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Electromyographic analysis of trapezius and sternocleidomastoideus muscles during nasal and oral inspiration in nasal- and mouth-breathing children

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Abstract

The purpose of this study was to evaluate sternocleidomastoideus (SCM) and trapezius (superior fibers) muscle activity patterns in mouth-breathing children, and to compare them with nasal-breathing children. Forty-six children, of both sexes, ranging from 8 to 12 years old, were evaluated through electromyography . The selected children were divided into two groups; Group I, was made up of 26 mouth-breathing children and Group II of 20 nasal-breathing children. Electromyographic recordings were obtained through surface electrodes in the SCM and trapezius muscles, bilaterally, during oral and nasal inspiration. Root-mean-square (RMS) data expressed in microvolts (μV), were analyzed using the Kruskall–Wallis statistical test. From the results obtained, we concluded that there was a significant difference in the muscle activity between the groups, with higher activity during nasal inspiration in the mouth-breathing group. During oral inspiration, there was no significant difference between groups. Within the groups, only the mouth-breathing group showed higher activity during nasal inspiration.

Keywords: Mouth-breathing; Sternocleidomastoideus muscle; Trapezius muscle; Electromyography; Head posture

1. Introduction

The biomechanical relationship among the cranium–mandibular, cervical and hyoid areas and airways is considered an indivisible unit. Therefore, the breathing mode has repercussions for the whole corporal posture.

Sartor [1] has described a sequence of biological events that starts with nasal obstruction and leads to cranium–cervical and mandibular physiological postural adaptations for easier breathing. The natural head position determines factors related to gravity resistance, breathing, swallowing, sight axis, vestibular mechanism and hearing.

Sollow and Sierbaek-Nielsen [2] have observed a cranium–cervical angle increase in patients with a narrowing naso–pharyngea passage.

Patients with a stomatognatic system dysfunction present anterior head and neck positions with loss of physiological lordosis and occipital extension over the atlas bone, due to bilateral hyperactivity of sternocleidomastoideus (SCM) muscles [3].

It is probable that the level of cervical muscle activity will be abnormal in mouth-breathing children, because they have to change their head and neck position in order to reduce the narrowing of airways.

This study aims to analyze the pattern of activity of the SCM and trapezius muscles during nasal and oral inspiration in mouth-breathing children, and to compare the activity of these muscles with those in nasal-breathers.

2. Method

Forty-six children, of both sexes, ranging from 8 to 12 years old were evaluated by electromyography. The children were selected by anamnesis, parental interview, medical diagnosis and direct observation of labial posture and were divided in 2 groups; group I contained

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26 mouth-breathing children and group II had 20 nasal-breathing children. The parents were questioned about the labial posture and slaving habits of their children while they were sleeping. We considered as nasal-breathing the children who breathed mainly through the nose and keep their lips in contact while resting, as observed by their parents. Mouth-breathers were the children who presented a medical diagnosis of obstructive airway disease, showed the presence of respiratory diseases and whose lips did not show contact while resting, according to parents observation.

The electromyography analysis was performed at the Research Laboratory of Electromyography, Morphology Department of Universidade Federal de Santa Maria, using an electromyography amplifier, a digital–analogic conversion board (model CAD10/26 of *Lynx Electronics Ltda*.[1]) and software especially developed to acquire and process data mathematically.

Electromyographic recordings were obtained with silver–silver chloride, bi-polar electrodes for surface electromyography (DUO-TRODE), which were placed in the medium third of SCM muscles and the superior portion of trapezius muscles, bilaterally. Skin was treated with ethyl alcohol (96°GL) before fixation of electrodes. In order to avoid electromagnetic interference during the examination and for the patients protection, a metallic electrode with gel linked to a thread earth was fastened to the patients' forearm.

The children were examined while seated comfortably in a chair, with the head naturally positioned and looking forwards. After a normal expiration, the children were instructed to inspire deeply and slowly, through the nose and soon afterwards electromyographic recordings were started (Test 1) . In the second test (Test 2), children were instructed to inspire deeply and slowly through the mouth.

The equipment was calibrated as follows:

- Frequency : 4000 Hz;
- Conversor A/D resolution: 10 Bits;
- High-pass filter: 10 Hz;
- Low-pass filter: 2000 Hz;
- Gain: 5000;
- Sweep: - 15 ms/division.

The amplitude of electrical activity was evaluated by RMS values. These values were calculated by our own acquisition data program (AQD) and expressed in microvolts (μV).

For the comparative analysis of groups, the results were analyzed statistically by the Kruskall–Wallis test for independent data, which was considered the best treatment for these data due to the variability in their values. The level of significance was set at 5% ($p<0.05$).

3. Results

There was a significant difference in the electrical activity of the muscles studied, which showed an increase during the nasal inspiration test in oral breathers. However, statistically, in the oral inspiration test there was no significant difference between the mouth- and nasal-breathing children, as shown in Tables 1 and 2.

Figs. 1–8 show the pattern of electric activity of the SCM and trapezius muscles, bilaterally, in nasal- and mouth-breathing children, respectively, during nasal inspiration (Test 1). Figs. 9–16 show the pattern of electric activity of the SCM and trapezius muscles, bilaterally, in nasal- and mouth-breathing children, respectively, during oral inspiration (Test 2).

Channel 0 – left sternocleidomastoideus muscle
Channel 1 – right sternocleidomastoideus muscle
Channel 2 – left trapezius muscle
Channel 3 – right trapezius muscle

4. Discussion and conclusion

These results demonstrate that mouth-breathing children present larger electric potentials in all the muscles studied during nasal inspiration. This suggests that an increase in airway resistance leads an increase in inspiratory effort which, in turn, leads to a larger performance of accessory inspiratory muscles.

The results of our study confirm Campbell's findings [4], where accessory muscle activity during breathing (scalene and sternocleidomastoid) became important when the breathing level was increased, and SCM muscle action increased when an individual needed to exercise with an inspiratory pressure larger than 20 cm of H_2O. Dispneic patients showed hyperactivity of these muscles. Sousa [5] has highlighted the activity of SCM in respiratory mechanics, where an action potential of this muscle was observed during maximum inspiration. These results confirm the opinions of Lehmkuhl and Smith, Rasch and Burke and Calais-Germain [6–8], who consider the SCM as an inspiration accessory muscle.

Hruska [9] explained that the overuse of both primary and secondary muscles of respiration often contributes to craniofacial pain and associated symptoms of cervical origin, largely because of their mechanical relation to the cervical and suboccipital regions and their influences on the forward head position. This forward head position occurs in most of mouth-breathings, because it helps them to reduce the narrowing of the airways, and it causes an increase of cervical muscle activity.

According to Weimert [10], mouth-breathing is an

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Table 1
Mean values and standard deviations (SD) of electromyographics recordings (RMS in μV) of right and left sternocleidomastoids and trapezius muscles during the nasal inspiration test

Group[a]	Muscles Sternocleidomastoideus right		Sternocleidomastoideus left		Trapezius right		Trapezius left	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
I	20.97*[b]	15.36	17.02*	7.44	12.43*	12.75	16.77*	7.64
II	7.88*	3.47	9.08*	2.89	5.61*	3.09	9.07*	4.01

[a] Group I, mouth-breathers; Group II, nasal-breathers.
[b] *Statistically significant at 5% level ($p<0.05$).

Table 2
Mean values and standard deviations (SD) of electromyographics recordings (RMS in μV) of right and left sternocleidomastoideus and trapezius muscles during oral inspiration test

Group[a]	Muscles Sternocleiodomastoideus right		Sternocleidomastoideus left		Trapezius right		Trapezius left	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
I	12.16	9.41	10.19	5.04	9.77	10.67	16.38	8.59
II	7.742	3.13	12.09	14.31	6.22	2.89	8.46	3.22

[a] Group I, mouth-breathers; Group II, nasal-breathers.

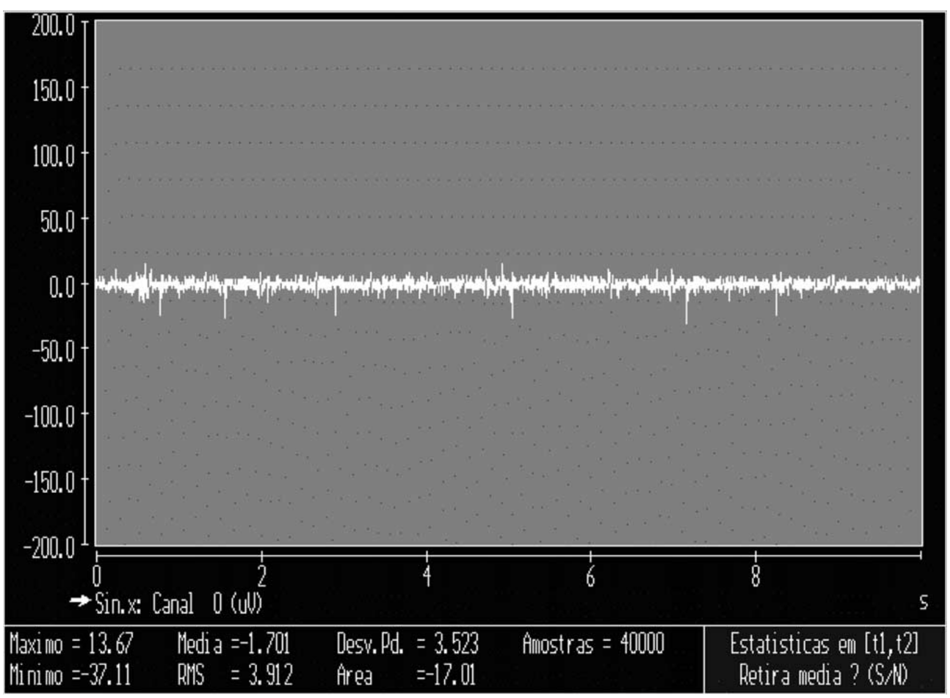

Fig. 1. EMG recordings of left SCM muscle during nasal inspiration in nasal breather.

inefficient form of breathing, and tolerance of this effort is remarkably reduced in a patient with a nasal obstruction. The author affirms that the patient is not capable of overcoming an obstruction by forcibly breathing through the nose, and the larger the effort the bigger the turbulence generated and the smaller the inspired air volume is. In situations of breathing action effort a more vigorous diaphragm contraction happens, preceded by inspiratory accessory muscle action [11]. This is demonstrated through the greatest activity of the SCM muscle in mouth-breathing children during nasal inspiration.

Breuer [12] also pointed out the importance of nasal-

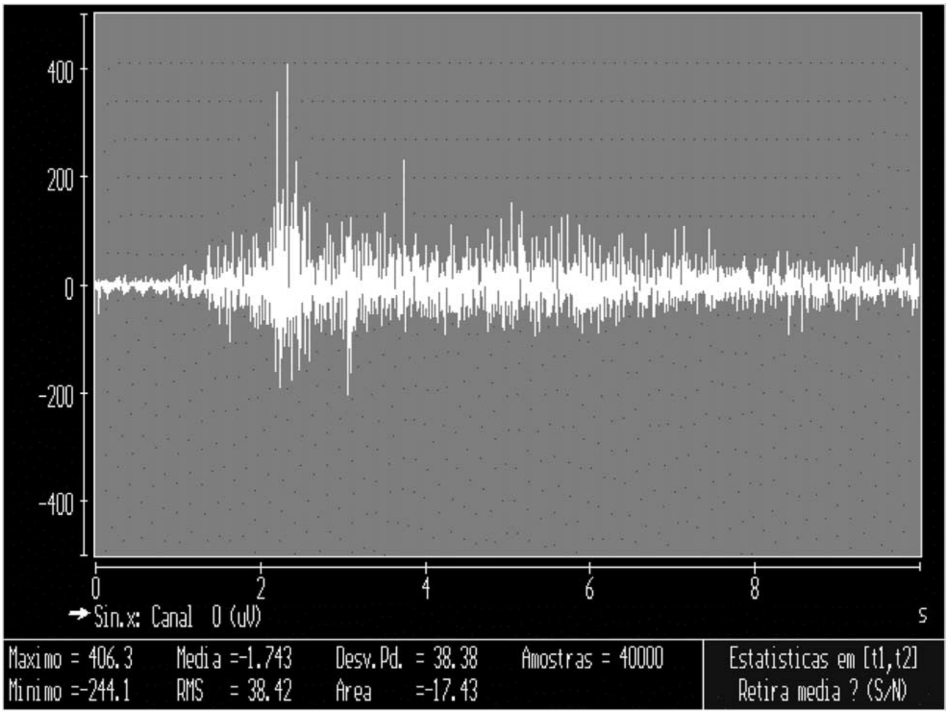

Fig. 2. EMG recordings of left SCM muscle during nasal inspiration in mouth breather.

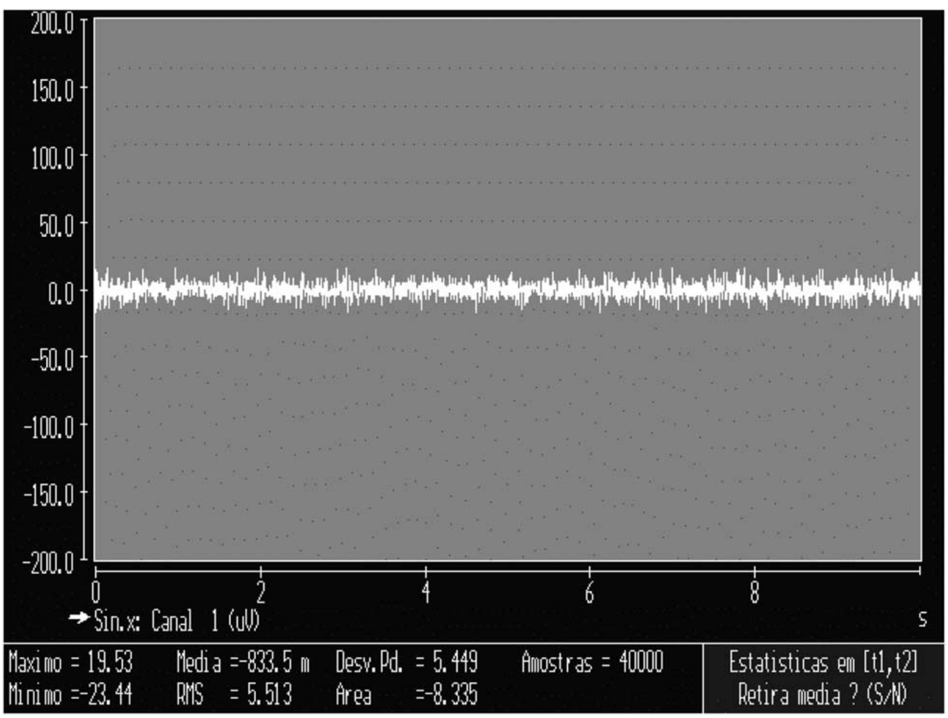

Fig. 3. EMG recordings of right SCM muscle during nasal inspiration in nasal breather.

breathing for several nose functions, commenting that air should go through the nose, and that mouth-breathing is only used in emergency cases or when under great ventilatory demand. Nasal obstruction increases posterior nasal resistance and leads to the mouth-breathing habit. This obstruction could turn into an abnormal breathing habit, which can persist even when original cause has been eliminated. After the obstruction has been treated, the mouth-breathing habit could persist due to important changes in posture and muscle shortening, that would be also need to be treated.

According to Novaes and Vigorito [13], nasal obstruc-

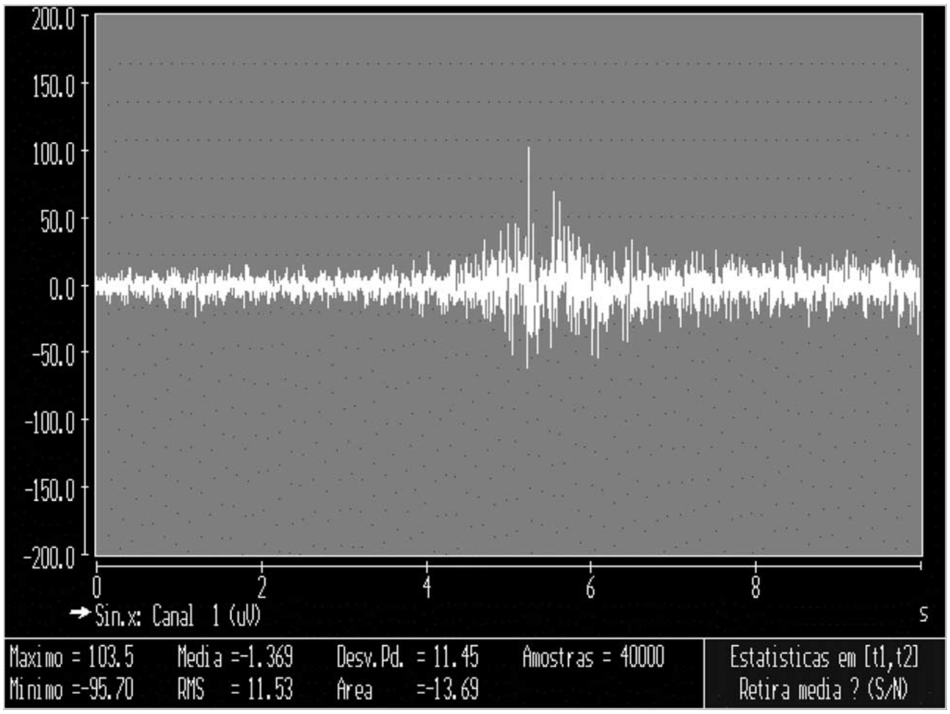

Fig. 4. EMG recordings of right SCM muscle during nasal inspiration in mouth breather.

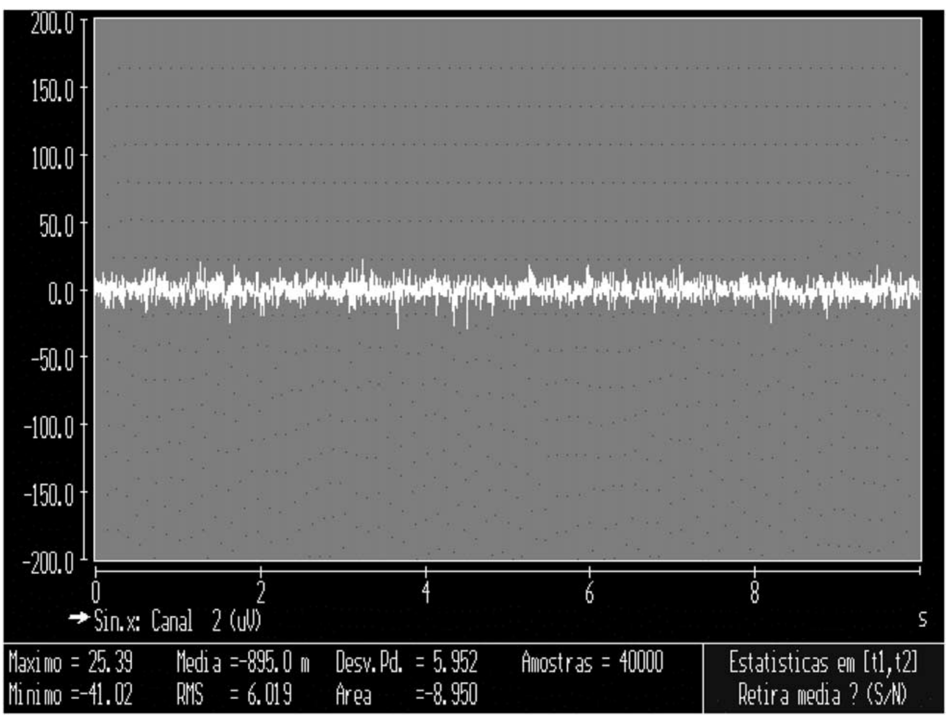

Fig. 5. EMG recordings of left Trapezius muscle during nasal inspiration in nasal breather.

tion increases the posterior nasal resistance, since it decreases the air pressure and volume and it also decreases blood oxygenation and reduces breathing depth and intensity. Therefore, we can attribute the largest activity of the inspiration accessory muscles to the effort of increasing lung volumes in mouth-breathing children because of airway obstruction. This was checked by Costa, who verified an increase in the activity of SCM in situations of breathing effort [14]. On the other hand, the author observed a larger activity of this muscle during free inspiration through the mouth, in relation to nasal inspiration, in healthy individuals

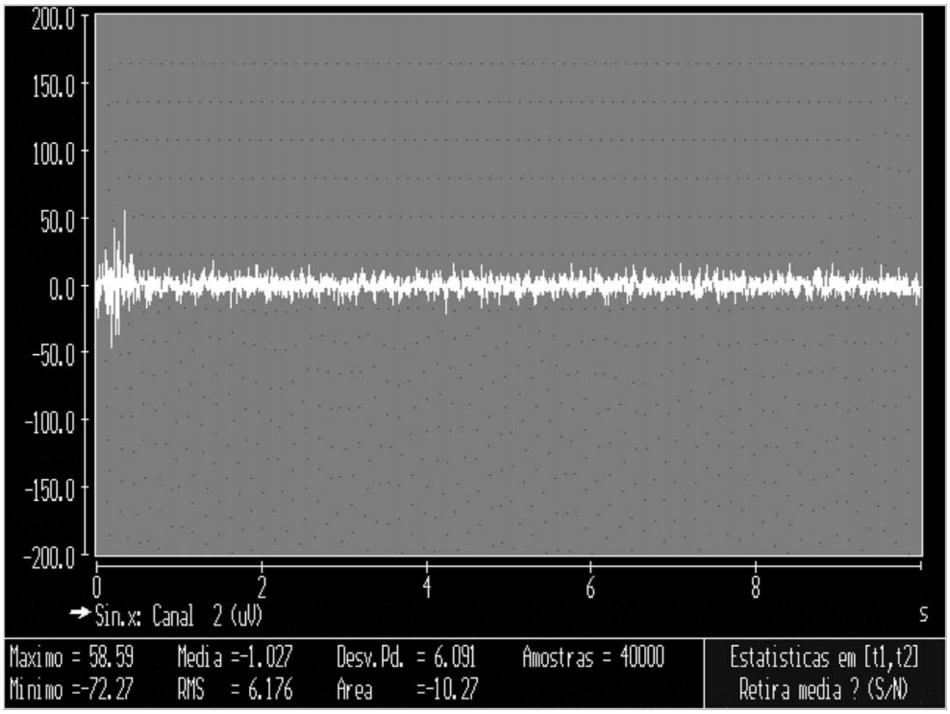

Fig. 6. EMG recordings of left Trapezius muscle during nasal inspiration in mouth breather.

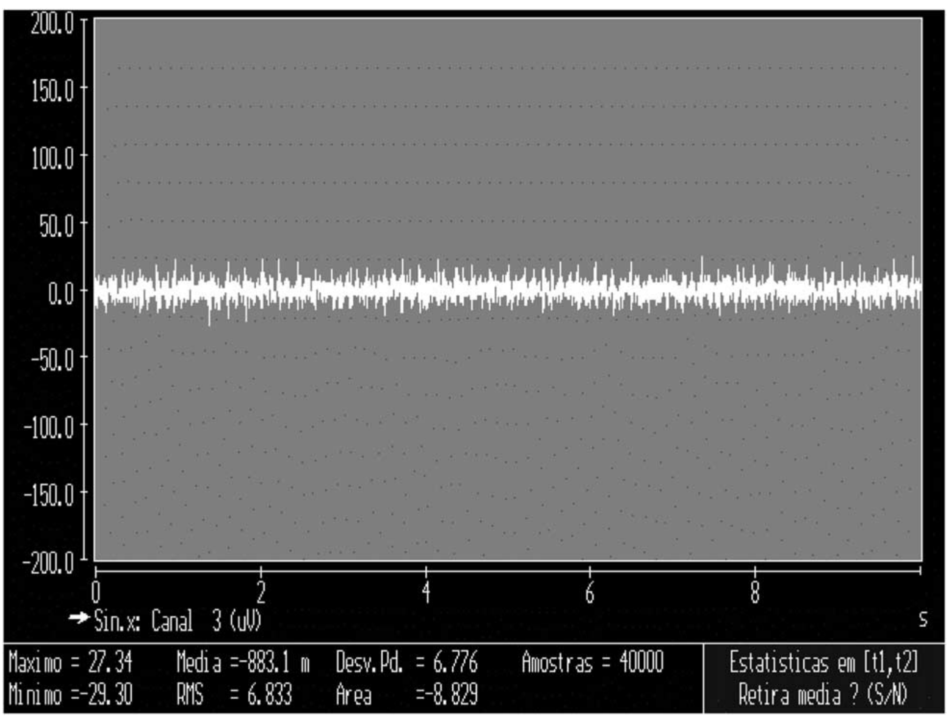

Fig. 7. EMG recordings of right Trapezius muscle during nasal inspiration in nasal breather.

without obstruction of superior airways. Such an observation can be related to the need to alter the head position to accomplish oral inspiration, which was demonstrated by Vig [15] when there was progressive extension of the head during total nasal obstruction.

Costa and co-workers [18] observed a larger electrical activity of SCM during fast deep inspiration. In order not to influence the activity of the muscles being examined fast inspiration movement was avoided during the tests.

Canongia et al. [16] commented that breathing with a prevalence of mouth inspiration leads to a reduction of

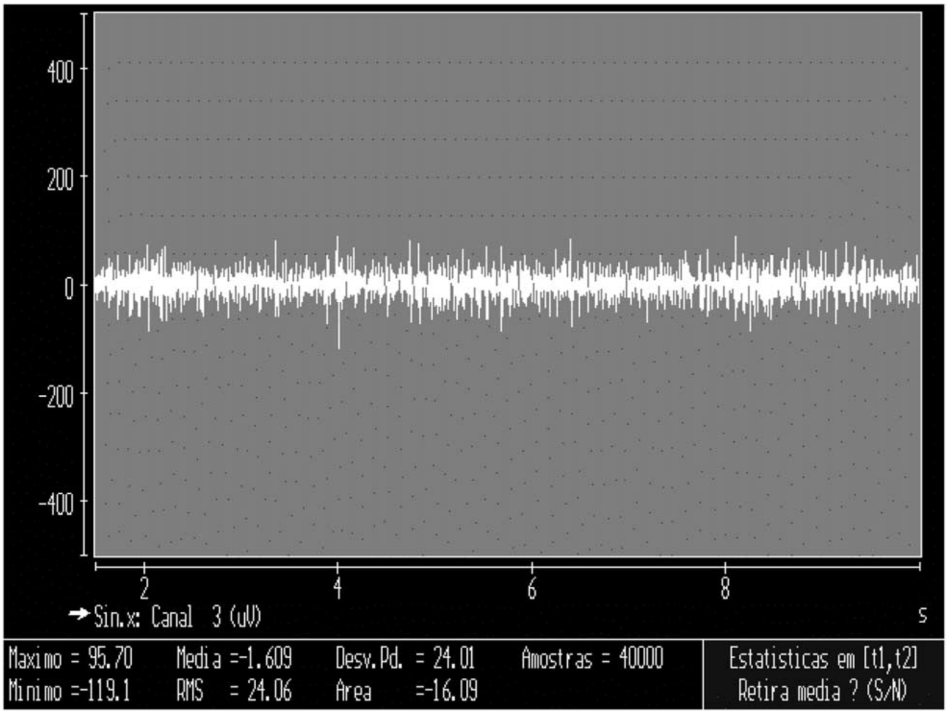

Fig. 8. EMG recordings of right Trapezius muscle during nasal inspiration in mouth breather.

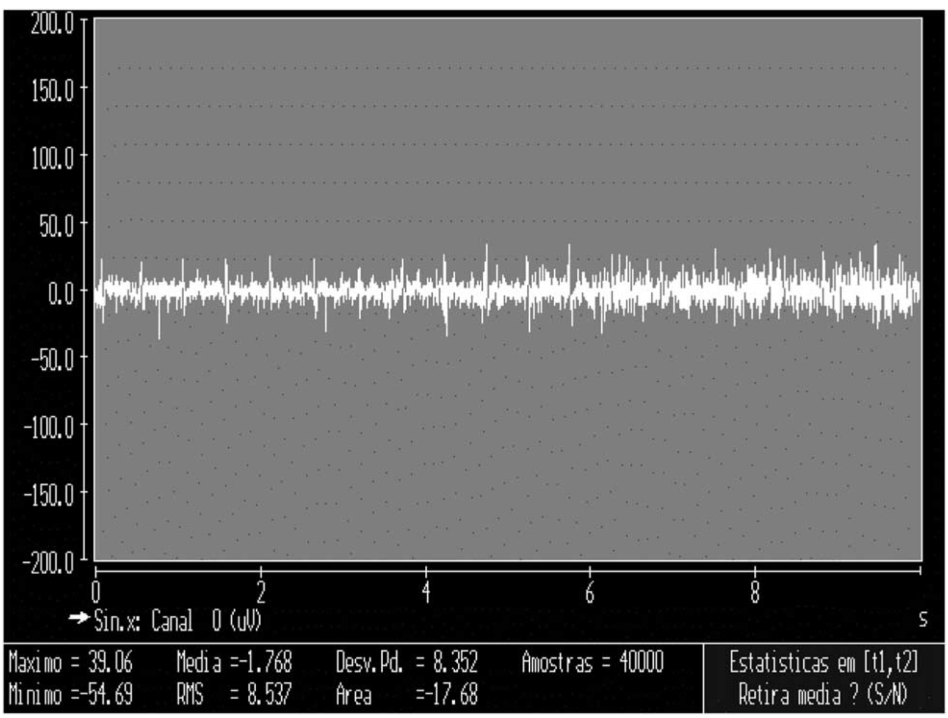

Fig. 9. EMG recordings of left SCM muscle during oral inspiration in nasal breather.

the inspiratory capacity and propitiates fatigue, because there is a modification in the sternum bone . This modification is due to SCM contraction, which leads to an elevation of the sternum position [8,11]. With the mechanical changes, there will need to be a bigger effort to breathe and a higher activity in the accessory muscles of inspiration.

The small electrical activity of the muscles studied during mouth-breathing, in both groups, is in accordance with Sartor, who considered the nasal resistance twice

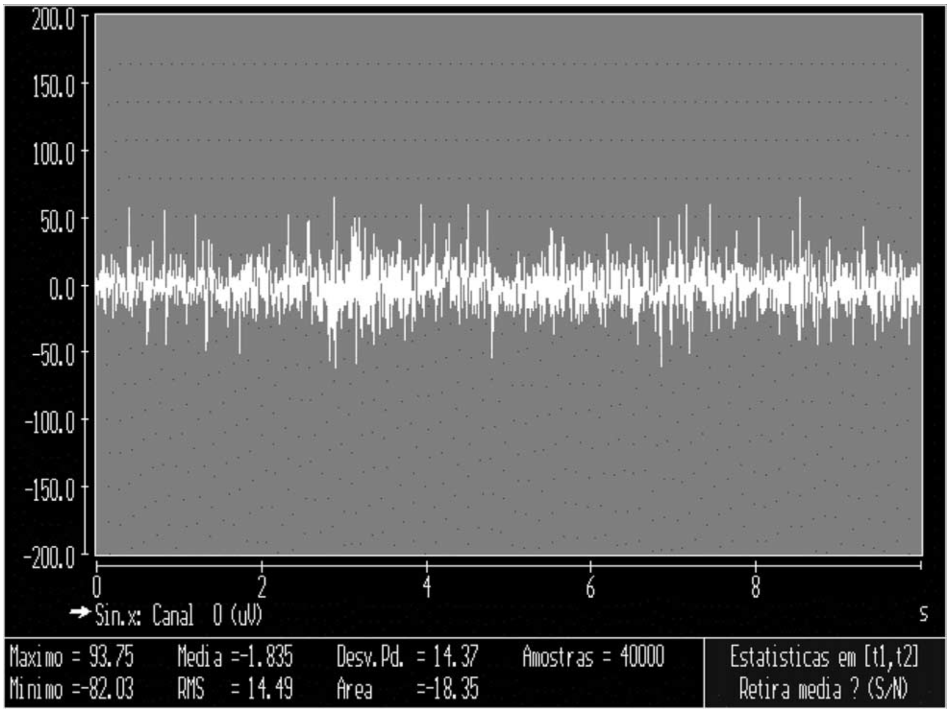

Fig. 10. EMG recordings of left SCM muscle during oral inspiration in mouth breather.

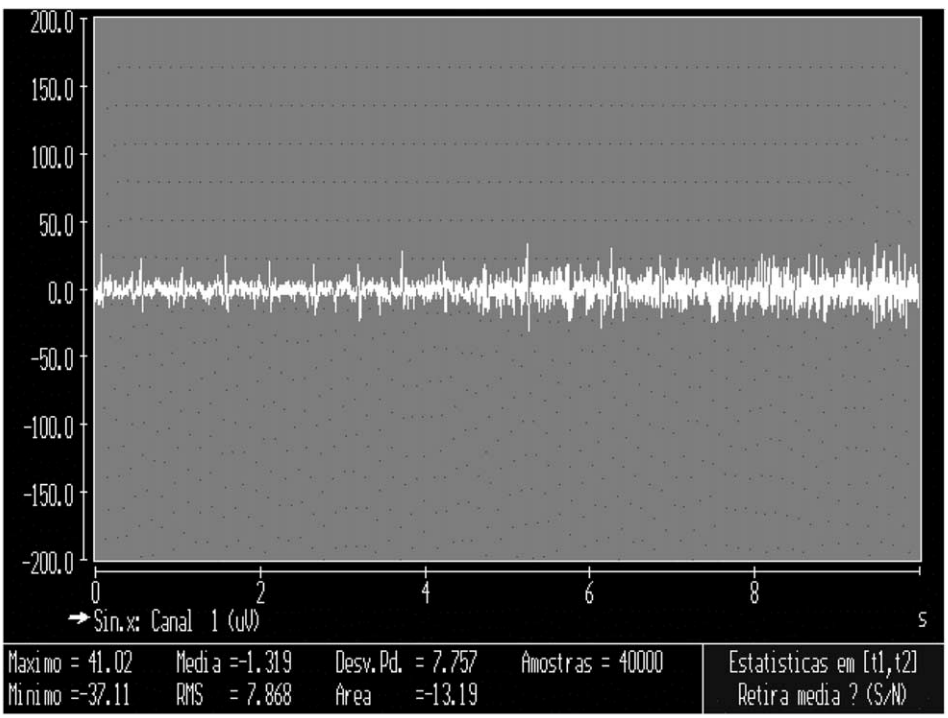

Fig. 11. EMG recordings of right SCM muscle during oral inspiration in nasal breather.

as large as the oral resistance, having a two-fold increase in breathing effort compared to the effort required for mouth-breathing [1]. Gross [17] considered that mouth-breathing can be a normal developmental stage, related to environmental factors, and he also assures that many young people and adults show this reaction even in the absence of significant alterations in the airways. Based on this author's opinion, our study does not agree that mouth-breathing can be normal in this age group and demands a smaller effort by children. This is because

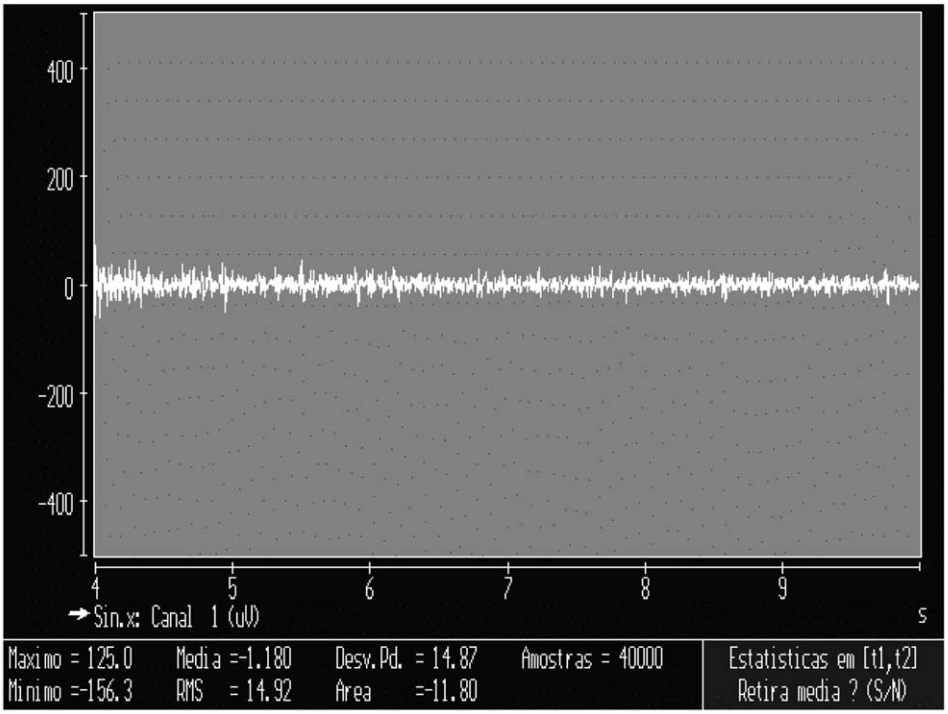

Fig. 12. EMG recordings of right SCM muscle during oral inspiration in mouth breather.

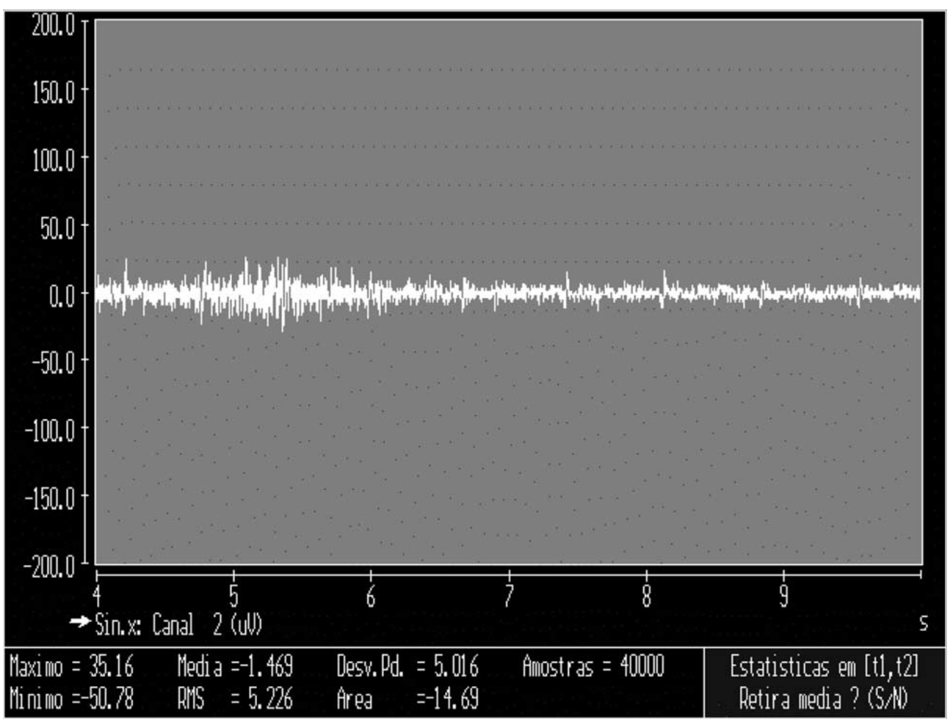

Fig. 13. EMG recordings of left Trapezius muscle during oral inspiration in nasal breather.

during nasal inspiration we did not observe a larger effort in relation to the oral inspiration in the nasal-breathing group, than in the mouth-breathing group.

The results obtained by Costa et al. [18] do not support the present study because the authors observed a small increase of SCM activity during free deep inspiration movement through the mouth, compared to breathing through the nose. It is also important to highlight that the aforementioned study was carried out with healthy individuals.

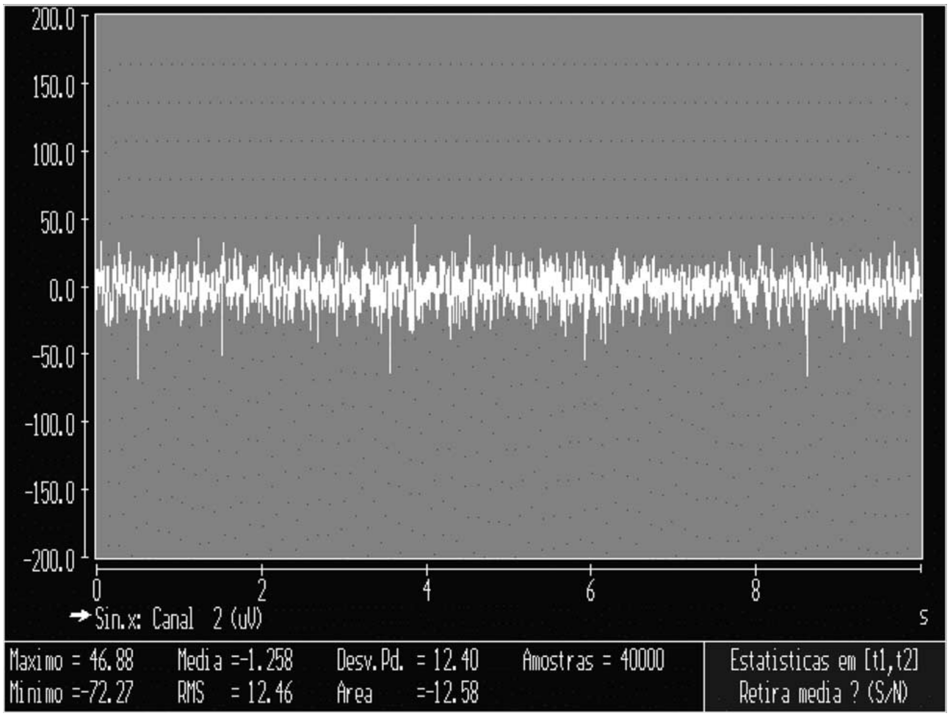

Fig. 14. EMG recordings of left Trapezius muscle during oral inspiration in mouth breather.

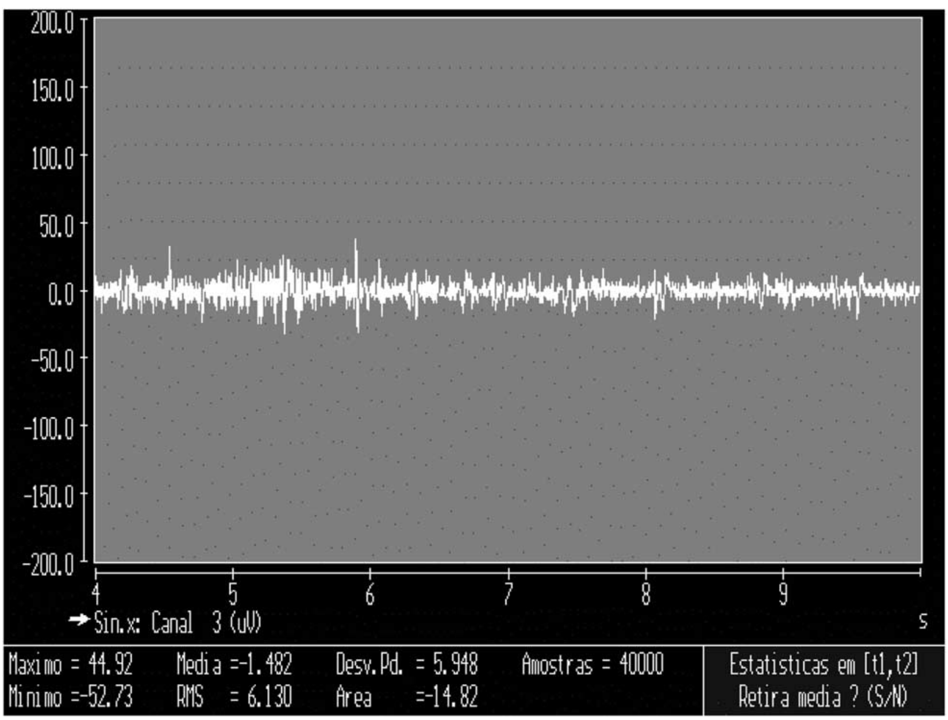

Fig. 15. EMG recordings of right Trapezius muscle during oral inspiration in nasal breather.

These results agree with Hellsing [19], who considered that mouth-breathing due to nasal occlusion, over a short period did not affect the head and jaw posture, the muscular activity of posterior cervical, supra and infrahyoid, anterior temporal, masseter and SCM muscles. Solow et al. [2] however, did not confirm these findings, because they observed an increase of the cranium–cervical angle in patients with nasopharyngeal passage narrowing, indicating a strong relationship between head position and airway adaptation. The results of a

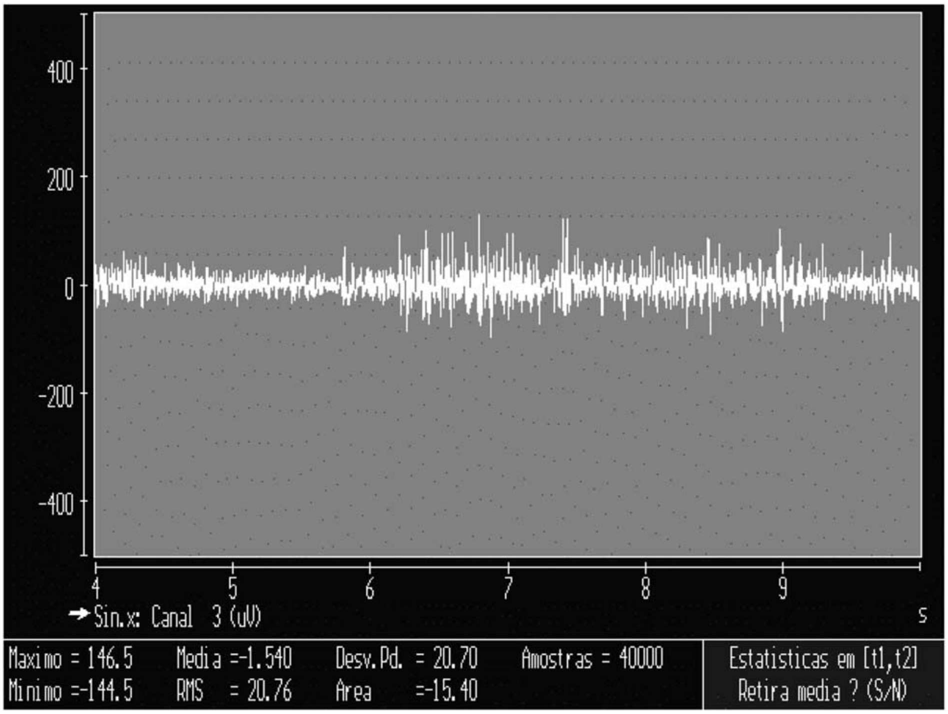

Fig. 16. EMG recordings of right Trapezius muscle during oral inspiration in mouth breather.

study by Vig [15] are also different, because the authors observed that after 2 h of induced mouth-breathing, the measure of the head extension reached 5°.

With these results it can be concluded that the muscles studied develop hyperactivity during nasal inspiration in mouth-breathers due to a larger breathing effort, caused by a larger resistance in the airways, resulting in action of the accessory breathing musculature. The importance of this conclusion is that therapy for mouth-breathing should not be carried out only for orofacial changes, because it also presents changes in cervical muscles. We suggest that further studies should be carried out related to the level of cervical muscle activity after postural and respiratory treatment.

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