Original Article

Influence of the technique of re-educating thoracic and abdominal muscles on respiratory muscle strength in patients with cystic fibrosis*

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ABSTRACT

Objective: To determine the effect that re-education of the thoracic and abdominal muscles has on the respiratory muscle strength of patients with cystic fibrosis evaluated over time at the Cystic Fibrosis Outpatient Clinic of the *Universidade Católica de Brasília* (Catholic University of Brasília). **Methods:** The sample consisted of 29 cystic fibrosis patients, characterized based on anthropometric, genetic and bacterial colonization data. The patients were submitted to physical therapy sessions, involving re-education of the respiratory muscles, twice a week for four months. Spirometry, pressure manometry and anthropometry were performed before and after each session. **Results:** Comparing baselines values to those obtained after physical therapy, increases in maximum inspiratory pressure and maximum expiratory pressure were observed in all patients, those without any obstructive respiratory disease and those with mild obstructive respiratory disease ($p < 0.05$). A positive correlation between age and maximum expiratory pressure was observed for most of the patients. Maximum inspiratory pressure correlated positively with age only in the group with mild obstructive respiratory disease ($p = 0.012$; $r = 0.817$). In female patients and in the group of patients without obstructive respiratory disease, a negative correlation was observed between maximum expiratory pressure and colonization with *Pseudomonas aeruginosa* ($p = 0.036$; $r = -0.585$). **Conclusion:** Use of the thoracic and abdominal muscle re-education technique increased respiratory muscle strength in the cystic fibrosis patients studied, a finding that underscores the importance of including physical therapy in the treatment of these patients.

Keywords: Cystic fibrosis/rehabilitation; Physical therapy technique; Respiratory muscles; Forced expiratory volume; Inspiratory capacity; Vital capacity

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INTRODUÇÃO

Cystic fibrosis (CF) is a genetic disease, transmitted through autosomal recessive inheritance, whose average frequency is estimated to be 1:2500 live Caucasian births. Its principal manifestations, appearing in different degrees of clinical expression, characterize the triad that consists of chronic obstructive suppurative pulmonary disease, increased electrolyte concentrations in the sweat and exocrine pancreatic insufficiency.[1]

To date, more than 1400 mutations in the gene of the cystic fibrosis transmembrane conductance regulator protein have been shown to be related to the disease.[2] The ΔF508 mutation consists of the deletion of three base pairs, which causes the loss of a phenylalanine amino acid at position 508 of the protein, and is responsible for approximately 60% of all CF cases.[3]

The physiopathology of the pulmonary involvement in CF has yet to be fully elucidated.[4] In some patients, the earliest alterations begin with changes in the caliber of the small airways. In others, pulmonary function remains normal in the first year of life.[5] The clinical course of the pulmonary aspect of the disease is influenced by chronic inflammation of the airways and by bacterial infections, which predispose to air trapping and modify the respiratory system compliance, increasing respiratory effort and decreasing respiratory muscle strength.[4,6] This last factor may be evaluated through pressure manometry, a noninvasive method that is simple and practical.[7]

Individuals with CF require multidisciplinary treatment due to the dysfunctions presented.[8] Respiratory therapy is an essential part of the treatment of the disease, and various physical therapy techniques can be used, from traditional ones, such as percussion, vibration and postural drainage, to nontraditional ones, such as noninvasive mechanical ventilation, flutter, autogenic drainage and active respiration cycle, as well as thoracic and abdominal muscle re-education. Although the thoracic and abdominal muscle re-education technique, devised by Lima,[9] is widely used in daily clinical practice, it has yet to be fully investigated.

Therefore, the objective of the present study was to determine the effect that thoracic and abdominal muscle re-education has on respiratory muscle strength in CF patients.

METHODS

A total of 38 CF patients, diagnosed based on the criteria recommended by the Cystic Fibrosis Foundation in 1999,[10] were evaluated.

The patients were participating in the multidisciplinary treatment program at the Cystic Fibrosis Outpatient Clinic of the Catholic University of Brasília. We excluded 4 patients who were under six years of age and 5 patients who, upon examination, showed signs of pulmonary exacerbation, including fever, increased cough or increased sputum production.[11] Therefore, the study sample consisted of 29 patients.

The study was approved by the Catholic University of Brasília Ethics Committee. All patients gave written informed consent.

The evaluations described herein were carried out prior to and after four months of therapy involving thoracic and abdominal muscle re-education, with the exception of the genetic evaluation and the bacterial culture, which were carried out based on data obtained from the medical charts of the patients.

In the genetic evaluation, we only observed the presence or absence of the ΔF508 mutation. The patients were classified as homozygous (ΔF508/ΔF508), heterozygous (ΔF508/Non-ΔF508), and as individuals with other mutations (Non-ΔF508/Non-ΔF508), based on the presence of two, one or no chromosomes presenting the ΔF508 deletion. Other mutations were not evaluated.

In the microbiological evaluation, we took only chronic colonization with Pseudomonas aeruginosa into consideration.

All spirometric tests were carried out according to the criteria for acceptability and reproducibility recommended by the First Brazilian Consensus on Spirometry.[12] The variables studied were forced vital capacity, forced expiratory volume in one second, and the ratio between them. Absolute values, as well as percentage of predicted values for gender, age and height,[13] were determined using a Vmax - 229 series spirometer (Sensor Medics, Yorba Linda, CA, USA). The degree of airway obstruction was determined according to the criteria established by the I Brazilian Consensus on Spirometry.[12]

Respiratory muscle strength was determined through the measurement of maximal inspiratory and maximal expiratory pressures (MIP and MEP, respectively) using a GeRar® pressure manometer.

To determine MIP, the patient was asked to inhale through the mouthpiece, beginning at residual volume and inhaling as deeply as possible. To determine MEP, the patient was asked to exhale, beginning at total lung capacity and continuing until no longer possible, and the peak pressure values were registered.[7] Five inspiratory and five expiratory maneuvers were performed, and the highest MIP and MEP values, expressed in cmH_2O, were selected. The values obtained were compared to the parameters of normality using the prediction equations developed by Wilson et al. (Chart 1).[14]

Body mass index was calculated as the relationship between weight in kilograms) and height^2 (in meters). The measurements were performed using a wall stadiometer (Kirchnner Wilhelm, Medizintechnik, Germany) and a digital scale (Filizola®, Indústria Filizola S/A, São Paulo, Brazil).

The patients were submitted to two 50-minute sessions of thoracic and abdominal muscle re-education per week for a period of four months. The sessions consisted mainly of the following: appropriate positioning; passive, active and active-assisted stretching of respiratory muscles and general muscles; respiratory muscle and general muscle strengthening; thoracic and abdominal strapping; and myofascial release techniques.[9] The physiotherapists who applied this method of treatment received specific training from the physicians who devised it and had ample practical experience.[9] Patient handling was oriented by the respiratory pattern and posture of each patient, as well as by the pulmonary auscultation findings.

Statistical analysis was carried out using the total patient sample and using groups selected based on gender, presence of colonization, genetic mutation and degree of airway obstruction. The variables were analyzed using the Statistic Package for Social Sciences (SPSS) software program, version 10.0 (SPSS, Inc.) Pearson's correlation test was used to evaluate the level of correlation among the variables studied. The Student's t-test was applied to paired samples in order to compare the measurements made prior to and after physical therapy and to independent samples in order to compare the measurements obtained in the various groups. The level of significance was set at $p < 0.05$.

RESULTS

The study sample consisted of 29 patients, and, of those, 13 were female. Mean age in the study sample was 10 ± 5.6 years, ranging from 7 to 28 years. Anthropometric, microbiological, nutritional and genetic data, as well as data regarding pulmonary function, are shown in Table 1. After four months of physical therapy, there was no significant change in spirometric or anthropometric data.

After physical therapy, there were significant increases in MIP (95 ± 26 cmH_2O versus 110 ± 20 cmH_2O) and MEP (92 ± 26 cmH_2O versus 110 ± 20 cmH_2O) ($p < 0.05$) for all patients (Figure 1). A positive correlation was found between MEP and age ($p = 0.007$; $r = 0.668$).

The application of the statistical tests in the various groups of patients (Table 2) revealed that, regarding gender, there was an increase in MIP and MEP in both male and female patients. A significant positive correlation was found between MEP and age ($p = 0.007$; $r = 0.645$) only in male patients.

Regarding the degree of airway obstruction, there was an increase in MIP and MEP in the patients presenting no obstructive respiratory disorder (ORD) ($p < 0.05$). In patients with mild ORD, only MEP increased significantly ($p < 0.05$), and there was a positive correlation between MEP and age ($p = 0.016$; $r = 0.796$) as well as between MIP and age ($p = 0.012$; $r = 0.817$). In patients with moderate or severe ORD, there was a positive correlation between MEP and age ($p = 0.035$; $r = 0.846$), MEP increasing

Chart 1- Prediction equations for MIP and MEP[14]

Prediction equations - MIP (cmH_2O)		Prediction equations - MEP (cmH_2O)	
Men:	142 - (1.03 × age in years)	Men:	180 - (0.91 × age in years)
Women:	-43 + (0.71 × height in cm)	Women:	3.5 + (0.55 × height in cm)
Boys:	44.5 + (0.75 × weight in kg)	Boys:	35 + (5.5 × age in years)
Girls:	40 + (0.57 × weight in kg)	Girls:	24 + (4.8 × age in years)

MIP: maximum inspiratory pressure; MEP: maximum expiratory pressure.

TABLE 1

Demographic, anthropometric, genetic, microbiological and nutritional data, as well as data regarding pulmonary function, of the total sample by gender

	Total sample	Males	Females
Number of patients*	29	16	13
Mean age (years) ± SD	10 ± 5.6	9.39 ± 5.7	11.2 ± 5.7
Mean BMI (kg/m2) ± SD	17.4 ± 2.5	17.5 ± 2.5	17.4 ± 2.4
FEV_1 (% of predicted) ± SD	80.4 ± 25.4	83.8 ± 21.5	71.4 ± 29.0
FVC (% of predicted) ± SD	84.5 ± 19.7	88.6 ± 21.0	73.4 ± 25.0
FEV_1/FVC ± SD	83.7 ± 12.7	82.3 ± 12.5	85.1 ± 15.0
Without ORD*	16	10	6
Mild ORD*	7	5	2
Moderate ORD*	3	0	3
Severe ORD*	3	1	2
Genotype			
ΔF508/ΔF508 *	7	5	2
ΔF508/Non ΔF508 *	8	6	2
Non ΔF508/Non ΔF508 *	14	5	9
Pseudomonas aeruginosa *	21	11	10

*Number of cases

SD: standard deviation; BMI: body mass index; FEV_1: forced expiratory volume in one second; FVC: forced vital capacity; ORD: obstructive respiratory disorder

in parallel with advancing age.

Regarding the genotype, we found an increase in MIP and MEP in patients presenting other mutations (Non-ΔF508/Non-ΔF508). The ones who were homozygous (ΔF508/ΔF508) only presented improvement in MEP ($p < 0.05$). In this group, MEP also correlated positively with age ($p = 0.002$; $r = 0.93$).

Regarding colonization with P. aeruginosa, there was an increase in MIP and MEP in colonized and noncolonized patients ($p < 0.05$). In the group of colonized patients, MEP again correlated positively with age ($p = 0.005$; $r = 0.59$).

In female patients, in addition to the respiratory pressures, colonization with P. aeruginosa was found to correlate negatively with forced vital capacity and forced expiratory volume in one second ($p = 0.016$; $r = -0.651$ and $p = 0024$; $r = -0.619$, respectively). In this group, the female patients presented a higher degree of airway obstruction than did the male patients, all except one of whom presented either mild ORD or normal spirometric parameters.

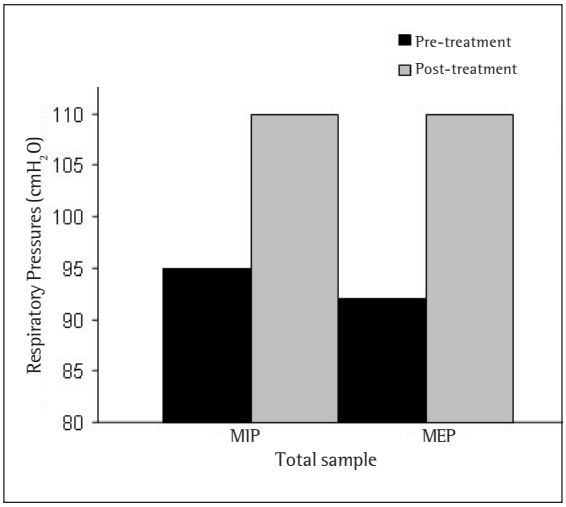

Figure 1. Maximum inspiratory and maximum expiratory pressures prior to and after physical therapy in the total sample of patients with cystic fibrosis ($p < 0.05$)
MIP: maximum inspiratory pressure; MEP: maximum expiratory pressure

DISCUSSÃO

There are conflicting data in the literature regarding respiratory muscle strength in CF patients. Some authors state that MIP and MEP values in healthy individuals are similar to those found for CF patients and might actually be above normal values in the latter.[15-16] In contrast, other authors have reported that maximum respiratory pressures are decreased in CF patients.[17-19]

The present study showed mean respiratory pressures values that were above the norm. This can

TABLE 2

Maximum inspiratory and maximum expiratory pressures prior to and after physical therapy in the various groups of patients with cystic fibrosis

	MIP (cmH_2O)		MEP (cmH_2O)	
	Pre-tratament	Post-tratament	Pre-tratament	Post-tratament
Female patients	82 ± 24	97 ± 30*	85 ± 23	106 ± 24*
Male patients	95 ± 26	110 ± 20*	92 ± 26	110 ± 26*
Without ORD	87 ± 24	106 ± 18*	88 ± 21	103 ± 25*
Mild ORD	105 ± 27	111 ± 23	94 ± 34	118 ± 22*
Moderate ORD	90 ± 25	108 ± 38	90 ± 15	113 ± 18
Severe ORD	110 ± 53	130 ± 71	120 ± 28	140 ± 57
Genotype				
ΔF508/ΔF508	99 ± 25	108 ± 19	83 ± 24	111 ± 22*
ΔF508/Non ΔF508	86 ± 24	110 ± 83	99 ± 24	109 ± 26
NonÄF508/Non ÄF508	101 ± 31	110 ± 22*	93 ± 33	111 ± 31*
Colonized with *P. aeruginosa*	99 ± 28	114 ± 21*	96 ± 28	110 ± 24*
Not colonized with *P. aeruginosa*	81 ± 15	98 ± 10*	80 ± 17	110 ± 35*

MIP: maximum inspiratory pressure; MEP: maximum expiratory pressure; ORD: obstructive respiratory disorder; Values are expressed as mean standard deviation ($p < 0.05$)

be explained by the fact that 55% of the patients studied had not yet presented any pulmonary function impairment. These data are corroborated by those from another study,[15] in which respiratory pressures were found to be preserved in CF patients, regardless of nutritional state or the presence of hyperinflation. In contrast, other authors[19] observed that, among the determining factors for respiratory muscle strength, muscle mass is preponderant. In healthy individuals, the determining factors for respiratory pressures have yet to be well established. Some authors[20] have found a correlation between MIP and age. Others[20] have found a correlation between age, MIP and MEP among boys, but only between MIP and age among girls. In contrast to what was reported in this last study,[21] we found no gender-related differences in respiratory pressures. This may be due to the low age of the patients studied. It has been observed that, in healthy individuals, although there is a linear regression of MIP with age, this regression is not significant in individuals under 55 years of age.[7]

In the present study, there was a significant positive correlation between MEP and age only in male patients, and a significant negative correlation between MEP and colonization with P. aeruginosa in female patients. Among those with mild ORD, age correlated positively and significantly with MEP and MIP. Among those with moderate or severe ORD, there was a significant positive correlation between MEP and age. Therefore, of all correlations found, the most consistent was that between advancing age and higher MEP. The negative correlation between MEP and colonization by P. aeruginosa might be attributable to the fact that colonized patients present greater pulmonary function impairment and air trapping,[4] which affects respiratory muscle strength.

In the present study, we observed that, in the patients submitted to four months of multidisciplinary treatment at the Cystic Fibrosis Outpatient Clinic of the Catholic University of Brasília, there was an increase in MIP and MEP without, however, any alterations in the degree of airway obstruction or body mass index. Therefore, we can infer that the thoracic and abdominal muscle re-education technique was efficient in promoting an increase in respiratory muscle strength in the patients evaluated. However, we should emphasize the effect of the multidisciplinary treatment, which is well known to be important in CF patients.[8]

Nutritional status may alter respiratory muscle strength.[18] However, since body mass index remained unchanged after four months of therapy, we concluded that nutritional support was not a determining factor in this result. In contrast, how can we explain the increase in respiratory muscle strength if no training of these muscles was done using resistive loads applied to the airways? As a result of the increased respiratory muscle effort, there is muscle shortening, inward dislocation of the ribs, and, consequently, decreased muscle efficiency. All patients, even those presenting no ORD, experience

periods of exacerbation of the pulmonary disease. In acute clinical profiles, muscle work increases as a result of the increased airway resistance, thereby generating asynchrony between the chest and the abdomen.[22-23] In addition, thoracic accessory muscles and abdominal muscles, in their primary action, optimize diaphragm action.[20] However, in the presence of respiratory dysfunction, some of these muscles lose their stabilizing action and begin to act as primary motors, which leads to their shortening due to excessive use.[9] Therefore, the correction of this biomechanical alteration, which is one of the principles of the thoracic and abdominal muscle re-education technique, may improve the capacity to generate respiratory strength. It is likely that this mechanism led to the increase in MIP and MEP in this group of patients.

The division of the groups of patients according to the degree of airway obstruction revealed that those with moderate or severe ORD presented no significant improvement in respiratory muscle strength. This may be explained by the fact that patients presenting greater pulmonary impairment probably present postural deformities that are difficult to correct.

It is difficult to evaluate the relevance of the genotypic condition of the patients to the determination of our results since the improvement in respiratory pressure occurred in individuals presenting other mutations, although MEP also improved in patients homozygous for ΔF508.

Despite the positive results obtained using the thoracic and abdominal muscle re-education technique, a limiting aspect of the present study was the fact that we did not evaluate a control group in order to determine, more accurately, the real effect of this technique on respiratory pressures.

In view of this, we conclude that, in the CF patients evaluated, thoracic and abdominal muscle re-education increased respiratory muscle strength, underscoring the importance of this type of physical therapy in these patients. Therefore, this technique should be more widely promoted in national and international CF treatment centers. However, further studies need to be carried out in order to determine, with greater clarity, all of the benefits of the technique, not only in CF, but also in other chronic pulmonary diseases.

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