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ORIGINAL ARTICLE

A SINGLE SECTION OF STRETCH OF THE RESPIRATORY MUSCLES DOES NOT INFLUENCE THE PULMONARY VOLUME OF ASTHMATICS DURING EXERCISE

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Keywords: Asthma, Muscle Stretching exercises, Respiratory muscles.

Goal: Evaluate the acute effects of respiratory muscles (RM) stretching in lung volume, respiratory rate (RR), minute volume (MV), shortening speed index of RM and exercise tolerance in asthmatic.

Methods: Crossover study, randomized, double blind, allocation in stretching group (SG) and placebo group (PG). Lung volumes, RR, MV and shortening speed index of RM were compared by two-way ANOVA, Bonferroni's post hoc. For the time of exercise tolerance and perceived exertion, the paired t-test.

Results: asthmatic 11 (35.5 ± 7.8 years, body mass index (BMI) = 24.4 ± 2.4 Kg/m^2, FVC and FEV_1 of 95.8 ± 10.3 and 85.3 ± 11.5 % of the predicted). There were no differences in lung volumes (SG vs. PG) in exercise, intra-group differences occurring during its steps ($p < 0.01$). The RR and MV were similar in the groups ($p = 0.52$ and 0.68). The shortening speed index of the RM showed no differences between the groups ($p = 0.27$). The time of exercise tolerance was similar in the groups ($p = 0.31$). The variance of the Borg scale (fatigue) was lower in SG ($p = 0.02$).

Conclusion: A single section of stretching of RM does not modify pulmonary volumes, RR, MV, and shortening speed index RM of asthmatic in the exercise. There was no influence on exercise tolerance, but we observed less fatigue in SG.

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INTRODUCTION

Asthma is a chronic inflammatory disease characterized by airway hyper responsiveness[1] and airflow obstruction, reversible spontaneously or pharmacologically[2]. Its symptoms include wheezing, dyspnea and dry cough, particularly in the morning and night period[3].

It is suggested that in its evolution occurs airway remodeling, which gives irreversibility in the structural aspect of the airway. Hypertrophy and hyperplasia of smooth muscle cells, edema, increased production of mucus, epithelial destruction with fibrous tissue formation and thickening discussion relate to the induction of remodeling[4-5]. These events can result in increased resistance to airflow and consequent overloading the respiratory muscles[4].

When considering its chronic character, the mentioned effects may modify the muscle contractility and compromise asthmatics' ventilation[6]. The respiratory muscles can suffer shortening and work in mechanical disadvantage, which aggravates their function by modifying the ideal length-tension relationship. This restricts the power production, especially of the inspiratory muscles, undergoing mechanical overload to overcome the resistive and elastic work of breathing and, in moments of crisis or exercise, keep minute ventilation[7-8].

The treatment of asthma is based on control of exacerbations of disease. For that, pharmacological conducts and respiratory physiotherapy programs[9] are used. These programs use the aerobic and respiratory muscle training associated with the muscle stretching, considered complementary and, according to some studies, seen as therapeutic option[7]. Sá[10] studied the acute effects of stretching of respiratory muscles in patients with chronic obstructive pulmonary disease (COPD) by the use of optoelectronic plethysmography (OEP). It was observed an increase in variations of the volumes of the pulmonary rib cage, abdominal rib cage and its percentage in relation to chest wall attributed to improvement in length-tension relationship of stretched muscles. In addition to encourage ventilation, it has been shown that an exercise program focused to increased thoracic mobility improves exercise tolerance in patients with COPD[8].

Although stretching seems to be a technique with potential efficacy in patients with COPD, few studies have investigated it in asthmatics. Moreover, its influence on the ventilation and exercise tolerance of asthmatics is still little explored. Therefore, this study is proposed to evaluate the acute effects of stretch of the respiratory muscles on pulmonary volumes, shortening speed index of respiratory muscles, exercise tolerance and perceived exertion in endurance test in asthmatics with controlled disease.

METHODS

Type of study and sample

Crossover clinical trial, conducted in the laboratory of PneumoCardioVascular Performance and respiratory muscles of the Federal University of Rio Grande do Norte (UFRN). Asthmatic patients were selected from hospital, outpatient and pharmaceutical services in the city of Natal-Rio Grande do Norte, between the ages of 25 and 65 years, BMI < 30 Kg/m^2, in medical follow-up, with controlled disease according to the guidelines recommended by GINA[11], non-smokers and without musculoskeletal conditions that limited the achievement of exercise protocols. Were excluded those who presented event that characterizes the abscense of asthma control, as well as those who refused to maintain their participation in the study. The research was approved by the Research Ethics Committee of UFRN (CAAE 20297213.3.0000.5537), according to the guidelines of the resolution 466/12 National Health Council (CNS). The volunteers agreed to participate in the study by signing of informed consent form.

Measuring Instruments

Anthropometric data

Anthropometric data were obtained by using the WELMY ® scale, model R110 (Welmy ®, São Paulo, Brazil). Mass and height variables were measured and used to determine the BMI.

Pulmonary function test

Lung function was evaluated by Koko Digidoser Spirometer portable spirometer (PDS Instrumentation, Louisville, CO, USA). Maneuvering was requested of forced vital capacity (FVC), according to American Thoracic Society/European Respiratory Society (ATS/ERS) recommendations[12] until they obtain three acceptable and two reproducible curves (best two measures of FEV_1 and FVC differing less than 0.15 L), limited to eight the number of attempts. The results were collected in absolute terms and compared to the reference values for the Brazilian population [13].

Manovacuometry

Maximal respiratory pressures obtained with an electronic manovacuometer (NEPEB-LabCare/UFMG, Belo Horizonte, MG, Brazil). For the measurement of the maximum inspiratory pressure (MIP), maximum inspiratory effort was conducted in the nozzle, against occluded airway, from the residual volume (RV); for maximum expiratory pressure (MEP), a peak effort, against the air occluded from total lung capacity (TLC) and the nasal inspiratory pressure during the sniff (SNIP), inspiratory effort fast and vigorous through the nose, using a nasal plug in one of the nostrils[14]. For analysis, were adopted the maneuvers with the highest value between the acceptable and reproducible and compared with reference values [15-16].

Incremental Shuttle Walking Test (ISWT)

The ISWT was held in plan runner, outlined in 10 meters, as described by Singh et al[17]. The subject walked over and over around two cones at the ends of the route, with incremental speed rhythmic by beep, which imposed its increasing every minute. The test was interrupted when the inability to maintain the speed required completing the course (> 0.5 m of the cone) before the issue of the tone, second report of 7 or greater effort on the Borg scale or when the individual has reached 85% of the maximum heart rate estimated for the age[17-18]. The distance traveled on the test allowed to estimate the maximum working load by the formula: $Wpeak = 0.0025 \times distance\ (m) \times weight\ (kg) + 10.19$[19]. For sample characterization, the distance traveled was compared with the predicted distance, calculated by a reference equation [20].

Stretching Protocol

The Protocol consisted of a set of maneuvers applied in the study of the Cunha [7]. The volunteers were placed in dorsal or lateral decubitus, knees bent, lumbar lordosis rectified, portrayed brackets and abducted shoulders. The stretches were applied on expiration, bilaterally, taking the muscle to maximum length, held in ten consecutive respirations.

Upper trapezius: patient in supine position with one hand the researcher supported the occipital region and laterally flexed to head to the opposite side of the elongated muscle. The contralateral hand was resting on the upper shoulder and, assuming this positioning, the muscle was pulled in the cranial-caudal direction;

Sternocleidomastoid: patient in supine position, the hands of the researcher in the occipital region and on the cranial portion of the sternum. The stretching was performed from the flexing with lateral rotation of the head to the opposite side of the elongated muscle and muscle tractor towards cranial-caudal;

Scalene: patient in supine position, the hands of the researcher in the occipital region and on the cranial portion of the sternum. The stretching was obtained with the offset of two points, the first being in the upper direction and second, bottom;

Pectoralis major muscle: patient in dorsal decubitus, ipsilateral to the shoulder muscle that was stretching abducted laterally flexed, forearm and hand in the occipital region. Hands of the researcher in the distal third of the arm and side of the upper thorax region. The points were displaced towards cranial-caudal following the guidance of muscle fibers;

Intercostal: patient in lateral decubitus on a half-moon-shaped roll in infra-axillary region, forearms flexed and hand in the occipital region. The therapist supported the patient's arm and a hand was positioned in the lower costal railing. In inspiration, was held opening of costal, displacing the railing arm of the patient towards caudal-cranial and returning to the starting position at expiration.

Endurance test

The test was run in stationary bike Corival (Lode BV Medical Technology, Groningen, the Netherlands) with 80-85% between the maximum working load calculated using the formula described. The exercise tolerance was determined by the amount of time, in seconds, completed by the patient until they reached cut-off criteria of the exercise (85% of the predicted maximum heart rate for age (FCmax = 220 – age) and/or the reporting of intense effort, i.e. value from the 7 on the modified Borg scale) [21]. The test consisted of a period of initial quiet breathing (QBini) (3 minutes), the warm-up period (WP) (2 minutes of pedaling without load), pedaling with load (PL), active recovery period (ARP) (2 minutes of pedaling without charge after achieving the criteria for stopping the exercise) and period of final quiet breathing (QBfin) (3 minutes).

Optoelectronic plethysmography (OEP)

We used a optoelectronic plethysmography (BTS Bioengineering ®, Milan, Italy) and 89 reflective markers distributed on the anterior surface, side and back of the trunk of subject[22]. Each marker was picked up by a system of six synchronized cameras that recorded their coordinates. Specific algorithms enabled the determination of variables (absolute, relative and operating) and the cycle by cycle. Obtaining the volumes allowed estimating the rate of speed inspiratory muscle shortening the ribcage muscle, diaphragm and abdominal muscles [23-25].

Procedures

The procedures were performed in three days (D1, D2 and D3). In D1, the participants underwent anamnesis, evaluation of anthropometric data (body weight, height and BMI), pulmonary function test and manovacuometry. Subsequently, the ISWT ran to, by the formula already described, estimate the maximum working load and determine the load endurance test. In D2, a researcher randomized and allocated the subjects in stretching (SG) or placebo (PG) group, with blinding of the researcher responsible for the endurance test and the subject, which ensured the double blinding of study. The SG received stretching protocol while the PG had the joints positioned without muscle tension. After the intervention, the endurance test with the load, frequency of rotation between 50 and 60 rpm and simultaneous measurement of peripheral oxygen saturation (SpO_2).

The posture adopted the test understand the maintenance of the trunk erect, shoulders abductees and hands supported in bars to allow visualization of the side-markers (Figure 1).

Figure 1: positioning of the subject during the exercise protocol

The perceived exertion (Borg scale modified from 0 to 10), heart rate and SpO_2 (Pulse Oximeter *MODEL 2500*[a], Plymouth, USA) was collected at the following times: minute end of initial end of PA QB, after first minute for every minute of the period and initial minute PC QB end. In the D3, the volunteers performed the procedures described above, except for the type of intervention, which differed from held in D2.

Analyzed variables

The variables selected for the analysis included as primary outcomes the tidal volume of the chest wall (VC_{pt}), tidal volume of pulmonary rib cage (VC_{ctp}), tidal volume of abdominal rib cage (VC_{cta}), tidal volume of the abdomen (VC_{ab}); operational volumes: inspiratory volume end of the chest wall (Vif_{pt}), expiratory volume end of the chest wall (Vef_{pt}) and, as secondary, the percentage of contribution from compartments to generation of VC_{pt}, called relative volumes, that is, the percentage contribution of the rib cage (Vc_{pt}), percentage of contribution from the abdominal rib cage (Vc_{ta}) and percentage of contribution of the abdomen (V_{ab}); respiratory rate (RR) and minute volume (MV); shortening speed index of inspiratory muscle of pulmonary rib cage, diaphragm and abdominal muscles through the formulas $\Delta VC_{ctp}/Ti$, $\Delta VC_{ab}/Ti$ and $\Delta VC_{ab}/Te$, respectively, where Ti represents the inspiratory time and Te, the expiratory time; perceived exertion and exercise tolerance.

Statistical Analysis

The statistical procedures were performed with the software GraphPad Prism 5.01. Categorical variables relating to the characterization of the sample were represented as relative frequency and the numerical in form of standard deviation average. The normality of the distribution of the data was analyzed by Shapiro Wilk test. For a normal distribution, the mean of the variables relating to lung volume, percentage of contribution from compartments, RR, MV and shortening speed index of respiratory muscles between the groups and at different times were compared by two-way ANOVA with Bonferroni post hoc. The time of exercise tolerance, as well as the perceived exertion were compared between groups by paired t-test. We considered as the value of statistical significance $p < 0.05$.

RESULTS

Of the total of 50 patients were recruited, 14 met the inclusion criteria and were assessed, 3 were excluded (BMI over 30 Kg/m^2, unfavorable as regards the participation in the study and episode of bronchospasm in the endurance test) and 11 were analyzed. Even considering the inclusion of subjects of both genders, only women agreed to participate of the study.

The data of sample characterization, pulmonary function test and anthropometrical are presented in table 1.

Table 1. Characterization of the sample data

Variables	Mean (standart deviation); absolute number/absolute number
Age (years)	35.5 (8.07)
Gender (M/F)	0/11
Weight (Kg)	60.8 (5.77)
BMI (Kg/m	24.4 (2.40)
FVC (% predicted)	95.8 (10.3)
FEV_1	85.3 (11.5)
FEV_1	83.8 (0.95)
MIP (% predicted)	98.2 (26.2)
MEP (% predicted)	98.0 (12.0)
SNIP (% predicted)	78.7 (20.7)
ISWT distance (m) / (% predicted)	490.91 (87.27) / 81.15 (8.33)

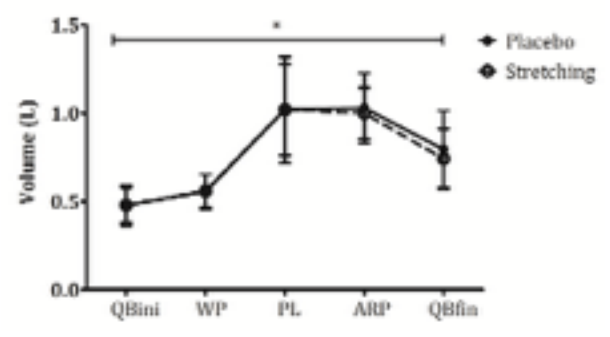
M: male; F: female; BMI: Body mass index; FVC: forced vital capacity; FEV_1: forced expiratory volume in one second; MIP: maximum inspiratory pressure; MEP: maximum expiratory pressure; SNIP: nasal inspiratory pressure; ISWT: Incremental Shuttle Walking Test.

The results regarding pulmonary volumes showed that there were no differences between the groups (stretching versus placebo) in VC_{ctp}, VC_{cta}, VC_{pt} and VC_{ab} during exercise, with differences on intra-group analysis between some steps of the exercise in both groups ($p < 0.01$) (Figure 2).

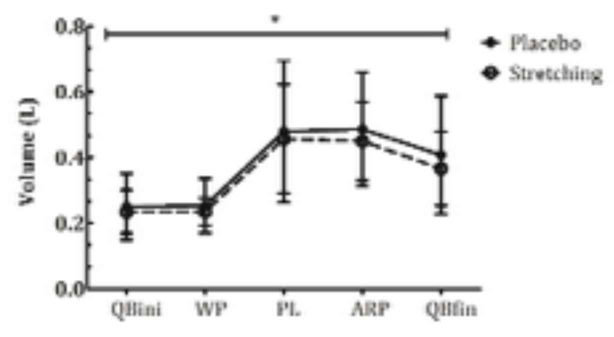
In the comparison of groups, was observed the absence of differences in the Vef_{pt} variation ($p = 0.13$) and Vif_{pt} ($p = 0.44$) during the endurance test. Was significant difference in intra-group analysis throughout the development of the test which we found a value of $p = 0.04$ when considering the Vef_{pt} and p 0.0001 in the case of Vif_{pt} < (Figure 3).

Figure 2. Lung pulmonary volumes during the stages of the exercise protocol

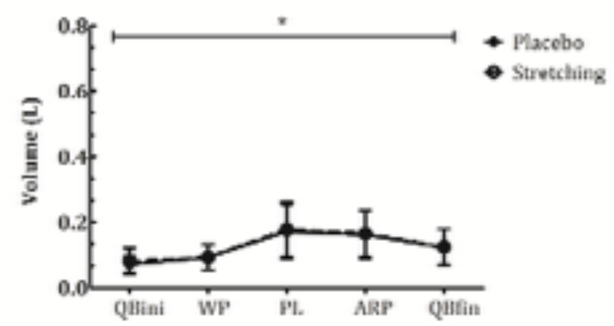
A



B



C



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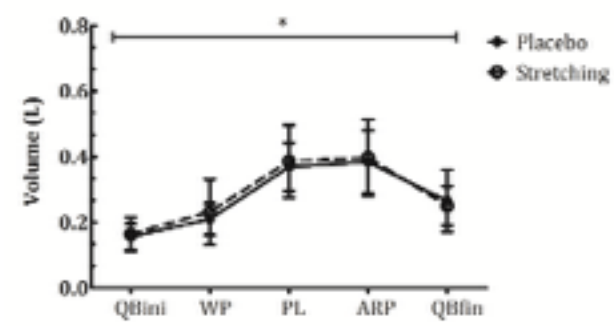
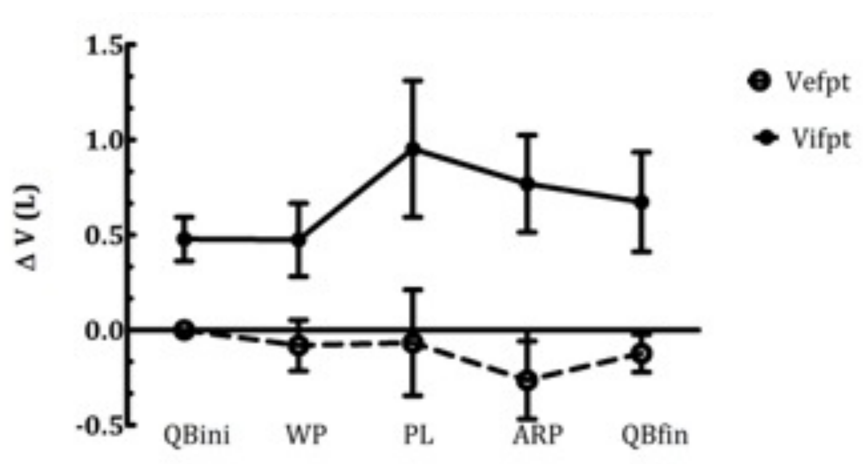


Figure 2. A- volume of compartment VCpt; B- volume of compartment VCctp; C- volume of compartment VCcta; D- volume of compartment VCab; VCpt: tidal volume of the chest wall; VCctp: tidal volume of the pulmonary ribcage ; VCcta: tidal volume of the abdominal rib cage; VCab: tidal volume of the abdomen; QBini: initial quiet breathing; WP: warm-up period; PL: pedaling with load; ARP: active recovery period; QBfin: final quiet breathing; L; litres; * $p < 0.01$ (intragroup analysis), except among QBini and WP, PL and ARP in 2.A; among QBini and WP, PL and ARP, ARP and QBfin in 2.B; among QBini and WP, PL and ARP, ARP and QBfin in 2.C; among QBini and WP, PL and ARP in 2.D.

Figure 3. Operational lung volume during the stages of the exercise protocol

A



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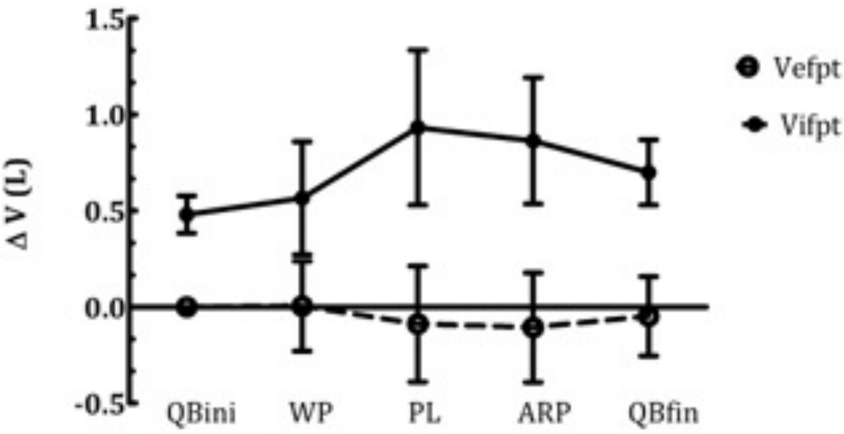


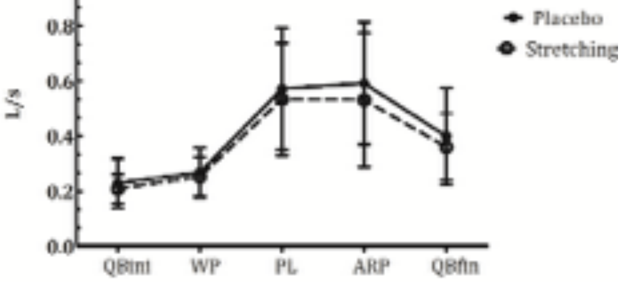
Figure 3. A: variation of operating volumes (placebo); B: variation of operating volumes (stretching); Vifpt: end-inspiratory volume of the chest wall; Vefpt: end-expiratory volume of the chest wall; QBini: initial quiet initial; WP: warm-up period; PW: pedaling with load; ARP: active recovery period; QBfin: final quiet breathing; Δ V (L): variation of the volume in liters.

The analysis of relative volumes showed lack of difference between the groups in the variables V_{ctp} (p = 0.38), V_{cta} (p = 0.37) and V_{ab} (p = 0.65). Regarding to RR, the comparison between the groups not indicated significant differences (p = 0.68), however, these were the moments of testing within each group ($p < 0.001$). The MV's behavior was similar to that of the RR, no differences between the groups (p = 0.52), but significant differences between the moments of intra-group analysis test ($p < 0.001$).

The shortening speed index of inspiratory muscles of pulmonary ribcage was similar among SG and PG (p=0.27). The same pattern was observed in relation to both index of diaphragm and abdominal muscles (p=0.97 and p=0.84, respectively) (Figure 4).

Figure 4. Shortening speed index of respiratory muscles during the steps of exercise protocol

A



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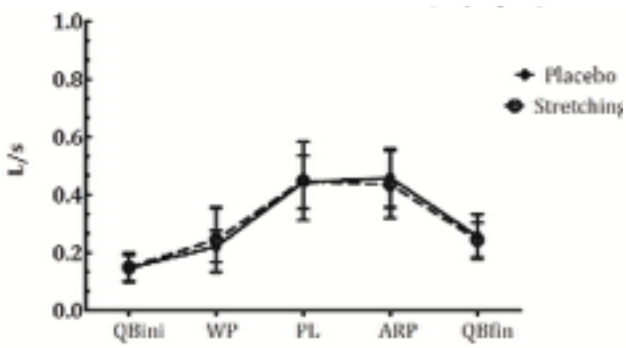

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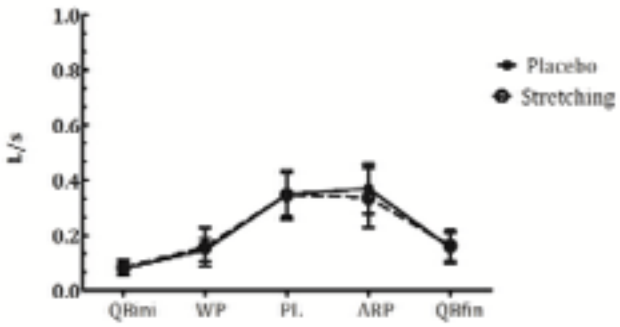

Figure 4. A: shortening speed index of inspiratory muscles of pulmonary ribcage; (B): shortening speed index of the diaphragm muscle; (C): shortening speed index of the abdominal muscles; QBini: initial quiet breathing; WP: warm-up period; PL: pedaling with load; ARP: active recovery period; QBfin: final quiet breathing; Δ V (L): liters/second

Comparison of tolerance to the period between the two groups has been found that the placebo group showed average time superior to the stretching Group (245 ± 109 sec versus 218 ± 55.5 sec), but these results did not show statistical significance ($p = 0.31$). The perceived exertion analysis showed that there were no differences in variation of the Borg Dyspnea scale was similar from the warm-up period until the interruption of the exercise among the two groups (PG = 5.05 ± 1.52; SG = 4.55 ± 1.81, $p = 0.34$). When considering the domain fatigue, existed difference between the groups where the placebo group showed higher scores (PG = 7.59 ± 0.73; SG = 6.86 ± 0.55, $p = 0.02$).

DISCUSSION

The results of the study indicated that a single section respiratory muscles stretching, considering their acute effects on asthma sufferers, does not induce changes in lung volume, RR, MV and shortening speed index of respiratory muscles in rest and/or exercise. In addition, the technique did not influence the time of exercise tolerance in the sample studied. However, we observed difference in fatigue scores between the two groups, where the SG smaller indices presented. We believe that this is the first study where the effects of elongation of respiratory muscles were assessed in asthmatics in the condition of exercise.

Although the respiratory muscles is not liable to immobilization respiratory cycles with the muscle shortening situation may restrict the thoracic mobility [26-27]. In this context, Lee [27] observed shortening of trunk muscles and shoulders and decreased chest expansion in children with severe asthma and suggested relationship of these changes with the severity of the disease. This theoretically justify the proposal of respiratory muscles stretching to increase mobility and provide a more effective ventilation, however studies are scarce and with little evidence.

Sá[10] assessed the acute effects of stretching using optoelectronic plethysmography (OEP) and noted an increase in the VC_{ctp} and VC_{cta} of patients with COPD, suggesting improved ventilation. The researcher attributed the results to the larger the ribcage because of flexibility of elongated muscles located in the upper chest. It is important to note that the protocol has predominant action on the muscles in this region which likely contributed to the increased ventilation in compartments mentioned, located in the thoracic segment.

Different from our study, Sá[10] included individuals with severe obstruction (FEV_1:48.79%), greater age range (61.79 years) and with inspiratory muscles more exposed to cumulative effects of obstruction, establishing appropriate circumstance to the effects of stretching. Our study assessed asthmatics with lower degree of obstruction (FEV_1:85.3%) and age 35.5 years. Comparatively, is less the probability of muscular impact in our sample. Different from our study, the author evaluated the condition of rest while our analysis also included the condition of exercise.

Application of the protocol used in our study was analyzed by Sá e Da Cunha[7] in patients with COPD. The program was composed of 16 sessions and resulted in increased tidal volume in the home, compared as the beginning of the program. The volumes measured by form ventilometry, which differed from our study. There were no changes in RR and MV on termination of the program that suggests a more effective displacement of the ribcage for stretches.

Paulin[8] examined the influence of physical exercises directed to increased thoracic mobility in patients with COPD (moderate and severe). A total of 24 sessions were held and we observed increase in mobility of the thorax evaluated by the cirtometry at the end of the program. Although the author has used a method of low reproducibility and haven't applied stretching, the findings suggest that a larger chest intervened in muscle, can be viable in rehabilitation programs of people with obstructive pulmonary disease to benefit the ventilation.

In our research, the opposite results to those favorable to the use of techniques to increase thoracic mobility can be explained by the nature of the study and the sample feature. The beneficial outcomes result from chronic interventions in subjects of greater age and more severe obstruction therefore more exposed to obstructive effects on the respiratory muscle. In the context of our study, acute intervention would have little or no effect on muscle, which follows principles of plasticity, such as periodic repetition of the stimuli.

We note that the shortening speed index of inspiratory muscle of the pulmonary rib cage was similar in the groups. Although we observed a behavior that suggests that stretching reduces this index, our sample had limited number, which might explain the lack of significant differences.

The dynamic hyper insufflation is a predictor of dyspnea, contributing to the exercise intolerance. The analysis of operating pulmonary volumes not revealed occurrence of the phenomenon, contesting Kosmas[28], which stated that asthmatics with controlled disease and normal spirometry may show dynamic hyper insufflation. The time of exercise tolerance was similar between groups; therefore, we propose that the lack of dynamic hyper insufflation promoted similarity in this respect.

The dyspnea is determined by mechanoreceptors activation and afferent stimuli of the respiratory muscles to central respiratory control. In this sense, the improvement of the thoracic mobility, resulting from the stretching, could reduce these stimuli, minimizing the dyspnea[8]. There was no such reduction in our study, because the variation of dyspnea reported between the start and end of the protocol exercise showed no statistically significant difference between groups (PG = 5.05; SG = 4.55; p = 0.34).

In chronic pneumopaths, the increase in ventilatory work during the exercise can induce targeting the blood flow to the peripheral respiratory muscles. This undermines the contraction of muscles, causing fatigue in the limbs, which limits exercise tolerance[29]. Our results have shown that stretching did not influence the exercise tolerance in spite of fatigue score have been lower in the stretching group (PG = 7.59 ± 0.73; SG = 6.86 ± 0.55, p = 0.02).

The limitations of the study consisted in the inclusion of patients with intermittent asthma, which did not allow the assessment of more severe asthmatics, situation in which are expected to impact on muscle and mobility system. In addition, the acute feature of the intervention was not enough to promote ventilation and performance effects of an exercise test. However, the shortening speed index of the respiratory muscles can point to a new focus of research, because these aspects have not yet been explored in relation to stretching.

CONCLUSION

Based on our results, we conclude that a single section of respiratory muscles stretching, whereas its acute effects, does not promote changes in lung volume during exercise in asthmatics with intermittent and controlled disease. The technique has also been unable to change the relative volume, respiratory rate and minute volume.

The stretching not modified the exercise tolerance with constant load and the shortening speed index of respiratory muscles although it was reported less sensation of fatigue in individuals who have received the technique. Therefore, studies on the chronic effects of stretching and its influence on the respiratory muscles and ventilation for asthmatics are suggested.

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