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# Correlation of biochemical and anthropometric parameters with tooth loss in older adults

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**ABSTRACT.** This study estimated the impact of tooth loss on biochemical parameters and anthropometric indicators of adiposity in older adults. A three-step data collection was conducted. First, trained interviewers applied a questionnaire for collecting sociodemographic and economic information to people aged 60 or over, in their households. Second, a dental surgeon and a physical educator assessed the oral condition and anthropometric measurements. Finally, biochemists obtained blood samples to analyze biochemical parameters. Descriptive analyses, Pearson's correlation, and multiple linear regression were performed using SPSS and STATA software. A total of 117 older adults, mean age of 71.2 years, were evaluated, 62.4% of whom were female. Cavities had a 100% prevalence, average DMFT index was 27.8, and missing component was the most prevalent (24.8). The final regression model found a correlation between tooth loss and females, vitamin B12, glycated hemoglobin, and magnesium. Older adults living in Aiquara showed a correlation between tooth loss and females, vitamin B12, glycated hemoglobin, and magnesium.

**Keywords**: older adults; tooth loss; vitamin B12; glycated hemoglobin; magnesium.

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## Introduction

Population aging is increasingly common worldwide (Li, Han, Zhang and Wang, 2017). In Brazil, tooth decay and periodontal disease are the most prevalent oral pathologies among older adults, with lack of treatment resulting in teeth loss, directly affecting oral health (Dietrich et al., 2024).

Tooth loss is a multifaceted phenomenon influenced by biological, cultural, economic, and behavioral factors (Cortez et al., 2023) which contributes to the systemic deterioration of individuals (Hag Mohamed & Sabbah, 2023). It is associated with nutritional and biochemical changes (Hung et al., 2003) and an important marker of social inequality, impacting behaviors and health conditions (Terra et al., 2022; Hag Mohamed & Sabbah, 2023).

The number of teeth in one's mouth directly influences chewing and nutrition capacity (Seraj et al., 2017).

Older adults with fewer financial resources and significant tooth loss seek carbohydrate- and lipid-rich foods with low nutritional content, which can harm the gastrointestinal tract and led to nutritional deficiencies (Nascimento et al., 2022).

A properly functioning stomatognathic system results in a healthier selection of foods. In these cases, individuals commonly choose processed and ultra-processed foods, rich in sugar and saturated fats but low in fiber and essential nutrients (Kossioni, 2018), leading to nutritional imbalances and vitamin and mineral deficiencies (Peyron et al., 2018). Mastication is the initial stage of digestion, essential for grinding food and increasing the surface area for digestive enzymes, thereby facilitating the breakdown of nutrients such as proteins, carbohydrates, and fats (Malik et al., 2023). Efficient chewing also stimulates production of saliva that contains amylase, responsible for the initial digestion of carbohydrates (Heianza et al., 2023). When mastication is inadequate, both saliva production and digestive efficiency are reduced (Malik et al., 2023). Poorly chewed food in the stomach hinders digestive enzymes action, compromising the proper absorption of nutrients in the small intestine, which negatively affects nutrition (Montoro-Huguet et al., 2021).

Notably, biochemical changes like nonenzymatic glycosylation and inflammatory mediators can alter the oral cavity (e.g., salivary changes and increased bacterial growth), resulting in cavities and tooth loss (Roopa et al., 2014). In turn, such processes are associated with the development of chronic noncommunicable diseases such as cancer, diabetes, and cardiovascular diseases (Martinon et al., 2021; Li et al., 2022), contributing to morbidity and mortality in older adults (Li et al., 2017).

Since nutrition is vital in preventing chronic diseases, including oral pathologies, understanding the relation between tooth loss and nutrient absorption is necessary. Thus, this study evaluated the impact of tooth loss on biochemical parameters and anthropometric indicators of adiposity in older adults in Aiquara, Bahia, Brazil.

## Material and methods

A cross-sectional, analytical epidemiological study was conducted with individuals aged 60 years or older, residing in the urban area of the municipality of Aiquara, BA, and participants of the cohort entitled "Health conditions and lifestyle of elderly residents in a small municipality." This sample was selected due to the need to understand the health conditions and specific risk factors of a population residing in small municipalities, whose characteristics may reflect similar scenarios in other regions of the country. The municipality of Aiquara was chosen due to its socioeconomic and geographic characteristics, which enable a detailed assessment of oral health determinants and nutritional conditions, important for healthy aging. Additionally, the choice to include only the urban area was based on its representativeness for access to healthcare services and lifestyle, while acknowledging that the results may not be fully generalizable to rural populations.

The research followed Resolution No. 466/2012 of the National Health Council and was approved by the Research Ethics Committee. Information about the study objectives, procedures, and voluntary nature was provided to all participants, who signed an informed consent form.

Data collection occurred in three steps. First, standardized professionals and students from health programs interviewed older adults in their homes to collect socioeconomic, behavioral, and health information (Casotti et al., 2021).

Second, a calibrated dental surgeon (Kappa=0.91) and a trained physical educator clinically assessed the oral cavity and anthropometric measurements. Oral examination was conducted in an office with adequate natural lighting, aided by a No. 5 flat mouth mirror and a periodontal probe (World Health Organization [WHO], 2020). Codes and criteria from the World Health Organization were used ([WHO], 2020). The following anthropometric measurements were collected in triplicates: body mass, height, waist circumference (WC), and hip circumference (HC) to calculate waist–hip ratio (WHR) and waist to height ratio (WHtR) (Casotti et al., 2021). Analysis used average values

Finally, biochemists collected, stored, processed, and analyzed the blood samples (Casotti et al., 2021).

Data were entered in duplicate into a Microsoft Excel spreadsheet and analyzed using SPSS (version 24.0) and STATA (5% significance level) programs after corrections.

Adjustment calculations used the following variables: gender (male or female); family arrangement (accompanied or alone); age group (60–79; ⩾ 80 years); self-declared skin color, categorized as White or non-White (White, Mixed and Asian); schooling level, categorized as with education or without education (never attended school and/or did not know how to write their own name); marital status (married/stable union, single/separated or widowed); income (⩽ 1 minimum wage or > 1 minimum wage; minimum wage in 2022: 1,212.00 BRL); use of alcohol and/or tobacco (yes or no); self-perceived health (excellent/very good/good, fair or poor); and nutritional status: BMI: body mass index; WHR**:** waist–hip ratio; WHtR**:** waist to height ratio; HC:hip circumference; WC: waist circumference.

Number of missing teeth was the dependent variable. Differences between number of missing teeth and the variables analyzed were tested using the Student's *t*-test. Given the data normality, Pearson's correlation analysis was performed to estimate the correlations between the independent variables (vitamin B12, HDL-cholesterol, Triglycerides, Iron, Hb1Ac, Magnesium, Folic Acid, Waist Circumference, Hip Circumference, Waist-Hip Ratio, and Waist-Height Ratio) and the outcome (missing teeth). Variables with p-value < 0.2 in the bivariate analysis were included in the multivariate linear regression model. These variables were selected based on evidence scientific literature, which indicates their influence on both biochemical parameters and oral health.

The model adopted the backward input method. Saturated models were formed by the independent variables with p-value < 0.2 in the bivariate analysis. Results were presented as a beta coefficient and 95%

confidence interval (95%CI). The multiple linear regression method, using the backward approach, enabled adjusting variables in the model and reduced the impact of potential biases. Nonetheless, we acknowledge the possibility of unmeasured variables, such as medication use or the presence of chronic diseases, which may have influenced the results.

## Results

A total of 117 older adults living in the urban area of Aiquara participated in the three data collection steps and thus were selected for this study. Mean age was 71.3 years (SD ± 7.8), ranging from 60 to 91, with a 62.4% prevalence of women (n = 73) and an average income of 1,269.00 BRL.

Cavities has a prevalence of 100%. Decayed, Missing, and Filled Teeth index (DMFT) showed a 27.8 (SD ± 6.1) mean, with 27.6 (SD ± 6.2) in women and 27.2 (SD ± 5.8) in men. DMFT index components presented the following means: decayed 2.8 (SD ± 3.46), missing 24.8 (SD ± 7.77), and filled 0.20 (SD ± 1.06).

We found no significant difference between the mean DMFT missing component and the sociodemographic variables, but it showed greater prevalence in females (24.6), among those aged 80 years or more (25.4), Whites (23.9), with income less than or equal to the minimum wage (24.1), with a partner (24.8), and with some education (24.4) (Table 1).

**Table 1.** Mean and standard deviation of the missing component in the Decayed, Missing, and Filled Teeth index, by sociodemographic variables of older adults.

| Parameter | Missing Teeth component | | P |
|---|---|---|---|
| | Mean | SD | |
| Gender (n = 117) | | | 0.1 |
| Female | 24.6 | 7.9 | |
| Male | 22.3 | 8.0 | |
| Age group (n = 117) | | | 0.3 |
| 60 to 79 years old | 23.5 | 0.8 | |
| 80 years or more | 25.4 | 1.9 | |
| Skin-color (n = 115) | | | 0.9 |
| White | 23.9 | 1.9 | |
| Not White | 23.6 | 0.8 | |
| Income (n = 79) | | | 0.9 |
| ≤ minimum wage | 24.1 | 8.2 | |
| > minimum wage | 23.8 | 8.6 | |
| Marital status (n = 117) | | | 0.1 |
| With partner | 24.8 | 0.9 | |
| No partner | 22.7 | 1.1 | |
| Education (n = 117) | | | 0.5 |
| No education | 23.4 | 1.0 | |
| Some education | 24.4 | 1.1 | |

In the studied population, glycated hemoglobin (HbA1c) presented a negative and significant correlation ($p < 0.05$) with the Missing teeth component of the DMFT index (Table 2).

**Table 2.** Correlation between biochemical parameters and nutritional status with the missing component in the Decayed, Missing, and Filled Teeth index in older adults.

| Parameter | Missing Teeth component | |
|---|---|---|
| | r | p |
| Vitamin B12 | −0.16 | 0.08 |
| HDL-cholesterol | 0.14 | 0.12 |
| Triglycerides | −0.13 | 0.17 |
| Iron | −0.17 | 0.06 |
| Glycated hemoglobin (Hb1Ac) | −0.25 | 0.02 |
| Magnesium | −0.15 | 0.10 |
| Folic Acid Dosage | 0.17 | 0.06 |
| Waist circumference (WC) | −0.07 | 0.42 |
| Hip circumference (HC) | −0.01 | 0.96 |
| Waist–hip ratio (WHR) | −0.09 | 0.34 |
| Waist–height ratio (WHtR) | 0.05 | 0.56 |

Of the variables (p < 0.2 in the bivariate analysis) included in the multivariate regression model, only female sex, vitamin B12, glycated hemoglobin (Hb1Ac), and magnesium remained associated with the DMFT missing component. We found no correlation between anthropometric variables and tooth loss (Table 3).

**Table 3.** Initial and final multiple linear regression model for independent variables and missing teeth component.

| Initial model | | | |
|---|---|---|---|
| Parameter | Missing Teeth component | | |
| | B | 95%CI | P |
| Female | −3.36 | −7.04 – 0.33 | 0.07 |
| No partner | 1.41 | −1.69 – 4.51 | 0.37 |
| Vitamin B12 | −0.01 | −0.01 – 0.00 | 0.05 |
| HDL-cholesterol | 0.02 | −0.10 – 0.15 | 0.69 |
| Triglycerides | 0.01 | −0.03 – 0.02 | 0.79 |
| Iron | 0.03 | −0.09 – 0.03 | 0.29 |
| Glycated hemoglobin (Hb1Ac) | −2.03 | −3.44 – −0.61 | < 0.01 |
| Magnesium | −12.75 | −20.14 – −5 .36 | < 0.01 |
| Folic acid | 0.16 | −0.29 – 0.60 | 0,06 |
| Final model | | | |
| Parameter | Missing teeth component | | |
| | B | 95%CI | P |
| Female | −4.05 | −7.24 – −0.86 | < 0.01 |
| Vitamin B12 | −0.01 | −0.01 – −0.01 | < 0.02 |
| Glycated hemoglobin (Hb1Ac) | −2.33 | −3.54 – −1.13 | < 0.01 |
| Magnesium | −12.85 | −20.11 – −5 .60 | < 0.01 |

As described in the multiple linear regression model, we observed a negative and significant correlation between the number of missing teeth (DMFT index) and the variables females (< 0.01), vitamin B12 (< 0.02), Hb1Ac (< 0.01), and magnesium (< 0.01) (Table 3).

## Discussion

This study's final regression model found a negative and significant correlation between tooth loss, females, vitamin B12, glycated hemoglobin, and magnesium.

Different factors influence the relation between tooth loss and being female. Although women exhibit better oral hygiene habits, they suffer more from tooth loss (Terra et al., 2022). Inflammatory indices are positively associated with estradiol, a female hormone, indicating a potential gender disparity in how inflammation affects tooth loss (Andriankaja et al., 2023).

Diet-related systemic inflammation, as measured by the Dietary Inflammatory Index (DII), increases the risk of periodontitis and tooth loss. Interactions between dietary inflammation and diabetes influence these outcomes (Tejada et al., 2022).

A study by Rahim et al. showed that uncontrolled type 2 diabetes mellitus (T2DM) is associated with a significant number of missing teeth and deterioration of periodontal status (Rahim et al., 2023). In adolescents with type 1 diabetes, elevated HbA1c levels correlated with early inflammatory periodontal changes, corroborating the impact of glycemic control on oral health (Ansari et al., 2023). In normoglycemic individuals, higher HbA1c levels were associated with severe stages of periodontitis, thereby confirming the interaction between glycemic control and periodontal health (Li, Mao and Zhou, 2023).

Individuals with elevated HbA1c levels present an increase in the non-enzymatic glycation of proteins—such as collagen in periodontal tissues—leading to the formation of advanced glycation end products (AGEs) (Ren et al., 2009). AGEs accumulate, altering tissues structure and making them more susceptible to inflammation and damage (Ren et al., 2009). Chronic hyperglycemia also impairs immune response, resulting in neutrophil dysfunction, which is essential to defend against bacteria present in the dental biofilm (Shetty et al., 2008). Additionally, AGEs interfere with osteoblasts (bone-forming cells) function and stimulate the activity of osteoclasts (bone-resorbing cells), increasing bone resorption and contributing to alveolar bone loss, a characteristic of advanced periodontitis. Hyperglycemia also affects periodontal blood vessels, thickening the basement membrane and reducing microcirculation, which impairs nutrient transport and waste elimination, exacerbating inflammation and hindering periodontal tissue regeneration (Wölfel et al., 2024).

Martinon et al. showed that the Western diet, characterized by the consumption of saturated fats, sucrose, fructose, and sodium, can increase blood glucose levels and the risk of diabetes-related complications (Martinon et al., 2021). Hence, older adults with diabetes and inadequate metabolic control are at greater risk of developing cavities and periodontitis, which if left untreated can result in tooth extractions (Rahim et al., 2023). A study found an association between significant reductions in HbA1c levels and nonsurgical periodontal therapy (Sun et al., 2011). These authors compared 190 individuals with poorly controlled type 2 diabetes and moderate periodontitis, randomly divided into two groups (with and without periodontal treatment), and observed that HbA1c levels were lower in the group undergoing periodontal treatment.

These findings suggest a bidirectional relation: diabetes favors the development of periodontal disease, which if left untreated, worsens diabetes control (Zong et al., 2016). This highlights the importance of good glycemic control for preventing dental and periodontal diseases, reinforcing the need for comprehensive approaches in managing oral and systemic health.

An additional finding in our study concerns magnesium and its negative yet not statistically significant correlation (< 0.01) with tooth loss, indicating that lower magnesium levels may be associated with greater tooth loss. Low dietary magnesium intake is linked to a higher prevalence of periodontitis, thus increasing its risk (Li et al., 2022).

Magnesium plays a vital role in regulating the inflammatory process. Its deficiency induces a pro-inflammatory state in the body, increasing the production of cytokines such as IL-6, TNF-α, and IL-1β, which are mediators directly involved in the destruction of periodontal tissues and the progression of periodontitis, a chronic inflammatory disease that affects the gums and supporting bones of the teeth (Kemp et al., 2023; Cazzola et al., 2024). Moreover, magnesium is crucial for the proper functioning of the immune system, and its deficiency can impair the activity of neutrophils and macrophages, essential cells in the combat against the periodontitis-causing bacteria (Ashique et al., 2023). Magnesium is also indispensable for the regulation of parathyroid hormone and vitamin D, which are essential for the activity of osteoblasts and osteoclasts (Lin et al., 2024). Magnesium deficiency can disrupt the RANK/RANKL/OPG signaling pathway, excessively stimulating osteoclasts and leading to bone loss (Lin et al., 2024).

Magnesium supplementation could increase hydrogen peroxide ($H_2O_2$) production by oral commensal streptococci, potentially promoting the establishment of better oral health-associated bacteria (Cheng et al., 2020). Injectable hydrogels containing magnesium have shown promising results in reducing inflammation and inhibiting osteoclast activity in periodontitis models, effectively repairing alveolar bone loss (Jiang et al., 2023). These hydrogels maintain cell viability and promote osteogenesis, suggesting a dual role in both controlling inflammation and promoting bone regeneration (Jiang et al., 2023).

Other studies also highlight the importance of maintaining optimal magnesium levels throughout life to prevent oxidative stress and age-related chronic conditions, including those affecting oral health (Barbagallo et al., 2021). Conversely, a study conducted with adults showed that magnesium in saliva does not actively modulate the periodontal disease process (Shetty et al., 2017).

However, maintaining adequate magnesium levels may be an essential strategy to prevent and manage periodontal diseases, as well as contribute to oral health. Dietary interventions and adequate magnesium supplementation can play an essential role in improving older adults' quality of life, reducing the prevalence of chronic diseases and improving oral health outcomes.

The present study observed a negative and statistically significant correlation between the number of missing teeth and plasma vitamin B12 levels. Vitamin B12 deficiency is common in older adults and can increase homocysteine and methylmalonic acid levels (Arendt et al., 2021).

Mastication, the initial stage of the digestive process, is essential for grinding food and mixing it with saliva (Malik et al., 2023). Inadequate mastication it compromises interaction with digestive enzymes such as amylase (Malik et al., 2023), thus interfering with the proper formation of the food bolus, hindering the digestion of nutrients such as vitamin B12 (Zhou et al., 2024). In the stomach, vitamin B12 is released via the action of hydrochloric acid and proteases, such as pepsin, which break down the proteins containing it (Andrès et al., 2000a). Poor mastication reduces the stimulus for gastric acid and enzyme production, impairing protein digestion and, consequently, the release and absorption of vitamin B12 (Dawson et al., 1984). Additionally, poor mastication allows larger food particles to reach the stomach and intestines, reducing the surface area for enzyme interaction, further compromising the absorption of this nutrient in the small intestine (Bjorkman, 2000).

Adequate vitamin B12 levels plays a crucial role in maintaining oral health, and its deficiency is linked to glossitis, burning mouth syndrome, ulcers, and other oral pathologies (Andrès et al., 2020b).

Older adults are particularly at risk due to common disorders and medications that affect vitamin B12 absorption (Cherdak et al., 2022). Low serum vitamin B12 levels have been associated with an increased risk of periodontal disease progression and tooth loss (Hans et al., 2023) (Watson et al., 2022). A study comparing individuals with and without chronic periodontal disease identified that serum vitamin B12 levels are directly related to inflammation and tissue destruction in the periodontium (Zong et al., 2016).

These findings highlight the importance of maintaining adequate vitamin B12 levels for periodontal health. Incorporating vitamin B12-rich foods or supplements into the diet can help prevent or treat oral diseases, emphasizing the potential role of vitamin B12 as a modifiable risk factor for oral health (Aboelsaad, 2019).

Planning strategies that combine oral rehabilitation and dietary interventions is crucial to control biochemical parameters in edentulous older adults. Edentulism has been associated with poor nutritional intake. Edentulous individuals consume less essential nutrients such as proteins, fiber, and vitamins (Qian et al., 2022). Oral rehabilitation, including dental prosthesis use, significantly impacts quality of life, improves chewing function, and aids in proper digestion. By combining these strategies we can address nutritional deficiencies and promote better health outcomes in edentulous older adults, thus emphasizing the importance of a holistic approach to oral and systemic well-being.

The main limitation of this study is its cross-sectional design, which prevents the determination of causal relations between tooth loss and biochemical parameters. Since data are collected at a single timepoint, it is not possible to determine whether the biochemical changes are the cause or consequence of tooth loss. Although the study adjusted for sociodemographic and lifestyle variables, unmeasured factors may have influenced the results such as medication use and chronic diseases.

Despite these limitations, the study provides important contributions by revealing correlations between tooth loss and levels of vitamin B12, HbA1c, and magnesium in older adults. For future studies, a longitudinal design is recommended, with larger samples and greater control of confounding variables.

## Conclusion

Prevalence of tooth loss in older adults living in the urban area of Aiquara was high, more significant in females and influenced plasma levels of vitamin B12, Hb1Ac, and magnesium. Further studies are needed to confirm the correlation between tooth loss and biochemical parameters to describe their actions in maintaining the stomatognathic complex.

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