

Association between respiratory and postural adaptations and self-perception of school-aged children with mouth breathing in relation to their quality of life

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ABSTRACT | Objective: To investigate the respiratory and postural adaptations associated with mouth and nasal breathing and to evaluate the associations of such adaptations in mouth breathers' self-perceived quality of life. **Method:** Cross-sectional study with mouth breathers (initial $n=116$ and final $n=48$) and nasal breathers (initial $n=131$ and final $n=24$) from elementary school, aged between 7 and 14 years. Chest expansion, using cirtometry, the breathing pattern and the use of accessory muscles, by means of clinical evaluations and photogrammetry, and flexibility tests were evaluated in both groups. Subsequently, the mouth breathers were asked to complete the quality of life questionnaire. Statistical tests: Chi-square, odds ratio, Mann-Whitney, and binomial tests were first applied followed by logistic regressions. **Results:** Thoracic breathing ($p=0.04$), using of accessory muscles ($p=0.03$) and reductions in flexibility ($p=0.001$) increased the chances of an individual being a mouth breather when compared to nasal breathers. Subsequently, using of accessory muscles decreased the chances of snoring among mouth breathers ($p=0.03$); the presence of shoulder asymmetry reduced the chances of experiencing quiet sleep ($p=0.05$) and increased the chances of coughing or being tired when playing or running ($p=0.008$). Finally, forward head position reduced the chances of waking up at night ($p=0.04$) and experiencing shortness of breath ($p=0.05$). **Conclusions:** Respiratory and postural adaptations increased the chances of individuals persisting with mouth breathing. Additionally, these adaptations could be associated with mouth breathers' self-perceived quality of life.

Keywords: preschool; mouth breathing; postural adaptations; self-perceived; quality of life; physical therapy.

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• Introduction

During mouth breathing (MB), accessory muscle overuse leads to a predominance of chest wall motion during inspiration^{1,2}, and forward head posture (FHP) is the most commonly adopted postural compensation among MB individuals³. Okuro et al.⁴ identified a correlation between FHP and the functional respiratory demand in MB individuals to facilitate air intake. One of the possible causes of FHP appears to be related to the overuse of accessory inspiratory muscles⁵. Persistent FHP can affect the entire body's posture due to the synergistic action of the head and neck muscles^{6,7}. Some studies have reported that head, neck and shoulder girdle muscle overuse can trigger secondary muscle weakness and promote shoulder asymmetry, which are signs of changes in the curvatures of the vertebral column^{6,8}. Furthermore, such weakness could be due to changes in the myofascial meridians, which, together, are responsible for maintaining stability and

discriminating how myofascial tension is distributed throughout the body during movement⁹. Thus, changes in posture, imbalance and muscle shortening influence the flexibility of certain muscle groups¹⁰.

Depending on its duration, MB can cause functional, structural, pathological, postural, occlusive and behavioral changes. Most studies on MB have focused on clinical aspects^{1,4,6,8}. Only in recent decades have behavioral aspects, such as hyperactivity, nonrestorative sleep, nocturnal enuresis, irritability, headache, and difficulties in concentrating and learning, been investigated as factors that impact the quality of life of MB individuals¹¹⁻¹⁴. Most studies evaluate these behavioral changes by means of various questionnaires^{13,14}, including those related to quality of life^{15,16}. Popoaski et al.¹⁶ developed a quality of life questionnaire exclusively for MB individuals and demonstrated that MB had a negative impact on the

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quality of life, especially with respect to behavioral aspects and respiratory disorders.

However, few studies have associated clinical evaluations and the quality of life of MB students, especially regarding their self-perception. Thus, the present study aimed to evaluate possible respiratory and postural adaptations of predominantly MB students compared to their predominantly nasal breathing (NB) peers and to subsequently associate the results obtained for the MB group with aspects regarding their self-perceived quality of life. The study was divided into two stages. The first stage assessed the prevalence and chances of respiratory and postural adaptations in MB students compared to their NB peers. The second stage evaluated the chances of respiratory and postural adaptations being risk or protective factors for the self-perceived quality of life of MB students, specifically regarding sleep, school performance, atopy and nasal problems.

● Method

This study was a clinical cross-sectional study approved by the Ethics Committee of the *Universidade Federal do Espírito Santo* (UFES), Vitória, ES, Brazil (Protocol nr. 162/2009) that was authorized by the Municipality Government of Vitória, Municipal Secretariat of Education, Vitória, ES, Brazil (Protocol nr. 281/2010). Ten elementary schools were randomly selected, and the inclusion criteria were as follows: students aged 7 to 14 years, previously screened and classified as mouth breathers by physicians and dentists ($n=116$), providing they also exhibited four or more of the ten craniofacial changes (described in the flowchart - Figure 1), including persistent MB, or classified as nose breathers ($n=131$) if they exhibited less than four or none of the above changes. Exclusion criteria were as follows: students whose parents did not sign the informed consent form prior to or during the study and students older than 12 years who did not sign the informed consent form at the beginning of the study; and students with craniofacial malformations, musculoskeletal, respiratory or neurological disorders. In the course of the study, the initial sample size was reduced in both groups, the causes of which are specified in the flowchart (Figure 1). The final sample size was of 24 males and 24 females ($n=48$) in the MB group and 11 males and 13 females ($n=24$) in the NB group.

To avoid a bias in the assessments and in the application of the questionnaire, the examiners were

trained by the most experienced examiner of the team of physical therapists, who was considered the gold-standard examiner. The obtained Cohen's kappa was above 0.9, which may be considered as an optimal agreement among the examiners of the present study¹⁷.

In the first stage of the study, the instrument used for respiratory and postural data collection was adapted from the study of Godoy et al.¹⁸. Each one of these tests was performed by physical therapists, who performed them in a blinded fashion. At each school selected, the students were randomly taken out of their classrooms by their supervisors and they underwent the same respiratory and postural evaluations in locations provided by the school. For the respiratory tests consisted of upper and lower chest expansibility, classification of the breathing pattern and identification of the use of accessory muscles. Chest expansibility was evaluated by dynamic cirtometry, using a SECA® anthropometric tape measure. The variation of maximal inspiration and expiration was measured as the circumference at the axillary and xiphoid regions. Variations between 3.0 and 7.5 cm were considered as normal¹⁹. The breathing pattern

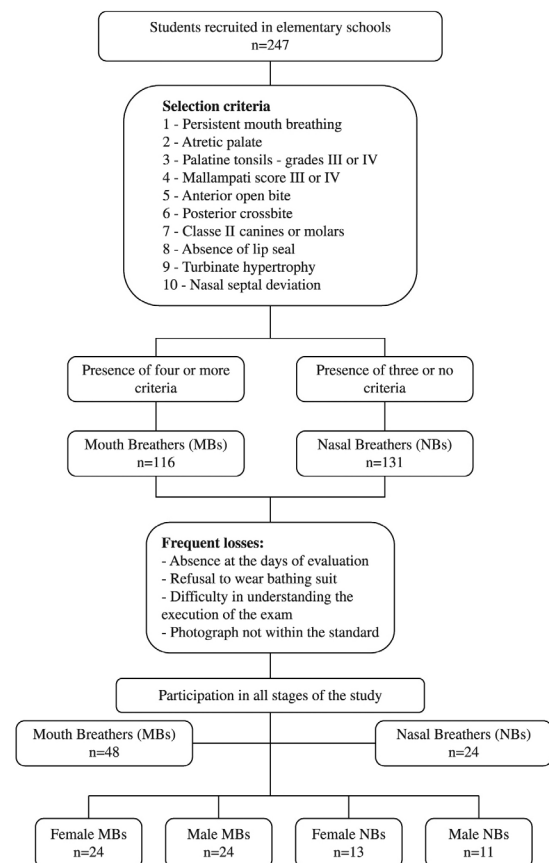


Figure 1. Flowchart of sample screening and final group composition.

and the use of accessory muscles were subjectively evaluated by visual and manual examination of the thorax. Subsequently, students were referred to a private room, in which body weight and height were assessed on a digital scale (GLASS200-G-TECH[®]) and by means of an anthropometric tape measure (SECA[®]), respectively, to calculate the body mass index (BMI). Flexibility was assessed by means of the fingertip-to-floor (FTF) test, during which the participant was asked to bend forward in an attempt to reach the floor with the middle finger while keeping the knees straight^{18,20}. For postural evaluation, a digital camera (Sony CyberShot 7.2 megapixels) was placed at a distance of 3.10 m from the wall on a 1.2-m-high tripod^{21,22}. Students, were photographed in an orthostatic position, while standing barefoot near a 1-m-long plumb line to their left side, on a carpet labeled with the position for their feet, which were parallel to each other. Prior to photography, anatomical landmarks were identified by the examiners using colored markers affixed with double-faced adhesive tape to the right and left acromia, the anterior superior iliac spines (ASIS) and posterior superior iliac spines (PSIS), the right and left tragus, and the 7th cervical vertebra (C7) (Figure 2). Photographs were analyzed by physical therapists using the postural analysis software (SAPO[®], version 0.67)²³, in the following order: the photograph was opened, zoomed to 40%, the photograph image was calibrated from the plumb line and the marked anatomical landmarks to the right and left acromia, the ASIS, the PSIS and right and left tragus, and the C7^{6,24}. In the frontal view, the lines plotted between the acromia (acromion-acromion) and between the ASISs (ASIS-ASIS) were analyzed to determine deviations of shoulders and pelvis, respectively. In the side view, the angle formed between spinous process of C7 with respect to the horizontal line to the chin and another until the tragus (C7-HOR-TRAGUS) and the line plotted between ASIS and PSIS (ASIS-PSIS) were analyzed to determine cervical lordosis/retification and deviations of pelvis, respectively (Figure 2). In the second stage of the study, still at school, only the MB group was studied. The instrument used was adapted from the quality of life questionnaire used in the study of Popoaski et al.¹⁶. Among the seven areas described in the study (nasal problem, sleep, eating problems, dentistry, school performance, communication and atopy), questions regarding nasal and sleep problems, atopy and school performance were applied by the physical therapists to each MB student, individually. This choice was based on the negative impacts these



Figure 2. Photogrammetry. A) Front view: angles between the acromia and between the anterior superior iliac spines. B) Side view: angle between C7 with respect to a horizontal line and the tragus and the angle between the anterior superior iliac spine and the posterior superior iliac spine.

aspects had on behavior and on the breathing disorders in the individuals evaluated in their study¹⁶. The answers given by the MB students regarding the self-perceived quality of life questionnaire that corresponded to a scale ranging from “sometimes” to “always” were grouped and considered as YES, whereas answers within the range of “never” to “almost never” were grouped and considered as NO.

Statistical analysis

In the first stage of the study, Pearson’s chi-squared test and the odds ratio (OR) were calculated to evaluate the association between MB and NB groups. The Mann-Whitney *U* test was used to assess the difference between quantitative independent variables of MB and NB students. The binomial and Mann-Whitney *U* tests were used to select the variables that would be used in the logistic regression model. Specifically, the binomial test selected the variables with prevalence values equal to 0.43 or above, regardless of their statistical significance. The Mann-Whitney *U* test

selected the variables by comparing the median of each continuous variable *versus* the general median of MB and NB individuals. After selecting these variables, logistic regressions were performed to verify whether the variables selected by the binomial test (i.e. sex, breathing pattern, use of accessory muscles, cirtometry, acromion-acromion, ASIS-ASIS, C7-HOR-TRAGUS, ASIS-PSIS measurements) and by the Mann-Whitney *U* test (i.e. age, height and FTF distance measurements) were risk or protective factors when related to the selected questions of the adapted instrument of the quality of life questionnaire in the MB group. The best regression model was chosen by means of the backward method of the Wald test, which removes the variables that do not influence the model. The level of significance was set at 5% and the confidence interval at 95%. Analyses were performed using the Statistical Package for Social Sciences Software (*SPSS19*, IBM Company, Armonk, New York, USA).

● Results

The results from the first stage revealed a statistically significant association between the MB and NB groups only with respect to respiratory variables regarding the breathing pattern and the use of accessory muscles (Table 1). Thoracic breathing increased the chances of the student being a mouth breather 3.8-fold compared to students without this pattern (NB) ($p=0.041$). The use of altered accessory muscles increased the chances of being classified as a MB 4.2-fold compared to NB ($p=0.031$). Table 2 shows that the medians of MB students significantly differed from those of their NB peers with respect to anthropometric variables (i.e. body weight and height), age and FTF distance measurements (flexibility) ($p<0.05$). However, the BMI exhibited no statistically significant difference between the groups ($p=0.27$).

In the second stage, some of the self-perceived aspects of the MB group, specifically regarding school

Table 1. Respiratory and postural variables of mouth breathers and nasal breathers, 7-14 years old, from the elementary schools of Vitória, ES, Brazil.

Variables	Categories	Breathers		p	OR	95% CI	
		Mouth	Nasal				
Gender	Female	24	13	0.80	0.84	0.31	2.26
	Male	24	11		-	-	-
Breathing pattern	Diaphragmatic	31	21	0.04*	-	-	-
	Thoracic	17	3		3.83	0.99	14.75
Accessory muscles	No	30	21	0.03*	-	-	-
	Yes	18	3		4.20	1.09	16.09
Axillary perimetry	Normal	42	18	0.66	-	-	-
	Reduced	6	1		2.57	0.28	22.92
Xiphoid perimetry	Normal	41	18	0.42	-	-	-
	Reduced	7	1		3.07	0.35	26.84
Acromium to acromium distance	Normal	5	2	0.99	-	-	-
	Shoulder deviation	43	22		0.78	0.14	4.35
ASIS to ASIS distance	Normal	4	3	0.67	-	-	-
	Pelvic deviation	44	21		1.57	0.32	7.66
C7-HOR-TRAGUS distance	Normal/rectification	9	4	0.82	-	-	-
	Anteriorization	39	20		0.86	0.23	3.16
ASIS to PSIS distance	Normal	1	0	0.99	-	-	-
	Anteversión or retroversion	47	24		#	#	#

Pearson's chi-square test. (-) Reference Category. (#) Value not computed because one of the categories is zero. OR: odds ratio. (*) Statistically significant difference ($p<0.05$). Reference values: variation of the axillary and xiphoid perimetry = 3.5 cm to 7.0 cm (Magee¹⁹). Normal angle between acromia = 0 ° and shoulder deviation ≠ 0 °; normal angle between the anterior-superior iliac spines (ASIS-ASIS) = 0 ° and pelvic deviation ≠ 0 °; normal angle between the antero-superior iliac spine and posterior superior iliac spine (ASIS-PSIS) = 0 ° and anteversión or retroversion pelvic ≠ 0 ° (Iunes et al.²⁵); normal or cervical rectification: the angle between the seventh cervical vertebra, horizontal line and tragus (C7-HOR-TRAGUS) > 48.9 ° and head anteriorization: the angle between the seventh cervical vertebra, a horizontal line and the tragus (C7-HOR-TRAGUS) < 48.9 ° (Raine and Twomey²⁶). Source: Magee¹⁹; Iunes et al.²⁵; Raine and Twomey²⁶.

Table 2. Anthropometric variables and flexibility of mouth breathers and nasal breathers aged 7-14 years old, from the elementary schools of Vitória, ES, Brazil.

Variables	Elementary school	Minimum	Maximum	Median	SD	p
Age (years)	MB	6	13	9.0	1.7	0.03*
	NB	6	10	8.0	1.0	
Height (m)	MB	1.2	1.7	1.4	0.1	0.01*
	NB	1.2	1.4	1.3	0.1	
Weight (Kg)	MB	18.0	54.0	30.0	8.7	0.04*
	NB	20.0	39.0	25.5	5.2	
BMI	MB	12.0	27.4	16.3	3.4	0.21
	NB	13.0	22.5	15.0	2.5	
Flexibility) (Middle finger to floor (cm))	MB	0	33	11.5	8.3	0.001*
	NB	0	23	0.0	7.5	

Mann-Whitney test. (*) Statistically significant difference ($p < 0.05$). SD: standard deviation; BMI: body mass index; MB: mouth breathers; NB: nasal breathers.

performance, atopy, sleep and nose problems, exhibited 50% or higher prevalence rates, namely: “Do you usually have a stuffed nose?” (79.2%); “Do you usually have a runny nose?” (50.0%); “Do you usually wake up at night?” (60.4%); “Are you usually sleepy during the day?” (52.1%); “Is your sleep usually quiet?” (87.5%); “Do you usually wake up with a headache?” (58.3%); “Do you usually wake up with a dry mouth?” (77%); “Do you usually cough when you lie down?” (56.3%); “Do you usually cough or get tired when you play/run?” (79.2%); “Do you usually feel shortness of breath?” (62.5%); “Do you usually have good memory?” (87.5%); and “Do you keep up with your class mates in school?” (83.3%). Further, Table 3 shows whether respiratory and postural variables of the MB group were risk or protective factors when associated with variables regarding the above-described aspects of self-perceived quality of life. Specifically, the use of accessory muscles decreased the chances of snoring at night among MB students ($p=0.03$). Additionally, shoulder asymmetry reduced the chances of quiet sleep among MB students ($p=0.05$) and increased their chances of coughing or feeling tired while playing or running ($p=0.008$). However, FHP reduced the chances of waking up at night ($p=0.04$) and having shortness of breath ($p=0.05$) among MB children. Sex was also considered a risk factor when related to the self-perception of MB students, as being female increased the chances of waking up at night ($p=0.02$) and experiencing shortness of breath ($p=0.03$).

● Discussion

The results of the first stage of this study showed that individuals classified as mouth breathers exhibited significantly increased chances of thoracic breathing and the use of accessory muscles related to the persistence of MB compared to NB individuals. Previous studies suggested the presence of increased nasal resistance in MB, which could lead to increased respiratory effort^{1,5}. This causes the accessory inspiratory muscles to be needed, thus leading to a predominantly upper thoracic inspiratory motion^{1,5,24}. According to Conti et al.²⁴, there was a 42.21% prevalence of thoracic breathing in MB individuals, whereas nasal breathers exhibited a 44.35% prevalence of abdominal breathing. Additionally, Yi et al.⁶ have shown that MB individuals exhibited lower diaphragmatic excursion, which further required the use of the accessory muscles. Other anatomical or functional changes resulting from MB are associated with FHP and head extension^{7,27}. Electromyogram studies of the cervical muscles, such as those of Ribeiro et al.⁵, have shown that the upper fibers of the sternocleidomastoid and upper trapezius muscles exhibit higher activity to obtain head posture control in MB individuals compared to nasal breathers during both resting and active situations. However, the postural imbalance of mouth breathers that begins in the head could be responsible for the more general involvement of the body posture due to the disorganization of the myofascial structures of the cervical and thoracic regions^{6,7,9}. Krakauer and Guilherme²⁸ have shown that these postural changes become predominant

Table 3. Relationships between respiratory and postural variables and questions of quality of life related to nasal problems, sleep, school performance and atopy in mouth breathers aged 7-14 years old, from the elementary school of Vitória, ES, Brazil.

		OR	CI 95%		p	R ²
1 – Do you usually have a stuffy nose?						
Accessory muscles	Yes	2.28	0.41	12.5	0.34	0.18
	No	1	-	-	-	
2- Does your nose tend to get runny?						
C7-HOR-TRAGUS Distance	Anteriorization	0.39	0.08	1.85	0.23	0.12
	Normal/Rectification	1	-	-	-	
3- Do you often snore at night?						
Accessory muscles	Yes	0.15	0.03	0.82	0.03*	0.18
	No	1	-	-	-	
4- Is your sleep usually calm?						
Acromium-acromium Distance	Shoulder deviation	0.11	0.01	0.98	0.048*	0.58
	Normal	1	-	-	-	
5- Do you often wake up at night?						
Gender	Female	5.24	1.37	20.1	0.01*	0.40
	Male	1	-	-	-	
C7-HOR- TRAGUS Distance	Anteriorization	0.08	0.01	0.85	0.04*	0.40
	Normal/Rectification	1	-	-	-	
6- Do you often complain of daytime sleepiness?						
Gender	Female	1.70	0.47	6.19	0.41	0.17
	Male	1	-	-	-	
Accessory muscles	Yes	1.68	0.44	6.38	0.44	0.17
	No	1	-	-	-	
ASIS-ASIS Distance	Pelvic deviation	0.28	0.02	3.13	0.30	0.17
	Normal	1	-	-	-	
7- Do you often wake up with a headache?						
Breathing pattern	Thoracic	0.44	0.11	1.62	0.21	0.26
	Diaphragmatic	1	-	-	-	
8- Do you often wake up with dry mouth?						
Distance from the middle finger to the floor	NA	0.93	0.85	1.01	0.11	0.18
9- Can you follow your classes at school?						
ASIS-ASIS Distance	Pelvic deviation	0.10	0.01	0.91	0.04*	0.14
	Normal	1	-	-	-	
10- Do you usually have a good memory?						
Gender	Female	7.70	0.80	73.42	0.07	0.31
	Male	1	-	-	-	
Acromium-acromium Distance	Shoulder deviation	0.11	0.01	1.03	0.054	0.31
	Normal	1	-	-	-	

Logistic Regression. (-) Reference Category. (*) Statistically significant difference ($p < 0.05$). CI: confidence interval. NA: Not applicable. R²: coefficient of determination. Reference values: Normal angle between acromia = 0 ° and shoulder deviation ≠ 0 °; normal angle between the anterior-superior iliac spines (ASIS-ASIS) = 0 ° and pelvic deviation ≠ 0 ° (Iunes et al.²⁵); normal or cervical rectification: the angle between the seventh cervical vertebra, a horizontal line and the tragus (C7-HOR-TRAGUS) > 48.9 °; head anteriorization: the angle between the seventh cervical vertebra, a horizontal line and the tragus (C7-HOR-TRAGUS) < 48.9 ° (Raine and Twomey²⁶). Source: Iunes et al.²⁵; Raine and Twomey²⁶.

Table 3. Continued...

		OR	CI 95%		p	R ²
11- Do you usually cough or feel tired when you play/run?						
Acromium-acromium Distance	Shoulder deviation	24.66	2.34	259.93	0.008*	0.27
	Normal	1	-	-	-	
12- Do you usually cough when you lie down?						
Accessory muscles	Yes	0.84	0.23	3.05	0.79	0.14
	No	1	-	-	-	
13- Do you often feel shortness of breath?						
Gender	Female	4.15	1.11	15.48	0.03*	0.22
	Male	1	-	-	-	
C7-HOR-TRAGUS Distance	Anteriorization	0.10	0.01	1.02	0.05*	
	Normal/Rectification	1	-	-	-	

Logistic Regression. (-) Reference Category. (*) Statistically significant difference ($p < 0.05$). CI: confidence interval. NA: Not applicable. R²: coefficient of determination. Reference values: Normal angle between acromia = 0 ° and shoulder deviation \neq 0 °; normal angle between the anterior-superior iliac spines (ASIS-ASIS) = 0 ° and pelvic deviation \neq 0 ° (Iunes et al.²⁵); normal or cervical rectification: the angle between the seventh cervical vertebra, a horizontal line and the tragus (C7-HOR-TRAGUS) > 48.9 °; head anteriorization: the angle between the seventh cervical vertebra, a horizontal line and the tragus (C7-HOR-TRAGUS) < 48.9 ° (Raine and Twomey²⁶). Source: Iunes et al.²⁵; Raine and Twomey²⁶.

in 8-year-old MB students when compared to their respective NB peers. The above authors showed that these postural imbalances were initially triggered as an adaptation to balance the action of gravity. On the other hand, Peolsson et al.⁷, have shown that FHP could favor other types of musculoskeletal adaptations such as increased extensor muscle activity²⁹, which, in turn, could increase gravitational load to some cervical and thoracic motion segments^{6,7,22,28,30}. In view of this information, overuse of the accessory muscles observed in MB students could cause an increase in muscle tension in the cervical segment promoting tensioning and fixings of myofascial lines⁹, which then leads to FHP. The persistence of the muscle tension along the other myofascial lines⁹ could reach other myofascial structures in the trunk and extremities, eventually triggering shoulder and pelvic asymmetry, which could, in turn, negatively affect flexibility among these individuals. The results of the present study showed that the flexibility of MB students was significantly reduced compared to their NB peers. Assuming that, in MB, the static muscles have evolved to hypertonicity and that this alteration leads to muscle shortening, this set of changes could entail loss of flexibility, especially of those muscles that do not reach the resting position during effort⁵.

The persistency of respiratory and postural adaptations in MB individuals can have a negative impact on the quality of life. In view of this observation, the second stage of this study showed the chances of these respiratory and postural adaptations in influencing the

quality of life of MB students, specifically regarding their self-perceived sleep, school performance, atopy and nasal problems. The use of accessory muscles increased the chances of MB individuals experiencing a stuffed nose. Interestingly, allergic rhinitis is one of the main causes of airway obstruction in students and adolescents³¹, suggesting that the chronic edema caused by the inflammatory process could cause a persistently stuffed nose, and due to the inflammation, the use of the accessory muscles might be a compensating adaptation that eases air intake. Given that the muscles are organized into myofascial chains³², constant physical effort of the accessory muscles might compromise other postural segments. Therefore, the other significant relationship shown in the present study was shoulder asymmetry. Specifically, this asymmetry was related to 25-fold higher chances of coughing or feeling tired during physical effort in MB students. The secondary involvement of neck and shoulder girdle muscles, influenced by accessory muscle overuse during inspiration, might be the most probable cause of shoulder asymmetry. This disorganization between cervical and thoracic posture is also known to impair pulmonary ventilation²⁷. Ribeiro and Soares³³, have shown a reduced pulmonary volume in MB individuals, in which spirometric values were below the predicted levels, with a predominance of airway obstruction. In view of these findings, the increased chances of MB individuals reporting coughing or being tired during physical activity are thought to be due to increased physical effort.

Even though the items regarding sleep were not significant in the present study, it is important to note that the use of accessory muscles in MB individuals increased the chances of daytime sleepiness, and there was a significant decrease of their self-perception of having a quiet sleep by 88.5% for each 1% increase in shoulder asymmetry, evaluated by the lines plotted between the acromia (acromion-acromion). Studies^{34,35} showed that there were intercostal and upper airway dilating, muscle hypotony during sleep and, during the slow-wave sleep phase, there was reduction or even abolition of the activation reflex of the genioglossus and tensor palatine muscles. Consequently, the caliber of the upper airways was reduced, and their resistance to airflow increased³⁴. These functional changes might promote sleep fragmentation, which is one of the causal factors of daytime sleepiness, and, thus, might recruit the accessory inspiratory muscles, as was observed in the present study.

Although studies have shown that MB is more prevalent among males^{27,31,36}, the results of the present study show that female MB students exhibited significant relationships with MB effects, including a 5.2-fold increase in the chances of waking up at night, a 4.1-fold greater chance of the feeling of having shortness of breath, and a tendency to daytime sleepiness, with respect to male students. It is worth mentioning that these results are in disagreement with the literature, since it is known that male individuals are more prone to MB due to the smaller size of their airways and the higher prevalence of allergic rhinitis³¹.

Furthermore, school failure might be related to MB and sleep disordered breathing during childhood^{13,14}. Allergic or infectious processes, along with processes of mechanic airway obstruction, are the major causes of the above respiratory problems. Allergic rhinitis is one of the main causes of MB¹² and can entail several compensatory postural adaptations. Recently, Hitos et al.³⁷ have shown that allergic processes, which are associated with postural complications, can lead to malformation of the eustachian tube, thus decisively interfering with the loss of speech sound perception and leading to difficulties in learning to read and write. These findings are in agreement with the relationships between risk or protective factors observed in the present study, which showed that MB students with shoulder asymmetry had reduced chances for exhibiting good memory. Similarly, the MB students with pelvic asymmetry had reduced chances of keeping up with classmates in school.

This study has some limitations. The reduced final sample size was a limiting factor for statistical power,

especially with respect to logistic regression. Some of the evaluations were more subjective because the study was exclusively performed in public schools. Although the literature suggests that the evaluation of a child's health-related quality of life must include information regarding both the patients' and their caregivers' perspective^{12,18}, the self-perceived quality of life questionnaire of this study was only administered to the MB group. Specifically, the original idea of including the parents and/or legal guardians as a parameter for comparison was hampered, in part due to the lack of the involvement and adherence of the parents and/or legal guardians, who gave inaccurate answers that did not correspond with those given by their children.

● Conclusion

In this study, respiratory and postural adaptations were associated with the self-perceived quality of life of MB students with respect to the variables of sleep, signs of atopy, respiratory changes and learning deficits.

The obtained results suggest that respiratory and postural adaptations, which were observed in MB individuals, increased the chances of persistent MB. From another point of view, this study suggests that the association of these adaptations with the self-perception of these individuals might be related to their quality of life.

These results demonstrate that greater attention must be given to the evaluation of the MB children's point of view about their quality of life, since, in most evaluations of quality of life, the impressions of third-party individuals (i.e., parents and legal guardians) did not represent the real impact on the quality of life of these individuals.

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