

## Original Article

## Artigo Original

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# Respiratory mode, nasal patency and palatine dimensions

## *Modo respiratório, patência nasal e dimensões palatinas*

## ABSTRACT

**Purpose:** To investigate the influence of breathing mode and nasal patency in the dimensions of the hard palate by comparing mouth breathing (MB) and nasal breathing (NB) adults. **Methods:** Seventy-seven individuals, distributed into the MB group (n=38) and the NB group (n=39), of both genders and aged between 18 and 30 years old, took part in the study. The respiratory mode diagnosis was based on anamnesis, physical characteristics, and otorhinolaryngological examination. The volunteers were evaluated in terms of nasal patency, with a peak nasal inspiratory flow (PNIF) meter, and obstruction symptoms, by a Nasal Obstruction Symptom Evaluation (NOSE) scale, and had their transversal and vertical hard palate dimensions measured with a digital caliper in plaster models. **Results:** Comparing both groups, the MB group presented significantly higher values in the NOSE scale, lower values in the PNIF, lower values in the transversal distance of the palate in the intercanine region, and significantly higher values in the vertical distance in the regions of the first and second premolars and molars. There was a negative correlation between PNIF and NOSE, and a positive correlation between PNIF and transversal distance of the palate in the region of the first premolars. **Conclusion:** MB adults presented reduced nasal patency and a higher degree of nasal obstruction symptoms. The hard palate was morphologically narrower and deeper in adults with the MB mode compared to the NB mode. Moreover, it was concluded that the smaller the nasal patency, the greater the obstruction symptoms and the narrower the hard palate.

## RESUMO

**Objetivo:** Verificar a influência do modo respiratório e da patência nasal nas dimensões palatinas, comparando adultos respiradores orais (ROs) e respiradores nasais (RNs). **Métodos:** Participaram do estudo 77 indivíduos, distribuídos em grupo de ROs (n=38) e grupo de RNs (n=39), de ambos os gêneros e idade entre 18 e 30 anos. O diagnóstico do modo respiratório se baseou na anamnese, nas características físicas e no exame otorrinolaringológico. Os voluntários foram avaliados quanto à patência nasal com um medidor do pico de fluxo inspiratório nasal (PFIN) e à sintomatologia de obstrução (escala NOSE — *Nasal Obstruction Symptom Evaluation Scale*), e tiveram as dimensões vertical e transversal do palato duro medidas por meio de um paquímetro digital em modelos de gesso. **Resultados:** Na comparação entre os grupos, os ROs apresentaram valores significativamente maiores na escala NOSE, menores no PFIN, menores na distância transversal do palato na região intercanina e maiores na distância vertical na região dos primeiros e segundos pré-molares e dos molares. O PFIN apresentou correlação inversa com a escala NOSE e direta com a distância transversal do palato na região dos primeiros pré-molares. **Conclusão:** Os adultos ROs apresentaram redução na patência nasal e maior grau de sintomatologia de obstrução nasal. O palato duro se apresentou mais estreito e alto nos adultos com modo respiratório oral, quando comparados aos com modo nasal. Ainda, concluiu-se que quanto menor a patência nasal, maior a sintomatologia de obstrução e mais estreito o palato duro.

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**Conflict of interests:** nothing to declare.

## INTRODUCTION

Nasal breathing (NB), which is inherent to the human being and has the important role of preparing the air to reach the greater structures of the respiratory system, stimulates the adequate growth of the craniofacial complex, with a direct influence on the development of the jawbones, the posture of the jaw, the positioning of the tongue, and the maintenance of the rhinopharyngeal space<sup>(1-3)</sup>.

Any factor that promotes obstruction of the upper airways leads to the partial or complete substitution of NB for mouth breathing (MB), and the persistence of this is responsible for major muscle imbalances, with repercussions on morphofunctional craniofacial features and the stomatognathic system<sup>(3,4)</sup>.

The reduction in nasal patency, a phenomenon that persists during the growth period, is an important etiologic factor for maxillary atresia in the MB adult<sup>(5)</sup> and is a result of the fact that the adequate jaw growth is stimulated both by the passage of air through the nostrils and the proper positioning of the tongue on the hard palate<sup>(6)</sup>.

Alterations in the vertical and transversal dimensions of the hard palate in MB<sup>(7-10)</sup> adults induce other adaptations of form and function, such as malocclusion, high arched, narrow, and deep palate, lack of lip closure, tongue lowered on the mouth floor or with interdental placement, flaccid orofacial muscles, and atypical swallowing<sup>(11)</sup>. These alterations contribute to the increase in the resistance to nasal airflow and to the reduction in the peak nasal inspiratory flow (PNIF)<sup>(12,13)</sup>.

The PNIF meter is a viable, noninvasive, easy handling, and cost-effective alternative for the evaluation of nasal patency. It is an indirect measure of nasal obstruction, which considers that the increase in nasal resistance modifies the nasal airflow and, consequently, the PNIF<sup>(12,13)</sup>. Previous studies<sup>(14,15)</sup> evaluated and considered the measuring features of this instrument appropriate. It is a commonly used method for evaluating the effectiveness of drugs or treatments, as well as for home monitoring the variations in circadian rhythms or the environmental effects on nasal patency<sup>(12)</sup>.

Another possibility to assess the effect of reduced nasal patency is the Nasal Obstruction Symptom Evaluation (NOSE) scale, which measures how much the obstruction interferes in the life of participants with increased nasal resistance<sup>(16)</sup>.

There are few studies about nasal patency and palatine configuration with adult participants. It is believed that the investigation of these aspects in adults may provide more specific information for the understanding of the impact of this syndrome over time, which contributes to a global diagnostic approach and a more complete therapeutic intervention.

On the basis of the points explained earlier, the objective of this study was to investigate the influence of the respiratory mode and nasal patency on the dimensions of the hard palate in view to comparing MB and NB adults.

## METHODS

Methods involved an exploratory, cross-sectional, and controlled study, approved by the Ethics Committee

at Universidade Federal de Santa Maria (Process No. 04039912.7.0000.5346), with the informed consent signed by all participants. The participants in the study were adults of both genders, aged between 18 and 30 years old, with mouth breathing mode (MB group) and nasal breathing mode (NB group), normoponderal, with no evidence of lung or neuromuscular diseases and chest deformities, no history of smoking and/or exposure to a risk environment, and without previous maxillary expansion. Individuals who used topical or systemic corticosteroids, nasal vasoconstrictors, muscle relaxants, and/or barbiturates, who had flu for the previous 3 weeks or an allergic crisis on the evaluation day, or who had prior thoracic, abdominal and/or rhinosinus surgery were excluded from the study. The diagnosis of MB was based on anamnesis, signs and symptoms, physical characteristics associated to MB, and otorhinolaryngological examination<sup>(17)</sup>.

The individuals referred to or who voluntarily came forward for the research underwent an initial interview with collection of demographic and anthropometric data that was relevant to the research. Then, the anamnesis was done by a speech language pathologist based on the orofacial myofunctional evaluation protocol (MBGR)<sup>(18)</sup>.

The tests were carried out with the individuals in a sitting position, upright torso, relaxed arms, hands on the thighs, eyes open oriented by the Frankfurt plane, and feet flat on the floor.

The PNIF was evaluated by the main researcher using the In-Check Inspiratory Flow Meter (Clement Clarke International, the United Kingdom) with the method of residual volume (RV), that is, a full exhale followed by a nasal inhale as fast and strong as possible, with the mouth closed and the mask well-adapted to the face<sup>(12,19)</sup>. When they achieved RV, participants signaled with the right thumb so that, simultaneously, the examiner would adapt the mask to the face for a strong and fast nasal inhale, with the following verbal stimulus "Release the air, close your mouth and draw (the air) strongly.." (Figure 1). The test was repeated at least three times or until three technically satisfactory measures could be obtained, with less than 10% variation between them, with the highest value being the one registered<sup>(14,19,20)</sup>. The time interval between each measure was



**Figure 1.** Measure of the peak nasal inspiratory flow

30 seconds<sup>(20)</sup>. Before the test, the demonstration was given and a brief training was provided.

The nasal obstruction was assessed subjectively by the main researcher using the NOSE scale. The scale consists of five questions that address how nasal obstruction represented a problem in the past month:

1. Nasal congestion or feeling of suffocation;
2. Nasal blockage or obstruction;
3. Difficulty of breathing through the nose;
4. Difficulty during sleep, and
5. Incapacity to inhale sufficiently through the nose during exercise or exertion.

These questions can have scores from zero to four (0=not a problem, 1=very light problem, 2=moderate problem, 3=very bad problem, 4=severe problem). These values are added and multiplied by five. The obtained score can range from 0, meaning that there is no problem, to 100, showing the worst possible problems when it comes to the nasal obstruction<sup>(16)</sup>.

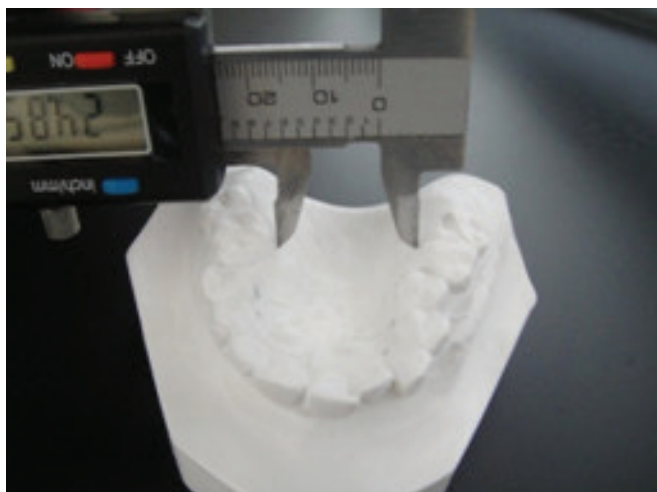
The measures of the hard palate were obtained from molding the jaw using alginate and the subsequent preparation of plaster models, both performed by a dentist. In these models, points of reference were marked using a mechanical pencil with 0.05 mm graphite, and the transversal (width) (Figure 2) and vertical (height) (Figure 3) distances between these points were calculated using a 150 mm digital caliper (Western®, DC-60 Model, the United States), with resolution of 0.01 mm and accuracy of  $\pm 0.03$  mm. In the regions of the canines and of the first and second premolars, the points were marked in the more apical gingival margin. For the first molars, the marking was made in the junction of the gingival margin with the palatine sulcus of these teeth, bilaterally<sup>(8)</sup>. For the vertical measurements, a stainless steel wire 1 mm thick and with the length corresponding to the transversal distance was fixed with hot wax between the previously marked points in each of the considered teeth. This wire served as a support for sliding the caliper rod and obtaining the vertical measure of the palate, which corresponded to the perpendicular distance between the median palatine line and

the steel wire, minus 1 mm (the value that corresponds to the thickness of the wire)<sup>(8)</sup>. Two dentists who collaborated in the research, previously trained, performed two measures each, starting with the canines and continuing with the first and second premolars and the first molars. Then, it was verified the intra- and interexaminer agreement.

Through the palatine height index (PHI = palatine height  $\times$  100/palatine width) in the region of the first molars, the height of the palate was assessed. The centesimal relationship between the palatine height and width helps in the classification of this structure in chamestaphyline (low palate) – values  $\leq 27.9$  mm, orthostaphyline (intermediate palate) – values between 28.0 and 39.9 mm, or hypsistaphyline (high palate) – values  $>40.0$  mm<sup>(21,22)</sup>. The palatine weight index (PWI) was not determined in this study because the plaster models do not allow the visualization of the staphyline anthropometric point, which is necessary to determine the length of the hard palate and the subsequent calculation of this index<sup>(22)</sup>.

The sample size calculation was estimated to achieve a significance level (alpha) of 5% ( $p < 0.05$ ) and power level (1-beta) of 80% (WinPepi software, version 1.5). For the calculation, the results of the vertical distance of the palate in the second premolar region was considered because this was the variable that presented greater variability in the pilot study with 10 participants in each group. Thus, the estimate was a sample of 36 subjects in each group.

The data were analyzed using descriptive statistics, the normality was verified through the Shapiro-Wilk test, and the groups were compared using the Student's t-test and Mann-Whitney test. The relationship ( $r$ ) between the variables assessed using Spearman's correlation test was as follows: weak correlation ( $0 < r < 0.3$ ), moderate correlation ( $0.3 < r < 0.7$ ), and



**Figure 2.** Measure of the palate's transversal distance



**Figure 3.** Measure of the palate's vertical distance

strong correlation ( $r \geq 0.7$ )<sup>(23)</sup>. The intraclass correlation coefficient (ICC) was used to verify the reliability of the palate measures. The ICC values were classified in poor reliability ( $ICC \leq 0.4$ ), moderate reliability ( $0.4 < ICC < 0.75$ ), and excellent reliability ( $ICC \geq 0.75$ )<sup>(24)</sup>.

The analyses were performed using the Statistical Package for the Social Sciences software (SPSS, version 17.0), and a significance level of 5% was assumed in all tests.

**RESULTS**

The sample consisted of 77 volunteers, 39 (28 women, 11 men) in the NB group and 38 (25 women, 13 men) in the MB group. According to the otorhinolaryngological examination, all the members of the MB group were classified as functional MBs of nonorganic cause, primarily allergic problems, and parafunctional habits.

The anthropometric and nasal permeability characteristics presented in Table 1 show that the nasal permeability (PNIF) was significantly lower (147.69 versus 121.45), whereas the perception of nasal obstruction (NOSE) was significantly higher (6.15 versus 47.11) in the MB group.

For the reliability of palate measures, inter- and intra-examiners presented an ICC with a level higher than 0.97 in all measures, assuming it excellent at  $>0.75$ <sup>(24)</sup>. Thus, the measures of the transversal and vertical distances of the palate in the MB and NB groups are a result of the arithmetic mean of intra- and interexaminers results.

There was a significant difference between the groups, with lower transversal distance in the intercanine region (Table 2) and higher vertical distance in the regions of the first and second premolars and the molars in the MB group (Table 3).

**Table 1.** Anthropometric and nasal permeability characteristics in the nasal breathing and mouth breathing groups

	NB Group (n=39)	MB Group (n=38)	p-value
	Mean±SD	Mean±SD	
Age (years)	22.56±2.89	22.71±3.50	0.99
Body mass (kg)	59.89±11.06	65.00±12.19	0.05
Height (m)	1.68±0.09	1.69±0.10	0.45
PNIF (L/min)	147.69±35.65	121.45±30.99	<0.01*
NOSE	6.15±13.15	47.11±19.85	<0.01*

\*Mann-Whitney test.

**Caption:** NB = nasal breather; MB = mouth breather; SD = standard deviation; PNIF = peak nasal inspiratory flow; NOSE = nasal obstruction symptom evaluation scale

**Table 2.** Measure of the transversal distances of the palate in nasal breathing and mouth breathing groups

Transversal distance	NB Group (n=39)	MB Group (n=38)	p-value
	Mean±SD	Mean±SD	
Intercanine (mm)	24.65±1.84	23.95±2	0.04*
First premolar (mm)	27.38±2	26.5±2.47	0.09
Second premolar (mm)	32.05±2.44	31.11±2.88	0.12
First molar (mm)	34.28±2.74	34.35±3.39	0.93

\*Mann-Whitney test.

**Caption:** mm = millimeters; NB = nasal breather; MB = mouth breather

**Table 3.** Measure of the vertical distances of the palate in nasal breathing and mouth breathing groups

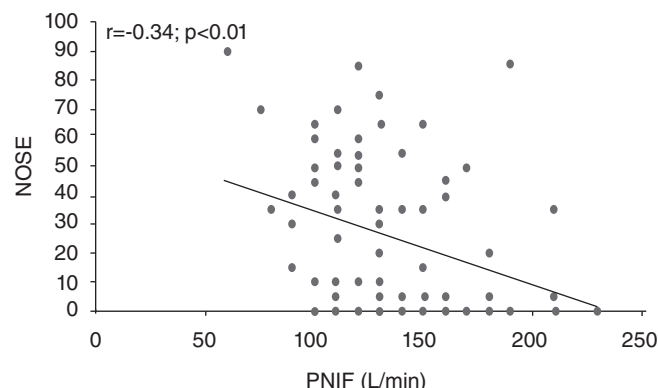
Vertical distance	NB Group (n=39)	MB Group (n=38)	p-value
	Mean±SD	Mean±SD	
Intercanine (mm)	5.76±1.80	6.13±1.92	0.20
First premolar (mm)	10.33±1.80	11.26±1.81	0.03*
Second premolar (mm)	13.51±1.90	14.86±2.15	0.03*
First molar (mm)	13.68±2.23	15.45±3.16	<0.01**

\*Student's t-test for independent samples; \*\*Mann-Whitney test.

**Caption:** mm = millimeters; NB = nasal breather; MB = mouth breather

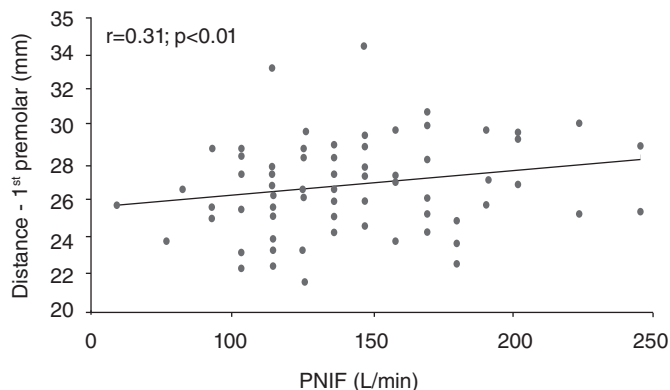
The PHI in the NB group was  $39.9 \pm 6.5$ , which corresponds to the intermediate palate classification. In the MB group, it was  $45.1 \pm 8.5$ , which corresponds to the high palate classification.

The correlations between NOSE scale versus PNIF ( $r = -0.34$ ) and PNIF versus transversal distance between the first premolars ( $r = 0.31$ ) was moderate to weak (Figures 4 and 5).



**Caption:** PNIF = peak nasal inspiratory flow; NOSE = nasal obstruction symptom evaluation scale

**Figure 4.** Correlation between the nasal obstruction symptom evaluation scale and the peak nasal inspiratory flow



**Caption:** PNIF = peak nasal inspiratory flow

**Figure 5.** Correlation between the transversal distances of the palate in the region of the first premolars and the peak nasal inspiratory flow

## DISCUSSION

In the objective assessment of the variation of nasal patency between the groups, it was observed that PNIF showed lower values in the MB group compared to the NB group. Similar results were found in a study of adults with and without nasal obstruction by rhinitis, in which the group with rhinitis had lower PNIF values (114.0 versus 154.3 L/min), with the same pattern being observed in the comparison between adults with and without nasal obstruction symptoms (123.6 l/min versus 151.4 L/min)<sup>(25)</sup>. These findings were expected as the MB mode is established when there is a reduction in nasal patency.

The subjective evaluation of nasal obstruction (NOSE scale) found a moderate impact on the quality of life in the MB group, with a higher score than the one found for the NB group (47.1 versus 6.2), showing the perception and the interference of obstructive symptoms, also during sleep and exercise. High scores were also observed in studies<sup>(26,27)</sup> of individuals with nasal obstruction by septal deviation (75 and 60.2), who had lower scores (10 and 11.3) after septoplasty.

In this study, a negative correlation between the NOSE scale scores and the PNIF values was observed, which showed that the more reduced the nasal patency, the worse is the perception of the obstruction symptoms. These same correlations between objective and subjective evaluation methods of nasal obstruction were also found in other studies<sup>(25,27)</sup>. Kahveci et al.<sup>(27)</sup> showed that the evaluation using the NOSE scale had good correlation with the findings of nasal obstruction obtained by computed tomography (CT) scan, without correlation with acoustic rhinometry. The assessment of nasal obstruction through a visual analog scale had a negative correlation with the PNIF measure<sup>(25)</sup>. These findings show that the objective and subjective evaluations add different information that is complementary and can be taken into account in clinical practice<sup>(28)</sup>.

The influence of the MB mode on the morphology of the hard palate of MBs, which was investigated in this study, revealed that the MBs had a palate with lower transversal distance (width) and higher vertical distance (height) compared to the NBs, except in the transversal measure for the molar region. Using the ratio of the means of vertical and transversal distances (PHI) in the region of the first molars, it was observed that the MBs presented a palate that could be classified as high. It was found that the morphological appearance of the adult palate was similar to that identified in MB children<sup>(7-10)</sup>, who also had lower values for the transversal measures and higher values for the vertical measures, compared to NB children. These findings were compared with results obtained in children, as studies with similar methodology, comparing the palatine dimensions linked to the breathing mode in adults, were not found.

In this study, a lower transversal measure was found in the canines region, a result similar to that found in MB children<sup>(29)</sup>, in which the dental and skeletal alterations, including the narrowing of the upper arch, were more frequent in the region of the canines. However, they were different from the findings of other studies<sup>(7-9)</sup>, in which this measure was lower in the molar region, suggesting that in MB children there is a

tendency of narrowing palate in the posterior region without interference in the anterior region.

The palate height in the adult MB group was higher in the region of the first and second premolars and the first molars. Similar results were observed in MB children, with greater height in the regions of the second premolars<sup>(7,8)</sup> and the second molars<sup>(9)</sup>.

The discovery of greater height in the posterior regions as a whole and of palate narrowing only in the region of the canines in adults that maintained the MB mode since childhood seems to indicate a trend that the impact of oral breathing becomes more evident in the vertical palatine dimension over the years. The findings of this study, supported by previous studies<sup>(7-10,29,30)</sup>, confirm that breathing through the mouth influences the hard palate morphology of mouth breathers.

According to the literature<sup>(5,6)</sup>, the palatine alterations evidenced in the MB group may be due to the loss of negative pressure in the nasal cavity, with consequent reduction in the stimulus for the lowering of the palate and of the positioning of the tongue in the floor of the mouth, preventing its expander stimulus on the jaw. In addition, the decrease in tension of orofacial muscles, often seen in the MB group<sup>(3,11)</sup>, causes the soft tissues to exert less force on the bone tissues that constitute the face, which could alter the growth and development of the craniofacial bone structure, including the jaw and the hard palate<sup>(8)</sup>. However, one cannot ignore the influence of genetic factors on the craniofacial growth and of the dolichofacial growth pattern, which can also determine morphological alterations in the palate, regardless of breathing mode<sup>(30)</sup>.

Considering that PNIF had a weak correlation with the width of the palate, only in the region of the first premolars, and that a relation to the vertical measures has not been found, the hypothesis that nasal patency affects the height of the hard palate requires more studies for confirmation.

The evaluation of the palatine measures and nasal patency in MBs could provide objective parameters to rate the intensity/severity of this respiratory mode. However, because of the absence of normative parameters for these variables, especially in adults, this classification is not yet possible. The assessment by the NOSE scale showed a difference between the NB and MB groups, with a moderate level of nasal obstruction symptoms in the MB group. Nevertheless, it is important to consider that the scale is a perceptual evaluation.

The difficulty to control variables, such as installation time, duration of oral breathing, and parafunctional habits, can be considered a limitation of this study.

It is believed that the magnitude of MB is associated with the impact on orofacial morphology. Therefore, this study owes its contribution for the clinical practice to the use of PNIF for evaluating and quantifying the nasal patency through an objective and of accessible use measure. In addition, it allows one to control the homeostasis and nasal congestion reflections, as well as the environmental effects on nasal patency.

Even today, the evaluation and the treatment of this condition are still addressed in a fragmented manner, limited to specific aspects of each professional involved. The importance of a comprehensive multidisciplinary approach to MB patients can be highlighted, from childhood to adulthood, which

includes, in addition to orthodontic aspects, those of ventilatory, postural, and orofacial motricity nature. Because it is a common condition, one recognizes the need for the awareness of parents, teachers, patients, and professionals about the systemic impacts of this breathing mode and the compromised quality of life of these patients.

## CONCLUSION

The adults with MB mode showed lower nasal patency, lower transversal distance (width), and higher vertical distance (height) of the hard palate when compared to NB adults.

*\*MET was responsible for the elaboration of the project, data collection and tabulation, analysis, interpretation, and preparation of the manuscript; JHB contributed with the data collection and tabulation; ABP contributed with the data collection and tabulation; LBA contributed with the data collection; AMTS contributed with guidance in the stages of implementation and review of the manuscript; ECRC was responsible for the overall orientation of the project and for the steps of implementation and preparation of the manuscript.*

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