

ORIGINAL ARTICLE

Incentive spirometry combined with expiratory positive airway pressure improves asthma control and quality of life in asthma: a randomised controlled trialTatiana Zacarias Rondinel, PT¹, Isadora Faraco Corrêa, PT², Luíza Machado Hoscheidt, PT², Mirelle Hugo Bueno, PT², Luciano Muller Corrêa da Silva, MD PhD³, Caroline Tozzi Reppold, PhD¹, and Pedro Dal Lago, PT, ScD^{1,4}¹Programa de Pós-graduação em Ciências da Saúde, Universidade Federal de Ciências da Saúde de Porto Alegre – UFCSPA, Porto Alegre, RS, Brasil,²Curso de Graduação em Fisioterapia, Universidade Federal de Ciências da Saúde de Porto Alegre – UFCSPA, Porto Alegre, RS, Brasil, ³Serviço de Pneumologia, Hospital Santa Casa de Misericórdia de Porto Alegre, Porto Alegre, RS, Brasil, and ⁴Departamento de Fisioterapia, Universidade Federal de Ciências da Saúde de Porto Alegre – UFCSPA, Porto Alegre, RS, Brasil**Abstract**

Objectives: The use of the incentive spirometer (IS) and expiratory positive airway pressure (EPAP) provides several benefits in patients with respiratory disorders. However, the effects of the use of these devices coupled (IS + EPAP) are still unknown in asthmatic patients. The aim of this study was to evaluate the effect of IS associated with EPAP on exercise tolerance (six-minute walk test – 6MWT), lung function (by spirometry), asthma control (Asthma Control Questionnaire – ACQ) and quality of life (Asthma Quality of Life Questionnaire – AQLQ) in patients with severe asthma. **Methods:** Patients were randomised into two groups: IS + EPAP ($n = 8$) and control ($n = 6$). The IS + EPAP group performed breathing exercises at home, twice daily for 20 min, over a period of 5 weeks. **Results:** There was no significant difference in spirometric variables and in the distance walked in the 6MWT in both groups. However, the IS + EPAP group showed an improvement in asthma control ($p = 0.002$) and quality of life ($p = 0.02$). **Conclusions:** These findings demonstrate that the IS + EPAP protocol, when performed at home, provides an improvement in asthma control and quality of life for patients with severe asthma when evaluated by ACQ and AQLQ, respectively.

Keywords

Breathing exercises, chest physical therapy, positive pressure, pulmonary function, functional capacity

History

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Introduction

Asthma is a worldwide chronic pulmonary disease that affects 300 million people [1] and represents one of the most prevalent chronic diseases in Brazil [2]. It is characterised by airway inflammation, bronchial hyper-responsiveness and variable airflow obstruction, which is reversible, either spontaneously or after treatment [3]. Asthma manifests clinically as symptoms including dyspnoea, chronic cough, chest tightness and wheezing, all of which are more pronounced in severe asthma [1]. Often, asthma is an underdiagnosed and undertreated disease, causing high morbidity and mortality [4]. Therefore, this represents a burden to the patient, especially those with more severe asthma and uncontrolled disease [5]. Most of this burden is a result of an underestimation of asthma severity and inadequate treatment, which could be avoided with correct intervention [6]. The assessment of asthma control has become essential to evaluate the intensity of treatment required for each patient [7].

Many patients have concerns about their disease and use complementary therapies, such as breathing techniques, with perceived benefits and acceptance by patients [8]. Studies using physiotherapy that include breathing exercises have reported improvements in quality of life [9–11], asthma control [10], and reductions in bronchodilator use [12]. However, few randomised controlled trials have tested the effectiveness of breathing techniques for asthma [13,14] and none have investigated severe asthma. A recent meta-analysis of randomised trials comparing breathing exercises in control groups and asthmatic patients was unable to show a strong effect regarding the use of breathing exercises, probably due to methodological differences between the studies [15]. Therefore, further studies are required to provide information regarding the use of these techniques in asthmatic patients [8].

To perform breathing exercises, two resources that are widely used in chest physiotherapy can be applied: incentive spirometry (IS) and expiratory positive airway pressure (EPAP). IS encourages the patient to perform slow and deep inspiration through visual feedback, providing the stretching and opening of collapsed airways. The EPAP increases alveolar pressure through a fixed resistance produced by a spring-loaded valve in expiratory way, which can prevent

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airway collapse at the end of expiration. Our hypothesis is that using IS + EPAP (lung expansion + reduction in airway collapse) in asthmatic subjects could prevent early collapse in the airway, mainly during expiration, which we believe could improve the quality of life, disease control, pulmonary function and the performance of activities of daily living. None of the studies in asthmatic populations have evaluated the use of IS in combination with EPAP.

Therefore, the aim of this randomised controlled clinical trial was to verify whether the combination of IS and EPAP (IS + EPAP) can improve asthma control, quality of life, pulmonary function and the 6-minute walk distance covered in asthmatic patients.

Methods

A randomised controlled clinical trial following CONSORT recommendations (Figure 1) was performed in the Laboratory of Physiology of the *Universidade Federal de Ciências da Saúde de Porto Alegre* (UFCSPA), using subjects with severe asthma (inhalation of high doses of steroids [≥ 800 mg per day], who use long-acting beta-2-agonists and FEV₁ post-bronchodilator ($< 80\%$), according to the Global Strategy for Asthma Management and Prevention (GINA) and Guidelines of the Brazilian Thoracic Association for the Treatment of Asthma, of the Pulmonology Outpatient Clinic from the *Irmandade Santa Casa de Misericórdia de Porto Alegre*. After approval from the UFCSPA Ethics and Research Committee (protocol 1206/10), written informed consent was obtained from the subjects. The trial was registered under the Clinical Trials number NCT01643421.

The inclusion criteria were: subjects aged 20 to 80 years old with severe asthma that was diagnosed by a physician at least 12 months prior to the study. The exclusion criteria were: history of chest surgery, the presence of another chronic lung disease, infectious lung diseases currently being treated, acute myocardial infarction in the last 6 months, another significant disease besides asthma, acute severe asthma at the moment of inclusion or recent hospitalisation for more than 24 h in the last 30 d before inclusion, recent acute illness, illiteracy, smoking (more than five packs per year, or stopped smoking less than 1 year ago), inability to perform spirometry and an inability to attend study visits.



Figure 1. Photo of the equipment used by IS + EPAP group.

Randomisation was performed with a computerised random number generator (www.randomization.com). The patients were randomised into two groups: intervention group (IS + EPAP) or control group (usual care). All subjects performed a total of six visits to the laboratory. Two visits were to perform evaluations (at baseline and at the end of the protocol, with a gap of 5 weeks), which consisted of measuring pulmonary function, performing the 6-minute walk test and completing the Asthma Control Questionnaire (ACQ) and Asthma Quality of Life Questionnaire (AQLQ). The main investigator, who was unaware of the group allocation of the subjects, assessed these evaluations. The other 4 weekly visits were assessed by the assistant researchers, and involved spirometry. Also, the intervention group performed a supervised session with equipment at each visit. Moreover, the subjects were contacted by phone once a week. No changes in methodological design were made throughout the study.

Pulmonary function

Pulmonary function was assessed by spirometry (Minispir, MIR, Bedford, NH) in all subjects' visits as recommended by the American Thoracic Society (ATS) and Brazilian Consensus of Spirometry. We analysed the forced expiratory volume in 1 s (FEV₁), forced vital capacity (FVC), FEV₁/FVC ratio and mean forced expiratory flow between 25 and 75% (FEF_{25–75}) of the FVC.

The patients were initially at rest and the technique was explained to the patient, with demonstrations by the researcher to enable better understanding. The patients were vigorously encouraged to perform a maximum inspiration followed by a long and forced expiration lasting 10 s. The measures were performed at least three times and a maximum of eight times; the highest value obtained was used. After bronchodilator administration (four inhalations of salbutamol 100 mcg), the procedure was repeated in order to assess response to the bronchodilator. This procedure was repeated at all visits.

Quality of life

Quality of life was assessed by the validated Portuguese version [16] of the Asthma Quality of Life Questionnaire (AQLQ) [17]. The questionnaire consists of 32 questions designed to evaluate daily symptoms that are typically found in asthmatic adults. Each question has seven response options, 1 represents very or always, 7 indicates none or never, and 2–6 are intermediate degrees. Responses referred to the 2 weeks immediately preceding evaluation. The questionnaire has four domains: symptoms (S), emotional function (EM), environmental stimulus (EN) and activity limitation (A). Each item has the same weight and the questionnaire analyses the mean scores of each domain as well as the global score, using a scale of 1–7. Higher scores represent a better quality of life. This was applied at the first and last evaluations.

Asthma control

For the assessment of asthma control, the validated Portuguese version [18] of the Asthma Control Questionnaire (ACQ) was used [19]. This is composed of

six simple questions, which are self-reported, plus a seventh question about the individual's FEV₁ value. Responses are graded 0–6 and refer to the last 7 d prior to assessment. An ACQ score higher than 1.5 indicates uncontrolled asthma, whereas a score below 0.75 indicates good control [20]. This was applied at the first and last evaluations.

Exercise tolerance

A six-minute walk test (6MWT) was performed, following the guidelines of the American Thoracic Society (ATS, 2002), in a 40-m corridor at the *Irmandade Santa Casa de Misericórdia de Porto Alegre*. A previous test was performed a few days prior to the first evaluation for learning and recognition of the test [21]. Before and after the test, heart rate, respiratory rate, blood pressure, peripheral oxygen saturation and the Borg scale for rating of perceived dyspnoea and for effort perception in lower limbs were measured. The patients were instructed to walk as fast as possible without running. They walked alone and each minute they were warned about the timing, with encouraging words used as necessary. At the end of the test, the distance walked in metres was recorded.

Intervention protocol

For the performance of breathing exercises, the patients randomised into the IS+EPAP group used volumetric incentive spirometry (Spiro-Ball, Leventon, Spain) alongside EPAP (Vital Signs, Totowa, USA). The IS+EPAP system consisted of a mouthpiece connected to a T-piece that had an inspiratory unidirectional valve connected to a corrugated tube of IS in one of its end circuits. At the other end of the circuit, the T-piece was connected to an expiratory valve in order to graduate the EPAP level (Figure 1).

At first assessment, patients received training on the equipment to perform the protocol at home, with guidance on handling and emphasis on the importance of performing the protocol. They trained twice a day at home, for 15–20 min per session, without any supervision; this was performed for a period of 5 weeks, as previously described by our group [22]. Once a week, a meeting was scheduled for supervised protocol execution and spirometry to measure FEV₁. Also, to monitor protocol compliance and execution, patients were contacted by phone once a week.

Patients were instructed to maintain diaphragmatic breathing and to work at 60–80% of their maximum inspiratory capacity, according to spirometric values measured on the first day. The initial expiratory pressure was set to 5 cmH₂O; in the third week, this was increased to 10 cmH₂O and then to 15 cmH₂O in the fourth week, maintaining this value until the end of the study.

All patients, including those from the control group (usual care) received an asthma explanatory folder containing, among other things, information on how to correctly use the inhaled medication and what to do if they had dyspnoea. Also, they attended clinic once a week for spirometry to measure FEV₁.

Statistical analysis

Due to the small sample size, Shapiro–Wilk test was used to assess normality. All variables are expressed as the median

(minimum–maximum). Baseline and spirometry data were compared using the Mann–Whitney *U* test, Wilcoxon Signed Ranks test or the Fisher exact test for categorical variables. To assess AQLQ, ACQ and distance walked in 6MWT, we determined the difference between pre- and post-evaluation in each group for this test and analysed this using the Mann–Whitney *U* test. Data were analysed using Graph Pad Prism 5 (Graph Pad Prism, version 5.0, San Diego, CA). A *p* value ≤ 0.05 was considered statistically significant for all tests.

Results

Subjects were studied from February 2011 until May 2012. A total of 14 subjects finished this study; the flow of subjects is shown in the CONSORT diagram (Figure 2). One subject was excluded from the analysis due to asthma exacerbation (and subsequent hospitalisation). As a result of the randomisation process, we found no differences between groups with regard to demographic factors and basal spirometric measures (Table 1). Also, there was no difference in the age of asthma onset [20 (4,55); 14 (4,55)] and a total of 83.3% of the control group and 80% of the IS+EPAP group had suffered from asthma for more than 20 years. Both groups had similar drug treatments [combination of inhaled corticosteroids – budesonide (control group 650 ± 251 and IS+EPAP group 712 ± 269 mcg) and long-acting bronchodilator – formoterol (34.6 ± 13.2 versus 35 ± 9.9 mcg), and had no concomitant diseases that hampered the study.

Pulmonary function

The results for the baseline measures of FEV₁, FEV₁/FVC and FEF_{25–75} were similar between groups, as shown in Table 1. Likewise, after the 5-week protocol intervention, we found no difference in these measures between groups or within groups.

Asthma control

There was no difference in ACQ in the pre-evaluation between the control group [2.1 (0.3,2.4)] and the IS+EPAP group [2.2 (1.0,3.6)]. However, after 5 weeks, the IS+EPAP group (*n* = 8) showed a significant decrease (*p* = 0.002) in the score compared with the control group (*n* = 6) [−1 (−1.6,0.6); 0.1 (−0.4,0.8)] (Figure 3). Additionally, a decrease of 0.5 on the scale indicates clinical improvement [23], which was achieved by 100% of the intervention group and none of the control group. Fisher's exact test was performed, which showed a difference between groups (*p* < 0.001), and corroborated the previous result.

Quality of life

There were no differences between groups in all domains and in the global score for the pre-evaluation. By comparing groups, we found that the score increased in all domains in the IS+EPAP versus the control group (Table 2). Also, the IS+EPAP group had a significantly increased global score (*p* = 0.02) compared with the control group, as shown in Figure 4. Unlike the ACQ, an increase of 0.5 on the scale indicates clinical improvement [24], which was also higher in the IS+EPAP group (87.5% versus 16.6% of control group),

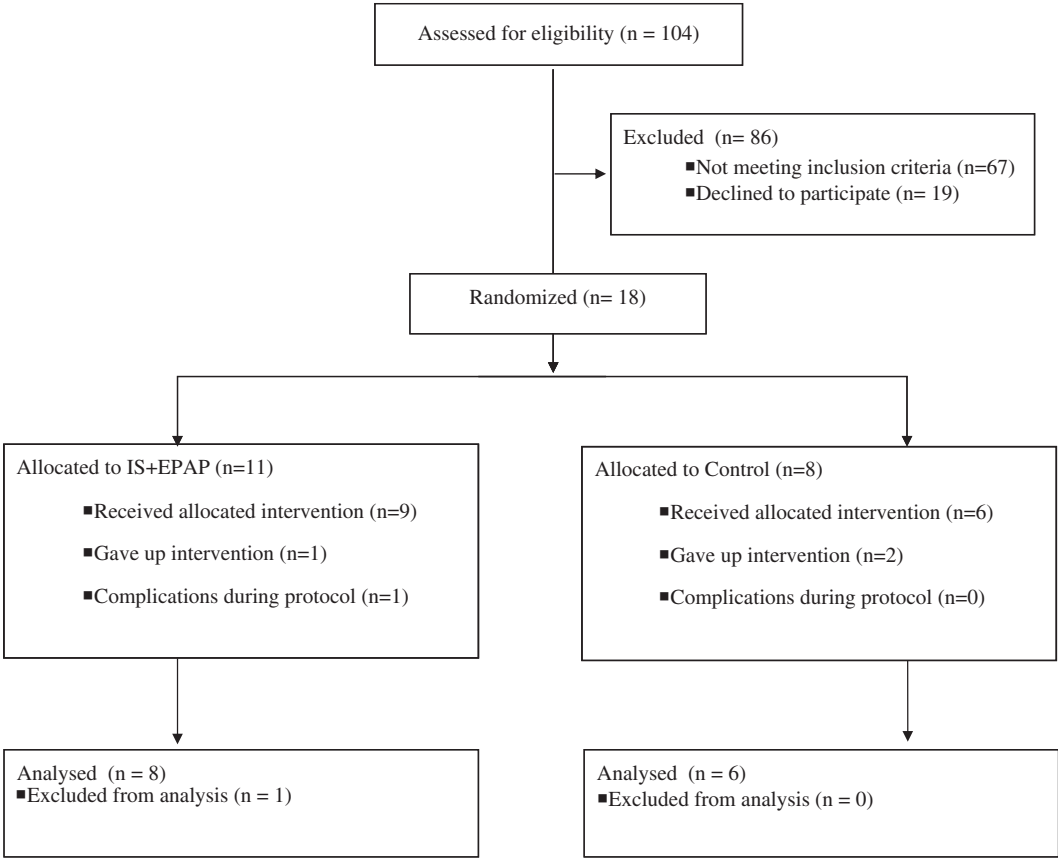


Figure 2. Flow diagram of the recruitment process and allocation of the participants.

Table 1. Baseline data sample of asthmatic subjects.

	Control group <i>n</i> = 6	IS + EPAP group <i>n</i> = 8
Demographic data		
Age (years)	63 (54–61)	57 (37–51)
Gender (male/female)	2/4	2/6
Body weight (kg)	66.5 (57–77)	72.5 (58–82)
Height (m)	1.59 (1.50–1.69)	1.60 (1.50–1.70)
BMI (kg/m ²)	27.1 (19.9–34.2)	28.2 (22.4–35.1)
Spirometric measures		
FEV ₁ (L)	1.56 (0.74–1.43)	1.30 (1.23–1.37)
FEV ₁ (%pred)	52.4 (34.1–85.1)	63.3 (24.1–90.7)
FEV ₁ /FVC (L)	0.62 (0.59–0.64)	0.60 (0.59–0.61)
FEV ₁ /FVC (%pred)	55.0 (36.6–96.6)	60.4 (25.1–89.9)
FEF _{25–75%} (L/s)	0.88 (0.87–0.90)	0.96 (0.95–0.97)
FEF _{25–75%} (%pred)	39.3 (19.4–66.1)	37.0 (12.5–74.9)
6MWT		
Distance walked (m)	532(458–619)	537(406–640)

Data are median (minimum–maximum).

FEV₁, forced expiratory volume in 1 s; FVC, forced vital capacity; FEF_{25–75}, mean forced expiratory flow at 25% point to the 75% point of FVC.

The variables were tested with Mann–Whitney test, except gender (Fisher exact test). There are no statistic significant differences between groups.

as demonstrated by the Fisher’s exact test ($p = 0.02$) when compared to the control group.

Exercise tolerance

There was no difference in the distance walked in the first evaluation when comparing the IS + EPAP group [537

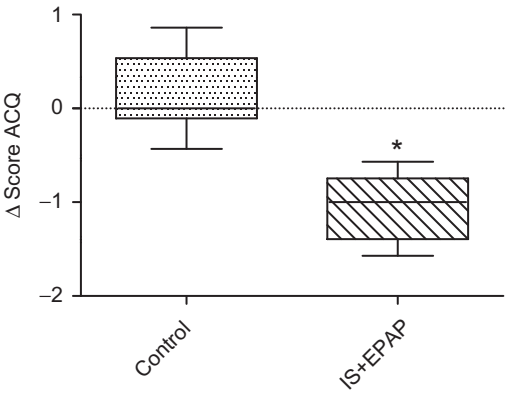


Figure 3. Data are median (minimum–maximum). *Decrease in scale value in IS + EPAP group ($p = 0.002$) when compared to control group. Mann–Whitney test.

(406,640)] with the control group [532 (458,619)]. After 5 weeks, the IS + EPAP group had a higher percentage (62.5%) of clinically significant differences (more than 25 m) in the 6MWT [25] than the control group (16.6%); however, this difference was not significant ($p = 0.13$).

Discussion

To our knowledge, this is the first randomised controlled clinical trial assessing the efficiency of the combined use of IS and EPAP in asthmatic patients. A previous study by our group used IS + EPAP in patients undergoing coronary artery bypass graft; after 4 weeks, they improved pulmonary

Table 2. ACQ and AQLQ data.

	Control group $n = 6$	IS + EPAP group $n = 8$
Δ ACQ	0.1 (−0.4,0.8)	−1 (−1.6,0.6)*
Δ AQLQ		
Global	0.3 (−0.1,1.3)	1 (0.4,2.7)*
A	0.7 (0.1,1.1)	1.9 (0.5,2.8)
S	−0.4 (−1.0,1.7)	1.2 (0.0,1.9)
EM	−0.4 (−0.8,0.6)	0.7 (0.0,3.4)
EN	0.2 (−2.2, 2.2)	0.5 (−0.5,2.7)

Data are median (minimum–maximum)

* $p < 0.05$; Δ , variation of the first and last score; ACQ, Asthma Control Questionnaire; AQLQ, Asthma Quality of Life Questionnaire; A, activity limitation; S, symptoms; EM, emotional function; EN, environmental stimulus. The variables were tested with Mann–Whitney test.

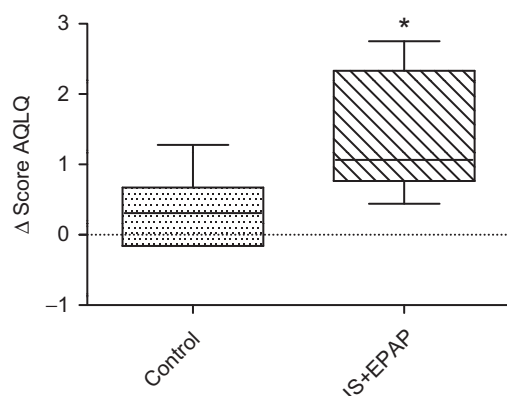


Figure 4. Data are median (minimum–maximum). *Increase in the global score value in IS + EPAP group ($p = 0.02$) when compared to control group. Mann–Whitney test.

function and 6-minute walk distance, while also showing a reduction in post-operative pulmonary complications [22]. The main findings of the present study are that the IS + EPAP group showed improved asthma control and quality of life in comparison to the control group, but that the protocol had no impact on pulmonary function and exercise tolerance. The rationale for the use of this protocol in asthmatic patients was that incentive spirometry, which is a device used to encourage the patient to perform slow and deep inspiration through a visual feedback, would have an effect on the stretching and opening of collapsed airways, whereas EPAP, which increases pressure during expiration, would sustain this airway recruitment, improving ventilation. Besides, these devices were not tested before in asthmatic severe adults.

The patients in our study had severe asthma. Previous studies have found that asthma is not optimally controlled in many patients [4] and that asthma severity is associated with poor asthma control [26–28] and the high use of quick relief medication [29]. To assess asthma control, we used the ACQ, a standardised tool for the evaluation of the degree of asthma control [19], since control is overestimated when only using patient perception [30]. It was established that the ACQ score for uncontrolled asthma is more than 1.5, a score between 0.75 and 1.5 represents partial control and scores below 0.75 indicate good control [20]. All patients had high scores at the first evaluation (median 2.1 and 2.2), which indicates uncontrolled asthma. However, after intervention, the

IS + EPAP group showed significantly improved asthma control by achieving a lower ACQ score (median 1.2). The ACQ contains five questions about symptoms, one about short-acting bronchodilators and one about FEV₁. The patients of the IS + EPAP group probably improved their ACQ score due to decreased symptoms and less of a need for bronchodilator use. Furthermore, a change of 0.5 in the score represents a significant clinical improvement [23], which was found only in the IS + EPAP group (but was achieved by all subjects).

Guidelines emphasise that the control of symptoms is the therapeutic priority in asthma [1]. Studies commonly use medications [31,32] or educational programmes [26,33] to evaluate changes in asthma control. One randomised controlled trial comparing a breathing training group with a control group found an improvement of ACQ in both groups [10]. Another study in the United States compared the effectiveness of breathing exercises and concluded that hyperventilation reduction techniques can improve asthma symptoms; however, the evidence is limited [14]. Also, a qualitative study showed that breathing training is acceptable as a non-pharmacological treatment to assist in breathing and reducing the use of reliever medication [34]. In our study, better control was only achieved by the IS + EPAP group, with significant clinical improvements. This indicates that performing this protocol of breathing exercises is effective for reducing symptoms, with a reduction in the use of quick relief medication, thus improving asthma control.

As for asthma control, quality of life was assessed by a questionnaire (AQLQ), which represents an important tool to evaluate responses to treatment [35]. In this questionnaire, higher scores indicate a better quality of life. The improvement in quality of life was only achieved, in the global score, by the IS + EPAP group. Other studies also found a better quality of life when asthmatics undertook breathing exercises [10], yoga [36], educational programmes [37] and rehabilitation programmes [9]. There was a tendency towards an improved quality of life in this group in the subdomains activities ($p = 0.06$), emotional function ($p = 0.07$) and symptoms ($p = 0.06$). A previous study with a bigger sample size found that the intervention group had significantly better scores than the control group in global score, but also in symptoms, activities and emotional function subdomains [10], as also found in another study which used yoga breathing exercises [36]. This may explain the tendency we found in our study, which could possibly have achieved significance if we had used a bigger sample. Also, a change in score of 0.5 represents a minimal important difference [24], but that was only found for the IS + EPAP group, confirming that the quality of life in this group was superior to that of the control group.

It is known that the level of asthma control is important to patients and has a direct impact on their quality of life [32]. Previous studies have shown a correlation between asthma control and quality of life: poorly controlled asthma is associated with a lower quality of life and a greater risk of emergency department visits [38], while better asthma control leads to a better quality of life [39]. This was also shown in our study, as the IS + EPAP group showed improved asthma control and quality of life, confirming the findings of a

previous randomised controlled trial which reported that the performance of breathing exercises improves asthma health status [10].

Regarding the 6MWT distance covered, the baseline walked distance was higher than 80% of that predicted, showing that the subjects had good prior exercise tolerance when compared to other populations [40]. Studies have shown that patients that undertook rehabilitation programmes with aerobic exercises improved their distance walked and exercise tolerance [9,41,42]. In the present report, there was no aerobic intervention, which could also explain the lack of change in the distance walked.

It is well known that, in patients with chronic obstructive pulmonary disease, a significant response in the 6MWT corresponds to an increase of approximately 25 m [25], with no reports of such data in the asthmatic population. As it is a chronic disease, we used this finding in our asthma patients, and found that more than 60% of the IS + EPAP patients walked further than 25 m, in comparison with 16.6% of the control group. Although there was no statistical difference between the groups, this is an important finding, which could represent an improvement in the ability to perform activities of daily living.

Conclusion

In conclusion, this randomised controlled trial demonstrated that IS + EPAP results in an improvement in asthma control and quality of life in severe asthmatics, providing new evidence regarding the use IS + EPAP in asthma. The use of IS + EPAP incurs a low cost and can facilitate patient adherence to breathing exercises that could be easily applied in their home.

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Declaration of interest

The authors have no conflicts of interest to disclose regarding this article.

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