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**Analysis of tongue pressure in Brazilian young adults****Análise da pressão da língua em indivíduos adultos****jovens brasileiros****ABSTRACT**

**Purpose:** To present the measures for tongue pressure in Brazilian young adults, considering specific tasks, and to verify the differences regarding gender and according to the tasks. **Methods:** Fifty-one volunteers aged 18 to 28 years, of both genders with normal occlusion and without speech disorders were evaluated. We used the Iowa Oral Performance Instrument in the evaluation of tongue pressure (kilopascal) during specific tests of elevation, protrusion, swallowing, and lateralization, in addition to the endurance test (seconds). The analysis was conducted using analysis of variance, followed by the Tukey's multiple comparison test, adopting a 5% significance level. **Results:** The values obtained for men and women in the tests were as follows: elevation, 63.94±12.92 and 50.27±15.29; protrusion, 60.22±13.62 and 44.30±12.95; swallowing, 33.94±12.06 and 34.27±13.25; lateralization on the right, 44.15±10.47 and 31.85±8.46; lateralization on the left, 43.15±10.22 and 29.55±8.91; and endurance test: 24.85±10.95 and 17.35±6.71, respectively. The values were higher in men compared with women for the protrusion and lateralization tasks. The measures of the protrusion and elevation tasks did not differ for men but were higher in both genders than those of the lateralization and the swallowing tests. There was no difference in lateralization according to side in both the genders. **Conclusion:** The measures for the tongue pressure in Brazilian young adults were determined by specific tasks. Gender influenced the pressure of the tongue values for the protrusion and lateralization tasks. Elevation and protrusion tasks measures were higher than those of the lateralization and swallowing tasks.

**RESUMO**

**Objetivo:** Apresentar valores para a pressão da língua em adultos jovens brasileiros, considerando provas específicas e possíveis diferenças quanto ao gênero e tipo de prova. **Método:** Foram avaliados 51 voluntários de 18 a 28 anos, ambos os gêneros, com boa relação dento-oclusal e sem alterações de fala. Utilizou-se o *Iowa Oral Performance Instrument* na avaliação da pressão da língua (Kilopascal) durante as provas de elevação, protrusão, deglutição e lateralização, além do teste de resistência (segundos). Na análise dos resultados foi utilizado o ANOVA, seguido do teste de comparações múltiplas Tukey, adotando o nível de significância de 5%. **Resultados:** Os valores obtidos, respectivamente para homens e mulheres, na prova de elevação foram 63,94±12,92 e 50,27±15,29, na protrusão 60,22±13,62 e 44,30±12,95, na deglutição 33,94±12,06 e 34,27±13,25, na lateralização à direita 44,15±10,47 e 31,85±8,46, na lateralização à esquerda 43,15±10,22 e 29,55±8,91, e no teste de resistência 24,85±10,95 e 17,35±6,71. Os homens apresentaram valor maior nas provas de protrusão e de lateralização; os valores das provas de protrusão e elevação não diferiram entre si para o gênero masculino, mas foram maiores que a lateralização e a deglutição em ambos os gêneros; não houve diferença na prova de lateralização em relação ao lado em ambos os gêneros. **Conclusão:** Valores de pressão da língua em adultos jovens brasileiros foram determinados para provas específicas; o gênero influenciou nos valores das provas de protrusão e lateralização; os valores obtidos nas provas de elevação e protrusão foram maiores que na lateralização e deglutição.

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## INTRODUCTION

The tongue plays an important role in the performance of orofacial functions and in the balance of the stomatognathic system<sup>(1)</sup>, besides influencing the craniofacial growth that also interferes in the execution of the functions<sup>(2,3)</sup>. Knowing the action of this organ in activities such as chewing, swallowing, and speech helps to understand its dysfunctions and repercussions in the craniofacial complex.

Therefore, both quantitatively and qualitatively, literature has tried to develop methods to measure the tongue's function in the oral cavity. In speech language pathology and audiology, the qualitative method is the most commonly used in clinical assessment, using the palpation of muscles to verify tone; however, this analysis presents a great variation because of its subjective character and the relationship with the professional's experience<sup>(3)</sup>. On the other hand, the quantitative evaluation uses instruments that can determine the pressure made by the tongue, which allows a more precise and sensitive diagnosis regarding this aspect.

In the early 1990s, an instrument was developed to measure the pressure generated by the contact between the tongue and the palate, an objective way to evaluate the tongue's pressure and resistance<sup>(4)</sup>, called Iowa Oral Performance Instrument (IOPI) system. It is portable and easy to use, is noninvasive, and presents fast, accurate, and reliable measurements<sup>(4-6)</sup>.

After that, many studies proposed to measure the pressure made by the tongue on the oral cavity<sup>(7)</sup> during functions such as speech<sup>(8)</sup>, swallowing,<sup>(5)</sup> and chewing<sup>(9)</sup>; at rest<sup>(10)</sup>; and during the maximum isometric contraction for comparing with different portions of the tongue (anterior and dorsum) among young adults<sup>(11)</sup>. The pressure of the tongue has also been studied in relation to gender<sup>(11-14)</sup> and age<sup>(5,13-15)</sup> in individuals diagnosed with obstructive sleep apnea<sup>(16)</sup>, neurological conditions<sup>(17)</sup>, and disorders in the head and neck area<sup>(18)</sup>.

Besides, it is possible to find studies related to the exercises of the tongue<sup>(17)</sup>; pressure of the lip and tongue regarding the type of bad occlusion<sup>(19)</sup>; the comparison between the maximum isometric pressure of the tongue of individuals with dentofacial deformity and those with adequate occlusal relationship<sup>(20)</sup>; and the comparison of pressure and resistance of the tongue among speakers of Brazilian Portuguese, and English, which obtained a lower resistance of the tongue for the latter<sup>(13)</sup>.

The diversity of instruments used to measure the pressure of the tongue and the lack of standardization in the evaluation of this skill makes it difficult to reproduce studies and to compare results<sup>(3,11,15)</sup>. Therefore, obtaining the values of pressure of the tongue in different tasks and the resistance of the tongue by the IOPI system, in a population of young adults, will help to understand the functioning of this structure and the diagnosis of oral dysfunctions.

Studies conducted in Brazil used some specific tasks based on the IOPI system, even though this instrument allows assessing the condition of the tongue in other tasks. Therefore, the objectives of the study were to analyze, among Brazilian young adults, the pressure made by the tongue in the tasks of maximum isometric contraction and deglutition; to verify the

resistance of the tongue; to analyze the relationship between the tasks, and to identify the influence of gender on the tasks of pressure and resistance.

## METHODS

This study is part of a large interinstitutional study approved by the Human Research Ethics Committee (report 406.337 and process 14.332/2011). All of the participants signed an informed consent form.

The study involved 51 volunteers (18 men and 33 women), aged between 18 and 28 years (mean age, 23 years), selected in the community where the study was conducted. The following inclusion criteria were considered: good general health, with at least 28 permanent teeth, and no periodontal disease; absence of relevant malocclusion (open anterior bite, crossbite of any kind, Angle class III, or dentofacial deformity); no chronic use of pain killers, anti-inflammatory or psychotropic medications, and absence of history of central or peripheral neurological disorders, surgeries and/or tumors or traumas on the head and neck regions, and no speech disorders according to the orofacial myofunctional evaluation.

The pressure of the tongue was measured by the IOPI system, model 2.2 (Northwest, Co., LLC, Carnation, WA, USA). During the evaluation, the participants remained seated on a comfortable chair, with their feet on the ground and their heads parallel to the horizontal plane. The IOPI system consists of a pressure transducer connected to a plastic bulb with the air inside. The device measure the pressure of the tongue by measuring the maximum peak pressure it exerts on the bulb, expressed in kilopascal (kPa).

After the instructions, the bulb was placed on the oral cavity and the participants pressed it as much as possible for 2 seconds. Three measurements were taken for each task, with a 1-minute break in-between. The following tasks were conducted:

- *Maximum tongue elevation*: to elevate the tongue toward the papilla incisiva and press the bulb placed in that region;
- *Maximum tongue protrusion*: to protract the tongue against the bulb placed on the lingual surface of the incisors attached to a wooden spatula with a duct tape;
- *Swallowing*: to swallow saliva normally with the bulb placed on the region of the papilla incisiva.

A part of the sample subjects (65%) also underwent the following tasks:

- *Maximum tongue lateralization*: to press the tongue laterally against the bulb placed on the lingual surface of molar and premolar teeth, being attached to a wooden spatula by a duct tape;
- *Resistance test*: to press the tongue against the bulb in the region of the papilla incisiva, using 50% of the pressure obtained in the maximum elevation task, monitored by the lights of the equipment. The result refers to the time, in seconds, up to which the person could hold the pressure.

The analysis of variance was used to analyze the results, followed by the Tukey's multiple comparison test, using the software Sigma Plot 12.0, adopting  $p < 0.05$  as significant values.

## RESULTS

The mean values and standard deviations of tongue pressure values for the maximum isometric contraction tasks during elevation, protrusion, lateralization, and the swallowing and resistance tests are shown in Table 1.

The result of gender comparison, in Table 2, showed higher values for men in the protrusion ( $p < 0.001$ ) and in the lateralization to the right ( $p = 0.002$ ) and the left tasks ( $p < 0.001$ ).

Table 3 shows the results of the comparisons between the tasks for both the genders. It is possible to observe higher values in the protrusion task in comparison with the lateralization to the right ( $p < 0.001$ ) and to the left ( $p = 0.001$ ), and for the elevation task in comparison with the lateralization to the right ( $p < 0.001$ ) and to the left ( $p < 0.001$ ). There were also lower values for the swallowing task in comparison with the elevation ( $p < 0.001$ ) and protrusion tasks ( $p = 0.021$ ) and lower values for the protrusion task in comparison with the elevation task, only among women ( $p < 0.001$ ).

## DISCUSSION

This article aimed at presenting the values of tongue pressure in different tasks, involving a group of 51 healthy Brazilian young adults. Knowing these values and understanding their influence in movements such as lateralization while chewing, anteriorization when speaking, and in the activity of pressing the palate during the oral phase of swallowing help in comprehension of the stomatognathic system dysfunctions and will thus contribute to the therapeutic planning.

Studies that aim at measuring the pressure of the tongue during specific tasks, using the IOPI system, and their applicability in speech language pathology and audiology clinic are scarce.

Considering the values obtained in this study for the tasks of protrusion and laterality, there were differences between genders, as men presented higher values than women; however, in the other tasks, there was no such difference. This result is not in agreement with other studies that also used the IOPI system. By investigating the pressure of the tongue in individuals with swallowing disorders and in a control group, there were higher values for the elevation task among men in the control group<sup>(12)</sup>. Another study assessed the pressure of the tongue in healthy

individuals who spoke Brazilian Portuguese but found no differences between the age groups and gender<sup>(13)</sup>. Using a dynamometer, the strength of the anterior region and the dorsum of the tongue was analyzed among healthy Brazilian young adults. The authors observed higher values among male participants<sup>(11)</sup>.

Therefore, it is possible to consider there is no consensus in the literature regarding the influence of gender on the pressure of the tongue. The analyses that found higher values for men attributed the findings to the anatomical differences between genders, as men present more muscle mass in the tongue, besides factors such as height and weight<sup>(11,12)</sup>.

The values obtained in the elevation task for men and women were  $63.94 \pm 12.92$  and  $50.27 \pm 15.29$ , respectively. In average, these values were close to those observed in the literature ( $57.62 \pm 7.78$ ) for Brazilians aged 20 to 40 years<sup>(13)</sup> and to the values presented in the manual of the equipment<sup>(6)</sup> for healthy North Americans aged between 20 and 39 years ( $65.73 \pm 12.95$ ). However, they are higher to the values observed among children ( $43 \pm 14.8$ )<sup>(21)</sup>, which can be attributed to age.

For the tasks of tongue lateralization to the right and the left sides and protrusion for male and female participants, the values obtained were  $44.15 \pm 10.47$  and  $31.85 \pm 8.46$ ;  $43.15 \pm 10.22$  and  $29.55 \pm 8.91$ ; and  $60.22 \pm 13.62$  and  $44.30 \pm 12.95$ , respectively. These are lower than those observed in a study involving North Americans aged 19 to 29 years, in which the lateralization task

**Table 3.** Result of the comparison of tongue pressure value between the different assessed tasks, in the studied groups

Gender	Male	Female
Comparisons		
Protrusion x Elevation	0.717	<0.001*
Protrusion x Swallowing	<0.001**	0.021**
Elevation x Swallowing	<0.001**	<0.001**
Right lateralization x Swallowing	0.193	0.571
Left lateralization x Swallowing	0.334	0.964
Protrusion x Right lateralization	<0.001***	<0.001***
Protrusion x Left lateralization	0.001***	0.001***
Elevation x Right lateralization	<0.001***	<0.001***
Elevation x Left lateralization	<0.001***	<0.001***
Right lateralization x Left lateralization	1.000	0.964

\*Lower value for the protrusion task; \*\*Lower value for the swallowing task; \*\*\*Higher value for protrusion and elevation tasks

**Table 1.** Means and standard-deviation of tongue pressure pattern according to gender in each tested task

Tasks	Elevation (n=51)	Protrusion (n=51)	Swallowing (n=51)	Lateralization		Resistance (n=33)
				Right (n=33)	Left (n=33)	
Gender						
Male	$63.94 \pm 12.92$	$60.22 \pm 13.62$	$33.94 \pm 12.06$	$44.15 \pm 10.47$	$43.15 \pm 10.22$	$24.85 \pm 10.95$
Female	$50.27 \pm 15.29$	$44.30 \pm 12.95$	$34.27 \pm 13.25$	$31.85 \pm 8.46$	$29.55 \pm 8.91$	$17.35 \pm 6.71$

**Table 2.** Result of gender comparison, for tongue pressure, in each tested task

Tasks	Elevation (n=33)	Protrusion (n=33)	Deglutition (n=33)	Lateralization		Resistance (n=33)
				Right (n=33)	Left (n=33)	
p-value	0.064	<0.001*	0.61	0.002*	<0.001*	0.058

\*Male higher than female by the Tukey test

showed, for both sides,  $57.5 \pm 17.6$ , and the protrusion task showed  $69.7 \pm 18.3$ <sup>(14)</sup>. This difference can be related to the method used for collection, as the authors adapted the bulb, which can interfere in the results and make it more difficult to compare the data.

As to the test of tongue resistance, among male participants the time observed was of  $24.85 \pm 10.95$  seconds, whereas for women, the time was  $17.35 \pm 6.71$  seconds. These values were, in average, higher to those observed in a study conducted with a similar age group, which was  $16.21 \pm 8.38$  seconds<sup>(13)</sup>; and higher than those observed among children,  $3.9 \pm 3.7$  seconds<sup>(21)</sup>. On the other hand, the time presented in the equipment's manual ranges from 30 to 35 seconds, which is more than the time intervals obtained in this study<sup>(6)</sup>. This fact can be justified by the variation in the number of individuals and age groups, which explains the conduction of studies involving a large number of cases at different age groups for both genders.

With regard to the comparison of the values obtained between the different tasks investigating the pressure of the tongue, the results were not different between the tasks of elevation and protrusion among male participants. This fact can be justified, because, in these tasks, the participants had to press the bulb as much as possible; from the three measurements taken, the highest value was considered<sup>(13,14,20-29)</sup>. Therefore, even though the values in the elevation task did not differ between the genders, the factor more muscle mass in the tongue, besides height and weight<sup>(11,12)</sup>, among male participants may have contributed for the similar values found in these tasks. On the other hand, during swallowing, as the participants did this naturally and as it does not require the use of maximum activity, it was expected to find lower values at this task.

Even though the IOPI system has been idealized to assess the strength and the resistance of the tongue in speech motor disorders and, later on, to assess the swallowing disorders<sup>(4)</sup>, this equipment can also be used to relate the values of specific tasks with specific functions, such as breathing, chewing, swallowing, and speaking<sup>(30)</sup>.

A detailed analysis showed that, in the swallowing task, the values were close to 50% of the pressure used in the elevation and protrusion tasks in men and about 60% for that in women. Therefore, this can be a way to quantify the results obtained with the several therapeutic procedures used in clinical practice.

These data will help the speech language pathology therapy, as it can prove the evolution or the non-evolution of the cases, guiding the process of myofunctional rehabilitation. Besides, they can contribute with the diagnosis of orofacial myofunctional disorders, characterizing the muscle condition.

It is suggested that more studies involving a larger sample should be conducted to investigate or confirm the influence of tongue pressure on the different structural and functional conditions according to gender, age, and occlusal condition. The clinical applicability in groups with specific changes, such as hypotonia and lingual frenulum, among others, will allow the understanding of functional adjustments.

Some limitations were observed in this study such as the difficulty to confront the results with more studies owing to methodological differences, as reported by some authors<sup>(3,4,11,15,30)</sup>.

## CONCLUSION

Tongue pressure values among Brazilian young adults were obtained for the maximum isometric contraction tasks of elevation, protrusion, and lateralization and for the tasks of swallowing and the tongue resistance test.

The values obtained in the tasks of elevation and protrusion were higher than those found in lateralization and swallowing tasks for both genders; however, the protrusion task presented lower values when compared with the elevation task values among female participants. Gender also influenced the values in the tasks of protrusion and tongue lateralization, as male participants presented higher values.

*\*TT and LDG were responsible for data collection; MRSB, RRR were involved in data collection, analysis, and interpretation; ELP, LVVT, GB, CMF were responsible for data analysis and interpretation, as well as writing of the article; KFG was involved in the idealization of the study, data analysis, interpretation, and writing of the article.*

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