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Original Article

Effects of manual therapy on the diaphragm in asthmatic patients: A randomized pilot study

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A R T I C L E I N F O

Keywords:
Asthma
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A B S T R A C T

Background: Stretching of respiratory muscles is included in what is known as manual therapy techniques. A diaphragm stretching technique has shown beneficial effects on respiratory function and thoracic and spinal mobility in healthy subjects. However, its effects on asthmatic patients have not been evaluated.
Objective: To evaluate the effects of manual therapy on the diaphragm in allergic and non-allergic asthmatic patients regarding respiratory pressures and chest mobility.
Design: Single-blinded randomized pilot study.
Setting: Faculty of Health Sciences of Granada, Spain.
Methods: Thirty-two participants were randomized into two groups: an intervention group in which a diaphragm stretching technique was performed and a placebo group. Respiratory pressures, thoracic and lumbar mobility, and flexibility were evaluated before the technique was performed, immediately afterwards, and at 5 and 20 min.
Participants: Allergic and non-allergic asthmatic patients.
Results: Our results support the immediate effectiveness of the technique in maximal inspiratory pressure at 5 min of diaphragm stretching ($p = 0.031$). Significant results were also shown in mobility and flexibility, with a significant improvement in the subaxillary and abdominal perimeter as well as in the finger-floor test and the Schober test ($p < 0.05$).
Conclusions: The results may show that a diaphragm stretching technique in asthmatic patients leads to an improvement in the following parameters: maximum inspiratory pressures 5 min after the technique; and flexibility and mobility of the rib cage at 5 min, which remains at 20 min. Further work is required to test the reproducibility of these results in a definitive trial.

1. Introduction

Asthma is a chronic inflammatory disease that leads to a reversible narrowing of the airways and causes lung hyperinflation due to air trapping [1]. In 2013, the World Health Organization (WHO) estimated that 300 million people suffered from asthma, which represents 5% of the population worldwide [2]. Asthmatic patients generally present dyspnea, cough, and wheeze. Previous studies [3–6] have shown that symptoms in allergic and non-allergic asthma are similar. Furthermore, the changes in bronchial epithelium and smooth muscle are similar in allergic and chronic asthma.

Airflow limitation interferes in the efficacy of respiratory biomechanics [7]. The mechanical alterations related to the overload of respiratory muscles observed in adults with persistent asthma can lead to the development of musculoskeletal dysfunction, chronic alterations in posture, and pain. Respiratory muscle activity may cause changes in chest wall compliance. Increases in the use of patients' respiratory muscles are detected during either asthma attacks or chronic airway inflammation [8].

The diaphragm is recognized as the primary muscle of respiration that contributes to increase all the diameters of the thoracic cage in the inspiratory movement [9]. If an increased activity of the diaphragm is maintained over time, it leads to a shortening of the muscle, reducing its mobility. This induces bad posture and causes excessive stress on joints, muscles, and ligaments [10]. Additionally, muscular tension can maintain thoracic pain [11].

In the study by Alburquerque et al. [12], it was shown that the posture of asthmatic patients can be affected; these patients showed a

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thoracic cage that tended to trap air. In the study by Lunardi et al. [13], it was shown that asthmatic patients had a reduction in flexibility of the lower thoracic spine and of the hamstring muscle. A possible explanation for the observed reduction in the flexibility of the spine may be related to the anatomical connection of the diaphragm with the posterior ribs and vertebrae of the lower thoracic and lumbar spine.

Stretching of respiratory muscles, myofascial release, and soft tissue massage are included in what is known as manual therapy techniques. The objective of most of these techniques is to increase movement of the rib cage and the spine in order to improve lung function and circulation [14]. Stretching is one of the most used techniques due to its multiple beneficial effects and few contraindications. A diaphragm stretching technique has shown beneficial effects on respiratory function [15] and thoracic and spinal mobility in healthy subjects [16].

Physiotherapy has been shown to be effective in increasing the mobility of patients with asthma [17]. However, two different systematic reviews [18,19] have examined the role of manual therapy in pulmonary pathologies, concluding that there is a lack of high quality research in this area and showing no evidence supporting its use in patients with chronic obstructive pulmonary disease or asthma. The effects of a diaphragm stretching technique on asthmatic patients have not been evaluated.

The objective of this study was to evaluate the effects of manual therapy on the diaphragm in chronic or seasonal asthmatic patients regarding respiratory pressures and chest mobility. As this was a pilot study, we aimed to test the study protocol, the data collection, the randomization procedure, the recruitment and consent procedures, the acceptability of the intervention, and the feasibility of using selected outcome measures.

2. Materials and methods

2.1. Design

A randomized controlled pilot study with a single-blinded design was carried out. The study was registered in a clinical trial registry: ClinicalTrials.gov, with identifier NCT02047370. It was performed in a laboratory of the Faculty of Health Sciences of Granada, Spain, from February to May 2017. Approval for the study was obtained from the Biomedical Research Ethics Committee of Granada. The CONSORT guidelines [20] were followed during the course of the research.

This study was conducted in accordance with the amended Declaration of Helsinki. Participants received written and oral instructions about the intervention, test protocol, and possible risk and benefits of the study. Written informed consent was obtained from all participants before their inclusion in the study.

2.2. Participants

Participants were recruited from the Respiratory Unit of the University Hospital Complex of Granada between February and May 2017.

Subjects were informed about the inclusion and exclusion criteria of the study at the time of recruitment. Inclusion criteria were a medical diagnosis of allergic or non-allergic asthma and age ranging from 18 to 45 years. Exclusion criteria were having suffered an exacerbation in the previous two weeks (asthma exacerbation is defined as a worsening of asthma requiring the use of systemic corticosteroids to prevent a serious outcome) [21] and having severe thoracic deformities (such as pectus carinatum or pectus excavatum), scoliosis, or physical or cognitive comorbid conditions that may affect or impede the performance of the evaluation or intervention.

Patients were randomly allocated into either the intervention or the placebo group. The randomization sequence was drawn up and kept off-site by a statistician who was not aware of the study aims, using a random number generator in blocks of eight with no stratification. The randomization schedule was delivered in a sealed envelope to a research assistant who assigned patients to the groups and organized appointments for the patients over the telephone.

Fig. 1. Diaphragm stretching.

2.3. Intervention

The intervention group underwent a stretching of the diaphragm as previously described by Chaitow et al. [22] Each subject was positioned in an erect seated position. The therapist stood behind the patient and passed his hands around the thoracic cage, carefully introducing his/her fingers under the costal margin. The patient rounded his/her trunk slightly in order to relax the rectus abdominis. When the subject exhaled, the therapist grasped the lower ribs and costal margin and eased his/her hands caudally. The stretching was performed once and the tension was maintained for 5–7 min.

The stretching technique is shown in Fig. 1.

In the placebo group, disconnected ultrasound was applied in the same position for 5–7 min as a placebo treatment. The patients had to be seated erect, and the ultrasound was applied in the costal margins. Both interventions were carried out by the same researcher.

2.4. Outcome measures

The study assessor who collected the outcome measurements was blinded to the study hypotheses and group allocation. After all the baseline measures were taken, subjects were led to another room where they underwent the diaphragmatic technique or the placebo intervention. Subjects were then taken back to the first room for the post-intervention measures. For descriptive purposes, age, sex, and anthropometric measurements such as body mass index were taken at baseline. Forced expiratory volume in the first second (FEV1%) was evaluated with a CareFusion PulmoLife spirometer as described by the Spanish Society of Thoracic Pathology and Surgery (SEPAR) [23].

Health-related quality of life was assessed with the EuroQol-5D[24] questionnaire and sleep quality was evaluated with the Pittsburg Sleep Quality Index [25].

Additionally, the Asthma Control Questionnaire (ACQ) [26] was used to measure the adequacy of asthma control and quality of life was evaluated as a specific parameter in asthmatic patients with the mini AQLQ [27] questionnaire, which evaluates functional impairment due to asthma in the past two weeks.

All subjects completed the same test before the intervention, immediately after the intervention, at 5 min, and at 20 min to evaluate the effects of the technique.

2.5. Assessment of respiratory pressures

Maximal respiratory pressures: maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were evaluated with the portable MicroRPM device (Mercé V. Electromedicina S.L. Valencia, Spain). These values determine the strength of the respiratory muscles: the MIP reflects the strength of the diaphragm and other inspiratory muscles, while the MEP reflects the strength of the abdominal muscles and other expiratory muscles [28]. All pressures were measured with a nose clip in seated subjects. The maneuver was repeated until three acceptable maneuvers were obtained, with a variation of less than 20%. The efforts were separated by an interval of about 1 min to avoid fatigue.

2.6. Mobility and flexibility assessment

Rib cage excursion measures: Abdominal and rib cage measurements can be used as a method to assess diaphragmatic breathing excursion in order to quantify possible alterations in thoracic capacity and abdominal and chest wall compliance as achieved by all expiratory and inspiratory muscles. By recording the abdomen and rib cage excursion with a measuring tape over the second intercostal space (axillary level), xiphoid process, and midpoint between the xiphoid process and umbilicus (abdominal level), competency in diaphragmatic breathing can be demonstrated by a reduction in rib cage excursion [29]. These indirect measurements have an intra-rater reliability of 0.96–0.98 and an inter-rater reliability of 0.84–0.87, with correlation coefficients no less than 0.84 [20,21].

Lumbar spine mobility was evaluated with the Schober test: While the subject is in the standing position, marks are made on the midpoint between the posterior superior iliac spines and 10 cm above this point. The 10 cm distance is then compared to the distance between the same two marks when the subject is in the forward flexed position [30]. An elongation of 5 cm or more between the two marks during forward flexion is considered to be normal lumbar spine movement. This test has been validated to be used as a clinical test.

Flexibility was evaluated with the finger-to-floor-test (FFT), which assesses the flexibility of the vertebral spine. In the FFT, patients stand on a stool and flex the trunk forward to reach as far as possible with both hands, without bending their knees. The distance (cm) between the level of the stool and the middle finger is measured by the therapist. Lower values indicate a shortening of the trunk and lower limb muscles [31]. This test has been validated to be used as a clinical test.

2.7. Statistical analysis

The data obtained were analyzed with the Statistical Package for the Social Sciences (SPSS), version 20.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to determine participants' characteristics. Variables were presented as the mean ± standard deviation for continuous variables and as a percentage for categorical variables. The Kolmogorov-Smirnov test to assess the normality of continuous data was performed prior to the statistical analysis. Normal distributed data were compared with an analysis of variance. Non-normal variables were compared using the Kruskal-Wallis test, with an alpha level of 0.05. The statistical analysis was conducted at 95% confidence level. A p-value of less than 0.05 was considered statistically significant.

3. Results

Forty-three patients were recruited for the study but the final sample included only 32 patients. The distribution of patients is shown in Fig. 2.

Table 1 shows the characteristics of the patients included in this study.

Patient characteristics were similar in both groups. Mean age was similar in both groups: under thirty years. Body mass index was normal in both groups. In both groups, patients reported a good level of perceived quality of life in the Visual Analogue Scale of the EuroQol-5D. The ACQ showed that patients had a good control of asthma and the spirometric value of FEV1% reinforced the results of the ACQ.

Respiratory characteristics are shown on Table 2.

No significant differences were observed between the groups in the respiratory characteristics at baseline ($p > 0.05$).

Significant differences were found between the assessment before the technique and at 5 min in the MIP in the intervention group, which showed an improvement of the MIP at 5 min of diaphragm stretching ($p = 0.031$). No significant differences were observed in other respiratory parameters at 5 min ($p > 0.05$).

No significant differences were observed in the intervention group Between the assessment prior to the technique and at 20 min ($p > 0.05$), however, significant differences were found in the MEP in the placebo group ($p = 0.046$), which had a poorer result; a significant difference was also found between the groups in the MEP at 20 min ($p = 0.048$).

Table 3 shows results regarding mobility and flexibility.

Table 3 shows significant differences in the intervention group regarding abdominal excursion measured with the finger-to-floor-test and the Schober test between the pre-technique and the assessment immediately after the technique; patients showed an improvement in mobility and flexibility outcomes immediately after the stretching of the diaphragm ($p < 0.05$). No significant differences were observed immediately after the technique in rib cage excursion ($p > 0.05$). No significant differences were observed in any variables in the placebo group ($p > 0.05$).

In the intervention group, significant differences were found between the pre-technique assessment and the assessment 5 min after the technique in abdominal and rib cage excursion (subaxillary and abdominal level) and the finger-to-floor-test, showing an improvement of the values at 5 min of the stretching of the diaphragm ($p < 0.05$). However, no significant differences were observed in the placebo group.

The results at 20 min of the technique showed significant improvement in abdominal excursion and the finger-to-floor-test in the intervention group. By contrast, no significant differences were observed in the placebo group.

Finally, between-group differences were only observed in the finger-to-floor-test at 20 min, with a better result in the intervention group ($p = 0.037$).

4. Discussion

The objective of this study was to evaluate the effects of manual therapy on the diaphragm regarding respiratory pressures and chest mobility in chronic or seasonal asthmatic patients immediately after the technique, and at 5 and 20 min. Our results showed an improvement in maximal inspiratory pressure at 5 min of diaphragm stretching ($p = 0.031$). Significant results were also shown in mobility and flexibility, with a significant improvement in the subaxillary and abdominal perimeter as well as in the finger-to-floor test and the Schober test ($p < 0.05$). The intervention group showed an improvement in all the variables measured, while the placebo group showed no changes.

This is the first study to evaluate the effects of a stretching technique on the diaphragm in asthmatic patients. Previous studies [15,32] have explored the effects of the same technique in healthy people. González-Alvarez et al. [15] evaluated the effects of diaphragm stretching on pulmonary function and respiratory pressures in healthy adults. Their results showed a significant increase of forced vital capacity, forced expiratory volume in the first second, and respiratory muscle strength immediately after the technique. Pulmonary function variables also showed a significant increase in FEV1 at 5 min and a decrease at 20 min. In line with the results obtained in healthy people, our results showed an increase in respiratory strength 5 min after the technique in asthmatic patients.

In another study [32] carried out in 2015, the effects of diaphragm

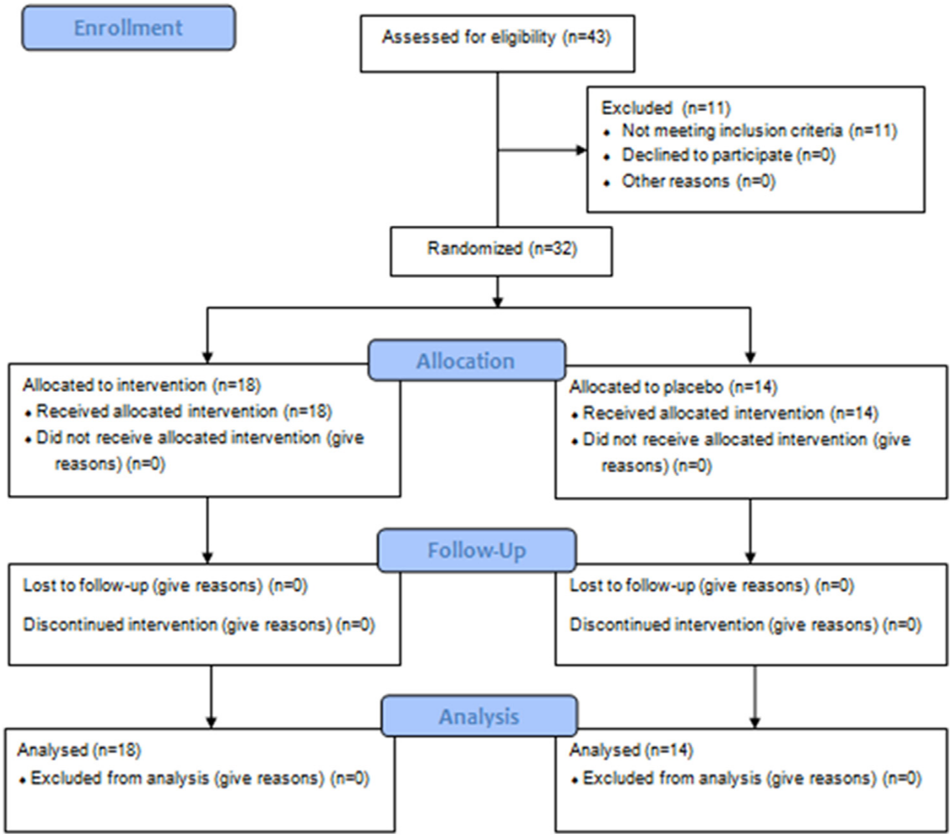

Fig. 2. CONSORT flow diagram.

Table 1
Characteristics of the patients included in the study.

	Intervention group (n = 18)	Placebo group (n = 14)	p-value
Age (years)	27.44 ± 8.162	26.86 ± 4.849	0.813
Sex n (% men)	5 (27.78)	4 (28.57)	0.252
BMI (kg/cm^2)	23.44 ± 3.698	25.43 ± 6.148	0.266
FEV_1%	99.11 ± 10.948	103.14 ± 7.410	0.247
EQ-5D mobility	1.11 ± 0.323	1.00 ± 0.000	0.210
EQ-5D self-care	1.00 ± 0.000	1.00 ± 0.000	1.00
EQ-5D usual activities	1.11 ± 0.323	1.14 ± 0.363	0.796
EQ-5D pain	1.11 ± 0.323	1.29 ± 0.469	0.222
EQ-5D anxiety/ depression	1.00 ± 0.000	1.14 ± 0.363	0.104
EQ VAS	91.11 ± 6.764	86.43 ± 10.271	0.131
Pittsburgh total	5.78 ± 3.655	6.29 ± 2.585	0.663
ACQ	0.44 ± 0.511	0.29 ± 0.469	0.374
MINI AQLQ: symptoms	6.33 ± 0.686	6.57 ± 0.514	0.288
MINI AQLQ: activities	6.44 ± 0.511	6.71 ± 0.469	0.135
MINI AQLQ emotions	6.33 ± 0.686	6.43 ± 0.514	0.668
MINI AQLQ environment	5.44 ± 1.464	5.43 ± 1.453	0.976
MINI AQLQ total	6.22 ± 0.428	6.14 ± 0.864	0.736

Results are shown as the mean ± standard deviation *p < 0.05; FEV_1%: forced expiratory volume in the first second; BMI: body mass index; EQ-5D: EuroQol-5D; MINI AQLQ: Mini Asthma Quality of Life Questionnaire; ACQ: Asthma Control Questionnaire; VAS: Visual analogue scale.

stretching were evaluated in patients with short hamstring syndrome. The aim of the study was to assess the effects of the technique on hamstring flexibility and spine mobility in patients with short hamstring syndrome. The results of the study showed a significant improvement in hamstring flexibility ($p < 0.001$) and in cervical and lumbar range of motion ($p < 0.05$) after the technique, while no significant changes were observed in the placebo group. In line with these results, our study showed the efficacy of the technique with significant results in mobility and flexibility, with a significant improvement in subaxillary and abdominal rib cage excursion, the finger-to-floor-test, and the Schober test.

A recent review performed by Wearing et al. [33] has shown that five of the six studies reported improvements in lung function and exercise performance following spinal manipulative therapy intervention in respiratory patients. Additionally, the study conducted by Cruz-Montecinos et al. [34] showed that a single application of a soft tissue manual therapy protocol appeared to have the potential to produce immediate clinically meaningful improvements in lung function in patients with severe and very severe COPD. These results are in line with those of our study, which showed immediate effects on a respiratory parameter: maximal inspiratory pressure in asthmatic patients.

Johansson et al. [35] evaluated whether a physiotherapeutic intervention could increase chest mobility in patients with sensory hyperreactivity. They found an improvement of chest mobility after the intervention. Their results indicated that patients may have acquired a dysfunctional breathing pattern. They concluded that the regular use of a training program and structural breathing instructions could be used to improve chest mobility in patients with sensory hyperreactivity and signs of dysfunctional breathing. Our results were similar in terms of improvement of chest mobility. However, the effects of our technique were immediate, while the effects of the intervention performed in the study of Johansson et al. were observed after 12 weeks.

Monteiro et al. [36] assessed diaphragm function during abdominal weight training and associated changes in the respiratory pattern. They found that abdominal weight increased proprioception related to the respiratory movements and descent of the diaphragm. Additionally, they reported that the loads on the abdomen produced minor changes in the mechanics of the diaphragm (1/3 of the load required to develop

Table 2
Respiratory characteristics.

	Pre-technique	Post technique	P between groups	5min Post technique	P between groups	20min Post technique	P between groups
MIP (cmH2O)							
IG (n = 18)	98.22 ± 28.852	90.33 ± 33.251	0.823	104.56 ± 37.848[b]	0.815	103.22 ± 32.697	0.809
PG (n = 14)	97.43 ± 17.105	98.00 ± 18.339		96.29 ± 17.626		96.86 ± 15.615	
MEP (cmH2O)							
IG (n = 18)	146.22 ± 53.718	136.89 ± 42.918	0.646	151.11 ± 66.517	0.288	139.22 ± 49.905	0.048[d]
PG (n = 14)	129.14 ± 26.541	130.14 ± 37.856		129.43 ± 38.757		101.57 ± 52.740[c]	

[a] Significant differences pre-post immediate.
[b] Significant differences pre-post 5min.
[c] Significant differences pre-post 20min.
[d] Between-group differences; IG: intervention group; PG: placebo group; results are shown as the mean ± standard deviation; $p < 0.05$; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure.

Table 3
Mobility and flexibility characteristics.

	Pre technique	Post technique	P between groups	5min Post technique	P between groups	20min Post echnique	P between groups
Rib cage excursion. Axillary level (cm)							
IG (n = 18)	3.67 ± 1.085	3.78 ± 1.263	0.887	4.33 ± 1.188*	0.627	3.78 ± 1.263	0.477
PG (n = 14)	3.86 ± 0.663	3.71 ± 1.204		4.57 ± 1.555		4.14 ± 1.610	
Rib cage excursion. Xiphoid level (cm)							
IG (n = 18)	5.00 ± 1.188	5.000 ± 1.6088	0.558	5.33 ± 2.000	0.211	5.00 ± 2.275	0.657
PG (n = 14)	6.00 ± 2.287	5.429 ± 2.4718		4.29 ± 2.644		5.43 ± 3.131	
Rib cage excursion. Abdominal level (cm)							
IG (n = 18)	1.22 ± 1.166	2.00 ± 0.840[a]	1.00	2.00 ± 1.283[b]	0.893	2.11 ± 1.132[c]	0.703
PG (n = 14)	1.43 ± 0.756	2.00 ± 1.359		2.00 ± 1.512		1.86 ± 1.027	
Schober test (cm)							
IG (n = 18)	14.56 ± 0.856	14.78 ± 0.943[a]	0.368	14.67 ± 0.970	0.378	14.56 ± 0.984	0.104
PG (n = 14)	14.29 ± 1.437	14.43 ± 1.222		14.29 ± 1.437		75.29 ± 154.521	
Finger-to-floor-test (cm)							
IG (n = 18)	4.22 ± 4.965	2.67 ± 3.325[a]	0.232	2.11 ± 3.160[b]	0.177	2.22 ± 3.318[c]	0.037[d]
PG (n = 14)	4.14 ± 5.390	5.00 ± 7.211		4.43 ± 6.173		6.29 ± 6.988	

[a] Significant differences pre-post immediate.
[b] Significant differences pre-post 5min.
[c] Significant differences pre-post 20min.
[d] Between-group differences; IG: intervention group; PG: placebo group; Results are shown as the mean ± standard deviation; $p < 0.05$.

fatigue in normal subjects). At least in normal subjects, these changes appeared to be insufficient to produce respiratory muscle training. Like our study, the study of Monteiro et al. focused on the diaphragm. However, our results showed the effect of stretching, with significant results in chest mobility and respiratory strength.

In the intervention group, no significant differences were observed between the pre-technique assessment and the assessment at 20 min ($p > 0.05$); by contrast, significant differences were found in MEP in the placebo group ($p = 0.046$), which showed poorer results; a significant difference between the groups was also observed in MEP at 20 min ($p = 0.048$). This could be explained by the position of the rectus abdominis during the placebo technique, which involved the muscle being held at a shortened length and with less ability to produce pressure during forced respiration; this reduced its effect as an accessory respiratory muscle.

Several limitations can be mentioned in this study. Small sample size is one of them. However, sample sizes in similar studies [33] ranged from 1 to 33 participants. The risk of bias was low in the randomized controlled trials and high in the other studies. This is only a pilot study so further trials are needed to determine whether our results are reproducible in a larger group of patients. Another limitation of this study could be the short length of the therapeutic session (5–7 min). However, previous studies [15] have explored the immediate effects of manual techniques with beneficial results. Indeed, the stretching of the diaphragm has shown beneficial effects in healthy people [15]. Finally, the absence of follow-up to determine how long the changes were maintained may be another limitation. Future studies could evaluate the effectiveness of this technique applied in several sessions to determine its long-term effects; they could also assess its effects taking into account other long-term variables such as inflammatory parameters, reduction of hospitalizations or exacerbations. Finally, it is important to mention that pilot studies are extremely useful and necessary, as conducting a clinical trial with no prior pilot study involves a high risk of compromising the results due to unplanned difficulties. In this case, the design, the recruitment strategies, and the intervention were appropriate. Future studies could include further analyses of variables such as age analysis or the inclusion of a third group of patients with different durations of the stretching.

5. Conclusion

Our results may show that a diaphragm stretching technique in asthmatic patients leads to an improvement in maximum inspiratory pressures at 5 min post-intervention and flexibility and mobility of the rib cage at 5 and 20 min post-intervention. The intervention group showed an improvement in all the measured variables, while the placebo group showed no changes.

Further trials are needed to determine whether these preliminary results are reproducible in a definitive trial.

Future studies could evaluate the long-term effects of the technique and its applicability in various clinical of daily situations of asthmatic patients.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

References

[1] Global Initiative for Asthma (GINA). Global strategy for asthma management and prevention. Bethesda, MD: National Heart, Lung and Blood Institute (NHLBI); 2009 Available at www.ginasthma.com, Accessed date: 21 May 2017.

[2] World Health Organisation Media Centre. [cited on 5 May 2017]; Available from: http://www.who.int/respiratory/asthma/es/index.html.

[3] Kämpe M, Vosough M, Malinovschi A, et al. Upper airway and skin symptoms in allergic and non-allergic asthma: results from the Swedish GA2LEN study. J Asthma 2017 May 2:1–9.

[4] Laitinen A, Altraja A, Kämpe M, Linden M, Virtanen I, Laitinen LA. Tenascin is increased in airway basement membrane of asthmatics and decreased by an inhaled steroid. Am J Respir Crit Care Med 1997;156:951–8.

[5] Laitinen A, Karjalainen EM, Altraja A, Laitinen LA. Histopathologic features of early and progressive asthma. J Allergy Clin Immunol 2000;105(2):S509–13.

[6] Holgate ST. Airway inflammation and remodeling in asthma: current concepts. Mol Biotechnol 2002;22(2):179–89.

[7] Lunardi AC, Marques Da Silva CC, Rodrigues Mendes FA, et al. Musculoskeletal dysfunction and pain in adults with asthma. J Asthma 2010;48:105–10.

[8] Barbarito N, Ceriana P, Nava S. Respiratory muscles in chronic obstructive pulmonary disease and asthma. Minerva Anestesiol 2001;67(9):653–8.

[9] Nason LK, Walker CM, McNeely MF, et al. Imaging of the diaphragm: anatomy and function. Radiographics 2012;32:E51–70.

[10] Silva AG, Punt TD, Sharples P, et al. Head posture and neck pain of chronic nontraumatic origin: a comparison between patients and pain-free persons. Arch Phys Med Rehabil 2009;90(4):669–74.

[11] Manning HL, Schwartzstein RM. Pathophysiology of dyspnea. N Engl J Med 1995;333:1547–53.

[12] Albuquerque Baltar J, Brasileiro Santos Mdo S, Justino da Silva H. Does asthma promote changes in static posture? - Systematic review. Rev Port Pneumol 2010 May-Jun;16(3):471–6.

[13] Lunardi AC, Marques da Silva CC, Rodrigues Mendes FA, et al. Musculoskeletal dysfunction and pain in adults with asthma. J Asthma 2011 Feb;48(1):105–10.

[14] Noll DR, Degenhardt BF, Johnson JC, et al. Immediate effects of osteopathic manipulative treatment in elderly patients with chronic obstructive pulmonary disease. J Am Osteopath Assoc 2008;108:251e9.

[15] González-Álvarez FJ, Valenza MC, Cabrera-Martos I, et al. Effects of a diaphragm stretching technique on pulmonary function in healthy participants: a randomized-controlled trial. Int J Osteopath Med 2015 March;18(1):5–12.

[16] González-Álvarez FJ, Valenza MC, Torres-Sánchez I, et al. Effects of diaphragm stretching on posterior chain muscle kinematics and rib cage and abdominal excursion: a randomized controlled trial. Braz J Phys Ther 2016 Jun 16;20(5):405–11.

[17] Holloway EA, West RJ. Integrated breathing and relaxation training (the Papworth method) for adults with asthma in primary care: a randomised controlled trial. Thorax 2007;62:1039–42.

[18] Heneghan NR, Adab P, Balanos GM, et al. Manual therapy for chronic obstructive airways disease: a systematic review of current evidence. Man Ther 2012;17:507–18.

[19] Hondras MA, Linde K, Jones AP. Manual therapy for asthma. Cochrane Database Syst Rev 2005;2:CD001002.

[20] Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMC Med 2010;8(1):18.

[21] Fuhlbrigge A, Peden D, Apter AJ, Boushey HA, Camargo Jr. CA, Gern J, Heymann PW, Martinez FD, Mauger D, Teague WG, Blaisdell C. Asthma outcomes: exacerbations. J Allergy Clin Immunol 2012 Mar;129(3 Suppl):S34–48.

[22] Chaitow L, Bradley D, Gilbert C. Multidisciplinary approaches to breathing pattern disorders. London: Churchill Livingstone; 2002.

[23] Sanchis J, Grupo de trabajo de la SEPAR. Normativa para la práctica de la espirometría forzada [Rules for the practice of forced spirometry]. Arch Bronconeumol 1989;25:132–42.

[24] Herdman M, Badia X, Berra S. EuroQol-5D: a simple alternative for measuring health-related quality. Atención Primaria 2001;28(6):425–30. October 2001.

[25] Buysse DJ, Reynolds CF, Monk TH, et al. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatr Res 1989 May;28(2):193–213.

[26] Jia CE, Zhang HP, Lv Y, Liang R, Jiang YQ, Powell H, Fu JJ, Wang L, Gibson PG, Wang G. The asthma control test and asthma control questionnaire for assessing asthma control: systematic review and meta-analysis. J Allergy Clin Immunol 2013 Mar;131(3):695–703.

[27] Juniper EF, Guyatt GH, Cox FM, et al. Development and validation of the mini asthma quality of life questionnaire. Eur Respir J 1999 Jul;14(1):32–8.

[28] Evans JA, Whitelaw WA. The assessment of maximal respiratory mouth pressures in adults. Respir Care 2009;54:1348–59.

[29] Cahalin LP, Braga M, Matsuo Y, et al. Efficacy of diaphragmatic breathing in persons with chronic obstructive pulmonary disease: a review of the literature. J Cardiopulm Rehabil 2002;22(1):7–21.

[30] Macedo CSG, Souza PR, Alves PM, et al. Study of validity and intra and interobserver reliability of the modified version of Schöber test modified in individuals with low back pain. Fisioter Pesqui 2009;16(3):233–8.

[31] Perret C, Poiraudeau S, Fermanian J, et al. Validity, reliability, and responsiveness of the fingertip-to-floor test. Arch Phys Med Rehabil 2001;82(11):1566–70.

[32] Valenza MC, Cabrera-Martos I, Torres-Sánchez I, et al. The effects of doming of the diaphragm in subjects with short-hamstring syndrome: a randomized controlled trial. J Sport Rehabil 2015 Nov;24(4):342–8. Epub 2015 Jun 24.

[33] Wearing J, Beaumont S, Forbes D, Brown B, Engel R. The use of spinal manipulative therapy in the management of chronic obstructive pulmonary disease: a systematic review. J Alternative Compl Med 2016;22(2):108–14.

[34] Cruz-Montecinos C, Godoy-Olave D, Contreras-Briceño FA, Gutiérrez P, Torres-Castro R, Miret-Venegas L, Engel RM. The immediate effect of soft tissue manual therapy intervention on lung function in severe chronic obstructive pulmonary disease. Int J Chronic Obstr Pulm Dis 2017;12:691–6.

[35] Johansson EL, Ternestén-Hasseus E, Olsén MF, et al. Physical therapy treatment of impaired chest mobility in patients with airway sensory hyperreactivity. Physiother Res Int 2017 Apr;22(2).

[36] Monteiro SG, Pessolano FA, Suárez AA, et al. Función del diafragma durante la colocación de cargas sobre el abdomen en sujetos normales [Diaphragm function while placing loads on the abdomen in normal subjects]. Medicina 2012;72(2):98–102.