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INFLUENCE OF RESPIRATORY BIOFEEDBACK ASSOCIATED WITH A QUIET BREATHING PATTERN ON THE PULMONARY FUNCTION AND HABITS OF FUNCTIONAL MOUTH BREATHERS

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ABSTRACT

Objective: To evaluate the effects of using respiratory biofeedback associated with a quiet breathing pattern, on chest circumference, pulmonary function, respiratory muscle strength and the following functional mouth-breathing habits: watching things with mouth open, sleeping with mouth open, dribbling on the pillow, difficulty in waking up, snoring and restlessness during sleep. Method: Twenty functional mouth-breathing children were evaluated. They underwent 15 sessions of respiratory biofeedback by means of the biofeedback pletsmovent (MICROHARD® V1.0), which provided biofeedback on thoracoabdominal movements. Chest circumference, spirometry and maximum static respiratory pressures were determined before and after the therapy. The adults responsible for these children were asked questions about the children's mouth-breathing habits. Student's t test for paired data and non-parametric tests were used to analyze the data. Results: The use of respiratory biofeedback in association with a quiet breathing pattern did not produce significant alterations in chest circumference or in forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), peak expiratory flow (PEF), Tiffeneau index (TI) or maximal expiratory pressure (MEP). However, there was a significant difference in maximal inspiratory pressure (MIP) (-53.6 ± 2.9 cmH_2O vs. -65.0 ± 6.0 cmH_2O; $p< 0.05$) and there were significant changes in the evaluated habits. Conclusion: The results allow the conclusion that respiratory biofeedback associated with a quiet breathing pattern improves the inspiratory muscle strength and habits of functional mouth-breathers. It can therefore be used as a therapeutic method for such individuals.

Key words: mouth breathing; physical therapy; respiration.

RESUMO

Influência do Biofeedback Respiratório Associado ao Padrão Quiet Breathing Sobre a Função Pulmonar e Hábitos de Respiradores Bucais Funcionais

Objetivos: Avaliar os efeitos da utilização do *biofeedback* respiratório (BR) associado ao padrão *quiet breathing* sobre a perimetria torácica, função pulmonar, força dos músculos respiratórios e os seguintes hábitos de respiradores bucais funcionais (RBF): vigília de boca aberta, boca aberta durante o sono, baba no travesseiro, despertar difícil, ronco e sono inquieto. Métodos: Foram avaliadas 20 crianças RBF, as quais foram submetidas a 15 sessões de BR por meio do *biofeedback* pletsmovent (MICROHARD® V1.0), o qual proporciona o *biofeedback* dos movimentos tóraco-abdominais. Perimetria torácica, espirometria e medidas das pressões respiratórias máximas estáticas foram realizadas antes e após a terapia. Questões respondidas pelos responsáveis foram utilizadas para avaliar os hábitos dos RBF. Os dados foram analisados por meio de teste t de Student para dados pareados e testes não paramétricos. Resultados: O uso do BR associado ao padrão *quiet breathing* não produziu alterações significativas na perimetria torácica e nos valores de volume expiratório forçado no primeiro segundo (VEF_1), capacidade vital forçada (CVF), pico de fluxo expiratório (PFE), índice de Tiffeneau (IT) e na pressão expiratória máxima (PEmáx). Entretanto, a pressão inspiratória máxima (PImáx) apresentou diferença estatisticamente significativa (-53,6 ± 2,9 cmH_2O vs. -65,0 ± 6,0 cmH_2O; $p< 0,05$) e ocorreram mudanças significativas nos hábitos avaliados. Conclusão: Os resultados permitem concluir que o BR associado ao padrão *quiet breathing* melhora a força da musculatura inspiratória e hábitos em RBF, podendo ser, portanto, utilizado como uma das formas de terapia nesses indivíduos.

Palavras-chave: respiração bucal; fisioterapia; respiração.

INTRODUCTION

Mouth breathing syndrome consists of a set of signs and symptoms that may be partially or fully present in individuals who, for various reasons, replace the correct nasal breathing pattern with mouth or mixed breathing[1].

Among these individuals, the functional mouth breathers stand out as their obstructions to nasal breathing have been corrected but they continue to breathe through the mouth in spite of having an absolutely permeable upper tract[2].

Mouth breathing causes respiratory[1,3], facial[4], postural[5,6] and behavioral[2,7] alterations which damage the mouth breather's quality of life[7]. All these characteristics produce a vicious circle which leads to a more serious problem, that is, a decrease in the self-esteem of the sufferers[4].

Because mouth breathing can cause serious alterations, it is extremely important for patients to undergo treatment. A professional team must be able to provide this treatment in order to assist the patient comprehensively[8]. Physical therapy plays a vital role in the treatment, as it corrects breathing, improves pulmonary ventilation, prevents and corrects chest deformities and posture alterations and re-educates the muscles involved in the alterations[9-11].

Several physical therapy techniques have been used to treat patients with respiratory disorders including respiratory biofeedback (RB), which provides the patient with visual information about one or more physiological events related to breathing, e.g. respiratory frequency, peripheral oxygen saturation, fraction of exhaled carbon dioxide, flow volume, respiratory flows, and chest and abdomen movements. These are shown to the patients to teach them how to manipulate these events for their own therapeutic benefit, which may lead them to improve respiratory performance[12].

The use of RB proved to be efficient among cystic fibrosis[13], chronic obstructive pulmonary disease[14] and asthma sufferers[15,16], however no reports were found in the literature regarding its application in the treatment of mouth breathers.

Taking these aspects into account, the intention of this study is to evaluate the effect of RB associated with a quiet breathing pattern on chest circumference, pulmonary function, respiratory muscle strength, and the following habits common to functional mouth-breathing children: watching things with mouth open, sleeping with mouth open, drooling on the pillow, difficulty in waking up, snoring and restlessness during sleep.

MATERIALS AND METHODS

For this study, we analyzed the data from twenty functional mouth-breathing children with a mean age of 9.4 ± 1.1 years, of which 60% were male and 40% female, selected among 3rd to 6th grade students from Objetivo School – Maringá – PR, all of whom had a similar socioeconomic background. The mean height of these children was 137.6 ± 10.7 centimeters and their mean weight, 33.54 ± 9.0kg.

The study received approval from the Committee for Ethics in Research of Universidade do Oeste Paulista – UNOESTE, under protocol number 013/01, according to Resolution 196/96 from the Conselho Nacional de Saúde (National Health Council) of 10/10/1996. The adults responsible for those children were duly informed about all the procedures used in the study and the proposed objectives and, upon agreement, they signed a free and informed consent.

For the selection, a questionnaire was filled out by the guardians to identify the children most likely to be mouth-breathers. This questionnaire was developed specifically for this purpose and referred to the children's identification, personal and family history, socioemotional relationships, social and home environment, socioeconomic evaluation and, especially, the presence of typical mouth-breathing habits and behaviors. After the analysis of the questionnaires, the children who presented signs and symptoms which indicated the presence of mouth breathing syndrome and whose guardians had allowed them to take part in the study were examined by a pediatrician to confirm the diagnosis, which was made by means of anamnesis and by a test where the child is asked to breathe steam against a mirror.

Children were excluded if they presented mechanical air flow obstructions, allergic rhinitis associated with any breathing pathology, neurological or orthopedic pathologies, or any visual or hearing impairment.

Before receiving treatment, the children underwent several tests, namely chest circumference taken at xiphoid process and axillary level; assessment of respiratory function through spirometry to determine forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), Tiffeneau index (TI) and peak expiratory flow (PEF); and measurement of maximum static respiratory pressures to determine maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP). The same procedures were repeated after treatment.

Chest circumference at axillary and xiphoid process level was taken with a measuring tape while the children stood on their feet, breathing through the nose at total lung capacity (TLC), residual volume (RV), and functional residual capacity (FRC), as described by Carvalho[17].

To carry out the spirometry, we used a MIR Spirobank spirometer following the criteria described by the Brazilian Consensus on Spirometry[18] and the Guidelines for Lung Function Tests[19]. The children sat at 90º with hip flexion, no back rest, arms relaxed and upright spine. During the test, they were allowed to move their trunk forward to exhale as much air as possible. The interpretation of the spirometries and the quantification of the ventilatory disorders were conducted according to Rozov's recommendations[20].

The maximum static respiratory pressure measures were taken with the use of a MVD300® digital manovacuometer following the criteria described by ATS/ERS[21]. The children were previously instructed on the test and remained seated, wearing a nose clip, during its execution. For the MIP measurement, the children were told to perform maximal inhalation from RV, and for the MEP measurement, the children were told to perform maximal exhalation from TLC. These measures were taken 3 times and the greatest value was considered for analysis.

Treatment was carried out with a biofeedback pletsmovent (MICROHARD® V1.0 developed by GLOBAL-MED – RS) connected to a Pentium II – 133 MHz computer which analyzed the thoracoabdominal movements. This equipment provided the children with visual feedback on their thoracic and abdominal breathing patterns. This feedback was displayed on the computer screen divided into three overlapping sections which showed thoracic breathing (upper line), abdominal breathing (middle line) and the difference between the thoracic and the abdominal breathing (lower line).

Figure 1 illustrates the screen displayed by the computer, before and after the performance of the RB therapy associated with a quiet breathing pattern in a functional mouth-breather.

The equipment was calibrated by inflating the bands positioned at axillary and epigastric levels, using a rubber tube, until the attached manometer displayed level zero.

There were fifteen daily treatment sessions, not including Sundays, each lasting 30 minutes. The children had a ten-minute rest before the start of the session to reach a quiet breathing pattern. After being fitted with the thoracic and abdominal bands, positioned in the axillary and epigastric areas respectively, the children were placed facing the computer screen in fowler position at 90º, with arms resting on their thighs, legs relaxed, and feet resting flat on the floor. The equipment was calibrated and the therapy was carried out with the child in this position.

During the sessions, the children, always accompanied by the physical therapist, visualized the lines shown on the computer screen and were advised to breathe using a quiet breathing pattern, which is characterized by calm, soft lung ventilation within near basal flow volume range and normal respiratory rate values[12]. These aspects were guaranteed by the guidance and monitoring of the physical therapist.

To achieve this pattern, the children breathed in such a way that the lower line of the computer screen remained flat. By constantly monitoring that line, the children corrected the breathing pattern whenever necessary.

The influence of RB, associated with a quiet breathing pattern, on common habits of mouth-breathing children was evaluated by means of questions to their guardians, before and after the treatment. These questions dealt with the following habits: watching things with mouth open, sleeping with mouth open, drooling on the pillow, difficulty in waking up, snoring, and restlessness during sleep.

To analyze the data on chest circumference, respiratory function, and maximum static respiratory measures, we first applied the Shapiro-Wilks test to verify the normality of the data. When normal distribution was accepted, we applied the Student t-test for paired data (FEV_1, FVC, PEF, and MEP) and, where normal distribution could not be accepted, we applied the Wilcoxon test (chest circumference, TI, and MIP).

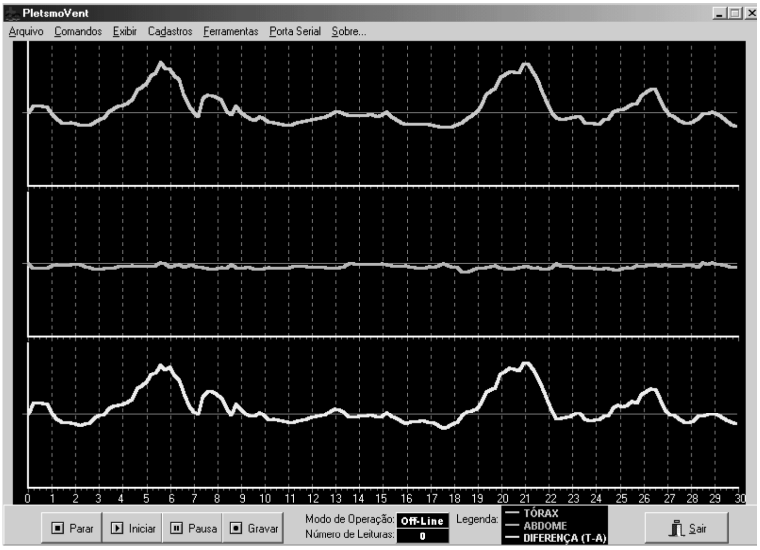
The analysis of the influence of RB application associated with a quiet breathing pattern on the habits of mouth-breathers was based on a frequency distribution table, and the non-parametric Cochran-Mantel-Haenszel test was used to verify the existence of association between the response and the groups. Differences in these tests were considered statistically significant when the "p" value was less than 0.05. In order to carry out the statistical analysis, the SAS (Statistical Analysis System) software version 8.1 was used.

RESULTS

The mean values for chest circumference at xiphoid process level, given in centimeters, in RV, TLC and FRC, before treatment were 65.0 ± 1.8; 68.3 ± 1.6 and 64.3 ± 1.8, respectively. After treatment, these values were 64.8 ± 1.7; 67.7 ± 1.7 and 63.5 ± 1.7, respectively. As for chest circumference at axillary level, given in centimeters, the values before treatment were 68.8 ± 1.8; 71.5 ± 1.7 and 67.1 ± 1.8, and after treatment, 68.9 ± 1.7; 71.7 ± 1.6 and 67.1 ± 1.7, respectively. The statistical analyses showed that the therapy did not produce significant alterations in these values (Wilcoxon test; $p > 0.05$).

The analyses of FEV_1, FVC, and PEF values

(A)



(B)

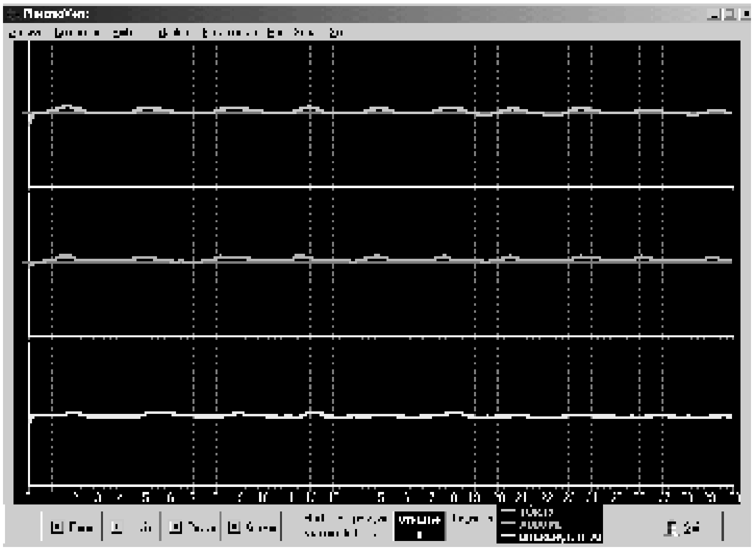


Figure 1. Illustration of the computer screen before (A) and after (B) the therapy with respiratory biofeedback associated with quiet breathing in functional mouth-breathers. The upper line indicates the thoracic movement, the central line abdominal movement, and the lower line the difference between these movements.

Table 1. Mean values and respective standard errors for the pulmonary function evaluation of functional mouth-breathers before and after the therapy with respiratory biofeedback associated with a quiet breathing pattern.

Spirometry	Pre-Treatment	Post-Treatment
FEV_1 (liters)	1.7 ± 0.07	1.7 ± 0.08
FVC (liters)	1.9 ± 0.09	1.8 ± 0.09
TI (%)	95.0 ± 1.5	96.5 ± 1.1
PEF (*liters/min*)	267.2 ± 14.5	272.9 ± 10.1

FEV_1 = forced expiratory volume in the first second; FVC = forced vital capacity; TI = Tiffeneau index; PEF = peak expiratory flow; FEV_1, FVC, PEF analyzed with paired Student t-test (p> 0.05); TI values analyzed with Wilcoxon test (p> 0.05).

showed that the application of RB associated with a quiet breathing pattern did not produce alterations in these parameters (Student t-test; p> 0.05; Table 1). The same occurred for the TI responses (Wilcoxon's test; p> 0.05; Table 1).

As for the FCV and FEV_1 values, FCV was on average 83.3% of the predicted value before treatment and 78.9% after treatment; and FEV_1 was on average 82% of the predicted value both before and after treatment. These children were classified, according to Rozov[20], as having restrictive respiratory disorders.

As seen in Table 2, there were no significant statistical differences in the MEP of functional mouth-breathers before and after the treatment (Student t-test; $p > 0.05$). In contrast, there were significant differences in MIP after the treatment (Wilcoxon test; $p < 0.05$; Table 2).

Table 3 shows statistically significant differences (Cochran-Mantel-Haenszel test; $p < 0.05$) in habits common to these children before and after the training with RB associated with a quiet breathing pattern.

Table 2. Mean values and respective standard errors for maximal expiratory pressure (MEP) and maximal inspiratory pressure (MIP) of functional mouth-breathers before and after the therapy with respiratory biofeedback associated with a quiet breathing pattern.

Maximal Respiratory Pressures (cmH_2O)	Pre-Treatment	Post-Treatment
MEP	70.2 ± 3.9	67.8 ± 2.8
MIP	-53.6 ± 2.9	-65.0 ± 6.0*

*Significant statistical difference when compared with the pre-treatment value (Wilcoxon test; $p < 0.05$).

DISCUSSION

The results of this study showed, by means of chest circumference evaluation, that the use of RB associated with a quiet breathing pattern in functional mouth-breathing children did not influence the expansion or retraction of the thorax and abdomen, which can be explained by the type of respiratory training used during the treatment. Apparently, the pattern used in training is also related to the non-occurrence of significant values for FEV_1, FVC, TI, and PEF.

As previously mentioned, the quiet breathing pattern is characterized by calm, soft lung ventilation within near basal flow volume range and normal respiratory rate values[12]. Thus, the manner in which training was conducted may explain the absence of alterations in the evaluated measures.

The values found for FVC and FEV_1 were below normal in relation to the predicted values, which allowed the individuals to be classified as having restrictive respiratory disorders[20].

These findings are in accordance with those by Dias et al.[22], which also classified mouth-breathing individuals as having restrictive ventilatory disorders, as they presented a decrease in FVC. The restrictive disorders presented by these individuals may be due to postural alterations and thoracic deformities, such as thoracic kyphosis and *pectus excavatum*[3,23].

The comparisons between maximum static respiratory pressures did not show statistically significant differences for MEP between the values collected before and after the treatment with RB associated with a quiet breathing pattern. Nevertheless, significant differences occurred to the MIP after the treatment that went from -53.6 ± 2.9 to -65.0 ± 6.0 cmH_2O. This MIP increase seems to indicate that the children developed a better use of their diaphragm muscles, reeducating their function and directly influencing inspiratory muscular strength.

Variations in respiratory muscle strength produce alterations in the dynamics of the respiratory movements and, consequently, alterations in the respiratory mechanics[24]. Changes were observed in the children's respiratory patterns through the evaluation of the RB screens.

In Figure 1A, which shows a child's pre-treatment respiratory pattern while breathing spontaneously and facing away from the equipment, one can observe an irregular respiratory pattern and a thoracic predominance (upper line), while the abdominal area (middle line) presents a smaller range of motion and little variation. Due to the difference between thoracic and abdominal breathing, the lower line is also irregular. The same respiratory pattern was observed before RB application in 50% of the children evaluated, whereas the other 50% had an irregular respiratory pattern, but with greater range of motion in the abdominal area.

Figure 1B shows the same child's post-treatment RB screen while breathing spontaneously and facing away from the equipment. One can observe that the respiratory pattern became more balanced and better distributed in relation to the thorax and to the abdomen. After RB use, all of the children presented the same breathing pattern as the one described above. Unfortunately the RB software does not provide the option of measuring this pattern in a quantitative way, which represents a methodological limitation. However, the graphics provided by the equipment clearly show an improvement in the ventilatory pattern with RB therapy associated with a quiet breathing pattern.

According to Costa[25], techniques for functional respiratory reeducation promote knowledge and automation of respiratory movements in patients who did not have a good level of awareness of these movements, adjusting them to the body's needs. The basis for these techniques is sensorial integration or reintegration of the thoracic and abdominal movements during the breathing phases. Once they are aware of their inspiratory and expiratory movements, individuals are able to control, among other things, the rhythm, frequency, and depth of their breathing, something which appears to have been achieved in the children through the application of RB associated with a quiet breathing pattern.

The results also showed that the treatment had a significant influence on the reduction of common habits among mouth-breathers, such as watching things and sleeping with mouth open, drooling on the pillow, snoring, and restless sleep,

Table 3. Pre and post-treatment percentage values and number of cases of presence, improvement, and absence of habits of functional mouth-breathers submitted to respiratory biofeedback therapy associated with a quiet breathing pattern.

	Pre-Treatment		Post-Treatment *		
Habits	**Presence**	**Absence**	**Presence**	**Absence**	**Improvement**
Watching things with mouth open	90.00 (18)[a]	10.00 (02)	5.00 (01)	35.00 (07)	60.00 (12)
Sleeping with mouth open	95.00 (19)	5.00 (01)	15.00 (03)	35.00 (07)	50.00 (10)
Drooling on pillow	70.00 (14)	30.00 (06)	10.00 (02)	70.00 (14)	20.00 (04)
Difficulty in waking up	60.00 (12)	40.00 (08)	25.00 (05)	45.00 (09)	30.00 (06)
Snoring	95.00 (19)	5.00 (01)	10.00 (02)	70.00 (14)	20.00 (04)
Restless sleep	85.00 (17)	15.00 (03)	20.00 (04)	20.00 (04)	60.00 (12)

[a] Number of cases; * Significant difference between pre-treatment for all habits (Cochran Mantel Haenszel test; $p < 0.05$).

thus improving the children's process of waking up.

After the treatment with RB associated with a quiet breathing pattern, most children presented improvements in lip closure, both while watching and resting, which seems to indicate an alteration in respiratory type, and possibly, an improvement in lung ventilation. These aspects may be related to reduced snoring and drooling on the pillow, and the improvement in the quality of sleep and in the process of waking up in the morning.

CONCLUSION

The results presented suggest that RB use associated with quiet breathing has the potential to be a therapeutic method for functional mouth-breathing individuals.

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