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Original Article

EFFECTS OF A RESISTANCE TRAINING WITH ELASTIC TUBING IN STRENGTH, QUALITY OF LIFE AND DYPSNEA IN PATIENTS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE

EFEITOS DE UM TREINAMENTO RESISTIDO COM TUBOS ELÁSTICOS SOBRE A FORÇA MUSCULAR, QUALIDADE DE VIDA E DISPNEIA DE PACIENTES COM DOENÇA PULMONAR OBSTRUTIVA CRÔNICA

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RESUMO
O objetivo deste estudo foi analisar os efeitos do treinamento resistido com tubos elásticos e aparelhos de musculação (convencional) sobre a força muscular, qualidade de vida e dispneia em pacientes com doença pulmonar obstrutiva crônica (DPOC). Pacientes alocados em grupos de treinamento com tubos elásticos (ETG, n=9) e convencional (CRG, n=10) foram avaliados por força isométrica e questionários de qualidade de vida (CRQ) e dispneia (MRC). A força isométrica aumentou em ~25% em ambos os grupos em todos os movimentos (p<0,05). MRC e o domínio dispneia de CRQ apresentaram melhoras de -28,70% e -6,05 % no ETG, e -33,33% e -16,23% no CRG, respectivamente. Força de flexão de ombro e cotovelo apresentaram correlação negativa com a variável MRC (p<0,05) para CRG. Ambas intervenções foram benéficas para aumento da força e redução do MRC, com aumento da força de membros superiores correlacionado à redução da sensação de dispneia nos pacientes com DPOC.
Palavras-chave: Exercício. Doença pulmonar obstrutiva crônica. Qualidade de vida.

ABSTRACT
The objective of this study was to analyze the effects of resistance training with elastic tubes and weight machines (conventional) on muscle strength, quality of life and dyspnea in patients with chronic obstructive pulmonary disease (COPD). Patients were allocated in training groups with elastic tubes (ETG, n = 9) and conventional (CRG, n = 10) and evaluated by isometric strength and quality of life questionnaire (CRQ) and dyspnea (MRC). Isometric strength increased by ~25% in both groups in all movements (p <0.05). MRC and the CRQ dyspnea domain showed improvement of -28.70% and -6.05% in the ETG, and -33.33% and -16.23% at CRG, respectively. Shoulder and elbow flexion showed a negative and significant correlation with MRC (p <0.05), for CRG. Both interventions were beneficial for increasing the strength and reducing the MRC score, and increased strength of upper limbs correlated to the reduction of the sensation of dyspnea in patients with COPD.
Keywords: Exercise. Chronic obstructive pulmonary disease. Quality of life.

Introduction

Musculoskeletal disorders, as well as dyspnea, are among the most common manifestations in patients with chronic obstructive pulmonary disease[1,2], impacting greatly on the exercise performance capacity[3,4] and muscular strength of these patients[5-7].

Previous studies in patients with chronic obstructive pulmonary disease (COPD) have demonstrated the existence of restrictions and greater dependence to perform activities of daily living [8] and decreased quality of life[9], as a result of dyspnea, musculoskeletal disorders and other associated co-morbidities[9-12].

Among the symptoms caused by pulmonary manifestations, dyspnea is present mainly in the more advanced stages of the disease, featuring a greater impairment of the pulmonary system[13,14]. Peripheral muscle dysfunction, characterized as an extrapulmonary manifestation, becomes a predictor of muscle atrophy and reduced muscular strength and endurance, promoting early muscle fatigue and reduced ability to execute physical exercise, quality of life and survival in these patients[15,16] .

Pulmonary rehabilitation programs (PR) are comprehensive interventions based on a thorough assessment of the patient, as well as therapeutic measures, including physical exercise designed to improve the physical function and psychological condition of patients with COPD[16]. Among the modalities of exercise, resistance training has gained significant attention in COPD, since as well as reducing the symptoms of the disease and improving cardiopulmonary capacity[17], as in aerobic exercise, it can also simultaneously increase muscle mass and peripheral muscle strength [18], being more effective than aerobic exercises for such benefits [19,20].

Previous studies have established that conventional resistance training (with weight training equipment and free weights) promotes significant improvements in quality of life[21], muscular strength[22] and dyspnea[23] in these patients. However, the behavior of these variables is not yet fully clarified for resistance training with the use of elastic tubing[24].

Elastic tubing is considered safe, easy to use, portable and low cost, and capable of increasing the tension linearly from the beginning to the end of the contraction movement, demonstrating advantages with respect to training with free weights[25].

Improvement in quality of life and dyspnea in patients with COPD has become an essential objective of PR programs, as these variables are able to reflect the benefits of the treatment, in addition to providing a multi-dimensional view of the patient[6]. Given the importance of resistance training for patients with COPD, and the gap in the literature on resistance training with elastic tubing, especially in patients with COPD, it is necessary to compare the effects of an intervention program using these materials, which can easily be applied in public health programs, long term care facilities, hospitals, and even in homes, with conventional training, the positive effects of which are already known. Similarly, establishing the magnitude of the effects of training on important variables in patients with respiratory disorders such as dyspnea, and quality of life, is essential with a view to the possible specific characteristics that will facilitate access to this type of low cost exercise to the population[27].

Thus, the objective of this study was 1) to compare the effects of resistance training with elastic tubing and weight machines on muscular strength, and 2) to analyze the correlations of alterations in muscular strength with quality of life indicators and dyspnea in COPD patients. Our null hypothesis was that strength gains resulting from the RT program with elastic tubing and conventional weight training would be similar.

Methods

Casuistry

Patients with COPD were evaluated, classified in degrees of severity according to the *Global Initiative for Chronic Obstructive Lung Disease* (GOLD)[28], followed for a period of 12 weeks in a specialized rehabilitation center.

As the inclusion criteria for this study, patients were required to have a diagnosis of COPD, FEV1/FVC <70%, be older than 45 years and be clinically stable.

As exclusion criteria, smokers, cardiac co-morbidities and musculoskeletal disorders that hindered the implementation of the experimental protocol were considered, as well as individuals that during the development of the exercise protocol presented exacerbations or complications that prevented the continuation of treatment or those who desisted from participation. These criteria were evaluated through the initial clinical evaluation. The individuals were previously informed of the objectives and procedures of the study and, after signing the free and informed consent, participated voluntarily and effectively in the study. All procedures were approved by the Research Ethics Committee (CAAE: 12492113.5.0000.5402) and followed Resolution 466/12 of the National Health Council.

Study design

A total of 70 patients, diagnosed with COPD, who were users of the physiotherapy clinic at the Faculty of Science and Technology, Universidade Estadual Paulista, were recruited for the study. Of these, 42 were excluded for refusing to participate (n = 27) or not meeting the inclusion criteria (n = 15). Therefore 28 patients were allocated to the intervention, of which three dropped out after the initial assessments and six discontinued the intervention. Thus, a final sample of 19 patients was obtained, nine in the group that performed resistance training with elastic tubing (ETG) and 10 who performed conventional resistance training (CRG) (Figure 1).

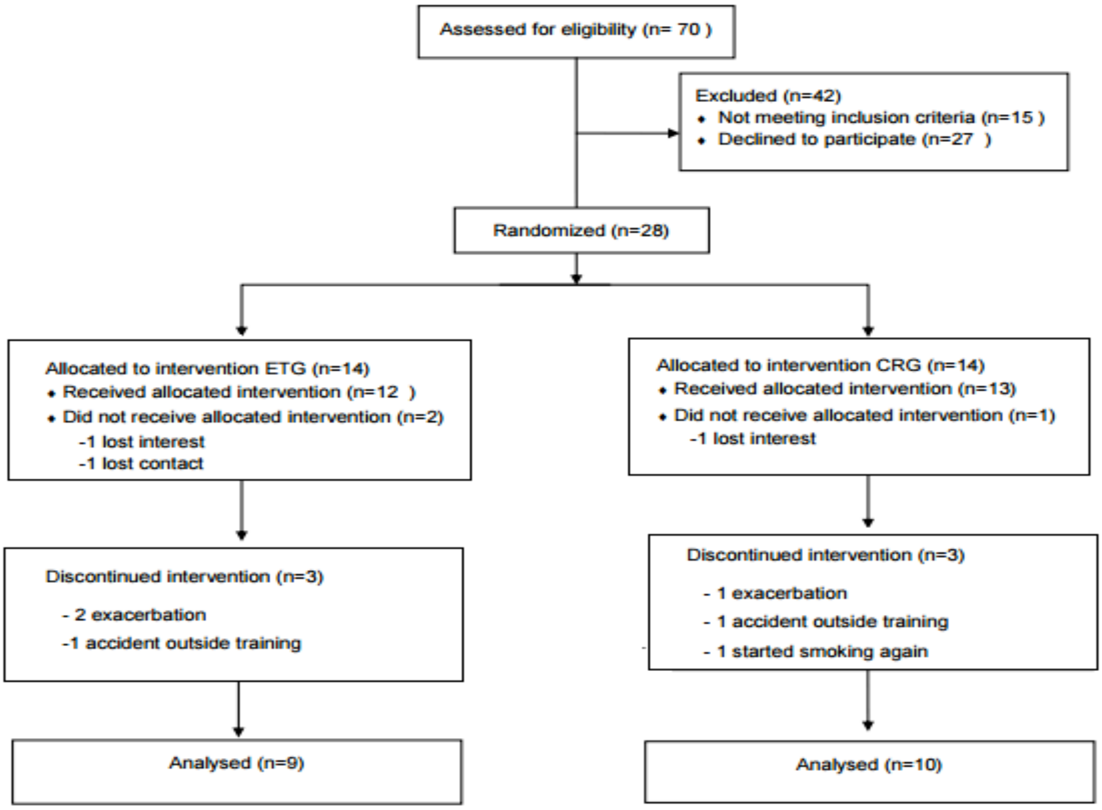

Figure 1. Flow chart of the study.
Note: ETG = training group with elastic tubing; CRG = conventional training group.
Source: Own source.

The subjects were randomized by strata as follows: first, classified in quartiles according to the individual relative strength of the lower limbs (maximum voluntary isometric contraction of the knee extension movement expressed in *Newtons* [N] - dynamometer) [29]. Next the individuals of each quartile were randomly assigned into two named groups according to the type of training program: one that performed resistance training with elastic tubing (ETG) and other that performed conventional resistance training (CRG). There was no blinding of therapists or patients during the course of the intervention; however data analysis was performed by an individual who was not involved in the study.

The initial evaluation was conducted over two days. On the first day, the identification and measurement of vital signs (blood pressure, heart rate, respiratory rate and oxygen saturation) was carried out. Carbon monoxide concentrations in expired air (COex) were measured to prove abstinence from smoking and then lung function testing was conducted through spirometry to classify the severity of the disease, according to the GOLD guidelines[28]. On the same day the *Chronic Respiratory Questionnaire* (CRQ) was applied to evaluate quality of life and the *Medical Research Council* (MRC) questionnaire to evaluate the level of dyspnea.

Finally, on the second day, muscular strength of the upper limbs (UL) and lower limbs (LL) was evaluated with a dynamometer, and the maximum repetition test (MRI) was performed with conventional weight training equipment in the CRG and elastic tubing in the ETG.

Training protocol

The ETG and CRG groups were submitted to training programs for 12 weeks with three sessions per week, totaling 36 training sessions, with recuperative intervals of 24 to 72 hours between sessions. The exercise sessions lasted 60 minutes and at the beginning and end of each session, the vital signs were checked and overall stretching was performed. The RM test was carried out for each resistance training exercise performed, with elastic tubing in the ETG and conventional weight equipment in the CRG. Familiarization with the exercises, equipment and elastic tubing was also performed prior to the start of training.

The training was performed in a periodized and progressive manner. The distribution of the training dynamics for both groups is described in Table 1.

Table 1. Training according to the dynamics of the exercise.

Weeks	Volume and workload
1st to 3rd	2x15 RM
4th to 6th	3x15 RM
7th to 9th	3x10 RM
10th to 12th	4x6 RM

Notes: RM - repetition maximum.
Source: Own source.

The execution speed of the concentric and eccentric phases was controlled by a metronome during the first three weeks of training. This was set to 2 beats for a complete movement, i.e., ~ 1.8 sec for concentric contractions and ~ 1.8 sec for eccentric contractions[30]. After this adjustment period the physiotherapist responsible for each patient controlled the speed of movements, based on the speed of this phase of "rhythm familiarization." There was also supervision so that a full movement amplitude was completed throughout the training.

Pulmonary Function Test

The evaluation of pulmonary function was performed prior to the training protocols through simple spirometry (spirometer brand MIR-Spirobank, version 3.6 connected to a microcomputer), according to the standards of the Guidelines for Pulmonary Function Tests[31]. The interpretation was performed according to the standards of *American Thoracic Society* (ATS) and *European Respiratory Society* (ERS)[32]. The normality values were related to the Brazilian population[33].

Evaluation of Quality of Life

The CRQ questionnaire or Chronic Respiratory Diseases questionnaire, proposed by Guyatt et al.[34] was used to evaluate the quality of life of the COPD patients. The Portuguese version for Brazil, published by Moreira et al.[35] (2009), was applied through an interview prior to the start of training and after 12 weeks of training. The questionnaire contains 20 questions divided into four domains: dyspnea (5 questions), fatigue (4 questions), emotional function (7 questions) and self-control (4 issues); the higher the score, the better the quality of life of the individual. The questionnaire was applied through an interview prior to the start of training and after 12 weeks of training.

Evaluation of Dyspnea Level

The MRC scale, validated in Portuguese by Kovelis et al.[36], was used. This scale consists of five items, of which one is chosen by the patient, corresponding to restrictions caused by dyspnea in daily life: intense exercise (0 points); walking fast on level ground or climbing light inclines (1); walking slower than people of the same age due to breathlessness or stopping to breathe when walking normally on level ground (2); Stopping to breathe after walking 90 meters or a few minutes on level ground (3); Not leaving home due to dyspnea (4). The questionnaire was applied through an interview prior to the start of training and after 12 weeks of training.

Measurement of Muscular Strength

The measurement of strength was performed in the dominant hemisphere, at baseline and after 6 and 12 weeks of training, through a digital dynamometer, brand Force Gauge®, model FG-100 kg and results are expressed in *Newtons* (N). The volunteers performed maximal voluntary isometric contractions for six seconds, followed by limb relaxation, according to Ramos et al.[23]. The measurement was repeated three times, with rest intervals of one minute and the highest value was recorded. The following muscle groups were evaluated: knee flexors and extensors, shoulder flexors and abductors and elbow flexors.

Resistance training with elastic tubing

To perform the resistance training with elastic tubing the following equipment was used: elastic tubing of the latex type, Lemgruber© brand, references (according to the manufacturer): 200, 201, 202, 203 and 204, metal rings, beams (Plastic cable ties) for attaching the elastic tubing to the rings, a specific chair with hooks to fix the tubing and knobs for the upper and lower limbs. According to a pilot study conducted in our laboratory, to acquire higher affinity for different diameters of elastic tubing and the loads that they provide, it is possible with the help of dynamometry of each patient, to infer or approximate the appropriate tube diameter for the different movements. It was found that the most commonly used tubing for the upper limbs were the references 200, 201 and 202 and for the lower limbs 202, 203 and 204. The initial lengths of the tubing were determined according to the individual distances from the upper or lower limb to the hook (fixed point) on the chair. Thus, the length of the tubes used for each individual was always the same in all sessions and differed from one individual to another. The muscle groups being trained were the same as those evaluated in the dynamometer test.

The chair for training with elastic tubing measured 72 cm high and 52 cm wide, and had an elastic tube fitting support for each muscle group to be worked (Figure 2). Therefore, one end of the elastic tubing was attached to the segment of the body that performed the arc movement and the other end was fixed to the chair support for both the upper and lower limbs (Figures 3a and 3b). Thus, for implementation of resistance training of the upper limbs and knee extension, the patient was positioned sitting in the exercise chair, while for knee flexion the patient was positioned orthostatically in front of the chair.

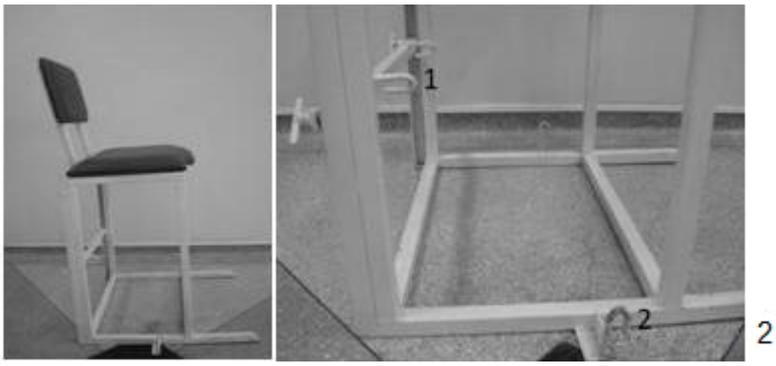

Figure 2 – Chair for training with elastic tubing, fitted with supports for lower limb (1) and upper limb (2) movements.
Source: Own source.

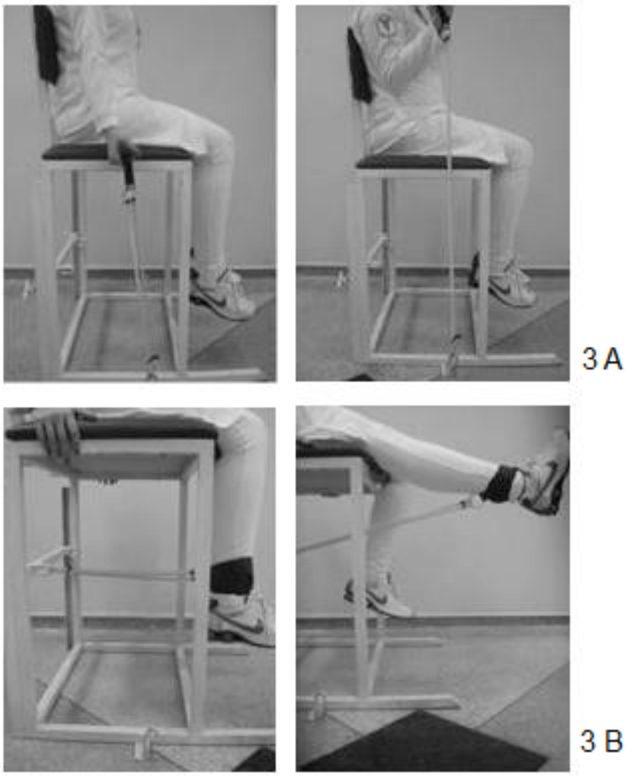

Figure 3. Elbow flexion (a) and knee extension movements with elastic tubing (b)
Source: Own source.

Repetition maximum test (RM) and resistance training with elastic tubing

The reference (tube) used for the elastic tubing resistance training was according to the RM test. For the test, as the first step of the protocol, the individual performed 15 RM; this being the number of repetitions used for the initial test. Therefore, the test was valid when performed with a tube reference whose load only enabled performance of 15 repetition maximums. Both in the test and the training, up to two additional repetition maximums were tolerated. At first, the repetitions were composed of 15 RM and at the end of training this was reduced to 6 RM, as described in Table 1. It is worth mentioning that the references of the tubing changed according to the reduction in the number of RM. The interval between sets of exercises was two minutes and the training protocol included a gradual reduction in repetition maximums. This protocol was based on previous studies and adapted according to the needs of the population studied[29,37].

Conventional resistance training

For the conventional strength training, training equipment of the Ipiranga® brand, Brazil was used. For the upper limb training, simple pulley equipment was utilized, and for training of the lower limbs, a flexor and extensor chair, with the exercises performed with one leg at a time. The training protocol followed the same method as that with the elastic tubing.

Protocol for increase in training load

In the session in which the patient was able to perform more than the stipulated repetitions, the load was increased to return to carrying out the predetermined number of repetitions in each stage of the protocol. Thus, the increments were carried out through visual control by the physiotherapist and reporting of each patient, and at the end of each series verbal encouragement was given so the patient always performed a maximum effort. In the resistance training with elastic tubing, the increments were carried out with the addition of parallel tubes. The CRG load increase followed the same method described above; however weights were added to the pulleys.

Statistical Analysis

For data analysis SPSS, version 22.0 was used (SPSS Inc., Chicago, IL, USA). The normal distribution of the data was assessed by the Shapiro-Wilk test. The descriptions of the results are presented as mean ± standard deviation values (50th percentile and interquartile ranges, when the data distribution was not normal). The comparison between the baseline and 12 week moments, for each group, was performed using the paired Student's t test (or Wilcoxon test for non-parametric data). For comparison between groups of the relative variation (%) between moments (baseline and 12 weeks) the Student's t test for independent samples was used (or the Mann Whitney test for non-parametric data). For analysis of the correlations between the strength variables and the quality of life and dyspnea variables, initially a correlation matrix was performed, and subsequently, simple linear regression analysis for variables with significant correlation values. The significance level was set at $p < 0.05$.

Results

Nineteen patients with COPD completed the study, divided into two groups: ETG (n = 9, age 62.3 ± 10.3 years, weight 71.1 ± 14.0 kg, height 1.63 ± 0.11 m) and CRG (n = 10; age 68.0 ± 7.2 years; weight 74.8 ± 15.9 kg; height 1.62 ± 0.09 m). The variables shoulder abduction (P50 = 49 kg; = interquartile ranges from 43.3 to 77.3 kg) for the ETG group and MRC (6.5; 5.1 to 7.0 pts) and self-control domain of the CRQ (2.0; 2.0 to 2.0 pts), of the CRG group, presented non-normal distribution of data, so were analyzed in a non-parametric manner.

In the analysis of isometric strength, the groups did not differ at the baseline moment (p> 0.05), and over the twelve weeks the ETG group presented higher percentage gains for the exercises of the upper limbs, while the CRG group presented greater gains for the lower limbs, however, with no statistically significant differences between groups (p> 0.05). For both groups, the largest percentage gains were recorded for the shoulder abduction exercise (> 40%), while the knee extension was the exercise with lowest gains (<20%). The sum of the values of the five exercises resulted in total strength, and the variation in the values of this variable was similar between groups (~ 25%) (Table 1).

Table 1. Mean and standard deviation values at the pre and post-training moments and relative variation in isometric strength in patients with COPD trained with elastic tubing and weight equipment (n = 19).

Muscle Group	Pre-training Mean ± SD	Post-training Mean ± SD	Variation %	p
Elastic tubing (Force expressed in N)				
Knee extension	243.13 ± 56.34	276.87 ± 55.46	14.83*	0.000
Knee flexion	134.00 ± 30.06	169.46 ± 31.18	27.98*	0.001
Shoulder abduction	56.67 ± 16.05	79.49 ± 15.75	43.42*	0.000
Shoulder flexion	64.99 ± 18.55	89.87 ± 17.41	43.15*	0.000
Elbow flexion	93.64 ± 35.20	122.88 ± 33.76	36.38*	0.000
Total strength	592.43 ± 131.65	738.56 ± 126.69	25.91*	0.000
Strength equipment (Force expressed in N)				
Knee flexion	247.54 ± 68.52	287.96 ± 75.14	17.61*	0.006
Knee extension	139.22 ± 36.62	184.26 ± 44.30	35.34*	0.002
Shoulder abduction	53.26 ± 18.57	72.52 ± 19.83	41.36*	0.000
Shoulder flexion	62.76 ± 20.02	78.02 ± 18.09	30.91*	0.001
Elbow flexion	102.32 ± 33.44	125.18 ± 31.87	28.26*	0.002
Total strength	605.09 ± 104.00	747.94 ± 138.83	23.69*	0.000

* p<0.05 between pre and post training moments.
Source: Own source.

When the variables related to dyspnea and quality of life (and the domains dyspnea, fatigue, emotional function and self-control) were analyzed, only the MRC presented a significant relative variation (p <0.05), for both groups, with a score reduction of approximately 30%. The dyspnea domain of the CRQ questionnaire, for the CRG group, presented a reduction of 10 percentage points greater than the ETG group. However, there was no difference in the variations between groups (Table 2).

Table 2. Mean and standard deviation values at the pre and post-training moments and relative variation for the CRQ and MRC in COPD patients trained with elastic tubing and weight equipment (n = 19).

Muscle Group	Pre-training Mean ± SD	Post-training Mean ± SD	Variation %	p
Elastic tubing (values expressed in points)				
CRQ – Dyspnea	5.17 ± 1.70	3.96 ± 1.44	-6.05	0.198
CRQ – Fatigue	4.03 ± 152	4.17 ± 1.45	9.37	0.689
CRQ – Emotional	5.18 ± 1.26	5.06 ± 1.66	-3.66	0.707
CRQ – Control	4.92 ± 2.00	5.28 ± 1.86	14.81	0.370
MRC (Dyspnea)	2.67 ± 1.00	1.78 ± 0.67	-28.70*	0.009
Strength equipment (values expressed in points)				
CRQ – Dyspnea	5.64 ± 1.16	4.74 ± 1.50	-16.23*	0.018
CRQ – Fatigue	4.78 ± 1.37	4.90 ± 0.98	6.51	0.660
CRQ – Emotional	5.77 ± 0.87	5.51 ± 0.78	-2.90	0.434
CRQ – Control	6.08 ± 1.08	6.00 ± 0.83	0.85	0.813
MRC (Dyspnea)	2.00 ± 0.47	1.40 ± 0.84	-33.33*	0.024

Notes: CRQ = chronic respiratory diseases questionnaire; MRC = evaluation of dyspnea; * P <0.05 between pre and post training moments.
Source: Own source.

A correlation matrix was carried out of the relative variations in the pre and post training moments of the strength variables with the CRQ and MRC variables. Only the variables shoulder flexion (r = -0.68; p = 0.031) and elbow flexion (r = -0.71; p = 0.021) presented statistically significant correlations (p <0.05) with the variable MRC (dyspnea) for the CRG group. The other variables presented correlation values between 0.61 and -0.37 (p between 0.08 and 0.96) for the ETG group and between 0.49 and -0.41 (p between 0.15 and 0.98) for the CRG group.

In the analysis of simple linear regression between the two strength variables (% variation in shoulder and elbow flexion) with MRC, it was possible to infer that for, approximately, each 1% increase in the strength of these variables, there was a reduction of 1% in the dyspnea sensation reported by the patients (Table 3). Variations in shoulder and elbow flexion explained 46% and 51% of the variations in the MRC variable, respectively.

Table 3. Linear regression analysis between MRC and shoulder and elbow flexion strength in the training group with weight equipment (n = 10).

Independent variable	Dependent variable = MRC			
	R^2	EPE	p	β (IC 95%)
Shoulder flexion strength	0.459	31.85	0.031	-0.997 (-1.879;-0.114)
Elbow flexion strength	0.506	30.43	0.021	-1.053 (-1.901;-0.205)

Note: MRC = evaluation of dyspnea.
Source: Own source.

Discussion

After twelve weeks of resistance training with elastic tubing (n = 9) and weight training (n = 10), it was found that both programs of resistance training promoted similar improvements in peripheral muscular strength and decreases in dyspnea in the specific questionnaire (MRC) however, only the conventional resistance training group presented improvement in the dyspnea domain of the CRQ, and for the same group there was a correlation between the strength gains of the upper limb movements with dyspnea, evaluated by the MRC.

It is known that training performed with elastic band resistance or weight machines promotes improved muscular strength, dyspnea[38], and quality of life in patients with COPD[23]. However, the comparison of these two tools with the performance of similar training protocols had not yet been studied and the present study, when performing this comparison, showed that the benefits promoted were similar in these variables.

Physiologically there are differences between training with weight machines and elastic band resistance. Studies using electromyographic analysis have shown that elastic band resistance promotes greater muscle activation levels during exercise compared to weight machines and free weights[39]. It has also been reported that the perception of fatigue on the Borg scale is significantly higher in exercise with elastic band resistance[40].

In addition, the linearity characteristic of load distribution during the exercises with elastic band resistance can promote a deficit in the execution of the eccentric phase of the movement (if the time of the stages is not controlled), since the elastic recoil favors completion of the arc movement with minimal effort from the patient. However, it is known that increased muscle activation occurs during the concentric phase[39], a factor that, together with the increased instability generated during the execution of the exercise with elastic band resistance compared to weight training equipment (load distribution on pulleys), may have been important in the similarity in increased muscular strength found between the groups.

Regarding the dyspnea, a significant improvement was found in the MRC questionnaire in both groups. However, although a significant improvement was not found in the ETG group for the CRQ questionnaire, there was a decrease of 1.21 points (6%). This decrease is greater than the minimum clinically important difference (MCID) of 0.43 to 0.5 for the dyspnea domain in chronic lung patients[41]. Thus, clinical improvement was evident in both the ETG and the CRG groups.

Studies have shown that there is a reduction in symptoms such as fatigue and dyspnea after pulmonary rehabilitation programs[42,43]. In a study by Gigliotti et al.[44] it was verified that training of the upper limbs, in a chronic manner, was able to reduce the symptom of dyspnea associated with increased inspiratory capacity and reduce the sensation of effort in the upper limbs.

It is worth mentioning that hyperinflation, both static and dynamic, or air entrapment caused by expiratory flow limitation can be found in patients with COPD[45]. In this case there are alterations in the dynamics of the thoracic wall, placing the respiratory muscles at a mechanical disadvantage and thus enhancing the respiratory drive and feeling of dyspnea[46]. Physical exercise helps in reducing hyperinflation, as it is able to promote improvements in respiratory drive, reduce lactic acid, thus improving breathing pattern, and also provide possible improvement in the indices of dyspnea.

In this sense, it is believed that the observed correlation between dyspnea and peripheral muscle strength of the upper limbs in the CRG group in the present study may be indirectly related to the improvement in respiratory function, through the concomitant strengthening of the respiratory muscles, as well as adequacy of volumes and lung capacity[47], thereby reducing hyperinflation with a consequent improvement in the sensation of dyspnea.

In the present study, although the groups were randomly allocated based on the isometric peripheral muscular strength[29,48], the ETG presented lower baseline spirometric indices of forced expiratory volume in one second (FEV1%) and forced vital capacity (FVC%). However, the groups were similar in the other study variables and the airflow limitation was shown not to influence the functional gains of patients, a fact that corroborates previous studies[49,50].

However, it is suggested that the fact that the ETG group presented a lower FEV1 than the CRG group indicates that the individuals had a higher expiratory flow limitation, which, despite not having demonstrated differences in the studied variables, may have influenced the lack of correlation between the muscular strength gains and dyspnea data in this group.

The principal limitation of the study was the low sample number; however, this situation is justified by the difficulty in finding a sample with such conditions, and above all, the sample loss, in view of the withdrawal of patients due to the disease itself (e.g., exacerbations).

As future perspectives, variables related to the training program content, such as number of sets, repetitions, rest interval, speed of muscle action, and different models of periodization (nonlinear, wave, etc.) should be studied.

Given the above, it is concluded that both types of training carried out were effective in improving peripheral muscle strength, quality of life and the sensation of dyspnea in patients with COPD. In addition, it was observed that there is a correlation between gain in peripheral muscle strength in the upper limbs and reduction in the sensation of dyspnea from conventional resistance training.

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