995-
Funções orais, mortalidade e estados físico e nutricional em idosos residentes em instituições de longa permanência / Mariana Marinho Davino de Medeiros. – Piracicaba, SP : [s.n.], 2024.

Orientador: Renata Cunha Matheus Rodrigues Garcia.
Tese (doutorado) – Universidade Estadual de Campinas (UNICAMP), Faculdade de Odontologia de Piracicaba.

1. Idosos. 2. Instituição de longa permanência para idosos. 3. Mastigação. 4. Mortalidade. 5. Fragilidade. I. Rodrigues-Garcia, Renata Cunha Matheus, 1964-. II. Universidade Estadual de Campinas (UNICAMP). Faculdade de Odontologia de Piracicaba. III. Título.

Informações Complementares

Título em outro idioma: Oral functions, mortality and physical and nutritional status among older adults living in long-term care facilities
Palavras-chave em inglês:
Older people
Homes for the aged
Mastication
Mortality
Frailty
Área de concentração: Prótese Dental
Titulação: Doutora em Clínica Odontológica
Banca examinadora:
Renata Cunha Matheus Rodrigues Garcia [Orientador]
Raquel Conceição Ferreira
Yuri Wanderley Cavalcanti
Mayara Abreu Pinheiro
William Custódio
Data de defesa: 29-08-2024
Programa de Pós-Graduação: Clínica Odontológica

Identificação e informações acadêmicas do(a) aluno(a)
- ORCID do autor: https://orcid.org/0000-0002-2472-8747
- Currículo Lattes do autor: http://lattes.cnpq.br/0102366389294926

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Faculdade de Odontologia de Piracicaba

A Comissão Julgadora dos trabalhos de Defesa de Tese de Doutorado, em sessão pública realizada em 29 de agosto de 2024, considerou a candidata MARIANA MARINHO DAVINO DE MEDEIROS aprovada.

PROFª. DRª. RENATA CUNHA MATHEUS RODRIGUES GARCIA

PROFª. DRª. RAQUEL CONCEIÇÃO FERREIRA

PROFª. DRª. MAYARA ABREU PINHEIRO

PROF. DR. YURI WANDERLEY CAVALCANTI

PROF. DR. WILLIAM CUSTODIO

A Ata da defesa, assinada pelos membros da Comissão Examinadora, consta no SIGA/Sistema de Fluxo de Dissertação/Tese e na Secretaria do Programa da Unidade.

DEDICATÓRIA

Dedico esta tese de Doutorado aos meus pais, Gerlane Pereira Marinho e Carlos Alberto Davino de Medeiros, por todo incentivo durante minha formação acadêmica. A vocês, minha gratidão.

AGRADECIMENTOS

À Fundação de Amparo à Pesquisa do Estado de São Paulo, pela concessão das bolsas de Doutorado no país e Estágio de Pesquisa no Exterior (BEPE), fundamentais para o desenvolvimento desta tese. O presente trabalho foi realizado com apoio da Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), processos nº 2021/02463-4 e 2022/08874-9.

À Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, pelo apoio ao Programa de Pós-Graduação em Clínica Odontológica. O presente trabalho foi realizado com apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) - Código de Financiamento 001.

À Universidade Estadual de Campinas, na pessoa do Magnífico Reitor, Professor Doutor Antonio José de Almeida Meirelles.

À Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas (FOP-Unicamp), nas pessoas do Diretor, Prof. Dr. Flávio Henrique Baggio Aguiar, e da Diretora Associada, Profª. Dra. Karina Gonzales Silverio Ruiz.

À Coordenador dos Cursos de Pós-Graduação da FOP-Unicamp, Prof. Dr. Valentim Adelino Ricardo Barão.

À Coordenadora do Programa de Pós-Graduação em Clínica Odontológica da FOP-Unicamp, Profª. Dra. Débora Alves Nunes Leite Lima.

Aos professores da área de Prótese Parcial Removível da FOP-Unicamp, Profª. Dra. Altair Antoninha Del Bel Cury, Profª. Dra. Renata Cunha Matheus Rodrigues Garcia, Prof. Dr. Wander José da Silva e Profª. Dra. Raissa Micaella Marcello Machado, e aos demais professores do Departamento de Prótese Dental pela oportunidade de aprendizado durante as disciplinas e clínicas.

Às bancas examinadoras da qualificação e defesa de tese, compostas por Profª. Dra. Altair Antoninha Del Bel Cury, Prof. Dr. Mario Augusto Brondani, Prof. Dr. Yuri Wanderley Cavalcanti, Prof. Dr. William Custodio, Profª. Dra. Raquel Conceição Ferreira e Profª. Dra. Mayara Abreu Pinheiro, pela disponibilidade em ler e contribuir com essa tese de Doutorado.

Aos funcionários da FOP-Unicamp, em especial à técnica do Laboratório de Prótese Parcial Removível, Gislaine Alves Pitton, e à secretária do Departamento de Prótese e Periodontia, Eliete Aparecida Ferreira Marin, pela atenção, solicitude e gentileza durante os anos em que estive na instituição.

Aos diretores e funcionários das Instituições de Longa Permanência para Idosos (ILPIs) de Piracicaba e João Pessoa, por anuírem esta pesquisa, e, principalmente, pela acolhida e apoio durante a coleta de dados.

Aos idosos, por consentirem participar desta pesquisa, mas também pelo carinho, conversa, atenção e ensinamentos. Espero que os resultados desse estudo sirvam de subsídio para qualificar o cuidado prestado aos idosos residentes em ILPIs, propiciando melhorias em sua saúde e qualidade de vida.

À Profª. Dra. Renata Cunha Matheus Rodrigues Garcia, por sempre acreditar na minha capacidade de executar os trabalhos propostos. Sou grata pela confiança em mim depositada e pelo apoio e incentivo durante o meu período de doutoramento. Para além da pós-graduação, continuarei me espelhando em sua ética, educação e organização, bem como na sua competência didática e clínica. Obrigada por todos os ensinamentos.

Ao Prof Dr. Mario Augusto Brondani, por ter aceitado ser meu supervisor durante o Doutorado Sanduíche. Agradeço também por todas as reuniões, reflexões e discussões frutíferas que tivemos, que enriqueceram e muito o nosso trabalho. Expresso aqui a minha gratidão.

Ao Prof. Dr. Yuri Wanderley Cavalcanti, por se fazer presente mesmo à distância, me auxiliando na execução deste trabalho. Agradeço também por se preocupar e lembrar de mim em diversas oportunidades.

À Lorena Tavares Gama e Juliana de Castro Godinho, discentes do Programa de Pós-Graduação em Clínica Odontológica FOP-Unicamp, pelo auxílio durante a coleta de dados da pesquisa.

Aos colegas do Laboratório de Prótese Parcial Removível FOP-Unicamp, pelo convívio harmonioso.

Aos amigos, Loyse Martorano, Allex Farias, Amanda Santos, José Welton Vasconcelos, Jannerson Xavier e Rennis Oliveira, por estarem comigo em todos os momentos e nunca deixarem nossa amizade se perder.

As amigas que fiz durante o Doutorado Sanduíche, Vanessa Souza, Débora Ungaretti e Ana Milani, que fizeram meu estágio em Vancouver ser ainda mais especial.

A minha família, por todo incentivo e torcida durante a minha formação na pós-graduação.

A todos que, de alguma maneira, contribuíram para esta etapa, meu sincero agradecimento.

RESUMO

O envelhecimento causa alterações nas funções orais. Quando deterioradas, as funções orais podem prejudicar os estados físico e nutricional dos idosos e, em último caso, levar a mortalidade. Apesar disso, a relação entre função oral, estados físico e nutricional e mortalidade têm sido pouco investigadas em idosos residentes em Instituições de Longa Permanência para Idosos (ILPIs). Diante disso, esta tese objetivou avaliar a associação entre função mastigatória e mortalidade, e entre funções orais e sarcopenia, fragilidade, dependência em atividades de vida diária (AVD) e estado nutricional em idosos residentes em ILPIs. Para isso, foram realizados dois estudos, um longitudinal e o outro transversal. No estudo longitudinal, no baseline foram coletados dados de 295 participantes, incluindo idade, sexo, polifarmácia, mobilidade, AVD, fragilidade, estado nutricional e função mastigatória objetiva (performance mastigatória - goma de mascar) e autorrelatada. Os participantes foram acompanhados por 4 anos para registrar dados de mortalidade. Regressões de Cox ($\alpha = 0,05$) foi utilizada para analisar os dados. No estudo transversal, 187 residentes em ILPIs foram avaliados quanto aos desfechos de: sarcopenia (SARC-CalF), fragilidade (componentes do fenótipo de Fried), dependência em AVD (escala de Katz) e estado nutricional (MNA-SF). A hipofunção oral (variável independente) foi considerada quando três ou mais dos seguintes sintomas estavam presentes: xerostomia, declínio da força oclusal, fala deteriorada, performance mastigatória comprometida e declínio da função de deglutição. Regressões de Poisson foram usadas para testar possíveis associações ($\alpha=0,05$). Como resultados, 124 (42,0%) participantes vieram a óbito durante os 4 anos de acompanhamento. Idosos com pior função mastigatória tanto objetiva (hazard ratio [HR] = 1,59, intervalo de confiança de 95% [IC 95%] = 1,07–2,36) quanto autorrelatada (HR = 1,48, IC 95% = 1,01–2,16) apresentaram maior risco de morte precoce. Além disso, idosos com hipofunção oral foram mais propensos a ter fragilidade (RP=1,37, IC 95%=1,03-1,83) e dependência em AVD (RP=1,61, IC 95%=1,17-2,22). No entanto, no modelo ajustado, apenas a associação com dependência em ADV se manteve (RP=1,52, IC 95%=1,09-2,12). Com base nos achados desta tese, concluímos que uma função mastigatória comprometida parece estar associada à morte precoce, e a hipofunção oral está associada à fragilidade e dependência nas AVD em residentes em ILPIs.

Palavras-chave: Idoso; Instituição de Longa Permanência para Idosos; Mastigação; Mortalidade; Fragilidade.

ABSTRACT

Aging causes changes in oral functions. When deteriorated, oral functions can impair older adults' physical and nutritional status and, ultimately, lead to mortality. However, the relationship between oral function, physical and nutritional status, and mortality has been paucity investigated in older adults living in long-term care facilities (LTCFs). Thus, this thesis aimed to evaluate the association between masticatory function and mortality, and between oral functions and sarcopenia, frailty, dependence in activities of daily (ADL) and nutritional status in older adults living in LTCFs. Two multicenter studies were carried out, one longitudinal and the other cross-sectional. In the longitudinal study, baseline characteristics of 295 participants were collected, including age, sex, polypharmacy, mobility, ADL, frailty, nutritional status, and objective (masticatory performance – chewing gum) and self-reported masticatory function. The participants were followed-up with for 4 years to record the mortality data. Cox regressions were used to analyze the data (α=0.05). In the cross-sectional study, 187 LTCF residents had the following outcomes assessed: sarcopenia (SARC-CalF), frailty (components of Fried's phenotype), dependence in ADL (Katz scale), and nutritional status (MNA-SF). Oral hypofunction (independent variable) was considered when three or more of the following symptoms were present: xerostomia, decline in occlusal force, deteriorated speech, impaired masticatory performance, and decline in swallowing function. Poisson regressions were used to test possible associations (α=0.05). As results, 124 (42.0%) participants died during the 4-year follow-up. Older adults with poor masticatory function both objective (hazard ratio [HR] = 1.59, 95% confidence interval [95% CI] = 1.07–2.36) and self-reported (HR = 1.48, 95% CI = 1.01–2.16) were at higher risk of early death. Moreover, older adults with oral hypofunction were more likely to be frail (PR=1.37, 95% CI=1.03-1.83) and dependent in ADL (PR=1.61, 95% CI=1.17-2.22). However, in the adjusted model, only the association with ADL remained (PR=1.52, 95% CI=1.09-2.12). Based on the thesis' findings, we concluded that impaired masticatory function appears to be associated with early death, and oral hypofunction is associated with frailty and dependence in ADL in LTCFs residents.

Keywords: Older people; Homes for the aged; Mastication; Mortality; Frailty.

SUMÁRIO

1 INTRODUÇÃO..... 11

2 ARTIGOS..... 17

2.1- Artigo 1: Masticatory function and mortality among older adults living in long-term care facilities in Brazil. 18

2.2- Artigo 2: Oral hypofunction in association with frailty, sarcopenia, activities of daily living and nutritional status among older adults living in long-term care facilities. 48

3 DISCUSSÃO..... 69

4 CONCLUSÃO..... 72

REFERÊNCIAS..... 73

ANEXOS 83

ANEXO 1 - Verificação de originalidade e prevenção de plágio 83

ANEXO 2 - Aprovação do Comitê de Ética em Pesquisa da FOP-Unicamp 85

ANEXO 3 – Manuscrito publicado na Gerodontology 86

1 INTRODUÇÃO

A população mundial vem passando por um processo de envelhecimento acelerado que se deu primeiramente em países desenvolvidos, localizados majoritariamente na Oceania, América do Norte e Europa (Reher, 2015), e nos últimos anos vem ocorrendo em países em desenvolvimento (Boing et al., 2020). Esse processo de envelhecimento está atrelado à declínios nas taxas de fertilidade que levam a um aumento da expectativa de vida (Reher, 2015; Mathers et al., 2015). Além disso, principalmente em países em desenvolvimento, a redução de desigualdades em indicadores socioeconômicos e de serviços de saúde como nível educacional, renda, proporção de domicílios com água e banheiro e proporção de médicos por habitante, tem papel importante na redução das taxas de mortalidade e no aumento da expectativa de vida (Boing et al., 2020). Diante disso, dos estimados 2 bilhões de idosos que representarão 22% da população mundial em 2050, 80% viverão em países em desenvolvimento, a exemplo do Brasil (Tramujas Vasconcellos Neumann & Albert, 2018).

Segundo o Censo Demográfico 2022 realizado pelo Instituto Brasileiro de Geografia e Estatística (IBGE), uma pessoa nascida no Brasil em 2022 tinha expectativa de viver, em média, até os 75,5 anos (79,0 anos para as mulheres e 72,0 anos para os homens) (IBGE, 2022). Ademais, a população idosa brasileira, com idade igual ou superior a 60 anos, passou de 20,5 milhões de pessoas em 2010 (10,8% da população total) para 32,1 milhões em 2022 (15,8% da população total), atingindo um crescimento de 46,6% (IBGE, 2022). Sendo assim, o índice de envelhecimento do país chegou a 80,0 em 2022, o que significa que há 80 pessoas idosas para cada 100 crianças de 0 a 14 anos (IBGE, 2022). O Brasil vem passando, portanto, por uma notável transição demográfica.

Embora muitos idosos vivam de forma saudável e independente na comunidade, outros necessitam de supervisão e/ou auxílio para realizar atividade diárias ou dependem de cuidados especializados. Sendo assim, o aumento do número de idosos vem acompanhado da necessidade de definir quem é o responsável pelo cuidado dessas pessoas (Medeiros et al., 2023). De acordo com o Estatuto do Idoso (Lei nº 10.741/2003), o primeiro responsável pelo cuidado dos idosos é a família, mas o atendimento asilar é aceito para aqueles que não a possuam ou careçam de condições de manutenção da própria sobrevivência (Brasil, 2003). Fatores como idade avançada, não ter casa ou companheiro, baixa escolaridade, sedentarismo, autoavaliação ruim do estado de saúde, polifarmácia e comprometimento funcional e/ou cognitivo são apontados como os

principais preditores do processo de institucionalização. Além disso, a falta de apoio e assistência aos idosos durante as atividades diárias é sugerida como um agravante da institucionalização (Luppa et al., 2010; Del Duca et al., 2012). Isto posto, as Instituições de Longa Permanência para Idosos (ILPIs) tornaram-se locais viáveis para os idosos viverem, recebendo, se necessário, suporte e cuidados de longa duração.

No Brasil, as ILPIs são definidas como "instituições governamentais ou não governamentais, de caráter residencial, destinada a domicílio coletivo de pessoas com idade igual ou superior a 60 anos, com ou sem suporte familiar, em condição de liberdade e dignidade e cidadania" (Brasil, 2005). O Censo de Unidades de Acolhimento Institucional 2019 (Giacomin, 2022) identificou 1.669 ILPIs localizadas majoritariamente nas regiões Sudeste, Sul e Nordeste, onde residiam 60.088 idosos. Quanto à natureza jurídica, 195 (10,9%) eram de caráter governamental, sendo 185 (10,4%) municipais e 10 (0,5%) estaduais (Giacomin, 2022). Além de moradia, as ILPIs costumam oferecer serviços de enfermagem e assistência em atividades de vida diária, incluindo cuidados bucais (Hoben et al., 2017). Sendo assim, os cuidadores representam 23% dos profissionais que atuam nas ILPIs (Giacomin, 2022). Além disso, a maioria das instituições (>50%) tem em sua equipe assistente social, psicólogo e enfermeiro, e uma menor parte (<50%) também tem nutricionista, fisioterapeuta, médico, educador e/ou terapeuta ocupacional no seu quadro de funcionários (Giacomin, 2022). No entanto, o cirurgião-dentista não costuma fazer parte da equipe de profissionais das ILPIs brasileiras (Ferreira et al., 2011).

Consequentemente, cuidadores e equipe de enfermagem são os principais responsáveis pelos cuidados bucais dos idosos residentes em ILPIs, embora muitas vezes eles não tenham conhecimento, formação ou treinamento adequados para prestar tais cuidados (Hoben et al., 2017; Unfer et al., 2012). Por isso, eles podem enfrentar dificuldades na identificação de problemas de saúde bucal, sejam estes dentários ou protéticos, que necessitem ser encaminhados para avaliação ou intervenção por parte do cirurgião-dentista (Chalmers et al., 2005). Além disso, devido a dificuldades de locomoção, o acesso a serviços de saúde bucal por parte dos residentes dessas instituições é bastante limitado (Piuvezam & Lima, 2013). Dessa forma, existem barreiras importantes no cuidado e acesso à serviços de saúde bucal dos idosos residentes em ILPIs que podem afetar ou agravar sua condição de saúde bucal.

Nesse cenário, uma revisão sistemática e uma meta-análise (Farias et al., 2020) sumarizou que idosos residentes em ILPIs tem maior número de dentes cariados e

perdidos e maior prevalência de edentulismo do que aqueles que vivem na comunidade. Adicionalmente, eles apresentam baixo uso de próteses dentárias (Ferreira, Magalhães & Moreira., 2008; Medeiros et al., 2020a). E dentre os usuários de próteses, muitos usam próteses antigas e não funcionais que precisam de rebasamento, reparo ou renovação devido à baixa estabilidade e retenção, oclusão inadequada e outros defeitos (Vigild, 1987; Janssens et al., 2017; Klotz et al., 2020; Medeiros et al., 2022). Portanto, idosos residentes em ILPIs costumam ter uma condição de saúde bucal ruim, principalmente em termos de perdas dentárias, uso e condição das próteses.

Apesar de alguns indivíduos conseguirem se adaptar às perdas dentárias ou edentulismo e ao não uso de próteses ou uso de próteses mal adaptadas, essas condições bucais costumam estar relacionadas à uma função mastigatória ruim (Zhang et al., 2019; Klotz et al., 2020; Medeiros et al., 2020a; Medeiros et al., 2022). Estima-se que uma em cada três pessoas idosas residentes em ILPIs tem dificuldades mastigatórias (prevalência agrupada=35%, intervalo de confiança de 95%=0,19-0,54, I^2=100%) (Abreu et al., 2021). Nesse contexto, uma recente revisão de escopo identificou a perda dentária como fator de risco mais comum para disfunção mastigatória e a substituição de dentes perdidos por meio de diferentes tipos de reabilitação protética foi o principal fator de proteção (Lahoud, Yu & King, 2023).

Sabe-se que a saúde bucal, incluindo a mastigação, é um componente fundamental da saúde geral, estando, por consequência, intimamente relacionada ao envelhecimento saudável (Bassim, 2008; Patel et al., 2021; Fukai, Dartevelle, Jones, 2022; FDI World Dental Federation, 2024; Poudel et al., 2024). Saúde bucal e mastigação comprometidas podem afetar a seleção e ingestão de alimentos, levando à uma dieta pobre tanto em quantidade, quanto em qualidade (Altenhoevel et al., 2012; Schimmel et al., 2015; Karawekpanyawong et al., 2023). Esses fatores também têm sido relacionados à resultados adversos à saúde (Smit et al., 2024), como maior risco de doenças cardiovasculares (Darnaud et al., 2020), pneumonia aspirativa (Awano et al., 2008; Pace & McCullough, 2010), incapacidade física/fragilidade (Horibe et al., 2018) e desnutrição (Fujimoto et al., 2020). Assim, estudos tem investigado se a saúde bucal e a mastigação são fatores preditores de mortalidade em idosos.

Shimazaki e colaboradores (2001) relataram um maior risco de mortalidade para indivíduos edêntulos sem próteses do que para aqueles com 20 ou mais dentes. De forma similar, outro estudo prévio (Caplan et al., 2017) observou que idosos residentes em ILPIs desdentados com ou sem próteses têm maior risco de morte precoce do que os

dentados. Além disso, Dewake et al (2018) reportaram que idosos residentes em ILPIs sem pares oclusais posteriores (POPs) protéticos apresentaram maior risco de mortalidade do que aqueles com POPs protéticos. Em termos de função mastigatória, estudos conduzidos em ILPIs da Finlândia encontraram uma associação entre dificuldades de mastigação e morte precoce (Saarela et al., 2011; Lindroos et al., 2019). No entanto, tais dificuldades foram avaliadas subjetivamente por meio da observação de enfermeiros. Dessa forma, ainda não se sabe se medidas objetivas de mastigação estão relacionadas à morte precoce em idosos residentes em ILPIs. Ademais, embora a função mastigatória objetiva esteja correlacionada com medidas de autopercepção (Medeiros et al., 2020a; Fueki, Yoshida & Igarashi, 2011), nenhum estudo avaliou se medidas de mastigação autorreferidas são substitutos adequados para avaliações objetivas de mastigação na predição de morte precoce em idosos.

Além da mastigação, a recuperação e manutenção de outras funções orais como salivação (boca seca/xerostomia), força oclusal, função motora de língua e lábios, fala e deglutição são fatores importantes para alcançar um envelhecimento saudável. Nesse sentido, em 2016, a 'FDI World Dental Federation' aprovou uma nova definição de saúde bucal, mais ampla e multidimensional, que inclui "a capacidade de falar, sorrir, cheirar, provar, tocar, mastigar, deglutir e transmitir uma variedade de emoções por meio de expressões faciais com confiança e sem dor, desconforto, e doenças do complexo craniofacial" (Glick et al., 2016). Assim, as pesquisas deixaram de focar apenas nas doenças bucais e passaram a investigar as funções orais.

Seguindo essa tendência, a Sociedade Japonesa de Gerontologia (Japanese Society of Gerodontology - JSG) propôs em 2018 o conceito de hipofunção oral, definido como um estágio, reversível por meio da realização de tratamento odontológico, que emerge durante o processo de disfunção oral (Minakuchi et al., 2018). Esse conceito considera a presença de 7 sinais ou sintomas: má higiene bucal, boca seca, redução da força oclusal, diminuição da função motora da língua e do lábio, diminuição da força de pressão da língua, diminuição da função mastigatória e deterioração da função de deglutição (Minakuchi et al., 2018). De acordo com a proposta da JSG, o diagnóstico de hipofunção oral deve ser considerado quando 3 ou mais dos sinais ou sintomas estiverem presentes. Diante a mudança e surgimento desses novos conceitos, um processo progressivo de declínio funcional geral por via da diminuição da função oral foi sugerido (Minakuchi et al., 2018). Dessa forma, estudos tem avaliado a relação das funções orais com os estados físico e nutricional em idosos.

Nesse contexto, uma revisão sistemática (Limpuangthip & Komin, 2023) demonstrou associações entre hipofunção oral e comprometimento da saúde geral, incluindo sarcopenia, fragilidade e desnutrição (conceitos descritos no Quadro 1) que foram encontradas em estudos transversais com idosos da comunidade (Kugimiya et al., 2021; Yoshida et al., 2022; Shimazaki et al., 2020; Iwasaki et al., 2022) e residentes em ILPIs (Cruz-Moreira et al., 2023). Adicionalmente, uma cascata clínica (pathway) entre parâmetros de hipofunção oral (boca seca e força máxima de mordida) e de fragilidade física (força de preensão palmar e velocidade de caminhada) foi identificada, especialmente em mulheres (Hihara, Goto & Ichikawa, 2020). Ainda, uma revisão sistemática demonstrou uma associação entre funções orais (dentição funcional e força máxima de mordida) e a incidência de fragilidade avaliada pelo fenótipo de Fried (Hakeem, Bernabé & Sabbah, 2019). De maneira similar, estudos longitudinais revelaram que uma função oral comprometida – em termos de desempenho mastigatório, capacidade mastigatória, número de dentes, habilidade de articulação oral, pressão da língua e dificuldades auto percebidas para comer e engolir – tem um papel importante no surgimento de sarcopenia, fragilidade física e desnutrição (Horibe et al., 2018; Tanaka et al., 2018; Iwasaki et al., 2020). Apesar dessas relações terem sido amplamente investigadas em idosos da comunidade, principalmente na Ásia, poucos estudos transversais avaliaram a relação entre função oral e estados físicos e nutricional em idosos residentes em ILPIs.

Quadro 1 - Definições de sarcopenia, fragilidade e desnutrição

Variáveis	**Definição conceitual**	**Referência**
Sarcopenia	Doença muscular progressiva e generalizada enraizada em alterações musculares adversas que se acumulam ao longo da vida.	Cruz-Jentoft et al., 2019
Fragilidade	Síndrome biológica caracterizada pela diminuição da reserva e resistência a estressores, resultantes de declínios cumulativos em múltiplos sistemas fisiológicos, causando vulnerabilidade a resultados adversos à saúde.	Fried et al., 2001
Desnutrição	Estado resultante da falta de ingestão ou absorção de nutrição que leva à alteração da composição corporal	Cederholm et al., 2017

	(diminuição massa magra e massa muscular esquelética) e da massa celular corporal, levando à diminuição da função física e mental e resultados clínicos adversos de doença.	

Fonte: Cruz-Jentoft et al., 2019; Fried et al., 2001; Cederholm et al., 2017

Um estudo desenvolvido na Finlândia por Hiulten e colaboradores (2021) observou uma relação linear entre o número de sinais de fragilidade oral (boca seca, resíduos de alimentos, incapacidade de manter a boca aberta, falta de clareza na fala, dieta pastosa ou mole e dor) e a presença de fragilidade física. O mesmo grupo de pesquisa encontrou que participantes com fragilidade oral grave tinham maior necessidade de assistência diária para locomoção e alimentação (Oura et al., 2022). Considerando que a fragilidade oral e a hipofunção oral são conceitos diferentes – fragilidade oral é o declínio funcional relacionado à idade das estruturas orofaciais – faltam estudos que avaliem a associação entre hipofunção oral, sarcopenia, fragilidade, dependência em atividades de vida diária (AVD) e estado nutricional em idosos residentes em ILPIs.

Diante o exposto, essa tese de Doutorado teve como objetivo avaliar a associação entre função mastigatória e mortalidade, bem como entre funções orais e estados físico (sarcopenia, fragilidade e dependência em AVD) e estado nutricional em idosos residentes em ILPIs.

2 ARTIGOS

Este trabalho foi realizado no formato alternativo, conforme deliberação da Congregação nº 306/2010 da Faculdade de Odontologia de Piracicaba e informação da Comissão Central de Pós-Graduação (CCPG) nº 002/2021 da Universidade Estadual de Campinas.

O artigo 1, intitulado “Masticatory function and mortality among older adults living in long-term care facilities in Brazil”, publicado no periódico *Gerodontology*.

O artigo 2, intitulado “Oral hypofunction in association with frailty, sarcopenia, activities of daily living and nutritional status among older adults living in long-term care facilities”, a ser submetido em periódico indexado.

2.1 ARTIGO 1

Original article

Masticatory function and mortality among older adults living in long-term care facilities in Brazil

Mortality and mastication in long-term care facilities

Mariana Marinho Davino de Medeiros[1]

Lorena Tavares Gama[1]

Danilo Augusto de Holanda Ferreira[2]

Yuri Wanderley Cavalcanti[2]

Mario Augusto Brondani[3]

Renata Cunha Matheus Rodrigues Garcia[1]

[1]Department of Prosthodontics and Periodontology

Piracicaba Dental School, University of Campinas, São Paulo, Brazil

[2]Department of Clinical and Social Dentistry

Federal University of Paraíba, Paraíba, Brazil

[3]Department of Oral Health Sciences

The University of British Columbia, Canada

Correspondence author:

Renata Cunha Matheus Rodrigues Garcia,

Department of Prosthodontics and Periodontology,

Piracicaba Dental School, University of Campinas,

901 Limeira Av., Areião, Piracicaba, Sao Paulo, Brazil.

Email: regarcia@fop.unicamp.br

Acknowledgements

This study was supported by the São Paulo Research Foundation (FAPESP; Process numbers 2021/02463-4 and 2022/08874-9) and Coordenação e Aperfeiçoamento de Pessoal de Nível Superior (CAPES; Finance Code 001).

Abstract

Objective: To investigate the association between mortality and masticatory function in older adults living in long-term care facilities (LTCFs), controlling for demographic and health covariates. **Background:** Poor oral health has been associated with mortality; however, no previous study investigated whether objective and self-reported poor masticatory function are predictors of early mortality in LTCFs. **Materials and methods:** Baseline characteristics of 295 participants were collected, including age, sex, polypharmacy, mobility, activities of daily living, frailty, nutritional status, and objective (masticatory performance – chewing gum) and self-reported masticatory function. The participants were followed-up with for 4 years to record the mortality data. Cox regression models were run to analyze the data (α=0.05). **Results:** During the 4-year follow-up, 124 (42.0%) participants died. Older adults with poor masticatory performance (hazard ratio [HR]=1.59, 95% confidence interval [95% CI]=1.07-2.36) and those who self-reported masticatory dysfunction (HR=1.48, 95% CI=1.01-2.16) were at higher risk of early death than those with good mastication. However, in a multivariate model including both objective and self-reported masticatory function, only the objective measurement remained associated with early death (HR=1.52, 95% CI=1.02-2.27). **Conclusion:** Poor masticatory performance seems to be associated with early death in older adults living in LTCFs, but they may have shared risk factors accumulated throughout life that were not covered by the study period.

Keywords: aged, geriatric oral health assessment index, long-term care, mastication, mortality, nursing homes, self report

Introduction

The Brazilian population is aging at an unprecedented rate, and although many older adults are living healthily in the community, others are placed in long-term care facilities (LTCFs).[1,2] Most LTCF residents have complex health statuses that may lead to adverse health outcomes and high mortality rates.[3,4] As such, there has been an increased interest in investigating whether oral health status can predict mortality in older adults, even after adjustment for demographic and general health factors. In this context, Shimazaki and coworkers[5] reported a higher mortality risk for edentulous subjects without dentures than for those with 20 or more teeth, while Darnaud and colleagues[6] found a strong association between the number of occluding molars and premolars—masticatory capacity—and cardiovascular mortality. Similarly, edentulous LTCF residents (with or without dentures) are more likely to experience early death than dentate ones, even after controlling for demographic and health factors.[7] Moreover, Dewake et al.[8] reported that LTCF residents with no prosthetic posterior occluding pairs (POPs) had a higher mortality risk than those with prosthetic POPs, corroborating Darnaud et al.'s study.[6] These dental and prosthetic factors, such as edentulism without dentures, are related to poor masticatory function[9-11] and nutritional intake.[12] Accordingly, a possible effect of poor masticatory function on mortality should be considered.

Previous studies reported an association between chewing difficulties and early death in LTCF residents.[13,14] However, such chewing difficulties were subjectively evaluated through nurses' reports based on their observations of their patients. In turn, it remains unknown whether objective chewing measures are related to early death among LTCF residents. Although objective masticatory function correlates closely with self-perceived measures,[10,15] no study has assessed whether self-reported chewing measures

are suitable surrogates for objective chewing assessments in predicting early death in LTCF residents. In addition, poorer masticatory function and greater mortality are commonly associated with tooth loss/non-functional dentition and poorer general health.[16] Therefore, poorer masticatory function and greater mortality in old age may share the same risk factors throughout life.

Accordingly, this study aimed to assess the association between objective and self-reported masticatory function and mortality of LTCFs residents in Brazil over a 4-year period, adjusting for demographic and general health covariates. We applied a life-course approach to interpreting the findings and used our data to illustrate the issues and methodological challenges encountered in our study.

Materials & methods

Ethical approval

This study was approved by the Institutional Ethics Committee (nos. 66122917.6.3001.5418 and 66122917.6.1001.5188). The research was undertaken with each participant's written informed consent and according to the ethical principles of the Helsinki Declaration (version 2008). In addition, this paper followed the STROBE guidelines.[17]

Study design, setting, and participants

Figure 1 shows the study flow diagram. A cohort study was utilized from a multicenter project conducted among 823 older adults (age ≥ 60 years) in 17 LTCFs from two cities, one in the southeast and the other in the northeast of Brazil.[10,18] Of the 823 residents, 27 (3.3%) refused to participate in the study, 430 (52.2%) were excluded due to scoring

under 13 points in the Mini-Mental State Examination (MMSE)[19,20] and 22 (2.7%) were excluded due to presenting with hearing and/or communication impairments. Thus, 344 residents were included in the multicenter project. Baseline data of the participants—including demographic characteristics, general health, and oral health—were collected from December 2018 to August 2019.

All 17 LTCFs were invited to participate in the follow-up evaluations; however, three of them did not participate due to closures (n=2) and restricted access into the LTCF due to COVID-19 (n=1). Thus, 14 LTCFs remained in the study. Of the 331 older adults in those facilities, 32 left the LTCFs during the follow-up periods. Thus, we included the remaining 299 eligible participants. Of those, four had missing data on mortality, and so, data from 295 participants were included in the analysis.

Variables and data sources/measurement

At baseline, we collected demographic, general health, and oral health information such as age, sex, length of institutionalization, comorbidities (hypertension and diabetes), polypharmacy, mobility, dependence in activities of daily living (ADL), frailty, nutritional status, dental and prosthetic status, masticatory performance, and self-perceived masticatory function. After that, participants were followed up to record mortality data.

Baseline characteristics

The age of the participants was recorded in years and categorized into three age groups: (1) oldest-old: > 84 years, (2) middle-old: 75-84 years, and (3) youngest-old: 60-74 years. The sex of participants was recorded as male or female. The length of

institutionalization was recorded in years and dichotomized into > 5 years and ≤ 5 years. Presence or absence of hypertension and diabetes were the comorbidities evaluated. Polypharmacy was recorded as residents taking more than five medications per day. Mobility was assessed at four levels: (1) bedridden; (2) wheelchair use; (3) walks with a cane or walker; and (4) walks independently.[18]

We also assessed the participants' dependence in activities of daily living using the Katz index.[21] This index evaluates whether a person is capable (independent: 0 points) or not (dependent: 1 point) of self-care in six functions—feeding, continence, transferring, going to the toilet, dressing, and bathing—without supervision, guidance, or active personal assistance. Thus, the individual is classified as (1) high dependence (5 and 6 points), (2) mild dependence (3 and 4 points), (3) low dependence (1 and 2 point(s)) or (4) independent (0 points).

Frailty was assessed by a validated five-question self-report scale based on Fried's frailty phenotype components (unintentional weight loss, exhaustion, low physical activity level, weakness, and slowness).[22] Each problem reported gets a point. Accordingly, respondents are classified as frail (≥ 3 points), pre-frail (1-2 points), or robust (0 points).

The Brazilian version of the Mini-Nutritional Assessment – Short Form (MNA-SF) was used to evaluate the participant's nutritional status.[23] This six-question screening tool considers food intake, weight loss, mobility, psychological stress or acute illness, and calf circumference to classify the person as malnourished (0-7 points), at risk of malnutrition (8-11 points), or nourished (12-14 points).

The dental and prosthetic status was divided into 4 categories: (1) edentulous without complete denture (CD), (2) edentulous with CD, (3) partially dentate without removable partial denture (RPD), and (4) partially dentate with RPD.[10]

Objective masticatory performance was determined by colorimetric analysis of a two-colored chewing gum (Vivident Fruitswing Karpuz, Turkey) chewed by participants for 20 masticatory cycles.[24] The chewed gum was flattened (1 mm thickness), scanned (300 dpi images), and imported into ViewGum© software, where values of variance of hue (VOH) were obtained. Higher VOH indicated worse masticatory performance. In this study, the masticatory performance was dichotomized into poor (VOH median > 0.40) or good (VOH median ≤ 0.40).

Self-perceived masticatory function was assessed by selecting specific questions from two oral health-related quality of life indicators, the Geriatric Oral Health Assessment Index (GOHAI) and the Oral Health Impact Profile – Short Form (OHIP-14).[25,26] The following questions were used:

- GOHAI Q1. How often did you limit the kinds or amounts of food you ate because of problems with your teeth or dentures?
- GOHAI Q2: How often did you have trouble biting or chewing any kinds of food, such as a firm meat or apples?
- OHIP-14 Q7: Has your diet been unsatisfactory because of problems with your teeth, mouth, or dentures?

- OHIP-14 Q8: Have you had to interrupt meals because of problems with your teeth, mouth, or dentures?

For the data analysis, response options were dichotomized into 1 – poor ('always' and 'sometimes') and 2 – good ('never') for GOHAI questions, and into 1 – poor ('very often', 'fairly often', and 'occasionally') and 2 – good ('never' and 'hardly ever') for the OHIP-14 questions.

Outcome measurements

Mortality (outcome measure) was recorded as "survival" or "deceased" over 4 years (2019–2022). The cause of death was also recorded. The researchers (MMDM and DAHF) collected the data from LTCF records. Yearly assessments were chosen due to the likelihood of incremental deaths after each year following admission into a LTCF.[27,28]

Statistical analyses

Cross-tabulations were used to determine the distributions of mortality by baseline characteristics. Bivariate survival analyses were used to plot multivariate survival analyses for the dependent variables with $p<0.20$ (masticatory performance, GOHAI Q1, and GOHAI Q2). Multivariate Cox regression models were run for all participants, excluding COVID-19 deaths (Figure 1) to assess the association between the year of death and masticatory function measures, controlling for covariates (age, sex, polypharmacy, mobility, dependence in ADL, frailty, nutritional status). The subgroup of participants without neurocognitive disorders was established according to the MMSE cut-offs proposed by Bertolucci[20] considering the educational level of the Brazilian population: 13 points for illiterate, 18 points for elementary and middle school education level, and

26 points for high education level. To obtain the adjusted models, a backward Wald procedure was performed. At each step, the variables with $p>0.20$ were regressively eliminated—from the greatest to the lowest—from the models. Hazard ratios (HR) and 95% confidence intervals (95% CI) were used to interpret the magnitude of the associations, and $p<0.05$ indicated statistical significance. Kaplan-Meier survival curves were plotted to illustrate the main associations. The Statistical Package for the Social Sciences (SPSS) software (version 20.0 for Windows; SPSS Inc, Chicago, IL, USA) was used to perform all statistical analyses.

Results

Of the 295 participants analyzed, 124 (42.0%) were listed as deceased during the 4-year follow-up, with 70.1% of the deaths occurring in 2020 (n=48) and 2021 (n=39). Regarding the cause of death, 17 older adults died of COVID in 2020, 4 in 2021, and 1 in 2022, totaling 22 COVID deaths (17.7%). The other causes of death included cardiopulmonary failure, heart failure, sepsis, pneumonia, cancer, respiratory failure, bleeding, natural causes, and others.

Table 1 presents participants' baseline characteristics. Most of the participants were partially dentate or edentulous without dentures and had poor masticatory performance. Despite that, most reported that they never limited the kinds or amounts of food they eat (GOHAI Q1), never have trouble biting or chewing any food (GOHAI Q2), never had an unsatisfactory diet (OHIP-14 Q7), or never had to interrupt meals because of problems with their teeth, mouth, or dentures (OHIP-14 Q8).

Figure 2 shows examples of masticatory performance in relation to mortality. The older adult who died were unable to mix the chewing gum, while the participant who survived, although not achieving a uniform color, mixed the chewing gum well.

In bivariate Cox regression analyses, masticatory performance, GOHAI Q1, and GOHAI Q2 reached $p<0.20$ and were included in the multivariate survival analyses. However, multivariate survival analyses were not run for OHIP-14 Q7 and Q8 due to the $p>0.20$ observed in the bivariate analysis.

Table 2 illustrates that older adults with poor masticatory performance and poor self-perceived masticatory function according to GOHAI Q2 were more likely to experience early death than those with good mastication, adjusting for covariates. However, when these mastication parameters were put together in the multivariate survival model, only masticatory performance remained significant for greater risk of mortality.

As seen in Table 3, a 51% greater risk of early death in older adults was noted for those with poor masticatory function; however, the range of the compatibility interval brings uncertainty to that association. Participants with poorer self-reported masticatory function according to GOHAI Q2 had a greater risk of death than those with good self-reported masticatory function, but the lower limit of the confidence interval is close to null.

In the subgroup analysis excluding COVID deaths (Table 4), masticatory performance remained as a predictor of early death, but self-perceived masticatory function assessed through GOHAI Q2 did not.

Figure 3 presents Kaplan-Meier plots for the association between mortality and masticatory function parameters (masticatory performance and GOHAI Q2). Cumulative mortality increased when the masticatory function was worse.

Discussion

Our study assessed the association between objective and self-reported masticatory function, adjusting for demographic and general health covariates, and mortality of LTCFs residents in Brazil following a 4-year period. It is known that the ability to masticate a variety of different foods has been associated with general health and improved quality of life (QoL), as it helps to maintain body weight, vestibular function, and bone density.[29] On the other hand, poor masticatory ability has been associated with mortality; however, this is based solely on considering the presence or absence of occluding posterior teeth.[6] In turn, we found an association between early death and poor masticatory performance among all participants and in the subgroup analysis without COVID-19 deaths. In addition, the self-perceived masticatory function assessed by GOHAI Q2 was also associated with higher risks of early death among all participants and those without neurocognitive disorders.

Furthermore, this study has some weaknesses. First, as the follow-up period is short, it prevents the observation of potential common risk factors for poorer masticatory function and earlier mortality, which have been present through the life course (from

childhood to old age) and may explain the association we found.[30] Second, the highest number of deaths in our study occurred in 2020 and 2021, when Brazil experienced a significant mortality rate from COVID-19 in LTCFs.[31] The impact of COVID-19 may be a confounding factor and should be considered when interpreting our findings. However, subgroup analysis that excluded the participants who died of COVID-19 still showed masticatory performance associated with early death. Third, although we included geriatric syndromes, such as dependence in ADL, frailty, and malnutrition as covariates (which has been linked to higher risk of death in LTCF),[3,4] we evaluated only hypertension and diabetes as comorbidities. Future investigations should include other relevant comorbidities or comorbidity index as covariates. Lastly, although this study was multicentered (i.e., conducted in two cities in Brazil with cultural and economic differences), older people with MMSE scores <13 points were not included due to their incapacity to respond to the research questionnaires. For this reason, our findings cannot be generalizable to all LTCF residents.

We used a two-colored chewing gum to evaluate the masticatory performance as a good method as evidenced in the literature,[32,33] although it has shown associations with subjective measures in some studies,[34] but not in others.[35] Nonetheless, it has been argued that, in people with reduced dentitions, masticatory performance tests using chewing gum differentiate better with regard to the mastication of normal food than comminution tests do.[32,33] Also, it is easy for participants to understand the test procedures, whilst it also provides objective measures once computerized analyses have been used to evaluate the degree of mixing of the colors of the chewing gum.[32,33] Previously, a relationship was observed between worse masticatory performance and edentulism without CD, edentulism without CD in only one jaw, and partial tooth loss without RPD.[9-11] Even with

the chewing gum being a soft food test material, most edentulous participants without CD have great difficulty chewing it, leading to higher VOH values and poor masticatory performance. That being said, we must acknowledge that some older adults may perceive their masticatory ability to be good even when their ability to chew some foods remains inadequate, while others may overcome functional deficiencies in their mastication.[36,37]

In our study, most of the LTCF residents were partially dentate or edentulous without dentures, which is in accordance with a previous study showing a prevalence of edentulism (74.9%) in residents and a lack of dentures in edentulous (42.6%) and partially dentate (66.7%) residents.[38] While it has been found that a lack of dentures in edentulous older adults may lead to masticatory dysfunction,[9-11] it is also know that less than three-quarters of removable denture wearers do not use them as planned,[39] and that there is no strong evidence on the effect of tooth loss *per se* on diet and nutrition with or without a prosthesis.

Our findings reveal that residents with poor masticatory performance were at greater risk of early death than those with good masticatory performance, supporting the Saarela et al.[13] findings that chewing difficulties, albeit reported by nurses, were associated with mortality in LTCF residents in Finland. In another Finnish nursing home study, mortality was also associated with the burden of oral symptoms (chewing problems, dry mouth, and swallowing problems) even after adjusting for age and sex.[14]

A suggested pathway explaining the relationship between masticatory function and mortality includes the potential effect of chewing on nutritional status (i.e., poor masticatory function can lead to malnutrition and, consequently, early death),[8,40] although

this apparent effect is not without controversy.[36,37] In fact, the relationship between higher rates of death and malnourishment disappeared in the multivariate regression model; yet, masticatory performance prevailed as a factor associated with mortality. To corroborate our findings, a previous study conducted by our research group did indeed show that masticatory performance was not significantly correlated with nutritional status in nursing home residents.[10] Therefore, another pathway between masticatory function and mortality in older adults (e.g., based on the life course) may exist and should be investigated in future studies.

Masticatory function and mortality in old age are likely related to tooth loss/non-functional dentition and poorer general health, respectively.[16] Both tooth loss and poorer general health may be caused by a lack of resources needed to achieve and maintain good oral and general health (financial capital), education and training to avoid risky exposures and behaviours (human capital), and personal interactions that stimulate the care of oral and general health (social capital).[30] These shared risk factors may have been in operation throughout the individual's life, but the relationship between mortality and masticatory function is unlikely causal.[30] Therefore, the associations found in our study should be interpreted with caution, considering older adults' life-course journeys.

The self-perceived masticatory function assessed by GOHAI Q2 was also a factor associated with mortality. However, this association disappeared in the multivariate model with the objective masticatory function measurement. Thus, when it is not feasible to evaluate mastication objectively, GOHAI Q2 might be a surrogate masticatory measure to attempt to predict mortality in older adults living in LTCFs. Still, further investigation is needed to confirm any predictive value.

Conversely, GOHAI Q1 and OHIP-14 Q7 & Q8, as self-reported masticatory function measures, were not associated with mortality. Perhaps an older adult may recognize having trouble biting or chewing hard foods (GOHAI Q2, 37.3%, Table 1) and they may adapt to it[36]; this may lead to them not limiting the kinds or amounts of food they eat (GOHAI Q1, 72.9%), interrupting meals (OHIP-14 Q7, 72.5%), or having an unsatisfactory diet (OHIP-14 Q8, 83.7%) because of problems in their teeth, mouth, or dentures (Table 1). Notably, LTCFs usually offer foods that are easier to chew, and this softness may have prevented residents from avoiding eating or may not have limited ingestion of foods or interrupted their meals.[41] However, it does not promote active mastication due to the softness of the food.[42]

Based on our findings, LTCF staff should be aware of the importance of monitoring residents' masticatory function as a potential marker of higher risk for mortality. However, the findings of this study do not mean that we should orally rehabilitate all edentulous older adults to save lives. We should consider and work on risk factors for tooth loss and poor general health such as socio-economic status, inequality, poor access to health care, and poor health care and behaviours that may exist throughout life, leading to general health problems and consequently mortality in old age. Future studies are encouraged to follow individuals throughout their life course to better understand associations found in studies conducted in old age.

Conclusion

Masticatory performance is a predictor of early death and the self-perceived masticatory function assessed by GOHAI Q2 seems to be a surrogate measure for an

objective masticatory performance test in predicting mortality among older adults living in LTCFs. However, further investigation is needed to confirm the predictive value and these associations should be interpreted with caution, considering a life-course approach and the issues and methodological challenges of such work.

Conflict of interest

The authors declare no conflict of interest.

Authors contributions

MMDM, YWC, MAB, and RCMRG contributed to the conception and design of the study. MMDM, LTG, and DAHF contributed to the acquisition of data. MMDM performed the data analysis. MMDM and MAB interpreted the data. MMDM drafted the first version of the manuscript. MAB and RCMRG revised the article critically for important intellectual content. All authors read and approved the final version of the manuscript.

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Tables

Table 1. Frequency of survival and mortality according to baseline variables of all participants living in long-term care facilities in Brazil.

Variables	Total n (%)	Survival n (%)	Deceased n (%)	P-value[a]
Age				
Oldest-old	68 (23.1)	30 (17.6)	38 (30.6)	0.024
Middle-old	108 (36.7)	64 (37.6)	44 (35.5)	
Youngest-old	118 (40.1)	76 (44.7)	42 (33.9)	
Sex				
Male	126 (42.7)	67 (39.2)	59 (47.6)	0.150
Female	169 (57.3)	104 (60.8)	65 (52.4)	
Length of institutionalization				
> 5 years	102 (36.2)	54 (33.1)	48 (40.3)	0.213
≤ 5 years	180 (63.8)	109 (66.9)	71 (59.7)	
Hypertension				
Yes	177 (60.6)	99 (58.6)	78 (63.4)	0.404
No	115 (39.4)	70 (41.4)	45 (36.6)	
Diabetes				
Yes	77 (26.4)	44 (26.0)	33 (26.8)	0.879
No	215 (73.6)	125 (74.0)	90 (73.2)	
Polypharmacy				
Yes	126 (44.4)	65 (39.4)	61 (51.3)	0.047
No	158 (55.6)	100 (60.6)	58 (48.7)	
Mobility				
Bedridden	17 (5.8)	7 (4.1)	10 (8.1)	0.044
Wheelchair use	56 (19.0)	32 (18.7)	24 (19.4)	
Walks with a cane or walker	73 (24.7)	35 (20.5)	38 (30.6)	
Walks independently	149 (50.5)	97 (56.7)	52 (41.9)	
Dependence in activities of daily living				
High dependency	43 (14.6)	24 (14.0)	19 (15.3)	0.010
Mild dependency	25 (8.5)	9 (5.3)	16 (12.9)	
Low dependency	64 (21.7)	31 (18.1)	33 (26.6)	
Independent	163 (55.3)	107 (62.6)	56 (45.2)	
Frailty				
Frail	171 (58.0)	93 (54.4)	78 (62.9)	0.186

Pre-frail	84 (28.5)	50 (29.2)	34 (27.4)	
Robust	40 (13.6)	28 (16.4)	12 (9.7)	
Nutritional status				
Malnourished	43 (14.6)	16 (9.4)	27 (21.8)	0.012
At risk of malnutrition	126 (42.9)	77 (45.3)	49 (39.5)	
Normal nutritional status	125 (42.5)	77 (45.3)	48 (38.7)	
Dental and prosthetic status				
Edentulous without CD	81 (27.9)	54 (32.1)	27 (22.1)	0.288
Edentulous with CD	71 (24.5)	39 (23.2)	32 (26.2)	
Partially dentate without RPD	116 (40.0)	62 (36.9)	54 (44.3)	
Partially dentate with RPD	22 (7.6)	13 (7.7)	9 (7.4)	
Masticatory performance				
Poor	138 (50.2)	74 (45.1)	64 (57.7)	0.041
Good	137 (49.8)	90 (54.9)	47 (42.3)	
GOHAI Q1				
Poor	80 (27.1)	41 (24.0)	39 (31.5)	0.154
Good	215 (72.9)	130 (76.0)	85 (68.5)	
GOHAI Q2				
Poor	110 (37.3)	57 (33.3)	53 (42.7)	0.099
Good	185 (62.7)	114 (66.7)	71 (57.3)	
OHIP-14 Q7				
Poor	81 (27.5)	43 (25.1)	38 (30.6)	0.296
Good	214 (72.5)	128 (74.9)	86 (69.4)	
OHIP-14 Q8				
Poor	48 (16.3)	27 (15.8)	21 (16.9)	0.792
Good	247 (83.7)	144 (84.2)	103 (83.1)	

[a]P-value according to Chi-square test.

Table 2. Adjusted multivariate Cox regression models for predictors of 4-year mortality among all participants living in long-term care facilities in Brazil.

Models	Variables	P-value	HR (95% CI)[e]
Model 1[a]	Masticatory performance		
	Poor	0.021	1.59 (1.07-2.36)
	Good		Reference category
Model 2[b]	GOHAI Q1		
	Poor	0.143	1.34 (0.90-2.00)
	Good		Reference category
Model 3[c]	GOHAI Q2		
	Poor	0.040	1.48 (1.01-2.16)
	Good		Reference category
Model 4[d]	Masticatory performance		
	Poor	0.036	1.52 (1.02-2.27)
	Good		Reference category
	GOHAI Q2		
	Poor	0.107	1.39 (0.93-2.07)
	Good		Reference category

[a]Masticatory performance and covariates (age, sex, polypharmacy, mobility, dependence in ADL, frailty, and nutritional status)

[b]GOHAI Q1 and covariates

[c]GOHAI Q2 and covariates

[d]Masticatory performance, GOHAI Q2 and covariates

[e]*Hazard ratio (95%* compatibility interval*)*

Table 3. Adjusted multivariate Cox regression models for predictors of 4-year mortality among participants without neurocognitive disorders living in long-term care facilities in Brazil.

Models	Variables	P-value	HR (95% CI)[d]
Model 1[a]	Masticatory performance		
	Poor	0.059	1.51 (0.98-2.34)
	Good		Reference category
Model 2[b]	GOHAI Q1		
	Poor	0.112	1.44 (0.91-2.26)
	Good		Reference category
Model 3[c]	GOHAI Q2		
	Poor	0.045	1.53 (1.00-2.33)
	Good		Reference category

[a]Masticatory performance and covariates (age, sex, polypharmacy, mobility, dependence in ADL, frailty, and nutritional status)

[b]GOHAI Q1 and covariates

[c]GOHAI Q2 and covariates

[d]*Hazard ratio (95%* compatibility interval*)*

Table 4. Adjusted multivariate Cox regression models excluding COVID deaths for predictors of 4-year mortality among participants living in long-term care facilities in Brazil.

Models	Variables	P-value	HR (95% CI)[d]
Model 1[a]	Masticatory performance		
	Poor	0.026	1.64 (1.06-2.55)
	Good		Reference category
Model 2[b]	GOHAI Q1		
	Poor	-	-
	Good		Reference category
Model 3[c]	GOHAI Q2		
	Poor	0.129	1.38 (0.91-2.09)
	Good		Reference category

[a]Masticatory performance and covariates (age, sex, polypharmacy, mobility, dependence in ADL, frailty, and nutritional status)

[b]GOHAI Q1 and covariates. GOHAI Q1 was excluded from the model in the first step of the backward Wald procedure (HR=1.682, 95% CI=0.97-2.90, p=0.682).

[c]GOHAI Q2 and covariates

[d]*Hazard ratio (95%* compatibility interval*)*

Figures

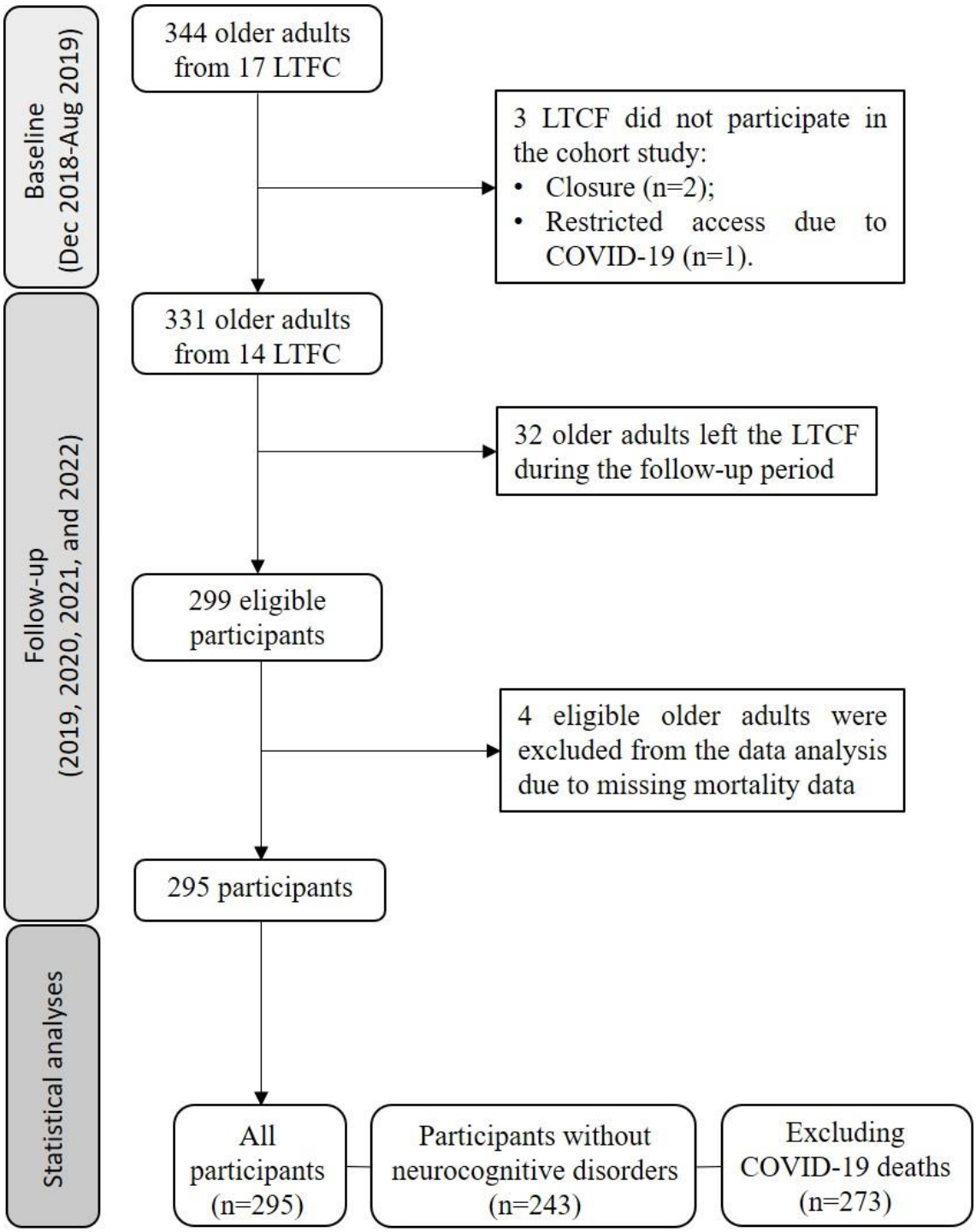

Figure 1. Flow diagram of the study

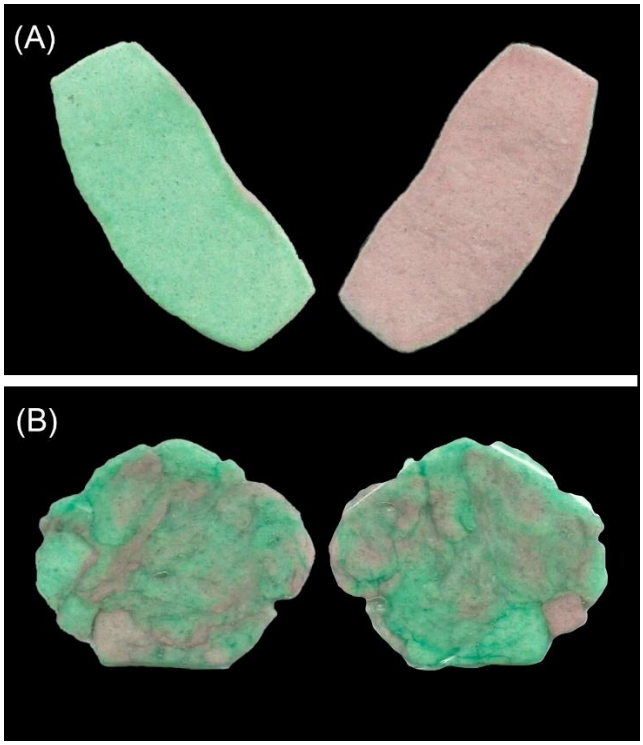

Figure 2. Examples of masticatory performance in relation to mortality. (A) Participant who deceased during the follow-up period: VOH=0.654, chewing gum is not mixed, impressions of cups or folded once. (B) Participant who survived during the follow-up period: VOH=0.295, bolus well mixed, but colour not uniform.

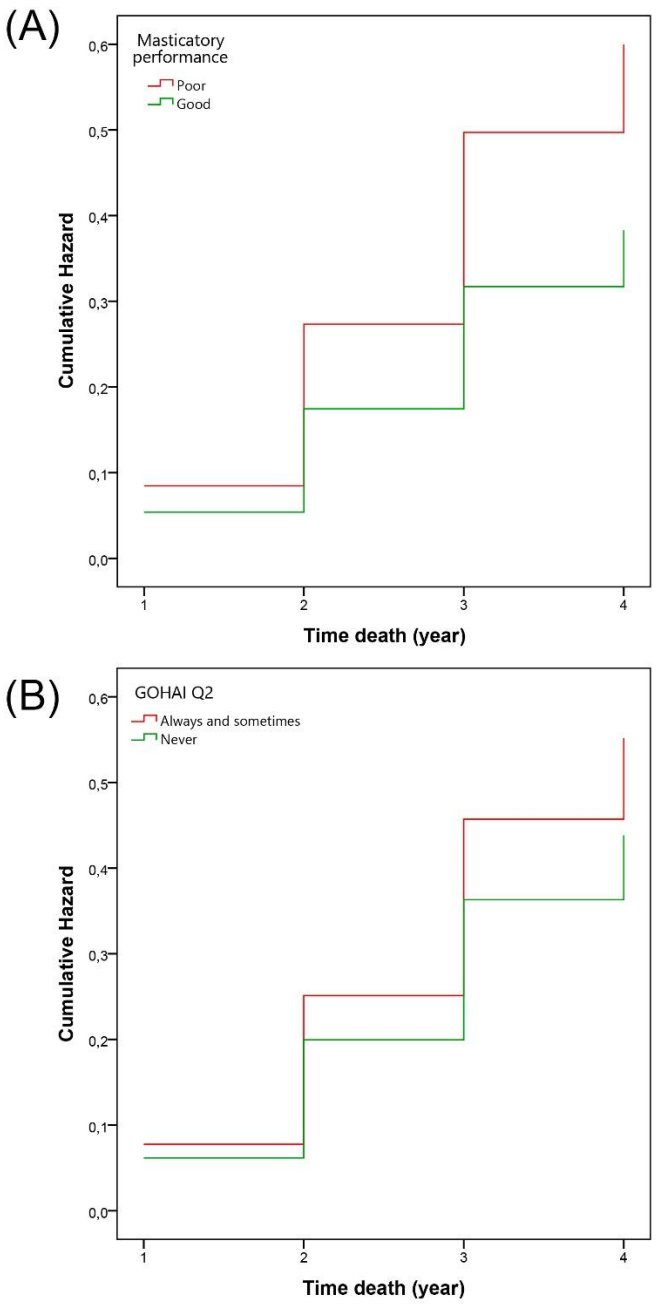

Figure 3. Kaplan-Meier cumulative mortality plots for the association between 4-year mortality and masticatory function among older adults living in long-term care facilities in Brazil. (A) Cumulative mortality over time according to masticatory performance ('poor' *vs.* 'good', p=0.021). (B) Cumulative mortality over time according to GOHAI Q2 ('always' and 'sometimes' *vs.* 'never', p=0.040).

2.1 ARTIGO 2

Original Article

Oral hypofunction in association with frailty, sarcopenia, activities of daily living and nutritional status among older adults living in long-term care facilities

Oral hypofunction and geriatric syndromes

Mariana Marinho Davino de Medeiros[1]

Lorena Tavares Gama[1]

Yuri Wanderley Cavalcanti[2]

Mario Augusto Brondani[3]

Renata Cunha Matheus Rodrigues Garcia[1]

[1]Department of Prosthodontics and Periodontology

Piracicaba Dental School, University of Campinas, São Paulo, Brazil

[2]Department of Clinical and Social Dentistry

Federal University of Paraíba, Paraíba, Brazil

[3]Department of Oral Health Sciences

The University of British Columbia, Canada

Correspondence:

Prof. Dr. Renata Cunha Matheus Rodrigues Garcia. Department of Prosthodontics and Periodontology. Piracicaba Dental School, University of Campinas. 901 Limeira Av., Areião, Piracicaba, Sao Paulo, Brazil, zip-code: 13414-903. E-mail: regarcia@fop.unicamp.br.

Acknowledgements

This study was supported by The São Paulo Research Foundation (FAPESP; Process numbers 2021/02463-4 and 2022/08874-9) and Coordenação e Aperfeiçoamento de Pessoal de Nível Superior (CAPES; Finance Code 001).

Abstract

Background: Although a clinical cascade of decreased oral function and deteriorated physical condition has been suggested, the relationship between oral hypofunction and geriatric syndromes has been paucity explored among older adults living in long-term care facilities (LTCFs).

Objective(s): To investigate the association of oral hypofunction with sarcopenia, frailty, dependence in activities of daily living (ADL), and malnutrition in LTCF residents.

Methods: A cross-sectional study including 187 older adults was conducted. Sarcopenia (SARC-CalF), frailty (components of Fried's frailty phenotype), dependence in ADL (Katz scale), and nutritional status (Mini Nutritional Assessment - Short Form) were the outcomes assessed. Oral hypofunction was the independent variable, and was considered as the presence of three or more of the following: dry mouth, decline in occlusal force, unclear speech, decline in masticatory performance, and decline in swallowing function. Age, sex, and polypharmacy data were collected as covariates. Poisson regression models were run to analyze the associations (α=0.05) and obtain prevalence ratio (PR) and confidence interval (95% CI) values.

Results: Older adults with oral hypofunction were more likely to be frail (PR=1.37, 95% CI=1.03-1.83) and dependent in ADL (PR=1.61, 95% CI=1.17-2.22) than those without oral hypofunction. However, when adjusted for age, sex, and polypharmacy, only the association between oral hypofunction and dependence in ADL remained (PR=1.52, 95% CI=1.09-2.12). Regarding the oral hypofunction components, swallowing dysfunction remained significantly associated with all outcomes.

Conclusion: Oral hypofunction was associated with frailty and dependence in ADL. Swallowing function seems to be a relevant oral hypofunction symptom for all outcomes.

Keywords: Long-Term Care, Nursing Homes, Frailty, Sarcopenia, Activities of Daily Living, Nutritional Status, Oral Hypofunction.

Background

The aging process seems to be associated with changes in the biological, physiological, environmental, psychosocial, and behavioral systems. Although some age-relate changes are minor for some, others experience a rise of certain diseases and syndromes such as sarcopenia, frailty, dependence on activities of daily living (ADL), and malnutrition. Sarcopenia is a generalized progressive loss of muscle mass and strength that accrues across the lifetime, which can result in frailty.[1,2] Frailty is a multifactorial geriatric syndrome characterized by reduced body reserves and resistance to stressors.[3] Like frailty, malnutrition is also a multifactorial geriatric syndrome characterized by decrease in food intake leading to energy deficit, and fat and muscle waste.[4] As sarcopenia, malnutrition is also closely related to frailty.[3,5,6] These geriatric diseases and syndromes reduce older adults' functional capacity and ability to perform ADL, being a concern for maintaining their health, well-being, and quality of life.

The general decline in physical conditions and functionality as we age has been also associated with the presence of 'oral hypofunction'.[7,8] This relative new concept proposed by the Japanese Society of Gerodontology in 2018 considers the presence of seven oral signs or symptoms, including poor oral hygiene, oral dryness, reduced occlusal force, decreased tongue-lip motor function, decreased tongue pressure, decreased masticatory function, and deterioration of swallowing function.[7] Cross-sectional studies have found associations between oral hypofunction, sarcopenia, frailty, and malnutrition in community-dwelling older adults.[9-12] Moreover, longitudinal studies revealed that poor oral function (masticatory performance, chewing ability, number of natural teeth, articulatory oral motor skill, tongue pressure, and self-perceived difficulties in eating and swallowing) plays a role in the onset of sarcopenia, frailty, disability, and deteriorating nutritional status.[13-15]

Although residents of long-term care facilities (LTCFs) tend to experience higher levels of geriatric diseases and syndromes than community-dwelling older adults,[16-18] few cross-sectional studies have investigated the relationship between oral function (i.e., oral frailty) and these geriatric conditions in LTCF settings,[19,20] and even less so on the relationships between oral hypofunction and these conditions.[21] Therefore, this study investigated the associations between oral hypofunction and sarcopenia, frailty, dependence in ADL, and malnutrition in older adults living in LTCFs.

Materials & methods

Ethical approval and research reporting guidelines

This study was approved by the Ethics Committee of the Piracicaba Dental School, University of Campinas, # 66122917.6.3001.5418. The research was conducted in full accordance with ethical principles of the Helsinki Declaration. All the volunteers signed an informed consent for participating in the study. This research was reported following the STROBE Guidelines.[22]

Study design, setting, and participants

This cross-sectional study was conducted from April to October 2022 in nine LTCFs in southeast Brazil. In Brazil, the LTCFs are governmental or non-governmental (non-profit or private) institutions for dependent or independent older adults. LTCF residents aged ≥ 60 years were included in the study. Older adults with cognitive disorders such as Dementia and Alzheimer's disease (Mini-Mental State Examination < 13 points),[23,24] and hearing or communication problems were excluded from the study. Four hundred fifty-two older adults were living in the LTCFs. Of them, 187 met the eligibility criteria.

Variables and data sources/measurement

Participants' physical statuses (sarcopenia, frailty, and dependence in ADL) and nutritional status were the outcomes assessed. Data regarding oral hypofunction, and demographic and health characteristics were also collected.

Outcomes

Frailty was assessed using a self-reported instrument comprising five dichotomous questions regarding the presence or absence of Fried's frailty phenotype components: unintentional weight loss, exhaustion, low physical activity level, weakness, and slowness.[25] Participants were then considered as frail (≥ 3 points), pre-frail (1-2 points), or robust (0 points). For statistical analysis purposes, frailty was dichotomized into frail and non-frail (including robust and pre-frail).

Sarcopenia was evaluated through the SARC-CalF questionnaire[26] validated for using in LTCF settings.[27] It includes six questions about strength, assistance in walking, rise from a chair,

climb stairs, falls, and calf-circumference. Each question score is summed up to get a total score ranging from 0 to 20. According to the total score, older adults are classified as having suggestive of sarcopenia (10-20 points) or not having suggestive signs of sarcopenia (0-10 points).

The Katz scale was applied to assess the dependence on ADL.[28] Six items evaluate the self-care performance during feeding, continence, transferring, going to the toilet, dressing, and bathing. Individuals performing all the abovementioned functions without supervision, guidance, or assistance were considered independent. In contrast, those needing any level of assistance (e.g., low, middle or high) with 1 or more functions were considered dependent.

The nutritional status was assessed via the Mini Nutritional Assessment Short-Form tool (MNA-SF).[29] It consists of six questions related to food intake, weight loss, mobility, psychological stress or acute illness, and calf circumference. The MNA-SF total score range from 0 to 14 points. Based on it, the participants were classified as of normal nutritional status (12 to 14 points), at risk of malnutrition (eight to 11 points), and malnourished (zero to seven points). For this study, the nutritional status was dichotomized into malnourished and nourished (including normal nutritional status and at risk of malnutrition).

Oral hypofunction

The oral hypofunction concept was constructed based on the position paper of the Japanese Society of Gerodontology.[7] They defined oral hypofunction as a presentation of oral uncleanness, oral dryness, decline in occlusal force, decline in motor function of tongue and lips, decline in tongue pressure, decline in chewing function, and decline in swallowing function. Oral hypofunction is diagnosed when three or more of these signs or symptoms are present.

For this study, we were not able to evaluate oral uncleanness and decline in tongue pressure. Consequently, the oral hypofunction comprised 5 of the 7 oral functions proposed by Japanese Society of Gerodontology: oral dryness (dry mouth), decline in occlusal force, decline in motor function of tongue and lips (unclear speech), decline in chewing function (masticatory performance), and decline in swallowing function (Table 1). However, the diagnostic criteria for oral hypofunction (≥ 3 signs or symptoms) was still followed.

Dry mouth was assessed through the overall question of the Summated Xerostomia Inventory: ‘How often is your mouth dry?’.[30] The participants were then considered as having

('occasionally', 'often', and 'always') or not ('never') dry mouth. Reduced occlusal force was assumed when the number of natural teeth was less than 20.[7,31] A decline in motor function of tongue and lips was considered when the older adult self-reported experiencing an unclear speech when they had to repeat themselves in order to be understood.[19,20]

Masticatory performance was measured by colorimetric analysis of two-colored chewing gum (Vivident Fruitswing Karpuz, Turkey).[32] The participants chewed the gum for 20 masticatory cycles. After that, the chewed gum was flattened into 1 mm thickness and scanned to obtain 300 dpi images. The images were analyzed in the ViewGum© software to get values of variance of hue (VOH) of the chewed gums. The VOH values were used to dichotomize the participants' masticatory performance into 'poor' (≥0.568) and 'good' (<0.568). This VOH cut-off value corresponds to score 2 of the visual assessment. Therefore, the 'poor' masticatory performance group includes chewing gums not mixed, impressions of cusps or folded once, and chewing gums with large parts unmixed.

The 10-item Eating Assessment Tool (EAT-10) was applied to assess the swallowing function, scored from zero (no swallowing problem) to four (severe swallowing problem) points in each item.[33,34] The scores are summed up to obtain the final score that can reach 40 points. Older adults with a total score ≥ 3 points were considered having swallowing problems.

Demographic and health characteristics

The age and sex of the participants were collected. Age was divided into oldest-old (>84 years), middle-old (75-84 years), and youngest-old (60-74 years). In addition, the number of medications taken per day was recorded, and >5 medications per day was considered polypharmacy. Age, sex, and polypharmacy were used as covariates.

Statistical analyses

The chi-square test was used to verify the distributions of frailty, sarcopenia, dependence in ADL, and nutritional status according to demographic and health characteristics and oral hypofunction. Poisson regression analyses were run to assess the bivariate association between physical state and nutritional status and oral hypofunction. Adjusted models were plotted for the variables with $p<0.20$ in the bivariate analyses, controlling for age, sex, and polypharmacy. Measures of

prevalence ratio (PR) and 95% confidence intervals (95% CI) were used to interpret the associations. The significance level was set at 0.05. All statistical analyses were performed in the Statistical Package for Social Sciences software (version 20.0 for Windows; SPSS Inc, Chicago, IL, USA).

Results

Of the 452 older adults living in the LTCFs, eighteen did not consent to participate in the study, and 247 were excluded from the study due to cognitive impairment (n=224), hearing or communication problems (n=15), and being hospitalized or not found during the research period (n=8). Therefore, 187 older adults were included.

Most of the participants were oldest-old age (33.0%, n=60) and female (58.3%, n=109), had suggestive signs of sarcopenia (36.9%, n=69), were frail (55.1%, n=103), dependent in ADL (52.9%, n=99), and malnourished (12.3%, n=23). Oral hypofunction was present in 59.2% (n= 109) of the participants. Moreover, the presence of dry mouth, reduced occlusal force, and poor masticatory performance were the most frequent oral hypofunction signs and symptoms (Table 1).

The distribution of physical state and nutritional status according to demographic and health characteristics and oral hypofunction are shown in Table 2. Most frail and dependent participants were female, and most frail, sarcopenic, and malnourished residents had polypharmacy ($p<0.05$). Also, the frail, malnourished, and dependent participants had significantly higher frequency of oral hypofunction ($p<0.05$).

Bivariate Poisson regression analyses (Table 3) revealed that older adults with oral hypofunction were 1.37 (95% CI=1.03-1.83, p=0.030) and 1.61 (95% CI=1.17-2.22, p=0.003) more likely to be respectively frail and dependent in ADL than those without oral hypofunction. However, oral hypofunction was not associated with sarcopenia and nutritional status. In the adjusted Poisson regression models (Table 4), participants with oral hypofunction were 1.52 (95% CI=1.09-2.12, p=0.012) more likely to be dependent in ADL compared to those without oral hypofunction.

Regarding the signs and symptoms of oral hypofunction in the bivariate analyses (Table 3), deteriorated swallowing function was associated with frailty. Decline in motor function of

tongue and lips (unclear speech) and in swallowing function was associated with sarcopenia. Deteriorated swallowing function was also associated with nutritional status. Dry mouth, unclear speech, and poor swallowing function was associated with dependence in ADL. All these associations remained significant after adjusting for age, sex, and polypharmacy (Table 4).

Discussion

The aging process can bring detrimental changes in oral health conditions and dental treatment needs,[35] while some older adults retain their natural dentition. In this scenario, geriatric dentistry has been focused on maintaining an adequate oral function instead of solely treating oral diseases.[7,35] This becomes especially relevant due to a suggested pathway between oral hypofunction/dysfunction and general hypofunction, dysfunction, and handicap.[7,8] However, this relationship has been scarcely explored in older adults living in LTCF. Thereby, our study assessed the association of oral hypofunction with sarcopenia, frailty, dependence in ADL, and malnutrition in LTCF residents. We found that oral hypofunction was associated with frailty and dependence in ADL, and deteriorated swallowing function was an important oral hypofunction component for all outcomes. These findings shed light on the need to maintain oral function and avoid developing oral dysfunction that may lead to geriatric diseases and syndromes.

In this study, oral hypofunction and some of its components (i.e., dry mouth, unclear speech, and swallowing function) were independently associated with dependence in ADL. This finding is supported by Oura et al (2022)[20] who reported a linear association between severe oral frailty and higher need for assistance with oral hygiene, eating and mobility. Usually, dependence in ADL is the final outcome of accumulated disability mainly caused by geriatric disease and syndromes.[3] It makes sense that older people with various disabilities have higher levels of compromised oral functions, leading to a stronger association with dependence in ADL that remained even after adjusting for age, sex, and polypharmacy. It becomes evident the need to avoid the accumulation of compromised oral functions in order to prevent adverse health outcomes such as dependence in ADL.

Although we did not find an association between sarcopenia and oral hypofunction, older adults with a decline in motor function of tongue and lips represented in this study by unclear speech, had a higher prevalence of sarcopenia. This result is in line with a previous study[36] who

found an association between oral diadochokinetic and sarcopenia indicators including decreased walking speed and skeletal muscle mass. We also observed that participants with a decline in swallowing function were more likely to have suggestive signs of sarcopenia. A recent meta-analysis[37] summarized that older adults with sarcopenia had lower tongue pressure - an indicator of decreased swallowing function - than those without sarcopenia.

An adequate swallowing function depends on the motor function of swallowing muscles and the tongue. Decreasing muscle mass and strength, and motor function of oral muscles and tongue (the so-called oral sarcopenia) may lead to swallowing dysfunction and, as a consequence, to a generalized loss of skeletal muscle mass and strength as seen in sarcopenia.[36,38,39] However, the pathway can also flow on the opposite direction. For example, a person with sarcopenia loses oral facial muscle mass, progressing to a swallowing dysfunction.[38,39] Thus, the relationship between sarcopenia and swallowing function can occur in two patterns: (1) sarcopenia due to a swallowing dysfunction and (2) swallowing dysfunction due to sarcopenia.[38,39] As cross-sectional studies can not precisely indicate the direction of this association, longitudinal studies are suggested.

The Bivariate Poisson regression analyses revealed that residents with oral hypofunction had a higher prevalence of frailty than those without oral hypofunction; however, this association has dissolved in the adjusted model. Similarly, a previous study[21] conducted in care homes in Ecuador found an association between frailty and oral hypofunction. Nevertheless, when stratified the sample by sex, those association only remained significant for the females,[21] exposing a sex influence in this relationship and agreeing with Hihara et al (2020). In our study, instead of sex, age (being oldest-old) was the covariate relevant for the prevalence of frailty (PR=1.346, 95% CI=1.004-1.804, p=0.047).

It is important to highlight that other studies conducted with community-dwelling older adults did found cross-sectional associations between frailty and oral hypofunction.[10,11] However, they used the deficit-accumulation model from Kihon Checklist for assessing frailty. This tool considerers not only the physical aspects of frailty, but also psychological and social aspects.[10] The methodological differences between our study and Yoshida et al (2022) and Shimazaki et al (2020) (i.e., physical vs comprehensive frailty assessment) may explain the different results.

Nonetheless, more studies are needed to clarify the association between frailty and oral hypofunction, taking into account different frailty-assessing methods.

In this study, deteriorated swallowing function was a key oral hypofunction component for all outcomes, even after adjusting for age, sex, and polypharmacy. This result is in accordance with previous findings in LTCF, short-term care, and community-dwelling settings.[11,21,40-44] As the decreased swallowing function was associated with sarcopenia that is related to frailty,[2,3] sarcopenia seems to be a mediator factor for frailty and swallowing dysfunction. In addition, swallowing difficulties affect oral intake of water and nutrients necessary for physical function.[45] Moreover, frailty impairs the individual's ability to perform ADL.[3] Thus, swallowing difficulties become relevant for dependence in ADL. Our findings confirm the relationship between swallowing function, nutritional status, sarcopenia, frailty, and dependence in ADL.[2,3,45]

Despite its findings, our study has limitations. The cross-sectional design does not infer a cause-effect relationship, and longitudinal studies exploring the associations we found should be performed. Moreover, the oral hypofunction was constructed with 5 of 7 signs and symptoms proposed by the Japanese Society of Gerodontology; however, the diagnosis criteria (≥3 or more signs and symptoms) was followed, which might have underestimated the prevalence of oral hypofunction in our study. We also adapted some criteria proposed to diagnose oral hypofunction. Although previous studies used a similar approach,[20] future investigations are encouraged to examine the validity and equivalency of such criteria. In addition, practicable diagnosis criteria are essential for being applicable by the LTCF staff during daily care routines. Thus, feasible diagnostic standards should be proposed for implementation in LTCF settings. Our findings further help to understand the relationship between oral hypofunction and geriatric diseases and syndromes, such as sarcopenia, frailty, dependence in ADL, and malnutrition in LTCF residents.

Conclusion

Oral hypofunction was associated with frailty and dependence in ADL. Swallowing function seems to be a relevant oral hypofunction symptom for the geriatric diseases and syndromes evaluated in this study, mainly sarcopenia, frailty, dependence in ADL, and nutritional status. Therefore, oral function, especially swallowing function, recovery and maintenance should be prioritized to maintain a good physical state for LTCF residents.

Conflict of Interest

The authors declare no conflict of interest.

Authorship

MMDM contributed substantially to the conception and design of the study and to the acquisition, analysis, and interpretation of data. LTG contributed substantially to the acquisition of data. YWC contributed substantially to the conception and design of the study and to data analysis. MAB contributed substantially to the conception and design of the study and to data interpretation. RCMRG contributed substantially to the conception and design of the study and to data interpretation. All authors were involved in drafting the manuscript or revising it critically for important intellectual content, approved the final version of the manuscript, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Data sharing and data accessibility

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Tables

Table 1. Construction criteria and prevalence of oral hypofunction in the study.

Oral hypofunction	Criteria	Prevalence ǂ
Dry mouth	Self-reporting of a feeling of mouth dry in the SXI overall question	112 (59.2)
Occlusal force	Number of natural teeth < 20	167 (89.8)
Unclear speech	Self-reporting of the necessity to repeat what is spoken to be understood	45 (24.1)
Masticatory performance	VOH value ≥ 0.568	127 (69.0)
Swallowing function	EAT-10 total score ≥ 3	69 (36.9)
Oral hypofunction	≥ 3 signs and symptoms	109 (59.2)

SXI, Summated Xerostomia Inventory; VOH, variance of hue of the chewing gum; EAT-10, Eating Assessment Tool-10; ǂ n (%).

Table 2. Frequency of frailty, sarcopenia, nutritional status, and dependence in ADL according to demographic and health characteristics and oral hypofunction among long-term care facilities' residents.

Variables	Sarcopenia		P-value†	Frailty		P-value†	Dependence in ADL		P-value†	Nutritional status		P-value†
	Suggestive of	No signs		Frail	Non-frail		Dependent	Independent		Malnourished	Nourished	
Age												
Oldest-old	26 (40.0)	34 (29.1)	0.149	40 (39.6)	20 (24.7)	0.097	37 (38.5)	23 (26.7)	0.221	7 (31.8)	53 (33.1)	0.973
Middle-old	14 (21.5)	40 (34.2)		28 (27.7)	26 (32.1)		25 (26.0)	29 (33.7)		7 (31.8)	47 (29.4)	
Youngest-old	25 (38.5)	43 (36.8)		33 (32.7)	35 (43.2)		34 (35.4)	34 (39.5)		8 (36.4)	60 (37.5)	
Sex												
Female	45 (65.2)	64 (54.2)	0.142	67 (65.5)	42 (50.0)	0.038	70 (70.7)	39 (44.3)	0.000	16 (69.6)	93 (56.7)	0.242
Male	24 (34.8)	54 (45.8)		36 (35.0)	42 (50.0)		29 (29.3)	49 (55.7)		7 (30.4)	71 (43.3)	
Polypharmacy												
Yes	57 (82.6)	80 (67.8)	0.027	84 (81.6)	53 (63.1)	0.005	77 (77.8)	60 (68.2)	0.139	21 (91.3)	116 (70.7)	0.037
No	12 (17.4)	38 (32.2)		19 (18.4)	31 (36.9)		22 (22.2)	28 (31.8)		2 (8.7)	48 (29.3)	
Oral hypofunction												
Yes	46 (66.7)	63 (54.8)	0.112	68 (66.7)	41 (50.0)	0.022	68 (70.1)	41 (47.1)	0.002	18 (78.3)	91 (56.5)	0.047
No	23 (33.3)	52 (45.2)		34 (33.3)	41 (50.0)		29 (29.9)	46 (52.9)		5 (21.7)	70 (43.5)	
Dry mouth												
Yes	41 (59.4)	71 (60.2)	0.920	63 (61.2)	49 (58.3)	0.694	68 (68.7)	44 (50.0)	0.009	15 (65.2)	97 (59.1)	0.578
No	28 (40.6)	47 (39.8)		40 (38.8)	35 (41.7)		31 (31.3)	44 (50.0)		8 (34.8)	67 (40.9)	
Occlusal force												
Decreased	63 (91.3)	104 (88.9)	0.599	92 (90.2)	75 (89.3)	0.838	89 (90.8)	78 (88.6)	0.624	22 (95.7)	145 (89.0)	0.321
Normal	6 (8.7)	13 (11.1)		10 (9.8)	9 (10.7)		9 (9.2)	10 (11.4)		1 (4.3)	18 (11.0)	
Unclear speech												

Yes	25 (36.2)	20 (16.9)	0.003	29 (28.2)	16 (19.0)	0.147	31 (31.3)	14 (15.9)	0.014	7 (30.4)	38 (23.2)	0.445
No	44 (63.8)	98 (83.1)		74 (71.8)	68 (81.0)		68 (68.7)	74 (84.1)		16 (69.6)	126 (76.8)	
Masticatory performance												
Poor	53 (76.8)	74 (64.3)	0.077	75 (73.5)	52 (63.4)	0.140	73 (75.3)	54 (62.1)	0.053	18 (78.3)	109 (67.7)	0.306
Good	16 (23.2)	41 (35.7)		27 (26.5)	30 (36.6)		24 (24.7)	33 (37.9)		5 (21.7)	52 (32.3)	
Swallowing function												
Deteriorated	32 (46.4)	37 (31.4)	0.040	48 (46.6)	21 (25.0)	0.002	46 (46.5)	23 (26.1)	0.004	14 (60.9)	55 (33.5)	0.011
Normal	37 (53.6)	81 (68.6)		55 (53.4)	63 (75.0)		53 (53.5)	65 (73.9)		9 (39.1)	109 (66.5)	

ADL, activities of daily living; †P-values according to Chi-square test.

Table 3. Bivariate Poisson regression analyses for the association of sarcopenia, frailty, dependence in ADL, and nutritional status with oral hypofunction among long-term care facilities' residents.

Variables	Sarcopenia		Frailty		Dependence in ADL		Nutritional status	
	PR (95% CI)	P-value	PR (95% CI)	P-value	PR (95% CI)	P-value	PR (95% CI)	P-value
Oral hypofunction								
Yes	1.37 (0.91-2.06)	0.122	1.37 (1.03-1.83)	0.030	1.61 (1.17-2.22)	0.003	2.47 (0.96-6.38)	0.060
No	Ref.		Ref.		Ref.		Ref.	
Dry mouth								
Yes	0.98 (0.67-1.43)	0.920	1.05 (0.80-1.37)	0.696	1.46 (1.07-1.99)	0.014	1.25 (0.56-2.81)	0.580
No	Ref.		Ref.		Ref.		Ref.	
Occlusal force								
Decreased	1.19 (0.59-2.38)	0.613	1.04 (0.66-1.63)	0.842	1.12 (0.68-1.84)	0.641	2.50 (0.35-17.54)	0.356
Normal	Ref.		Ref.		Ref.		Ref.	
Unclear speech								
Yes	1.79 (1.25-2.56)	0.001	1.23 (0.94-1.61)	0.121	1.43 (1.10-1.86)	0.006	1.38 (0.60-3.14)	0.442
No	Ref.		Ref.		Ref.		Ref.	
Masticatory performance								
Poor	1.48 (0.93-2.36)	0.094	1.24 (0.91-1.69)	0.163	1.36 (0.97-1.91)	0.072	1.61 (0.63-4.13)	0.317
Good	Ref.		Ref.		Ref.		Ref.	
Swallowing function								
Deteriorated	1.47 (1.02-2.13)	0.037	1.49 (1.16-1.91)	0.002	1.48 (1.14-1.92)	0.003	2.66 (1.21-5.82)	0.014
Normal	Ref.		Ref.		Ref.		Ref.	

ADL, activities of daily living; PR, prevalence ratio; CI, confidence interval; Ref., reference category.

Table 4. Adjusted Poisson regression analyses for the association of sarcopenia, frailty, dependence in ADL, and nutritional status with oral hypofunction among long-term care facilities' residents.

Models	Variables	Sarcopenia		Frailty		Dependence in ADL		Nutritional status	
		PR (95% CI) †	P-value	PR (95% CI) †	P-value	PR (95% CI) †	P-value	PR (95% CI) †	P-value
Model 1	*Oral hypofunction*								
	Yes	1.38 (0.90-2.12)	0.134	1.32 (0.99-1.77)	0.055	1.52 (1.09-2.12)	0.012	2.62 (0.91-7.54)	0.073
	No	Ref.		Ref.		Ref.		Ref.	
Model 2	*Dry mouth*								
	Yes	-		-		1.42 (1.03-1.95)	0.031	-	
	No					Ref.			
Model 3	*Occlusal force*								
	Decreased	-		-		-		-	
	Normal								
Model 4	*Unclear speech*								
	Yes	1.75 (1.21-2.54)	0.003	1.24 (0.96-1.60)	0.094	1.37 (1.06-1.77)	0.016	-	
	No	Ref.		Ref.		Ref.			
Model 5	*Masticatory performance*								
	Poor	1.55 (0.95-2.51)	0.075	1.22 (0.90-1.64)	0.185	1.32 (0.94-1.86)	0.101	-	
	Good	Ref.		Ref.		Ref.			
Model 6	*Swallowing function*								
	Deteriorated	1.48 (1.02-2.15)	0.036	1.40 (1.09-1.80)	0.008	1.35 (1.04-1.76)	0.021	2.23 (1.00-4.94)	0.048
	Normal	Ref.		Ref.		Ref.		Ref.	

ADL, activities of daily living; PR, prevalence ratio; CI, confidence interval; Ref., reference category; †Adjusted by age, sex, and polypharmacy.

3 DISCUSSÃO

O envelhecimento é um processo dinâmico e progressivo que causa danos biológicos em nível molecular e celular (OMS, 2015). O processo de envelhecimento causa alterações morfológicas, fisiológicas, ambientais, psicossociais e comportamentais que resultam em maior risco de incidência de processos patológicos, inclusive na cavidade bucal, afetando muitas vezes a mastigação e a deglutição (OMS, 2015; Abreu et al., 2021). Embora uma condição bucal ruim, caracterizada, por exemplo, por perdas dentárias devido à cárie e doença periodontal, não seja inerente ao processo de envelhecimento (Müller, Naharro & Carlsson, 2007; Peres et al., 2013), alterações nas funções orais tendem a acontecer na velhice (Abreu et al., 2021). Funções orais deterioradas comumente estão associadas à resultados adversos à saúde como comprometimento dos estados físico e nutricional que podem levar a mortalidade (Kugimiya et al., 2021; Yoshida et al., 2022; Shimazaki et al., 2020; Iwasaki et al., 2022). Esses desfechos costumam ser ainda mais prevalentes em idosos residentes em ILPIs (Chan et al., 2012; Vossius et al., 2018), uma vez que eles estão em uma situação de maior vulnerabilidade, com maior dependência e menor acesso a serviços de saúde (Luppa et al., 2010; Del Duca et al., 2012; Piuvezam & Lima, 2013). Por isso, torna-se importante avaliar essas relações nessa população. Diante disso, esta tese de Doutorado avaliou a associação entre função mastigatória e mortalidade e entre funções orais e sarcopenia, fragilidade, dependência em AVD e estado nutricional em idosos residentes em ILPIs.

A partir dos estudos desenvolvidos nesta tese de Doutorado, nós encontramos que idosos residentes em ILPIs com mastigação ruim tem maior risco de mortalidade e aqueles com função oral comprometida são mais propensos a ter fragilidade e dependência em AVD, mesmo depois de controlar por importantes variáveis demográficas e de saúde como idade, sexo e polifarmácia. Nós também observamos que a deglutição deteriorada foi associada a sarcopenia, fragilidade, dependência em AVD e desnutrição. Esses achados reforçam a necessidade de manutenção da função oral a fim de evitar o surgimento ou agravamento de doenças e síndromes geriátricas que podem, em último caso, levar a mortalidade.

A associação entre mastigação objetiva e autorrelatada e mortalidade encontrada no primeiro estudo desta tese foi corroborada por uma recente revisão sistemática (Smit et al., 2024) que reportou que uma menor força máxima de mordida - avaliação objetiva indireta da função mastigatória (Gonçalves et al., 2021) - foi associada a um maior risco de mortalidade em idosos da comunidade. Da mesma forma, um estudo prévio (Okura, Ogita & Arai, 2020) encontrou que declínios na capacidade mastigatória autorrelatada estão ligados a riscos mais

elevados de mortalidade também em idosos da comunidade. Sabe-se que uma mastigação comprometida afeta a seleção e ingestão de alimentos e nutrientes (Altenhoevel et al., 2012; Schimmel et al., 2015; Karawekpanyawong et al., 2023). Dessa forma, uma via possível para explicar a associação entre a mastigação e mortalidade, passa pelo estado nutricional. No entanto, a ausência de correlação entre a mastigação e o estado nutricional em idosos residentes em ILPIs (Medeiros et al., 2020a) gera controvérsia a essa hipótese. Portanto, outra via entre a função mastigatória e a mortalidade em idosos pode existir e explicar tais achados.

Vale ressaltar que a saúde do idoso é complexa e reflexo do acúmulo de vários fatores ao longo da vida. Uma pior função mastigatória e uma maior mortalidade na velhice muitas vezes estão relacionadas a perdas dentárias ou dentição não funcional (Lahoud, Yu & King, 2023; Polzer et al., 2010). Por isso, função mastigatória e mortalidade tendem a compartilhar os mesmos fatores de risco que se acumularam ao longo da vida (por exemplo, fatores socioeconômicos, educacionais e sociais) (Thomson, 2023). Sendo assim, fatores não avaliados nesta tese de Doutorado podem ser os responsáveis por uma maior mortalidade na velhice em indivíduos com pior função mastigatória. Dessa forma, os achados dos nossos estudos não querem dizer que idosos com pior mastigação necessariamente vão morrer mais cedo ou que perdas dentárias necessariamente devam ser substituídas por próteses para salvar vidas. A interpretação de dados de saúde bucal de pessoas idosas, especialmente dados transversais, deve levar em consideração o seu percurso de vida (Thomson, 2023).

No segundo estudo desta tese observou-se que a hipofunção oral foi associada a fragilidade. Esses achados estão em concordância com estudos prévios conduzidos no Japão em idosos da comunidade (Limpuangthip & Komin, 2023; Yoshida et al., 2022; Shimazaki et al., 2020) e no Equador com idosos residentes em ILPIs, esse demonstrando ainda uma forte influência do sexo nesta associação (Cruz-Moreira et al., 2023). Possíveis mecanismos entre hipofunção oral e sarcopenia tem sido propostos. Um deles é a via nutricional que sugere que uma função oral prejudicada pode levar à desnutrição com consequente redução da massa muscular, aumentando, assim, o risco de desenvolver sarcopenia e, por fim, fragilidade (Limpuangthip & Komin, 2023). Entretanto, no nosso estudo, essa associação foi dissolvida no modelo multivariado ajustado por idade, sexo e polifarmácia. Portanto, uma possível associação independente entre hipofunção oral e fragilidade não foi encontrada no nosso estudo, devendo, então, ser vista com cautela.

Nosso segundo estudo também revelou uma associação entre a hipofunção oral e dependência em AVD. Esse achado é suportado por Oura et al (2022) que encontrou uma

associação linear entre fragilidade oral grave e maior necessidade de assistência com higiene oral, alimentação e mobilidade. Maior dependência em AVD costuma ser o resultado final do acúmulo de incapacidades físicas causadas principalmente por doenças e síndromes geriátricas (Fried et al., 2001). Dessa forma, faz sentido que os idosos dependentes sejam mais propensos a ter funções orais comprometidas.

Por fim, ainda no segundo estudo, idosos com deglutição deterioradas foram mais propensos a apresentar todos os desfechos avaliados (sarcopenia, fragilidade, dependência em AVD e desnutrição), estando esse achado em concordância com diversos estudos (Shimazaki et al., 2020; Cruz-Moreira et al., 2023; Iwasaki et al., 2021; Hägglund et al., 2019; Nakamura et al., 2021; Suzuki et al., 2021; Wakabayashi et al., 2016). Este é um indicativo de que a deglutição pode ser um sintoma relevante de hipofunção oral para o surgimento de doenças e síndromes geriátricas. Considerando que a sarcopenia e a desnutrição são componentes da fragilidade (Fried et al., 2001; Medeiros et al., 2020b), esses fatores podem estar mediando a associação entre fragilidade e deglutição deteriorada. Como já é bem conhecido, dificuldades de deglutição afetam a ingestão nutrientes necessários para manutenção da função física (Robison et al., 2023), levando a fragilidade que, quando presente, costuma prejudicar a capacidade do indivíduo de realizar as AVD de forma independente (Fried et al., 2001). Portanto, provavelmente existe uma relação cíclica entre deglutição, estado nutricional, sarcopenia, fragilidade e dependência em AVD (Robison et al., 2023; Fried et al., 2001; Medeiros et al., 2020b). No entanto, esse achado deve ser confirmado por outros estudos, principalmente de natureza longitudinal.

Algumas limitações devem ser consideradas na interpretação dos nossos achados como o período de acompanhamento e a pandemia de COVID-19 no primeiro estudo, a natureza transversal e a construção da variável hipofunção oral no segundo estudo, e a exclusão de idosos com problemas cognitivos nos dois estudos. Esses fatores podem trazer vieses importantes para os resultados. Por isso, reforça-se a necessidade de realizar estudos longitudinais com longos períodos de acompanhamento que avaliem fatores que se acumulam ao longo da vida do idoso para melhor entender a relação entre função oral e desfechos adversos à saúde na velhice. Ademais, sugere-se que estudos futuros conduzidos com idosos de ILPIs avaliem a hipofunção oral utilizando os parâmetros originalmente propostos pela JSG ou validem um instrumento mais simples e viável que possa ser aplicado pela equipe de enfermagem das ILPIs para fazer tal avaliação. Assim, as relações entre mastigação e mortalidade e entre função oral e estados físico e nutricional em idosos residentes em ILPIs serão melhor esclarecidas.

4 CONCLUSÃO

A partir dos achados encontrados nos trabalhos desenvolvidos nesta tese de Doutorado, conclui-se que uma função mastigatória comprometida parece estar associada à morte precoce em idosos residentes em ILPIs. Além disso, a hipofunção oral foi associada à fragilidade e dependência nas AVD, e a deglutição deteriorada pareceu ser um sintoma de hipofunção oral relevante para presença de sarcopenia, fragilidade, dependência nas AVD e desnutrição em idosos que vivem em ILPIs.

No entanto, estas associações devem ser interpretadas com cautela, considerando o percurso de vida dos idosos e as questões e os desafios metodológicos de tal trabalho. Ainda assim, a manutenção ou recuperação de funções orais, especialmente da mastigação e deglutição, devem ser priorizadas para evitar o surgimento ou agravamento de doenças e síndromes geriátricas, alcançando, assim, resultados positivos em saúde para os idosos residentes em ILPIs.

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ANEXOS

ANEXO 1 – VERIFICAÇÃO DE ORIGINALIDADE E PREVENÇÃO DE PLÁGIO

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ANEXO 2 – APROVAÇÃO DO COMITÊ DE ÉTICA EM PESQUISA DA FOP-UNICAMP

COMITÊ DE ÉTICA EM PESQUISA
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UNIVERSIDADE ESTADUAL DE CAMPINAS

CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa "Processo de envelhecimento em instituições de longa permanência: avaliação multicêntrica dos estados físico e nutricional, autopercepção de saúde, distúrbio de voz, qualidade de vida e condição bucal", CAAE 66122917.6.3001.5418, dos pesquisadores Yuri Wanderley Cavalcanti, Renata Cunha Matheus Rodrigues Garcia, Mariana Marinho Davino de Medeiros, Mayara Abreu Pinheiro, Luiz Fabricio Santos De Oliveira e Danilo Augusto de Holanda Ferreira satisfaz as exigências das resoluções específicas sobre ética em pesquisa com seres humanos do Conselho Nacional de Saúde – Ministério da Saúde e foi aprovado por este comitê em sua versão original 14/09/2018 e na versão emendada em 30/09/2022.

The Research Ethics Committee of the Piracicaba Dental School of the University of Campinas (FOP-UNICAMP) certifies that research project "Aging process in nursing homes: multicentric assessment of physical and nutritional status, self-perception of health, voice disorder, quality of life, and oral health condition", CAAE 66122917.6.3001.5418, of the researcher's Yuri Wanderley Cavalcanti, Renata Cunha Matheus Rodrigues Garcia, Mariana Marinho Davino de Medeiros, Mayara Abreu Pinheiro, Luiz Fabricio Santos De Oliveira and Danilo Augusto de Holanda Ferreira, meets the requirements of the specific resolutions on ethics in research with human beings of the National Health Council - Ministry of Health, and was approved by this committee on 14th of september of 2018 (original version) and 30nd of september of 2022 (amended version).

Prof. Jacks Jorge Junior
Coordenador
CEP/FOP/UNICAMP

Nota: O título do protocolo e a lista de autores aparecem como fornecidos pelos pesquisadores, sem qualquer edição.
Notice: The title and the list of researchers of the project appears as provided by the authors, without editing.

ANEXO 3 – MANUSCRITO PUBLICADO NA GERODONTOLOGY

Accepted: 31 January 2024
DOI: 10.1111/ger.12744

ORIGINAL ARTICLE

Gerodontology WILEY

Masticatory function and mortality among older adults living in long-term care facilities in Brazil

Mariana Marinho Davino de Medeiros[1] | Lorena Tavares Gama[1] | Danilo Augusto de Holanda Ferreira[2] | Yuri Wanderley Cavalcanti[2] | Mario Augusto Brondani[3] | Renata Cunha Matheus Rodrigues Garcia[1]

[1]Department of Prosthodontics and Periodontology, Piracicaba Dental School, University of Campinas, São Paulo, Brazil
[2]Department of Clinical and Social Dentistry, Federal University of Paraíba, Paraíba, Brazil
[3]Department of Oral Health Sciences, The University of British Columbia, Vancouver, British Columbia, Canada

Correspondence
Renata Cunha Matheus Rodrigues Garcia, Department of Prosthodontics and Periodontology, Piracicaba Dental School, University of Campinas, 901 Limeira Av., Areião, Piracicaba, Sao Paulo, Brazil.
Email: regarcia@fop.unicamp.br

Funding information
Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), Grant/Award Number: 2021/02463-4 and 2022/08874-9; Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001

Objective: To investigate the association between mortality and masticatory function in older adults living in long-term care facilities (LTCFs), controlling for demographic and health covariates.

Background: Poor oral health has been associated with mortality; however, no previous study investigated whether objective and self-reported poor masticatory function is a predictor of early mortality in LTCFs.

Materials and Methods: Baseline characteristics of 295 participants were collected, including age, sex, polypharmacy, mobility, activities of daily living, frailty, nutritional status, and objective (masticatory performance – chewing gum) and self-reported masticatory function. The participants were followed-up with for 4 years to record the mortality data. Cox regression models were run to analyse the data ($\alpha = .05$).

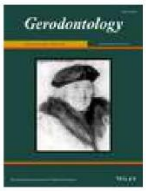
Results: During the 4-year follow-up, 124 (42.0%) participants died. Older adults with poor masticatory performance (hazard ratio [HR] = 1.59, 95% confidence interval [95% CI] = 1.07–2.36) and those who self-reported masticatory dysfunction (HR = 1.48, 95% CI = 1.01–2.16) were at higher risk of early death than those with good mastication. However, in a multivariate model including both objective and self-reported masticatory function, only the objective measurement remained associated with early death (HR = 1.52, 95% CI = 1.02–2.27).

Conclusion: Poor masticatory performance seems to be associated with early death in older adults living in LTCFs, but they may have shared risk factors accumulated throughout life that were not covered by the study period.

KEYWORDS
aged, geriatric oral health assessment index, long-term care, mastication, mortality, nursing homes, self report

1 | INTRODUCTION

The Brazilian population is aging at an unprecedented rate, and although many older adults are living healthily in the community, others are placed in long-term care facilities (LTCFs).[1,2] Most LTCF residents have complex health statuses that may lead to adverse health outcomes and high mortality rates.[3,4] As such, there has been an increased interest in investigating whether oral health status can predict mortality in older adults, even after adjustment for demographic and general health factors. In this context,



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