# Characterization of tongue pressure in the elderly

## Caracterização da pressão da língua em idosos

*Hipólito Virgílio Magalhães Junior[1], Juliana Carvalho Tavares[2], Amanda Almeida Batista Magalhães[3], Hébel Cavalcanti Galvão[4], Maria Angela Fernandes Ferreira[5]*

## ABSTRACT

**Purpose:** To characterize tongue pressure in elderly individuals. **Methods:** This was a cross-sectional study involving 45 individuals aged between 61 and 96 years old (34 [75.6%] women; 11 [24.4%] men) with no neurological or cognitive disorders, no history of head or neck cancer, and no history of radiotherapy. The subjects were surveyed with a questionnaire that recorded the presence or absence of complaints about swallowing problems and an orofacial myofunctional evaluation, which examined the movement and tension of the tongue. The Iowa Oral Performance Instrument (IOPI) was used to measure tongue pressure. The data analysis was descriptive, with significance set at the 5% level. **Results:** The mean pressure peak was 44.6 kPa (±16), with minimum and maximum values of 9 and 88 kPa, respectively. Pressure peak and age were moderately and negatively correlated. The oldest subject had the lowest average pressure peak, which was less than the normal range. The mean pressure peak differed according to the use of dentures, tongue pressure, and tongue mobility during clicking. **Conclusion:** The pressure peak and the pressure of the tongue decreased moderately with increasing age, decreasing tongue tension, and mobility during clicking. In contrast, the pressure peak values were higher in the elderly who used dentures than those who did not.

**Keywords:** Pressure; Tongue; Aged; Prostheses and implants; Deglutition

## RESUMO

**Objetivo:** Caracterizar a pressão da língua em idosos. **Métodos:** Estudo transversal, com a participação de 45 idosos, de 61 a 96 anos, sendo 34 (75,6%) do gênero feminino e 11 (24,4%) do masculino, sem distúrbios neurológicos e cognitivos, sem histórico de câncer de cabeça e pescoço e de procedimento radioterápico. Consistiu na aplicação de questionário, com registro da presença ou ausência de queixa de problemas na deglutição, seguido da avaliação miofuncional orofacial, enfocando a mobilidade e tensão de língua. Para a mensuração da pressão da língua, foi utilizado o *Iowa Oral Performance Instrument* (IOPI). A análise dos dados foi descritiva, com nível de significância de 5%. **Resultados:** A média do pico pressórico foi de 44,6 KPa (±16), com os valores mínimo e máximo entre 9 e 88 KPa. Houve correlação moderada negativa entre pico pressórico e idade. Os longevos apresentaram a menor média de pico pressórico e inferior ao padrão de normalidade. Houve diferença entre a média de pico pressórico e uso de próteses, tensão de língua e mobilidade de língua no estalo. **Conclusão:** Houve diminuição moderada do pico pressórico da língua com o aumento da idade e redução pressórica com o decréscimo da tensão da língua e de sua mobilidade no estalo. Em contrapartida, os valores de pico foram maiores nos idosos que utilizam próteses dentárias, quando comparados aos que destas não fazem uso.

**Descritores:** Pressão; Língua; Idoso; Próteses e implantes; Deglutição

## INTRODUCTION

The aging process results in several anatomical and functional changes including a reduction in muscle tissue and its function, which occurs as a result of sarcopenia. Sarcopenia is a consequence of muscle fiber decline and atrophy, a decrease in the number of motor units, and a more sedentary lifestyle, in addition to hormonal factors, metabolic factors, a decrease in the activity of certain enzymes, and an increase in the amount of connective tissue and fat[1].

Among the modifications in orofacial structures, hypertrophy of the tongue may occur due to increased connective tissue and fat deposits. This causes a loss of muscle tone and tongue mobility, with a consequent impairment in motor performance in the execution of the movements that are necessary for efficient[2] and safe[3] swallowing.

Specifically, studies have demonstrated that there is a loss in the elasticity of the oral mucosa, lower saliva production, and decreased lip motor function in the orofacial structures of the elderly, which can compromise the oral phase of swallowing[4,5]. The tongue acts directly on the process of chewing by manipulating and maintaining a cohesive alimentary bolus and propelling the bolus from the oral cavity to the pharynx[6,7].

In the aging process, the change in the efficiency of swallowing, which results from natural decreases in the functional reserve, may contribute to decreases in the tongue's strength during the pressure that it exerts against the palate to propel the bolus[8]. Therefore, tongue pressure measurements are useful for evaluating the biomechanical performance of these muscles during movements in order to assess whether there are impairments in its functions[9]. Different types of instruments measure tongue pressure. These include dynamometers, resistive sensors, bulbs, and palatal plates[5,10].

One device that uses a bulb to measure tongue pressure is the Iowa Oral Performance Instrument (IOPI). This device consists of a pressure transducer that is connected to an air--filled bulb, which must be pressed against an individual's hard palate by their tongue[10]. The pressure change that is generated by pressing the bulb is captured by the device and displayed on its own LCD screen in kilopascals (KPa). The use of this equipment allows measurements of the maximum pressure that is generated by the tongue and its resistance[11].

Studies have shown this device's efficiency in measuring tongue pressure for the evaluation of changes that are caused by dysphagia, individuals with dysarthria, the physiological pressure of the tongue during swallowing, or even the effectiveness of speech therapy[12-15].

In Brazil, some recent studies have used the IOPI. Measuring tongue pressure can be very useful for determining the mean pressure peaks of a large sample of elderly Brazilians. Thus, this study aimed to characterize tongue pressure in the elderly and examine the association between mean pressure peak and complaints that were related to problems in swallowing, age, and/or gender.

## METHODS

This investigation was designed as a descriptive and analytical cross-sectional observational study. Data collection was performed at the Clinical School of Speech Pathology in the Universidade Federal do Rio Grande do Norte (UFRN) in collaboration with the Geriatric Outpatient Clinic at Onofre Lopes University Hospital from April 2012 to October 2012.

Non-probability sampling was used because of the convenience of examining the elderly who sought care at these locations. The sample comprised of 45 elderly people with an age range of 61–96 years (11 men and 34 women); mean age, 74.2 years (±8.9). Those participating in the research were edentulous or used dentures, had no neurological disorders or cognitive changes, no history of head or neck cancer, and had not undergone radiation therapy according to the information provided by the geriatric clinics that referred the patients with their medical records.

The volunteers that were referred to the Clinical School were informed of the purpose of the research and the procedures for data collection. After agreeing to participate in the study, they signed a Free and Informed Consent Form. The study was approved by the Research Ethics Committee at Onofre Lopes University Hospital under CAAE 3468.0.000.294-10.

The questionnaire for data collection included personal identification, recordings of the presence or absence of self--reported swallowing complaints, and questions about the use of dental prostheses. The elderly underwent an orofacial myofunctional evaluation that focused on tongue mobility, tension, and pressure.

In order to evaluate tongue mobility, the patient was asked to perform the following movements to the four cardinal points with a stable jaw: retraction, protrusion, and clicking[9]. To evaluate tongue tension, the participant was required to protrude the tongue and push it against the examiner's index and middle fingers, which were gloved and wrapped with gauze, for 3s.

It should be noted that the examiner has over 20 years of clinical experience in orofacial myology and dysphagia. The criteria used to analyze tongue tension were in accordance with the elderly's ability to protrude their tongue and maintain the pressure against the examiner's fingers, and their performance was classified as adequate or decreased/hypotensive[16].

To evaluate tongue pressure, the IOPI model 2.0 was used to measure the maximal isometric pressure. The bulb was positioned between the anterior third of the tongue dorsum and the participant's hard palate without occluding the teeth. The individual was asked to press on the bulb with maximum force for 3s. This procedure was repeated twice with an interval of 30 s between the repetitions. The highest pressure measurement out of the three results was considered the pressure peak. For

the data analysis, the mean normal pressure peak that was listed in the device's manual (37 KPa) was considered normal. Values below 37 KPa were considered abnormal for the age group under study[11].

The data were presented descriptively as the absolute and relative frequencies of the measures of central tendency and dispersion for age and pressure peak with the PSPP program.

In order to evaluate the correlation between mean age and mean pressure peak, Pearson's correlation test was used. In order to identify the age group that had the greatest association with pressure peak, the ages were categorized into quartiles. Subsequently, in order to determine whether the mean pressure peaks differed in the age groups, an analysis of variance test (ANOVA) was used with a Tukey's post-hoc test in order to identify the differences in each category.

Student's *t*-tests were applied to examine the effects on the mean pressure peak of the following variables: the use of dentures, age (dichotomized by the median), gender, complaints about swallowing, and tongue mobility and tension.

The test results were considered significant at p values less than 0.05.

## RESULTS

The mean (SD) pressure peak in the sample was 44.6 KPa (±16 KPa) with minimum and maximum values of 9 and 88 KPa, respectively.

A moderate negative correlation was observed between the mean pressure peak and age (Table 1).

**Table 1.** Correlation of mean pressure peak and age

|  | Mean value | Standard deviation | r | p-value |
|---|---|---|---|---|
| Pressure peak (KPa) | 44.6 | 16.0 | -0.321 | 0.031* |
| Age | 74.2 | 8.9 | | |

*Significant value (p≤0.05; Pearson's Correlation)

The oldest age group (81–96 years old) had the lowest mean pressure peak compared to the other age groups, and their mean pressure peak was below the standard of normality. ANOVA showed a significant difference between the 67–73-year-old group and the 81–96-year-old group and a significant decrease in the mean peak of the youngest group compared with the oldest group, which had a value around 18.7 KPa (Table 2).

There were differences in the mean pressure peaks according to the use of dentures, tongue tension, and tongue mobility during clicking, which indicated smaller pressure means in the groups that presented these altered variables (Table 3).

For tongue mobility and tension, most of the elderly were able to perform the tongue movements for the three parameters that were evaluated, and 33 (73%) exhibited normal tongue tension (Table 3).

## DISCUSSION

The mean maximum isometric pressure peak that was found in this study was lower compared with the results reported in other studies with subjects within the age range compatible for analysis [60–79 years old: 54.5 KPa (±11.1)[14] and 68.81 KPa (±5.4)[17]].

In a study[18] with 171 participants, the mean pressure peak that was found in the 60–89-year-old group (n = 43) was 51 KPa (±15), which is a value that was slightly above that of this study (44.6 KPa). However, it is worth noting that this research is being developed in Brazil, where the reference values for pressure peak are still under study. A previous study that was conducted on 75 participants, which included 10 elderly people who were between 61 and 80 years old, reported a mean value of 54.4 KPa (±5.94)[19].

A decrease in the tongue's maximal isometric pressure with increasing age has been reported previously[14,17,19], with those results indicating that the decrease ranged from 9 to 15 KPa, which was equivalent to the decrease found in this study.

One advantage of the current study was that this sample's study comprised only the elderly, which enabled an analysis of which age group had the greatest decrease in maximal isometric pressure. These results, which are found in most elderly, can be explained by the prevalence of sarcopenia, which is found in 13%–24% of individuals with ages of 65–70 years, and approximately 50% in those older than 80 years[20].

According to gender, there were no differences in pressure peak. These results were similar to those of some studies[5,17,18,19], while they differed from the findings of other studies[14,21]. Additional studies, particularly some that examine the Brazilian population, need to be conducted in order to better understand the role of gender in tongue pressure.

Among the three parameters of tongue mobility that were evaluated, a difference was found only in tongue clicking. This

**Table 2.** Distribution of the measures of central tendency and the variability in the maximum pressure peak according to age group

| Age (quartiles) | n | Mean (± standard deviation), KPa | CI of the mean | p-value |
|---|---|---|---|---|
| 61-67 | 14 | 44,86 (±12,74) a,b | 37,50 – 52,21 | |
| 67-73 | 10 | 52,10 (±18,03) a | 39,20 – 65,00 | 0,052* |
| 73-81 | 11 | 47,64 (±16,5) a,b | 36,55 – 58,72 | |
| 81-96 | 10 | 33,40 (±16,03) b | 23,79 – 43,01 | |

*Significant value (p≤0.05; ANOVA); a, b: Tukey's post-test
**Note:** CI = confidence interval

**Table 3.** Mean pressure peak according to the independent variables

| Variables | n (%) | Mean pressure peak (KPa) | Standard deviation | t | p-value |
|---|---|---|---|---|---|
| **Use of dentures** | | | | | |
| Yes | 32 (71,1) | 48.09 | 16.57 | 2.87 | 0.02 * |
| No | 13 (28,9) | 36.00 | 10.92 | | |
| **Dichotomized age** | | | | | |
| 61–73 years | 23 (51,1) | 48.13 | 15.53 | 1.53 | 0.13 |
| 73–96 years | 22 (48,9) | 40.91 | 16.05 | | |
| **Gender** | | | | | |
| Female | 34 (76) | 46.71 | 15.48 | 1.58 | 0.12 |
| Male | 11 (24) | 38.09 | 16.64 | | |
| **Swallowing complaint** | | | | | |
| Yes | 15 (33,3) | 43.53 | 15.06 | -0.31 | 0.76 |
| No | 30 (66,7) | 45.13 | 16.71 | | |
| **Tongue mobility** | | | | | |
| To the four cardinal points | | | | | |
| Yes | 41 (91,1) | 45.93 | 15.72 | 1.82 | 0.07 |
| No | 4 (8,9) | 31.00 | 14.01 | | |
| Retraction and protrusion | | | | | |
| Yes | 44 (97,8) | 44.48 | 16.19 | -0.34 | 0.73 |
| No | 1 (2,2) | 50.00 | - | | |
| Clicking | | | | | |
| Yes | 41 (91,1) | 46.49 | 15.25 | 2.71 | 0.01* |
| No | 4 (8,9) | 25.25 | 10.81 | | |
| Tension | | | | | |
| Adequate | 33 (73,3) | 47.42 | 15.18 | 2.03 | 0.05* |
| Decreased/hypotensive | 12 (26,7) | 36.83 | 16.34 | | |
| Total | 45 (100) | - | - | - | - |

*Significant values (p≤0.05; Student's t-test)

movement involves lifting the anterior two thirds of the tongue. The lifting makes a difference in the maximum pressure peak[5], and it is involved in positioning the bolus, the force that is applied by the anterior third of this muscle against the alveolar region, and the propulsion of the bolus to the oropharynx[22].

Differences were observed in the peak according to tongue tension, which can be explained by the observation that this muscle's pressure peak involves its ability to contract against the bulb[11]. This is an important finding as it is possible to observe an association in the results that were found in the clinical evaluation compared with the instrumental results.

The differences found in the pressure peak according to the use of dentures can be explained by the dentures' influence on the stability of tongue movement. Edentulous individuals show a pattern of tongue movement that is considered unstable due to a loss of occlusal support and, consequently, jaw clamping. This instability is characterized by tongue movements in different directions, difficulties with anchoring against the hard palate, and imperfection in sealing against the lateral alveolar ridge[23].

Because the movement that is required for an evaluation of the maximum isometric pressure involves raising the tip of the tongue against the hard palate, tongue instability, which is often present in edentulous patients, may have contributed to the lower mean pressure peak that was observed in such subjects compared with those who did not use dentures.

In this study, the interest in evaluating the relationship between pressure peak and self-reported complaints of swallowing problems was related to the expectation that the elderly who had swallowing complaints would have a lower mean pressure peak, which was not found. This finding can be explained by the observation that swallowing disorders have an insidious onset. The onset of symptoms occurs over many years or even decades, and the elderly develop compensations that help them maintain functional swallowing until the time when the complications that have a greater impact on swallowing appear[22,24]. One can then assume that elderly people at more advanced ages, which were the participants in this study, with a swallowing disorder may not have reported the complaint because it only presented mild changes in their swallowing. This reinforces the need for studies that investigate how much tongue pressure reduces the influence of the swallowing process's efficiency.

This study had a number of limitations. First, the cutoff point was based on the international reference. Second, the sample was not population-based, although it was representative. Finally, the analysis of the clinical evaluation was performed without examining intra- and inter-examiner reliability. In order for this to be done, other examiners need to participate in order to compare the values.

It should be noted that this research will continue until a representative population is obtained in order to further compare the findings with those in the literature, contribute to determining national benchmarks, as well as evaluate the impact that changes in tongue pressure can bring to the mechanism of swallowing.

## CONCLUSION

This study demonstrated that tongue pressure peak decreased moderately with increasing age. In addition, the mean values decreased with reductions in tension and mobility when clicking the tongue. In contrast, the mean increased with the use of dentures.

## REFERENCES

1. Lacourt MX, Marini LL. Decréscimo da função muscular decorrente do envelhecimento e a influência na qualidade de vida do idoso: uma revisão de literatura. Rev Bras Ciênc Envelhec Hum. 2006;3(1):114-21.

2. Feijó AV, Rieder CRM. Distúrbios da deglutição em idosos. In: Jacobi JS, Levy DS, Muller LC. Disfagia: avaliação e tratamento. Rio de Janeiro: Revinter; 2004. p.225-31.

3. Fiorese AC, Bilton T, Venite JP, Sanches EP. Estudo das alterações de maior ocorrência nas fases oral e faríngea da deglutição, entre 20 e 93 anos de idade, avaliadas pela videofluoroscopia. Distúrb Comuni. 2004;16(3):301-12.

4. Dias BKP, Cardoso MCA. Características da função de deglutição em um grupo de idosas institucionalizadas. Estud Interdiscip Envelhec. 2009;14(1):107-24.

5. Yoshida M, Kikutani T, Kazuhiro T, Utanohara Y, Hayashi R, Akagawa Y. Decreased tongue pressure reflects symptom of dysphagia. Dysphagia. 2006;21(1):61-5. http://dx.doi.org/10.1007/s00455-005-9011-6

6. Clark HM, Henson PA, Barber WD, Stienwalt JAG, Sherrill M. Relationships among subjective and objective measures of tongue strength and oral phase swallowing impairments. Am J Speech Lang Pathol. 2003;12(1):40-50. http://dx.doi.org/10.1044/1058-0360(2003/051)

7. Kennedy D, Kieser J, Bolter C, Swain M, Singh B, Waddell JN. Tongue pressure patterns during water swallowing. Dysphagia. 2010;25(1):11-9. http://dx.doi.org/10.1007/s00455-009-9223-2

8. Ney D, Weiss J, Kind A, Robbins J. Senescent swallowing: impact, strategies and interventions. Nutr Clin Pract. 2009;24(3):395-13. http://dx.doi.org/10.1177/0884533609332005

9. Hori K, Ono T, Nokubi T. Coordination of tongue pressure and jaw movement in mastication. J Dent Res. 2006;85(2):187-91. http://dx.doi.org/10.1177/154405910608500214

10. Furlan RMMM. Desenvolvimento de um aparelho portátil para quantificação e reabilitação da força na língua humana [dissertação]. Belo Horizonte: Universidade Federal de Minas Gerais; 2011.

11. IOPI Northwest. Iowa oral performance instrument: user's manual. Carnation: IOPI Northwest; 2011.

12. Solomon NP, Clark HM, Makashay MJ, Newman LA. Assessment of orofacial strength in patients with dysarthria. J Med Speech Lang Pathol. 2008;16(4):251-8.

13. Neel AT, Palmer PM, Gass CA. Can IOPI be used to measure tongue pressure for speech sounds? J Med Speech Lang Pathol. 2008;16(4):235-41.

14. Youmans SR, Stierwalt JAG. Measures of tongue function related to normal swallowing. Dysphagia. 2006;21(2):102-11. http://dx.doi.org/10.1007/s00455-006-9013-z

15. Robbins J, Kays SA, Gangnon RE, Hind JA, Hewitt AL, Gentry LR et al. The effects of lingual exercise in stroke patients with dysphagia. Arch Phys Med Rehabil. 2007;88(2):150-8. http://dx.doi.org/10.1016/j.apmr.2006.11.002

16. Perilo TVC, Motta AR, Casas EBL, Saffar JME, Costa CG. Avaliação objetivadas forças axiais produzidas pela língua de crianças respiradoras orais. Rev Soc Bras Fonoaudiol. 2007;12(3):184-90. http://dx.doi.org/10.1590/S1516-80342007000300005

17. Youmans SR, Youmans GL, Stierwalt JAG. Differences in tongue strength across age and gender: Is there a diminished strength reserve? Dysphagia. 2009;24(1):57-65. http://dx.doi.org/10.1007/s00455-008-9171-2

18. Clark HM, Solomon NP. Age and sex differences in orofacial strength. Dysphagia. 2012;27:2-9.

19. Vitorino J. Effect of age on tongue strength and endurance scores of healthy Portuguese speakears. Int J of Speech-Language Pathol. 2010;12(3):237-43.

20. Doherty TJ. The influence of aging and sex on skeletal muscle mass and strength. Curr Opin Clin Nutr Metab Care. 2001;4(6):503-8.

21. Stierwalt JAG, Youmans SR. Tongue measures in individuals with normal and impaired swallow. Am J Speech Lang Pathol. 2007;16:148-56.

22. Issa PCM. Avaliação estrutural e funcional da deglutição em idosos, com e sem queixas de disfagia, internados em uma enfermaria geriátrica [dissertação]. Ribeirão Preto: Universidade de São Paulo; 2003.

23. Yoshikawa M, Yoshida M, Nagasaki T, Tanimoto K, Tsuga K, Akagawa Y. Effects of tooth loss and denture wear on tongue-tip motion in elderly dentulous and edentulous people. J Oral Rehabil. 2008;35(12):882-8. http://dx.doi.org/10.1111/j.1365-2842.2008.01882.x

24. Schindler JS, Kelly JH. Swallowing disorders in the elderly. Laryngoscope. 2002;112(4):589-92. http://dx.doi.org/10.1097/00005537-200204000-00001