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Original articles

The impact of oronasal breathing on perioral musculature

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ABSTRACT

Purpose: to compare the behavior of perioral muscles in nasal, oral and oronasal respirators.

Methods: a sample consisting of three distinct groups, equally subdivided into Nasal, Oral and Oronasal Respirators. The behavior of the orbicular muscle of the mouth (upper part) and mentual one was measured by surface electromyography at rest, swallowing and labial isometry.

Results: in all situations investigated, the orbicular muscle of the mouth (upper part) and mental muscle showed no significant difference in relation to *Root Means Square*, that is, average electrical activity between Oral and Oronasal Respirators. The data showed a significant difference in In Nasal Respirators, as compared to the other groups.

Conclusion: similarity was seen in the comparison of perioral muscles behavior between oral and oronasal respirators, however, a significant difference in relation to nasal respirators.

Keywords: Electromyography; Respiration; Muscle

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INTRODUCTION

The breath, physiological, vital and innate function of the human being, protects the upper airway and allows the satisfactory development of the craniofacial complex if performed correctly[1-4]. For proper nasal breathing, lip sealing is indispensable for generating a differentiation system of intra and extra-oral pressures in the so-called Oronasopharyngeal Space. This system, in turn, is responsible for the adequate maintenance of muscle tone[5] that favors the correct development of the oral cavity, since there is a bone and dental response to muscle action[6,7].

When, however, nasal respiratory failure due to obstructive or non-obstructive causes occurs, compensatory mechanisms such as oral breathing can be triggered[8,9]. In this case, a new pressure condition is generated and the musculature needs to be readapted[5]. In the literature, damages caused by oral breathing due to a new muscular condition are already consecrated[10]. As well as the new condition sequelae: open bite, retrognathism, high and narrow palate among others[11].

Although, in the oronasal respirator – also called vicious[12,13], mixed [14] or partial[8,15] – even after clearing the upper airways, the systematic nasal breathing does not occur. Either by habit or muscle memory the mouth remains ajar. In these cases, muscle activity has never been investigated. Perhaps because it is considered that intra and extra-oral pressure differentiation does not interfere with muscular behavior[16]. Or because it is associated with chronic diseases of difficult treatment and continuous control such as rhinitis[17,18]. Thus, albeit the oronasal respirator is considered a distinct group[19], it is often disregarded or grouped as an oral respirator.

If, however, the musculature in the oronasal respirator is compromised in the same way as in the oral respirator, some care must be guaranteed, once the incidence of chronic diseases[20,21] is high, such as rhinitis in children, from 26.6% to 53.3%[22]. Unfortunately, when untreated, they can cause similar morphological damage to the mouth respirator, besides compromising orthodontic interventions with relapses or treatment limitations due to inadequate muscular action[23].

In particular, two muscles have a significant participation with the oral cavity development, the orbicularis muscle of the mouth (upper part) and the mental muscle[24]. When lip sealing does not occur the orbicularis muscle of the mouth (upper part) is shortened, a condition that favors dental protrusion and imbalance in facial morphology[13]. Studies have also shown that the muscles in these cases perform more effort in activities such as suction and swallowing[23,24]. On the other hand, the mental muscle[23,25], which is responsible for positioning and directing the lower lip[23], is hypertrophied in the oral respirator due to its excessive recruitment when sealing the lips[26]. With a volume increase, it tends to accentuate the eversion of the lower lip[23] and the buccal inclination of the incisive teeth[27], since its insertion lies in the alveolar eminence of the canine teeth to the lateral incisors [25].

Due to the expressive participation of the orbicular muscles of the mouth and mentual muscles in skeletal and dental development, this study aims to compare the behavior of the perioral muscles in nasal, oral and oronasal respirators.

METHODS

The study was approved by the Research Ethics Committee of UNICAMP under No. 1,125,115 according to Resolution 466/12 of the National Health Council (CNS). The legal representatives of the selected patients signed the Free and Informed Consent Form for the authorization of data collection.

Sample

It's consisted of 48 patients, divided equally into three groups: Nasal Respirators (RN), Oral Respirators (ORO) and Oronasal Respirators (RON), aged between 6 and 12 years old, male and female, selected from the waiting list of a Basic Health Unit.

- **Inclusion criteria:** medical records of otorhinolaryngological evaluation of the upper airways.

NASAL RESPIRATOR: clearing of the upper airways with effortlessly sealed lips during rest, chewing and with the tongue contained in the oral cavity[28].

ORAL RESPIRATOR: obstruction of the upper airways, breathing with difficulty through the nose, showing signs of fatigue, dyspnea and needing to open the mouth to inspire when at rest and chewing[28].

ORONASAL RESPIRATOR: clearing of the upper airways, breathing through the mouth and nose, but being able to breathe through the nose without showing signs of fatigue or dyspnea[28].

- **Exclusion criteria:** neurological, cognitive impairment, peripheral and/or central facial paralysis, syndromes, lip and palate cleft, making use of myo relaxing medicine, facial trauma, submitted to myotherapic and/or orthodontic and/or facial orthopedic treatment.

Procedures

The evaluation consisted of the analysis of the medical records for the investigation of otorhinolaryngological opinion regarding the respiratory mode, protocol of Miofunctional Evaluation with Scores (AMIOFE)[28] and electromyographic examination. AMIOFE was also used to define the respiratory mode[28], being this protocol applied integrally once the observation of the patient throughout the evaluation is necessary to define different respiratory modes.

Figure 1 measures the different respiratory modes. However, in this study, mild oronasal breathing was considered Oronasal Respiration and severe oronasal breathing, Oral Respiration.

Breathing		Scores
Nasal breathing	Normal	(3)
Oronasal breathing	Mild	(2)
Result of the evaluated subject	Severe	(1)

Figure 1. AMIOFE Protocol. Specific cut-off of the "functions" criterion for respiratory mode

In order to define the different respiratory modes, the protocol considers the following characteristics:

- **Nasal Respiration (normal nasal breathing):** lips sealed effortlessly during rest and chewing with the tongue contained in the oral cavity.
- **Oronasal breathing (mild oronasal breathing):** breathing through the nose and mouth without showing signs of fatigue or dyspnea.

Oral Respiration (severe oronasal breathing): breathing with difficulty, showing signs of fatigue, dyspnea and needing to open the mouth to breathe at rest and chewing.

Surface Electromyography

The study was carried according to the recommendations of the *European Applications of Surface Electromyography* (SENIAM)[29]. Myosystem and Myosystem BRI software, version 2.52, 12-bit resolution signal conditioner with 112 dB Common Rejection Mode, 60 Hz and Myosystem Digital Analog Converter, model PCI-DAS 1200, were used.

Bipolar disposable electrodes of Chicopee MA01 (Meditrace, Kendall-LTP) with a diameter of 1cm were coupled to a preamplifier (model PA 1010-VA, 20-fold gain) to form a differential circuit. This circuit subtracts the common signal and amplifies the differential signal of interest to attenuate artifacts and avoid crosstalk[30,31]. The monopolar stainless steel reference electrode was attached to the sternum of the patient. In the other muscles, the inter-electrode distance was 1cm, and in the mental muscle it was positioned in its womb to 2mm below the edge of the lower lip and in the orbicularis muscle of the mouth (upper part) in its midline[13].

To capture the signal, the sampling frequency was 2 kHz. After collecting, the signals were submitted to a Butterworth filter, bandpass of 20-500 Hz, rectification with low-pass filter of 4 Hz and calculation of the average electrical activity of the signal through Root Means Square (RMS)[31,32].

The duration of the records was 5 seconds at rest, swallowing and labial isometry, with one-minute interval between the abstractions[33]. For swallowing, 1ml of water was inserted into the patient's mouth with a syringe and after 60 seconds the swallowing was requested. Finally, for isometry the patient maintained an eccentric contraction of the lips for 5 seconds. The tests used were *Chi-Square*, *Fisher*, *ANOVA* and *Box Plot*, and the value considered significant was $p < 0.05$.

RESULTS

Sample characterization

In the comparison between NG, GO and GON – regarding to the male and female gender – there was no significant difference between the groups, according to Table 1 below:

Regarding age, the data also showed no significant difference between the groups, according to Table 2.

Table 3 below quantified the values of the electromyographic examination in the Group / Muscle ratio.

In the electromyographic data between the groups there was similarity between ORO and RON, and a significant difference in relation to RN. Also a significant difference between both muscles. However, there was no correlation between the group and muscle factor.

Table 1. Gender-specific sampling in different respiratory patterns

Gender	Groups			Total
	RN	RO	RON	
Female (freq.)	5	6	4	15
%	31.25	37.50	25	
Male (freq.)	11	10	12	33
%	68.75	62.50	75.00	
TOTAL	16	16	16	48

RN: Nasal Respirator, RO: Oral Respirator; RON: Oronasal Respirator p: 0.7476 (Chi-Square and Fisher, $p < 0.05$), frequency: %, percentage.

Table 2. Sampling in relation to age

Group	N	Mean	Median	SD	Minimum	Maximum
RN	16	7.94	7.5	2.05	6.0	12
RO	16	6.69	6.0	1.01	6.0	9
RON	16	7.00	6.0	1.37	6.0	10

N: Sample, SD: Standard Deviation, RN: Nasal Respirator, RO: Oral Respirator, RON: Oronasal Respirator, p: 0.1550 (ANOVA test, $p < 0.05$).

Table 3. Quantitative description of Root Means Square (RMS), mean electric activity of the Groups / Muscle ratio in electromyography (ANOVA for repeated measures)

Group	Variable	N	Mean	Mediam	SD	Minimum	Maximum
RN	rephab (m.orbicular)	16	4.23	3.61	2.30	1.25	7.89
	rephab (m.mentual)	16	6.64	7.44	3.36	0.77	11.31
	degl (m.orbicular)	16	5.87	5.28	3.57	0.77	13.82
	degl (m.mentual)	16	10.88	9.87	9.32	1.74	39.15
	labial isometry (m.orbicular)	16	6.72	6.01	5.23	0.65	18.04
	labial isometry (m.mentual)	16	30.46	10.82	42.07	2.81	160.77
RO	rephab (m.orbicular)	16	10.33	8.10	7.10	4.09	31.39
	rephab (m.mentual)	16	22.32	16.37	21.49	5.45	92.53
	degl (m.orbicular)	16	28.37	19.45	28.92	6.42	103.68
	degl (m.mentual)	16	52.88	50.07	19.21	27.53	91.48
	labial isometry (m.orbicular)	16	69.14	55.02	63.48	6.79	220.53
	labial isometry (m.mentual)	16	101.27	70.45	60.16	30.90	205.78
RON	rephab (m.orbicular)	16	6.36	5.67	5.37	1.32	20.08
	rephab (m.mentual)	16	15.84	13.76	10.97	5.04	41.13
	degl (m.orbicular)	16	25.76	24.53	21.96	3.25	79.66
	degl (m.mentual)	16	40.77	43.65	17.87	6.23	71.01
	labial isometry (m.orbicular)	16	66.73	48.44	53.36	9.32	168.80
	labial isometry (m.mentual)	16	91.25	69.62	61.31	21.56	258.11

N: sample, SD: Standard Deviation, RN: Nasal Respirator, RO: Oral Respirator, RON: Oronasal Respirator, m: muscle, degl: deglutition

Thus, in the separated analysis the mental muscle presented a difference between the groups; and the orbicularis muscle of the mouth (upper part) presented similarity between ORO and RON, and a significant difference in relation to RN. Finally, in the analysis separated by group only RN did not present significant difference between the muscles, according to Figure 2 below:

Variable	Factor	p-value	Analysis separated by muscle	
	- Group	<.0001*	Mentual muscle	
RPH	- Muscle	<.0001	Factor	p-value
	- Muscle group	0.1887	Group	<0.0001^{+}
	- Group	<.0001*	Orbicularis muscle	
DEGL	- Muscle	<.0001	Factor	p-value
	- Muscle group	0.2251	Group	0.0011*
			Analysis separated by group	
			Group RN	p-value
	- Group	<.0001*	Muscle	0.8970
ISOM.LAB	- Muscle	<.0001	Group RO	
	- Muscle group	0.6125	Muscle	<.0001
			Group RON	
			Muscle	0.0024

Figure 2. Electromyographic data between the groups and analysis dismembered by muscle; with variables: RPH (rest in usual position), DEGL (swallowing) and ISOM. LAB (labial isometry)

The results showed that in the mental and orbicular muscles of the mouth there was a significant difference for the three studied groups with smaller measures for NG and similar for GO and GON. However, there was no significant difference in relation to the orbicular muscles of the mouth (upper part) and mentual muscles, but in GO and GON groups there was a significant difference with larger measures in the mental muscle, as shown in Figures 3, 4, 5 .

USUAL REST

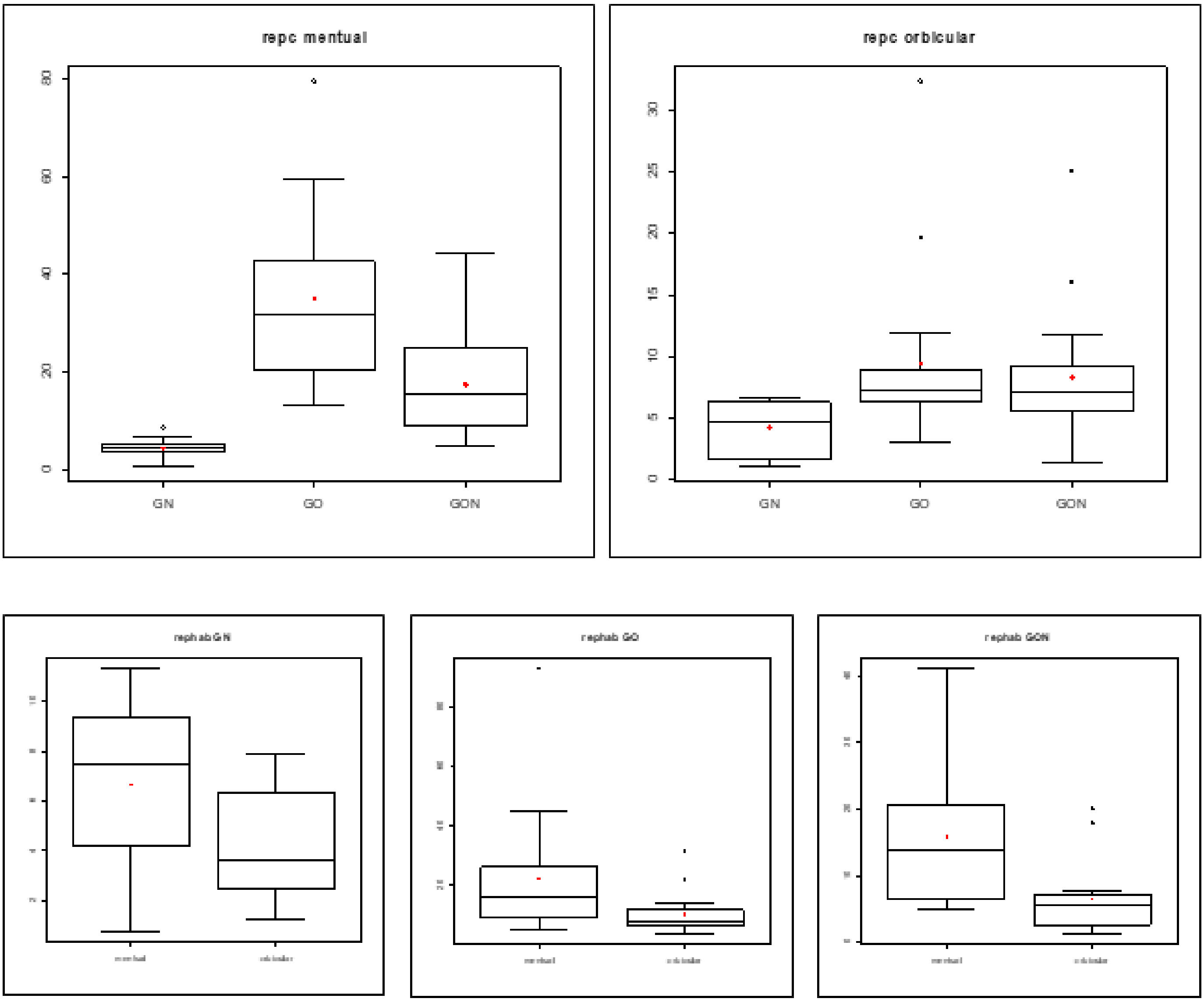

Figure 3. Box Plot for the distribution of the average electrical activity of the electromyographic record in relation to RMS (Root Means Square) in the usual rest (repc) of the mentual muscle, orbicularis muscle of the mouth (upper part) of nasal, oronasal. ANOVA for repeated measurements. Significant difference * (Tukey's test). * RN ≠ RO / RON

DEGLUTITION

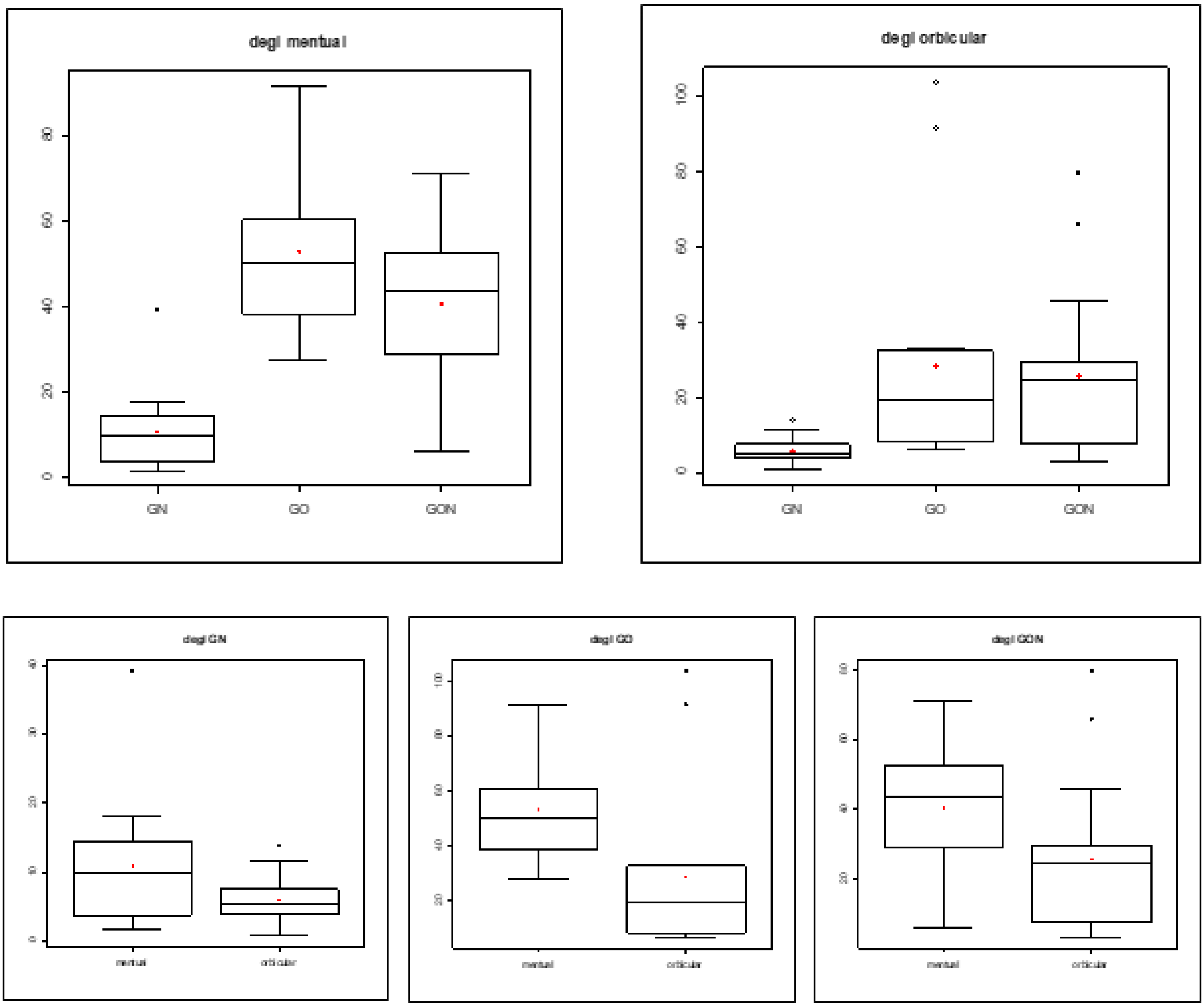

Figure 4. Box Plot for the distribution of the average electrical activity of the electromyographic record in relation to RMS (Root Means Square) in the swallowing of the mentual muscle, orbicularis muscle of the mouth (upper part) of the nasal, oral and oronasal respirators. ANOVA for repeated measurements. Significant difference * (Tukey's test). * RN ≠ RO / RON

ISOMETRY LIP

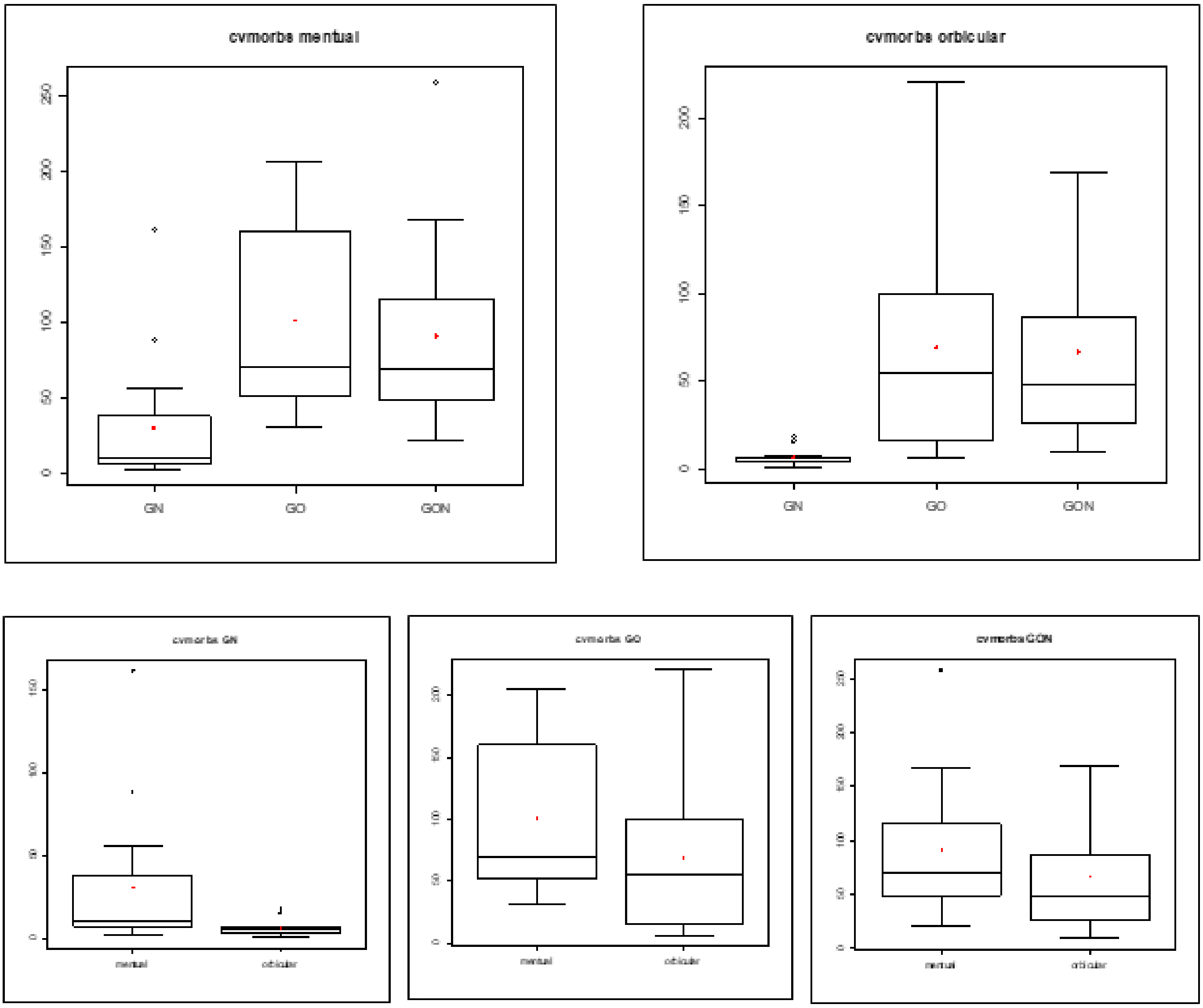

Figure 5. Box Plot for the distribution of the average electrical activity of the electromyographic record in relation to the RMS (Root Means Square) in the situation of lip isometry of the mentual muscle, orbicularis muscle of the mouth (upper part) of the nasal, oral and oronasal respirators. ANOVA for repeated measurements. Significant difference * (Tukey's test). * RN ≠ RO / RON

DISCUSSION

The data revealed that the behavior of the perioral musculature in the oronasal respirator is similar and in some muscles even more intense than in the oral respirator. To characterize RON as a distinct group some care was taken. Besides the otorhinolaryngological evaluation, a specific protocol – Myofunctional Orofacial Evaluation with Scores[28] – was used to define qualitatively and quantitatively different breathing modes (Figure 1). The protocol determined to use only this age group of patients: between 6 and 12 years old. The average age obtained in the study was ± 7.21 years old, with no significant difference between RN, ORO and RON, p: 0.1550 (Table 2). Similarly with gender, among the groups RN, ORO, RON, p: 0.07476 (Table 1), whose data go against literature[1,2] which disregards the equal distribution of gender in the group and only stands out the classification to presence or absence of nasal obstruction.

However, in the behavior investigation between muscles and RN / ORO / RON groups, there was no correlation between both. The factors were then analyzed separately (Figure 2). The criterion *Root*

Means Square (RMS) was used to measure the average electrical activity of the signal [19]. The orbicularis muscle of the mouth (upper part) presented similarity between ORO and RON, and significant difference in relation to RN. In the mental muscle, a significant difference was found in all the situations investigated[34] (Figures 3, 4, 5).

In the usual rest, the literature considers absence of muscular activity values of up to 5µv[35]. In this study, the orbicularis muscle of the mouth (upper part) presented an average RMS value of 3.61µv considered normal, and the mental muscle, 7.44µv, close to the normality pattern. In ORO and RON groups, RMS values were much higher in the orbicularis muscle of the mouth (upper part) and in the mentual[34] (Table 3). These results confirm that not only intra-oral pressure is different in the inefficient labial sealing, as well as the behavior of the perioral muscles[5].

During swallowing and labial isometry there was also a pattern of similar behavior: GRN low values, GRO and GRON elevated (Figures 3, 4). As muscular dynamics influences skeletal and occlusal development, the obtained data in the GRO and GRON agree with studies associating ORO with cases such as retrognathism and open bite[27]. The results are reaffirmed as the three situations – habitual rest, swallowing and lip isometry – presented a profile of similar behavior with progressive increase of RMS when performed in this sequence due to the need for greater recruitment so the activities could be performed[26] (Figures 3, 4, 5).

Another significant difference found was regarding the mental muscle. In the analysis between muscles in ORO and RON groups, in swallowing and isometry, their activity was high and significant (Figures 3, 4, 5)[23]. Such findings are probably related to two aspects: anatomical location and function exerted by the muscle. In other words, the insertion in the inferior incisor muscle, which in turn has the function of the labial depression, in the case of ORO, requires the mental muscle to be more recruited to maintain the lip seal. About the function of positioning and directing the lower lip, there is also a need for greater effort because the lips are half open[23].

CONCLUSION

In the comparison of the behavior of the perioral muscles between oral and oronasal respirators, there was similarity but very significant difference in relation to nasal respirators.

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