REVISTA DA FACULDADE DE ODONTOLOGIA DE PORTO ALEGRE
V. 65 (jan./dez. 2024) – REVISÃO DE LITERATURA
DOI: 10.22456/2177-0018.135599

# TONGUE STRENGTH IN NASAL-BREATHING VERSUS MOUTH-BREATHING CHILDREN: A SYSTEMATIC REVIEW

## Força da língua em crianças respiradoras nasais e orais: uma revisão sistemática

Liandra Fritzen[a]
Larissa Dill Fuchs[b]
Rafaela Soares Rech[a]
Monalise da Costa Batista Berbert[a]
Márcia Angelica Peter Maahs[a]

[a] Speech therapy School, Federal University of Health Sciences of Porto Alegre, Porto Alegre, RS, Brazil.
[b] Dental School, Federal University of Rio Grande do Sul, Porto Alegre, RS, Brazil.
**Autor correspondente:** Marcia Angelica Peter Maahs E-mail: marciama@ufcspa.edu.br
**Data de envio:** 17/09/2023 **Data de aceite:** 28/11/2023

## ABSTRACT

**Aim**: To compare the findings in the literature regarding the tongue pressure/force measurements in children with mouth-and-nasal-breathing or nasal-breathing. **Literature review**: This is a systematic review based on the research question "What are the differences in tongue strength between nasal-breathing and mouth-breathing individuals?". Electronic searches were carried out in the following databases: MEDLINE, EMBASE, SciELO, Cochrane Library, Web of Science, Scopus and LILACS. In addition, manual searches were made in the references of included articles. The review was registration under the number CRD42020212366. Studies involving children (3-12 years) with a nosological diagnosis, and a quantitative description of tongue pressure/strength, were included. Studies including samples with a history of speech therapy were excluded. The recommendations from PRISMA and Cochrane were followed for observational studies. **Results**: Of the 366 identified articles, four studies were included in the review. The tongue pressure/force values for nasal-breathers group were 51.4kPa, 53.73kPa, and 7.3N, whereas mouth-breathers were measured at 5.6N, 6.0N, 34.3kPa, 32.4kPa, and 38.27kPa. **Discussion:** This systemic review shows that there is a difference between the tongue strength of MBs when compared to RBs and discusses the main causes. Furthermore, highlights the importance of quantitative measurement of tongue strength as a complementary exam to clinical perceptual assessment. **Conclusion**: Tongue strength was lower in mouth-breathing children than in nasal-breathing ones. However, the studies that comprised the sample of this review did not present sufficient data to summarize measurements.

**Keywords**: Child. Tongue. Pressure. Muscle strength.

## RESUMO

**Objetivo**: Comparar as medidas de pressão/força da língua entre crianças respiradoras orais/oronasais e nasais descritos na literatura. **Revisão de literatura**: Trata-se de uma revisão sistemática baseada na pergunta "Qual a diferença do valor de força da língua entre indivíduos com respiração nasal e respiração oral?". Foram realizadas buscas eletrônicas nas seguintes bases de dados: MEDLINE, EMBASE, SciELO, Cochrane Library, Web of Science, Scopus e LILACS. Além disso, foram feitas buscas manuais nas referências dos artigos incluídos. A revisão foi registrada sob o número CRD42020212366. Foram incluídos estudos com crianças (3-12 anos), com diagnóstico nosológico de respiração oral ou oronasal com descrição quantitativa de pressão/força de língua. Foram excluídos estudos com amostra após tratamento fonoaudiológico. As recomendações do PRISMA e Cochrane foram seguidas para estudos observacionais. **Resultados:** Dos 366 artigos identificados, quatro estudos foram incluídos na revisão. Os valores de pressão/força de língua do grupo dos respiradores nasais foram 51,4 kPa, 53,73 kPa e 7,3 N e dos respiradores orais de 5,6 N; 6,0 N; 34,3 kPa; 32,4 kPa e 38,27 kPa. **Discussão**: Esta revisão sistemática mostrou que há diferença entre a força da língua dos ROs quando comparados aos RNs e discute as principais causas. Além disso, destaca a importância da medida quantitativa da força da língua como exame complementar à avaliação clínica perceptiva. **Conclusão**: Observou-se que a força de língua é menor nos respiradores orais quando comparados aos nasais, entretanto, os estudos incluídos nessa revisão não foram suficientes para sumarização de medidas.

**Palavras-chave:** Criança. Língua. Pressão. Força muscular.

## INTRODUCTION

Breathing is a physiological process that is vital for human survival. Normally, air enters through the nose where it is purified, humidified, and heated before reaching the lungs. Nasal breathing (NB) is essential for the proper growth and development of the craniofacial complex and favors the adequate overall functioning of the stomatognathic system (SS)[1].

When NB is affected by anatomical or functional factors, subjects may compensate with mouth breathing (MB) or mouth-and-nasal breathing (MNB), during which the respiratory cycle begins not only in the nose but also the mouth[2]. In this study, the term mouth-breather also refers to mouth-and-nasal breathers.

The consequences of MB are widely described in the literature[2,3] since this breathing pattern can lead to structural and functional impairment, as well as reduced quality of life[4]. One of these changes relates to the tongue posture in the oral cavity. It is usually found in a low and forward position, with a more enlarged and flaccid aspect[5].

The clinical assessment of the muscle tone of the tongue is performed perceptually and depends on the evaluator's experience[5]. For example, it can be complemented by quantitative assessments that describe muscle performance through pressure (the ratio between applied force and contact area, in pascal units (kPa)[6]) or force (the vector quantity that is defined in newtons (N)[7] according to its module and direction in relation to the tongue[5]). The quantification of tongue performance verifies measured quantitative data, as well as comparisons with normative data and previous measures. In addition, it enriches diagnoses regarding functioning and biofeedback strategies for speech therapy, thus facilitating the patient's understanding of their real status[8,9].

This is the background to the research addressing the strength that the tongue is capable of producing, and the correlation between this data and possible MB etiologies, as well as sex and age variables[1,5]. Significant correlations have been found between increases in tongue pressure and older ages. Similarly, decreased maximum tongue pressure has been correlated with some of the causes of MB (pharyngeal tonsil hypertrophy and palatine tonsil hypertrophy). Mouth-breathers (MBs) also present lower tongue pressure than nasal-breathers (NBs)[1,5,10].

Quantitative assessments of tongue tension increase the probability of reaching an appropriate diagnosis, thus contributing to a better understanding of dysfunctions.

This can result in more efficient and individualized therapeutic planning[5]. Through measuring and comparing tongue pressure and pressure results[1], clinical practice and health research can become more precise, objective, and standardized.

The objective of this study was to compare the findings regarding tongue strength among children with MB or NB in indexed literature.

## LITERATURE REVIEW

### RESEARCH STRATEGIES

This is a systematic review based on the research question "What are the differences in tongue strength between nasal-breathing and mouth-breathing individuals?". We defined the PECO pillars, Population (children), Exposure (mouth breathing), Comparison model (nasal breathing), Outcome/outcome (quantitative analysis of tongue pressure/force), used in Evidence-Based Practice (EBP). Additionally, we followed the PRISMA recommendations[11-13] from the Cochrane Handbook. This research was registered in Prospero (The International Prospective Register of Systematic Reviews) under number: CRD42020212366.

A systematic review of the literature was carried out on April 21, 2022, and updated in September 2023, in the following eletronic databases: MEDLINE (accessed through PubMed), EMBASE, Scientific Electronic Library Online (SciELO), the Cochrane Central Register of Controlled Trials (Cochrane CENTRAL), Web of Science, Scopus and LILACS (*Literatura Latino-Americana e do Caribe em Ciências da Saúde*). A manual search was also performed on the Google Scholar platform and in gray literature. The search strategy was adapted to suit each database. No search filters for language or time were used; all results were included.

We used the following search terms and alternatives: 'Tongue (mesh, DeCS and entry terms)', 'Pressure (mesh, DeCS and entry terms), 'muscle strength (mesh, DeCS and entry terms)', and 'Weights and Measures' (mesh, DeCS and entry terms). The search strategies used for each database are presented in Table 1.

### SELECTION CRITERIA

Concerning inclusion criteria, we selected observational studies that made mention of the instrument used to collect the measurements of children aged 3 - 12 years old, male or female, of any race or ethnic origin, with nosological diagnoses of mouth or mouth-and-nasal breathing and descriptions of the quantitative measures of tongue pressure/force. Studies that measured tongue strength in children with a history of speech therapy were fully excluded since those results could be affected by bias and reflect close-to-normal values because of therapy.

The study selection and extraction were performed independently by two reviewers, LF and LD, according to the inclusion and exclusion criteria. EndNote reference manager software, version X7, was used. First, the reviewers (LF and LD) included or excluded articles based on the titles and abstracts. Next, a complete analysis of the texts selected in the first phase was carried out. Studies of uncertain relevance were reanalyzed by other independent reviewers (RSR, MBCB, MAPM) to determine eligibility. Any disagreements between LF and LD were resolved by RSR, who made the final decision to include or exclude the article from the research. For the studies that were included but were found to have "insufficient data", their authors were contacted by email for clarification to request missing data such as the standard deviation of means and means of maximum tongue pressure/force. If there was no reply, these data were flagged as “not informed” (NI).

To characterize the experimental group in our study design, we chose to use the term "mouth-breathers" to refer to individuals with atypical breathing types, including MB and MNB. This choice is justified because it was the most frequently used term in the publications, and none of the studies differentiated between diagnoses of MB and MNB. The expression buccal breather was not used since the word buccal refers to the cheek[14].

Table 1: Literature search strategy.

| **Extraction date** | **Electronic databases** | **Search strategy** |
|---|---|---|
| 04/21/2022 | PubMed | ((((((child[MeSH Terms]) OR (child)) OR (children))) AND ((Tongue[MeSH Terms]) OR (Tongue))) AND ((pressure[MeSH Terms]) OR (pressure)) AND (((Mouth Breathing[MeSH Terms]) OR (Mouth Breathing)) OR (Oral Breathing)) |
| 04/21/2022 | Scielo | (child OR children) AND (tongue) AND (pressure) AND (Mouth Breathing) OR (Oral Breathing) |
| 04/21/2022 | Lilacs | (child OR children) AND (tongue) AND (pressure) AND (Mouth Breathing) OR (Oral Breathing) |

| Extraction date | Electronic databases | Search strategy |
|---|---|---|
| 04/21/2022 | Embase | #1: 'child'/de OR child OR children<br>#2: 'tongue'/de OR tongue<br>#3:'pressure'/de OR pressure<br>#4: 'mouth breathing'/de OR 'mouth breathing' OR ‘oral breathing’<br>#5: #1 AND #2 AND #3 AND #4 |
| 04/21/2022 | Web of Science | (((((child) OR (children) ) AND ((Tongue) ) AND ((Pressure) ) AND ((Mouth Breathing) OR (oral breathing) )))) |
| 04/21/2022 | Scopus | ALL ( "child" OR "children" ) AND ( "tongue" ) AND ( "pressure" ) AND ( "mouth breathing" OR "oral breathing" ) |

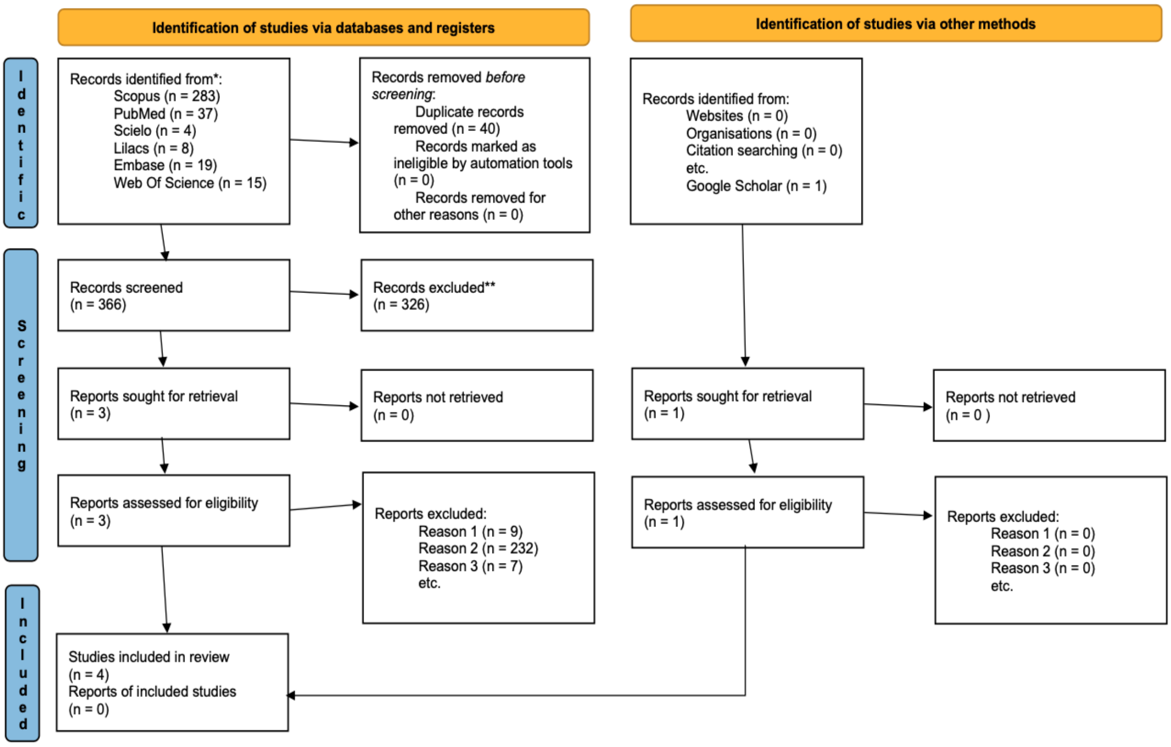
## DATA ANALYSIS

The two independent reviewers (LF and LD) extracted the following data from the selected articles, authors, year, study site, nosological diagnosis, sample characteristics, quantitative tongue pressure/force instrument, collection methodology, pressure/ force, and the mean of the sample maximum and tongue pressure/force, along with the standard deviation. The evaluators organized the collected data using Microsoft Excel (2010), in pre-established, standardized spreadsheets. A summary will be presented in a comparative table. The analysis of the methodological quality of the studies was performed by three independent reviewers (LF, LD, and MBCB) using the “JBI Critical Appraisal Checklist for Studies Reporting Prevalence Data”[15]. This systematic review did not receive any specific funding from commercial, non-profit, or public agencies. The authors declare no conflicts of interest.

## RESULTS

Initially, 366 studies were found. After removing 40 duplicate articles, 326 went through the first stage of the analysis, which consisted of checking the titles and abstracts. Three articles were left after excluding 323. One more article was included through the manual search on Google Scholar, bringing the total to four publications. These were fully analyzed for this review. Figure 1 shows the flowchart of the search and selection process according to the PRISMA[13] recommendations. The main reasons for excluding articles were: the study was a systematic review, there was no description of tongue strength, tongue strength was assessed in a different population.

Figure 1: Flowchart of the search and selection process according to the PRISMA.




Captions: Reason 1: the study was a systematic review; Reason 2: there was no description of tongue pressure/strength; Reason 3: tongue strength was assessed in a different population.

All the studies were carried out in Brazil, in the states of Pernambuco[5] and Minas Gerais[1,10,16], and were published in 2007[16], 2018[10] and 2019[1,5]. Of the four included studies, 3 (75%) used a control group[5,10,16]. Table 2 presents a summary of the articles that made up the sample.

The children's ages ranged from 3 and 12 years in the sample. Regarding gender, in the studies that described the number of members per sex[1,5,10], there was a higher prevalence of boys at 67%[1], 65%[10,] and 55%[5] in the respective groups. Regarding the type of evaluation, the subjects underwent, 100% of the studies issued nosological diagnoses for the MB group.

Table 2: Summary of the articles that made up the sample.

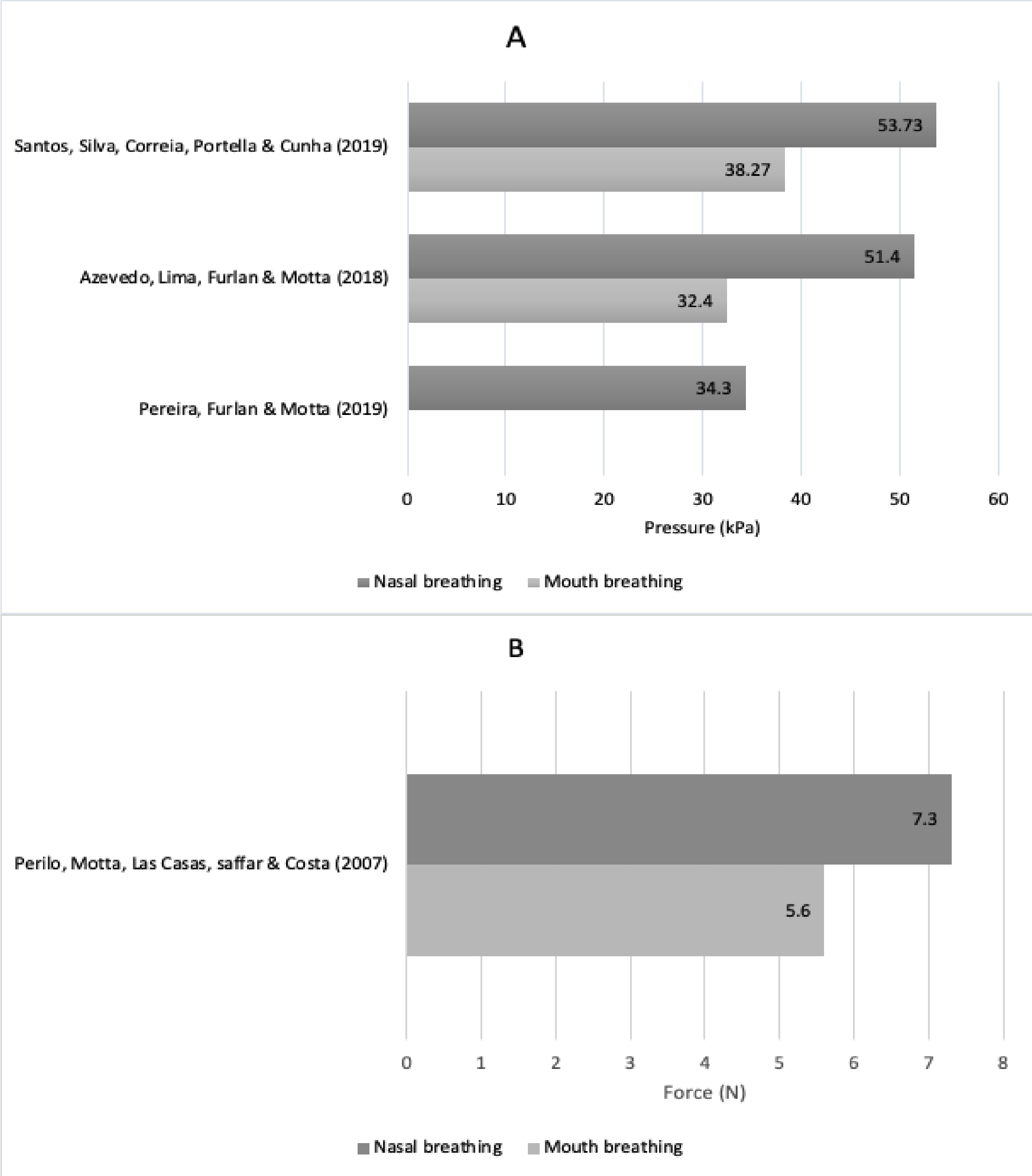
| **Variables** | **Pereira et al. (2019)[1]** | **Azevedo et al. (2018)[10]** | **Santos et al. (2019)[5]** | **Perilo et al. (2007)[16]** |
|---|---|---|---|---|
| Nosological diagnosis | yes | yes | yes | yes |
| Sample | 59 | 40 | 60 | 15 |
| Control group | no | yes | yes | yes |

| Variables | Pereira et al. (2019)[1] | Azevedo et al. (2018)[10] | Santos et al. (2019)[5] | Perilo et al. (2007)[16] |
|---|---|---|---|---|
| Age group | 3 a 12 | 5 a 12 | 4 a 9 | 8 a 12 |
| Instrument | IOPI | IOPI | IOPI | piston-cylinder assembly |
| Physical quantity | pressure (kPa) | pressure (kPa) | pressure (kPa) | force (N) |
| Intraoral sensors | bulb | bulb | bulb | plunger |
| Bulb/Plunger Position | incisive Papilla | posterior to the central incisors | palate vault | tip of the tongue |
| Repetitions | 3 | 3 | 3 | 4 |
| Seconds (s)* | 3 | 3 | 2 | 7 |
| Time between repeated measurements (s)** | 30 | 30 | 40 | 120 |
| Measurement used for average pressure/force*** | mean of the obtained pressure values (3x) | mean of the obtained pressure values (3x) | mean of the obtained pressure values (3x) | mean of the obtained force values (4x) |
| Measurement used for maximum pressure/force**** | highest value between measurements (3x) | highest value between measurements (3x) | highest value between measurements (3x) | highest value between measurements (4x) |
| Mean pressure/force MB | 34.3kPa ±14.9 | 32.4kPa ±6.0 | 38.27 kPa (SD NI) | 5.6 N ±3.46 |
| Mean pressure/force NB | - | 51.4kPa ±8.81 | 53.73 kPa (SD NI) | 7.3 N ±1.86 |
| Maximum pressure/force MB | 37.8 kPa ±15.3 | NI | NI | 8.18 N ±4.18 |
| Maximum pressure/force NB | - | NI | NI | 10.36 N ±2.55 |

Captions: *sustained pressure timed in seconds; ** time in seconds between repeated measurements; ***for each individual the highest measure of strength or the average of three attempts was recorded; IOPI: Iowa Oral Performance Instrument; kPa: kilopascal; N: newtons; mouth breathing (MB); nasal breathing (NB); SD: standard deviation; NI: not informed.

To assess the performance of orofacial structures, the authors used instruments to measure the physical magnitude of force (N) and pressure (kPa). Different methods were used to assess the direction of force or pressure and sensor placement. The results for the mean tongue pressure of a group of newborns were 51.4 kPa[10], 53.73 kPa[5], and for tongue force 7.3 N[16]. Not all the articles reported the standard deviation associated with the overall mean. The results for one group of MBs were 5.6 N[16], 34.3 kPa[10], 32.4 kPa[1] and 38.27 kPa[5]. Figure 2 presents a comparative graph of the means of tongue pressure/force.

Figure 2: Comparative graph of the means of tongue pressure and force




Captions: In “A”, tongue pressure results are presented in kilopascals (kPa). In “B”, tongue force results are presented in newtons (N).

Regarding the number of measurements performed, each subsequent measurement in the same individual increased the pressure exerted by the tongue, with subsequent means of 33.4 kPa ±15, 34.2 kPa ±15.6, and 35.1 kPa ±15.3, for ROs[1].

The main findings of the studies were: greater tongue strength in NBs than MBs[5,10,16]; increased tongue pressure with age[1,10]; increased tongue pressure with each consecutive measurement in the same individual[1]; a statistically significant association between decreases in maximum tongue pressure and pharyngeal and palatine tonsils[1].

Regarding the methodological quality of the four articles, a critical evaluation of cross-sectional design was performed[15] (Table 3). Studies with the following characteristics were considered to have insufficient methodological data: convenience sampling, no sample calculation, faulty statistical analyses (no correlation between the mean strength, standard deviation, and sample maximum per study group, and/or no correlation with sex, and/or no correlation with age) and no clear reporting of dropout rates.

Table 3: Analysis of the methodological quality of the studies[15].

| First author, year (reference) | CHECKLIST FOR STUDIES REPORTING PREVALENCE DATA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Pereira et al. (2019)[1] | Yes | No | No | Yes | Yes | Yes | Yes | No | Unclear |
| Azevedo et al. (2018)[10] | Yes | No | No | Yes | Yes | Yes | Yes | No | Unclear |
| Santos et al. (2019)[5] | Yes | No | No | Yes | Yes | Yes | Yes | No | Unclear |
| Perilo et al. (2007)[16] | Yes | No | No | Yes | Yes | Yes | Yes | No | Unclear |

Captions: 1. Was the sample frame appropriate to address the target population? 2. Were study participants sampled in an appropriate way? 3. Was the sample size adequate? 4. Were the study subjects and the setting described in detail? 5. Was the data analysis conducted with sufficient coverage of the identified sample? 6. Were valid methods used for the identification of the condition? 7. Was the condition measured in a standard, reliable way for all participants? 8. Was there appropriate statistical analysis? 9. Was the response rate adequate, and if not, was the low?

## DISCUSSION

The studies showed that there was a difference between the tongue strength of MBs and that of NBs. For the former group, the pressure is lower, suggesting some impairment of the tongue muscles[5,10,16]. This reduction in tongue strength may be associated with the breathing mode since MB exerts an influence on the SS that has been widely described in the literature, including a low position of the tongue along the floor of the mouth, thrusting between the dental arches and hypotonia of the tongue muscles[17-19].

Tongue pressure is also related to other factors, such as increased age[1,10]. Vanderwegen et al.[20] reported a marked increase in pressure for children between 6 and 7 years old. Potter & Short[21] suggested that the peak of tongue strength lasts until young adulthood, and measured the average tongue strength for a 16-year-old at 61.1 kPa.

In the correlation with sex, there was a higher prevalence of males in the MB group, with no statistically significant association between sex and tongue pressure[1,5,10]. Similar findings were described by Vanderwegen et al.[20] in their research with a sample of healthy children. They found no evidence of sex influencing the maximum tongue pressure and reported an average anterior tongue pressure (without visual feedback) of 43.55 kPa for boys and 38.8 kPa for girls.

In their analysis, Potter & Short[21] also found no statistically significant differences between the sexes and reported that tongue strength is slightly higher in girls at 10 years old and boys at 14. Another study measured tongue force in adolescents and adults with normal and reduced tongue strength. The authors described higher results in males than in females, 15.9 N±5.6 and 11.9 N ±3.2[7] respectively. Although we also describe the comparative values of the sexes, we could only analyze the absolute value and not corresponding values. This is because they are presented as physical magnitude and population age, different from the studies we reviewed.

The suggested values for normal tongue pressure[22] are 63 kPa for young adults aged 20 to 39 years, 63 kPa for adults aged 40 to 60, and 53 kPa for adults over 60. The normative values for children have not been established[21]. It is important to determine the values for this age group and there should be further clinical research addressing this population to produce normative values for children based on scientific evidence.

As for the instruments used for the quantitative assessment of tongue pressure/force, three[1,5,10] of the four studies chose to use the Iowa Oral Performance Instrument (IOPI), which is considered one of the most commercially available instruments for such measurements in children and adults worldwide. It allows professionals to compare and publish research with an international scope[20]. However, data should be presented as the magnitude of a force, in newtons (N). This would standardize measurements since pressure is dependent on the area where force is applied.

The fact that the physical quantities analyzed in the included articles are different makes it impossible to compare measurements and perform a meta-analysis. For this reason, the work by Perilo et al. (2007) was analyzed in absolute values because the device was used differently to present results in newtons (N)[16]. This type of presentation represents the ideal for greater comparisons, even between studies. It would also be interesting to set parameters for the position of sensors and the use of devices that measure force (N).

Concerning the position of intraoral sensors to measure tongue pressure, more specifically the IOPI bulb, a statistically significant difference was found between the anterior and posterior tongue pressure (with and without visual feedback). Posterior pressure was greater than anterior pressure, 55 kPa and 51 kPa respectively[20]. This fact may explain the higher pressure values Santos et al.[10] reported since they measured the pressure of the dorsal region of the tongue at 38.27 kPa for MBs. Other researchers measured at the tip of the tongue and described values of 32.4 kPa[10] and 34.3 kPa[1]. In adults, usually, the result is the opposite: the tip of the tongue exerts greater pressure[20,23]. This can be explained by the fact that fast fibers (stronger and less resistant) are more abundant at the tip of the tongue, while slow fibers (weaker and more resistant)[24] concentrate further back. Since seconds-long tests were not enough to cause tongue fatigue, the performance of the tip muscles stood out[23]. However, in children, this does not always occur. This difference may be due to the size of a child's palate (smaller than in adults) in relation to the bulb sensor, as well as the less agile movements of their tongue tip than those of older individuals[20].

Regarding the measuring times using the IOPI, there was no statistically significant difference between intervals of 60 seconds and 30 seconds. This can accelerate the pace of the clinical evaluation[20]. Furthermore, in the same individual[1,7], a training effect was observed in the axial force of the tongue between the first and third measures.

Quantitative tongue pressure/force assessment instruments, such as the IOPI, should ideally complement clinical perceptual assessments. This is because the latter will depend on the experience of each professional and subjective criteria, making it impossible to compare or properly measure results. The importance of objective data is the basis they provide for health professionals and researchers to compare values and establish normative data. Therefore, for oral structures, it would be of similar benefit for quantitative measures to complement clinical perceptual assessments. These objective measures show the muscle performance of oral structures and may be an important strategy for speech and orofacial myofunctional therapy. They can contribute to clinical assessments, therapeutic feedback, and scientific evidence about the effectiveness of therapy produced in the academic field. Recording quantitative data about the strength of oral structures could help to answer, for example, how the time of exposure to mouth breathing could interfere with lip, tongue, and cheek performance. Would there be a correlation between the strength values of the lips, tongue, cheek, and nasal airflow or resistance?

The implementation of the objective measurement of tongue pressure is significant, as it enables the development of further studies, as demonstrated in the recent systematic review conducted by Fonseca et al.[25]. This review aimed to evaluate the effectiveness of myotherapy exercises in improving tongue muscle strength. Its conclusions reinforce the notion that speech therapy rehabilitation exercises effectively enhance both anterior and posterior tongue pressure in adults.

As shown in Table 3, the methodological quality of the study results was low. This was due to the absence of important data from the analysis with instruments. As such, it was not possible to carry out a meta-analysis to provide global estimates since data such as the standard deviation of the means would be necessary, as well as larger samples with sample size calculations and greater homogeneity in the analyses of results, collection instruments and quantities used in the description of the findings.

Our data similarly emphasize the relevance of using instruments that present results in physical magnitudes. This would facilitate the comparison of results among peers. Sensor placement is related to the aim of the assessment; however, it is a parameter that should be carefully considered by researchers to allow subsequent comparisons and evidence construction.

The main limitations of this systematic review were insufficient methodological data in the study sample, heterogeneity among studies regarding analyses and the description of results, and the small number of publications that addressed our research question.

## CONCLUSION

The mean tongue pressure/force in the NB group was higher than that of the MBs. Although the studies in this review have demonstrated the feasibility of their research, there still was not enough data to summarize measures. We are left with this encouragement to conduct further research into the subject, with methodological designs that aim to explore this gap with a higher quality of methodological standardization and more robust samples to increase the power of the evidence.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

## REFERENCES

1. Pereira TC, Furlan RM, Motta AR. Relationship between mouth breathing etiology and maximum tongue pressure. CoDAS. 2019 Aug;31(2).
2. Chambi-Rocha A, Cabrera-Domínguez ME, Domínguez-Reyes A. Breathing mode influence on craniofacial development and head posture. J Pediatr. 2018 Mar;94(2):123-30.
3. Lima AC, Cunha DA, Albuquerque RC, Costa RN, Silva HJ. Sensory changes in mouth breathers: systematic review based on the prisma method. Ver Paul de Pediatr. 2019 Jan;37(1):97-103.
4. Mattos FM. Orofacial myofunctional characteristics of oral and oronasal breathers. Revista CEFAC. 2018 Aug;20(4):459-67.
5. Santos EC, Silva HJ, Correia AR, Portella PR, Cunha DA. Quantitative evaluation of tongue pressure in children with oral breathing. Revista CEFAC. 2019 Mar;21(2).
6. Vilanova LC. Fluid mechanics. 3. ed. Santa Maria, Rio Grande do Sul: Colégio Técnico Industrial de Santa Maria, curso em Automação Industrial; 2011. Chapter 1, Fluid Statistics; p. 15-30.
7. Motta AR. Quantitative analysis of axial force of tongue [Dissertation]. São Paulo (SP); Universidade Federal de São Paulo; 2001.
8. Furlan RM, Valentim AF, Motta AR, Barroso MF, Costa CG, Las Casas EB. Quantitative methods for assessing tongue force. Revista CEFAC. 2012 Nov;14(6):1215-25.
9. Maia AV, Furlan RM, Moraes KO, Amaral MS, Medeiros AM, Motta AR. Tongue strength rehabilitation using biofeedback: a case report. CoDAS. 2019 Dec;31(5):e20180163.
10. Azevedo ND, Lima JC, Furlan RM, Motta AR. Tongue pressure measurement in children with mouth-breathing behaviour. J Oral Rehabil. 2018 Jun;45(8):612-7.

11. Santos CM, Pimenta CA, Nobre MR. The PICO strategy for the research question construction and evidence search. Rev Lat Am Enfermagem. 2007 Jun;15(3):508-11.

12. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al. (editors). Cochrane handbook for systematic reviews of interventions version 6.2. Cochrane. 2021.

13. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. PLoS Med. 2021 Mar;18(3):e1003583.

14. Motta AR, Duarte LIM, Migliorucci RR, TVC P. Scientific technical vocabulary in Orofacial Motricity. In: Rahal A, Motta AR, Fernandes AG, Cunha DA, Migliorucci RR, Felix GB, editors. Orofacial Motricity Manual. 1st ed. São José dos Campos: Puslo; 2014. p. 77-122.

15. Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. Int J Evid Based Healthc. Sept 2015;13(3):147-53.

16. Perilo TV, Motta AR, Casas EB, Saffar JM, Costa CG. Objective evaluation of axial forces produced by the tongue of oral breathing children. Rev Soc Bras Fonoaudiol. 2007 Sept;12(3):184-90.

17. Pereira TS, Oliveira FD, Cardoso MC. Association between harmful oral habits and the structures and functions of the stomatognathic system: perception of parents/guardians. CoDAS. 2017 Nov;29(3).

18. Milanesi JM, Berwig LC, Schuch LH, Ritzel RA, Silva AM, Corrêa EC. Nasal patency and otorhinolaryngologic-orofacial features in children. Braz J Otorhinolaryngol. 2019 Nov;85(1):83-91.

19. Costa MD, Valentim AF, Becker HM, Motta AR. Findings of multiprofessional evaluation of mouth breathing children. Revista CEFAC. 2015 Jun;17(3):864-78.

20. Vanderwegen J, Guns C, Van Nuffelen G, Elen R, De Bodt M. The Influence of age, sex, bulb position, visual feedback, and the order of testing on maximum anterior and posterior tongue strength and endurance in healthy belgian adults. Dysphagia. 2012 Sept;28(2):159-66.

21. Potter NL, Short R. Maximal tongue strength in typically developing children and adolescents. Dysphagia. 2009 Dec;24(4):391-7.

22. IOPI® User manual; iowa oral performance instrument. Model 2.3, 800-2301-02 LS3 2014.05. [cited 2023 Oct 5]. Available from: https://manualzz.com/doc/7303147/iopi%C2%AE-user-manual.

23. Nascimento KS. Functional performance of the tongue in dentofacial deformity [Thesis]. Ribeirão Preto (SP); Universidade de São Paulo; 2015.

24. Martinelli RL, Marchesan IQ. Is training of the lingual musculature necessary to treat orofacial functions? Revista CEFAC. 2018 Dec;20(6):689-91.

25. Fonseca N de F, Motta AR, Freitas FC de, Nonato MR, Francelino EM, Furlan RMMM. Efeitos do treinamento da língua: revisão sistemática com metanálise. CoDAS. 2023;35(5):e20210324.