

CLINICAL AND SURFACE ELECTROMYOGRAPHY EVALUATION PRE AND POST OROFACIAL MYOLOGY THERAPY

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ABSTRACT

Purpose: The objective of this study is to observe the efficacy of orofacial myofunctional therapy in children who breathe through their mouths “mouth breathers” using a clinical assessment and surface electromyography. *Method:* 30 nasal breath (control group) and 30 mouth breathers (study group) were evaluated initially, and the study group was re-evaluated after 12 sessions of orofacial myofunctional therapy. Assessments involved the MBGR protocol and surface electromyography. *Results:* The control group had significantly better scores on all nasal breathing tests compared to mouth breathers both before and after therapy. However, mouth breathers demonstrated statistically significant improvements over time with therapy. *Conclusion:* After twelve orofacial myology therapy sessions, the mouth breathers improved but not to normal levels. Inadequate muscular strength remained for the required tasks suggesting that additional therapeutic intervention is needed or that therapeutic success is inhibited by a vertical craniofacial growth pattern.

KEYWORDS: Speech, Language and Hearing Sciences; Electromyography

INTRODUCTION

Breathing is a vital function for humans, and the nasal mode is the physiological form. Multifactorial causes can be associated with mouth breathing (Berger, 2004; Garde, Suryavanshi, Jawale, Deshmukh & Dadhe, 2014; Barraza, Carminatti, Carneiro, Pinto & Gomes, 2020). In orofacial myology therapy, assessments are conducted to identify muscular and functional imbalances that may negatively interfere with the stomatognathic systems and, consequently, the process of breathing treatment (Vianna-Lara & Caria, 2006; Grippaudo, Paolantonio, Antonini, Saulle, La Torre & Deli, 2016; Batista & Bagarollo, 2020). Clinical assessment protocols have been discussed and published to establish an orofacial myology therapy diagnosis for mouth breathing. Two main protocols that are validated include: MBGR (Marchesan, Berrentin-Felix, Genaro, Rehder) (Genaro, Felix, Rehder & Marchesan, 2009) and AMIOFE (Expanded Orofacial Myofunctional Assessment) (Felício, Folha, Ferreira & Medeiros, 2010). To perform an objective assessment, the surface electromyography (EMG) was used, which assists in the diagnosis of mouth motor disorders (Armijo-Olivo, Gadotti, Kornerup, Lagravère & Flores-

Mir, 2007; Hermens & Freriks, 2000; Solow & Sandham, 2002). Surface electromyography consists of the electrical recording of the action potentials captured on the skin surface, arising from depolarizations that occur in muscle fibers and neuromuscular junctions (Winter, 1987). The myoelectric activity in electromyographic analysis is the sum of the action potentials of a group of motor units.

Because of the high incidence of children with mouth breathing and the necessity for objectively assessing orofacial myology therapy treatment for these children, the objective of this study is to observe the efficacy of orofacial myology therapy in mouth breathers using a clinical assessment (MBGR protocol) and surface electromyography.

MATERIALS AND METHODS

This was a longitudinal, prospective clinical research study approved by the ethics and research committee FCM – UNICAMP under number 1023/2010.

The inclusion criteria for the study group were to be in the age group from 7 to 13 years old of both sexes, having been previously diagnosed as a mouth breather by the Mouth Breathing Outpatient Clinic and have signed the Consent Form. All cases received previous otorhinolaryngological treatment. Exclusion criteria were: craniofacial deformities such as cleft lip and palate, cleft palate, otomandibular defects and neural tube closure that effect the cephalic pole; skin changes or other cutaneous aspects that could interfere with the contact of the electrodes, having undergone orofacial myology therapy, or not signing the consent form. For the control group, the same inclusion and exclusion criteria were used, differentiating themselves only from not belonging to the Mouth Breathing Outpatient Clinic.

The MBGR protocol and surface electromyographic analysis were performed during the 1st orofacial myology session in both groups as a means of collecting the initial data. In the MBGR protocol, the analyzed variables included "lips – intra and extra oral", "tongue", "mastication" and "swallowing". The surface electromyography tests consisted: "test - a" observation of habitual posture; "test - b" lip sealing; "test - c" lip clenching; "test - d" maximum dental intercuspation (using cotton rolls); "test - e" mastication of cheese bread (standardized by weight and origin); "test - f" coupling of the tongue on the palate and "test - g" swallowing. The tests "a", "b", "c", "d" and "f" were analyzed for 15 seconds. For test "e", the first five cycles of mastication were assessed, and three swallowing cycles were evaluated for "g". To capture and analyze the best signal, three measurements were performed for each test, with a rest time of 2 minutes between each stage of the assessment. To standardize the EMG data, the electrodes were positioned according to the direction of the muscular bundles on the suprahyoid, upper and lower orbicularis oris and masseter muscles. The sequence and command of movements were standardized. Bipolar, disposable Ag-AgCl double Hal® electrodes were utilized. A disposable unipolar reference electrode was placed on the lateral epicondylus of the right elbow. The data were gathered within an audiometric cabin to avoid interference from artifacts.

The electromyographic signals were conditioned and amplified using a MIOTOOL 400 – Miotec® four-channel electromyograph, with a 16-bit A/D converter and an input range of +/- 2 V. A.

Butterworth filter was used, with a high pass frequency of 10 Hz and a low pass frequency of 1000 Hz. The signals were collected with Migrap 2.0® (Miotec) software, quantified in RAW (raw signal), converted to the RMS (root mean square), expressed in μ V (microvolts) and saved in an *HP Pavilion notebook dv6* without contacting the electrical grid. A statistical analysis of the electromyographic data was performed using the average value of the signal in the RMS (absolute data) and with means of the normalized data (transformed into a percentage). The examinations were performed with the patient sitting on a chair without head support, in a normal posture, with relaxed pending upper limbs and both feet on the floor to stabilize the body posture. The same person performed all clinical and electromyographic tests on both groups. The therapy was provided over twelve weekly sessions in the study group, which included orofacial myology maneuvers and isometric, isotonic and isokinetic exercises. Therapeutic planning was performed according to the initial assessment of each subject, who was included in this group.

The MBGR protocol and EMG were applied to the control and study groups during session 01. A second assessment reproducing the same initial tests was performed only in the study group during session 12.

RESULTS

To analyze the data, the population of mouth breathers was divided into pre-therapy mouth breathers and post-therapy mouth breathers. An MS-Excel spreadsheet (MS-Office 2010 version) was used to organize the data, and the statistical package SPSS (Statistical Package for Social Sciences), version 20.0, was used to analyze the results.

With the objective of searching for possible differences between the groups under study (Mouth Breathers – OB and Nasal Breathers – NB) with respect to the variables of interest, including the morphological assessment of the lips, tongue, mastication and swallowing function, the *Mann-Whitney Test* was applied. For all variables, at the 'pre-therapy' time point, statistically significant differences were observed between the groups. (Tables 1-4)

The *Wilcoxon signed-rank test* was used to evaluate possible differences between pre-therapy and post-therapy in the mouth breather group with respect to the variables. For all variables in the mouth breather group, there was a statistically significant difference between the time points of observation.

In comparing the sexes on the variables under study in the MBGR, the *Mann-Whitney Test* indicated a non-significant difference. The *Spearman Correlation Analysis* was used to determine the level of relationship between the variable 'age' and other pre- and post-therapy

variables. There was no statistically significant difference at the time points of observation. The *Mann-Whitney Test* was applied to search for possible differences between the groups under study for the pre and post-therapy variables of interest. For almost all derivate variables of interest, statistically significant differences were found between the two groups under study. However, the differences in the pre- and post-therapy lip rest results were found to be non-significant.

Table 1: Morphological Evaluation of Mouth and Nasal Breathers

Variable	Group	N	Media	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 50 (Median)	Percentile 75	Sig. (p)
pre-t-lips MBGR	RO	30	9.53	1.66	6.00	12.00	9.00	10.00	10.25	< 0.001
	RN	30	0.40	0.62	0.00	2.00	0.00	0.00	1.00	
	Total	60	4.97	4.77	0.00	12.00	0.00	4.00	10.00	
pre-t-tg MBGR	RO	30	8.63	2.79	6.00	16.00	7.00	7.50	10.00	< 0.001
	RN	30	1.40	1.40	0.00	6.00	0.00	1.00	2.00	
	Total	60	5.02	4.25	0.00	16.00	1.00	6.00	7.75	
pre-t- MBGRmas t	RO	30	8.03	1.19	6.00	10.00	7.00	8.00	9.00	< 0.001
	RN	30	1.43	0.90	0.00	3.00	1.00	2.00	2.00	
	Total	60	4.73	3.49	0.00	10.00	2.00	4.50	8.00	
pre-t- MBGRswa ll	RO	30	9.13	2.68	6.00	16.00	6.75	9.00	10.25	< 0.001
	RN	30	2.43	0.82	1.00	4.00	2.00	2.00	3.00	
	Total	60	5.78	3.91	1.00	16.00	2.00	5.00	9.00	

Table 1 - Morphological Evaluation of Mouth and Nasal Breathers: N (number), Sig (significance), pre-t-lips MBGR (pre-therapy), pre-t-tg MBGR (pre-therapy tongue), pre-t-MBGR mas (pre-therapy mastication), pre-t-MBGR swa (pre-therapy swallowing)

Table 2 - Pre and Post Therapy Differences in Mouth Breathers

Variable	N	Media	Standard deviation	Minimum	Maximum	Percentile 25	Percentile 50 (Median)	Percentile 75	Sig. (p)
MBGR lipspre-t	30	9.53	1.66	6.00	12.00	9.00	10.00	10.25	< 0.001
MBGR lipspos-t	30	5.73	1.68	3.00	9.00	4.00	6.00	7.00	
MBGR tgpre-t	30	8.63	2.79	6.00	16.00	7.00	7.50	10.00	< 0.001
MBGR tgpos-t	30	5.43	2.11	3.00	12.00	4.00	5.00	7.00	
MBGR mast pre-t	30	8.03	1.19	6.00	10.00	7.00	8.00	9.00	< 0.001
MBGR mastpos-t	30	5.60	1.50	4.00	9.00	4.00	5.00	6.25	
MBGR swallowpre-t	30	9.13	2.68	6.00	16.00	6.75	9.00	10.25	< 0.001
MBGR swallowpos-t	30	6.57	2.27	4.00	12.00	5.00	6.00	8.00	

Table 2 - Pre and post therapy differences in mouth breathers: MBGR lips pre-t (pre-therapy), MBGR lips pos-t (post therapy), MBGR tg pre-t(pre-therapy),MBGR tg pos-t(post therapy),MBGR mast pre-t(pre-therapy),MBGR mast pos-t(post therapy),MBGR swallow pre-t(pre-therapy),MBGR swallow pos-t(post therapy).

Table 3 – Electromyographical Pre And Post Therapy Differences In Mouth Breathers

Variable	n	Media	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 50 (Median)	Percentile 75	Sig. (p)
Normal lippre-t	30	4.00%	0.55%	3.16%	5.63%	3.49%	4.06%	4.27%	0.001
Normal lippos-t	30	4.17%	0.51%	3.44%	5.48%	3.72%	4.22%	4.40%	
Lipsealingpre-t	30	12.29%	3.66%	5.31%	18.92%	9.44%	13.26%	14.31%	< 0.001
Lipsealingpos-t	30	7.74%	2.05%	3.86%	10.90%	6.06%	8.03%	9.39%	
MasticationRmaspre-t	30	26.56%	2.99%	20.99%	33.93%	24.55%	26.42%	28.11%	0.004
MasticationRmaspos-t	30	27.43%	2.70%	21.64%	32.06%	26.11%	27.28%	29.58%	
MasticationLmaspre-t	30	25.75%	2.28%	21.71%	30.22%	24.10%	25.94%	27.53%	0.003
MasticationLmaspos-t	30	26.23%	2.59%	20.82%	32.31%	24.41%	26.42%	28.15%	
Swallowingpre-t	30	44.72%	6.23%	33.57%	57.68%	40.62%	43.50%	48.48%	< 0.001
Swallowingpos-t	30	38.18%	5.30%	30.17%	50.74%	33.99%	37.54%	41.58%	

Table 3 –Electromyographical pre and post therapy differences in mouth breathers: Normal lip pre-t(Normal lips pre-therapy),Normal lip pos-t(Normal lips post-therapy),Lip sealing pre-t (pre-therapy),Lip sealing pos-t (post-therapy),Mastication Rmas pre-t (Right masseter muscle mastication pre-therapy), Mastication Rmas pos-t(Right masseter muscle mastication post-therapy),Mastication Lmas pre-t(Left masseter muscle mastication pre-therapy),Mastication Lmas pos-t(Left masseter muscle mastication post-therapy),Swallowing pre-t (pre-therapy), Swallowing pos-t (post-therapy)

Table 4 - Electromyographical differences between nasal breathers and pre and post therapy oral breathers

Variable	Group	N	Media	Standard Deviation	Minimum	Maximum	Percentile 25	Percentile 50 (Median)	Percentile 75	Sig. (p)
Normal lip pre-t	OB	30	4.00%	0.55%	3.16%	5.63%	3.49%	4.06%	4.27%	0.280
	NB	30	4.08%	0.35%	3.39%	4.58%	3.86%	4.13%	4.37%	
	Total	60	4.04%	0.46%	3.16%	5.63%	3.72%	4.11%	4.36%	
Lipsealing pre-t	OB	30	12.29%	3.66%	5.31%	18.92%	9.44%	13.26%	14.31%	< 0.001
	NB	30	4.08%	0.35%	3.39%	4.58%	3.86%	4.13%	4.37%	
	Total	60	8.19%	4.87%	3.39%	18.92%	4.13%	4.94%	13.29%	
Mastication Rmas pre-t	OB	30	26.56%	2.99%	20.99%	33.93%	24.55%	26.42%	28.11%	< 0.001
	NB	30	30.58%	3.10%	23.86%	35.66%	28.40%	31.00%	33.10%	
	Total	60	28.57%	3.63%	20.99%	35.66%	26.05%	28.23%	31.45%	
Mastication Lmas pre-t	OB	30	25.75%	2.28%	21.71%	30.22%	24.10%	25.94%	27.53%	< 0.001
	NB	30	30.15%	2.98%	23.75%	36.58%	28.04%	29.87%	32.49%	
	Total	60	27.95%	3.44%	21.71%	36.58%	25.55%	27.80%	29.95%	
Swallowing pre-t	OB	30	44.72%	6.23%	33.57%	57.68%	40.62%	43.50%	48.48%	< 0.001
	NB	30	30.87%	3.14%	25.72%	39.82%	29.02%	30.81%	31.96%	
	Total	60	37.80%	8.53%	25.72%	57.68%	30.77%	36.47%	43.65%	
Normal lip post-t	OB	30	4.17%	0.51%	3.44%	5.48%	3.72%	4.22%	4.40%	0.734
	NB	30	4.08%	0.35%	3.39%	4.58%	3.86%	4.13%	4.37%	
	Total	60	4.12%	0.43%	3.39%	5.48%	3.78%	4.15%	4.37%	
Lipsealing post-t	OB	30	7.74%	2.05%	3.86%	10.90%	6.06%	8.03%	9.39%	< 0.001
	NB	30	4.08%	0.35%	3.39%	4.58%	3.86%	4.13%	4.37%	
	Total	60	5.91%	2.35%	3.39%	10.90%	4.04%	4.50%	8.20%	
Mastication Rmas post-t	OB	30	27.43%	2.70%	21.64%	32.06%	26.11%	27.28%	29.58%	< 0.001
	NB	30	30.58%	3.10%	23.86%	35.66%	28.40%	31.00%	33.10%	
	Total	60	29.01%	3.29%	21.64%	35.66%	26.58%	28.90%	31.56%	
Mastication Lmas post-t	OB	30	26.23%	2.59%	20.82%	32.31%	24.41%	26.42%	28.15%	< 0.001
	NB	30	30.15%	2.98%	23.75%	36.58%	28.04%	29.87%	32.49%	
	Total	60	28.19%	3.40%	20.82%	36.58%	25.77%	28.09%	30.03%	
Swallowing post-t	OB	30	38.18%	5.30%	30.17%	50.74%	33.99%	37.54%	41.58%	< 0.001
	NB	30	30.87%	3.14%	25.72%	39.82%	29.02%	30.81%	31.96%	
	Total	60	34.52%	5.68%	25.72%	50.74%	30.65%	33.05%	38.39%	

Table 4 - Electromyographical differences between nasal breathers and pre and post therapy oral breathers: Normal lip pre-t(pre-therapy), Lip sealing pre-t(pre-therapy), Mastication Rmas pre-t(Right masseter muscle mastication pre-therapy), Mastication Lmas pre-t(Left masseter muscle mastication pre-therapy), Swallowing pre-t (pre-therapy), Normal lip post-t (post-therapy), Lip sealing post-t (post-therapy), Mastication Rmas post-t(Right masseter muscle mastication post-therapy), Mastication Lmas post-t(Left masseter muscle mastication post-therapy), Swallowing post-t (post therapy)

DISCUSSION

In the MBGR protocol, the mastication and swallowing functions were chosen among other stomatognathic functions because they are intrinsically related to breathing with the synergy of the orofacial myology muscles (Winter, 1987; Weir, Mahoney, Haan & Davis, 1999; Busanello-Stella, Blanco-Dutra, Corrêa & Silva, 2015). According to the results obtained by assessing the MBGR protocol without the etiology of mouth breathing, the pre-therapy results were worse for mouth breathers and all variables showed significant improvement in the final assessment (post-therapy), indicating the efficacy of orofacial myology therapy for all aspects studied. The non-significant effect of the variable 'age' may be explained by the short time lapse between the collection of data (3 months).

The literature reports that the amplitude and frequency of an electromyographic signal are sensitive to intrinsic factors, such as the depth and diameter of the muscular fiber, and extrinsic factors, such as the form of and distance between the electrodes. Considering other individual morphological differences and various approaches for potential acquisition, it was necessary to normalize the signal (Hermens & Freriks, 2000; Armijo-Olivo, Gadotti, Korneru, Lagravère & Flores-Mir, 2007; Duarte Kroll, Bérzin & Alves, 2010).

To perform the normalization, we transformed the absolute values of the amplitude of the obtained wave into relative values, referring to a value of the amplitude characterized as 100%. According to the known signal variability, not only among subjects but also among data gathering trials, different techniques were developed; for example, one technique starts at the moment of the

maximum voluntary isometric contraction - MVIC (Burden & Bartlett, 1999).

The variables of interest in this study were significant, except for "lip rest pre- and post-therapy". This result is likely because lip rest does not require open, semi-open or closed lips. We analyzed the lip rest as the normal posture for each subject.

Mouth breathers performed better after therapy compared with before therapy. By contrast, when comparing the study and control groups, the mouth breather group performed worse after therapy than the control group (1st assessment). This result can be explained by the insufficient time for therapy or the lower averages of electrical activity on the muscles of mastication for mouth breather children, who have a tendency to exhibit a vertical craniofacial growth pattern; however, this finding is not observed in all studies (Bianchini, Guedes & Vieira, 2009; Franco, Souki, Cheib, Abrão, Pereira, Becker & Pinto, 2015). To understand the average number of orofacial myology therapy sessions necessary to automate nasal breathing, longitudinal studies on clinical and electromyographic assessments of the etiology of mouth breathing, facial patterns, occlusive relations and employed therapeutics are needed.

For mouth breathers, after twelve myofunctional orofacial myology therapy sessions, the nasal breathing perception and regulation of the muscular strength according to the functional activity demands improved.

After twelve orofacial myology therapy sessions, the mouth breathers still presented with inadequate muscle strength when compared with nasal breathers; however, some improvement was observed.

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AUTHOR DECLARATION

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property. We further confirm that any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript. We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author and which has been configured to accept email from: almiromachadophd@gmail.com

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