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ORIGINAL ARTICLE

Effects of inspiratory muscle training and breathing exercises in children with asthma: a systematic review

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Abstract

Introduction: Asthma is characterized by a narrowing and inflammation of the bronchi, with symptoms of dyspnea, fatigue and exercise limitation. Physical therapy includes inspiratory muscle training and breathing exercises, given that an increase in inspiratory muscle strength and resistance can improve the symptoms of the disease.

Objective: To describe the effects of inspiratory muscle training (IMT) and breathing exercises in children with asthma.

Methods: This is a systematic review of the literature using the Cochrane, PubMed Scopus e Web of Science databases. The following descriptors were used: asthma, inspiratory muscle training, breathing exercises and child in Portuguese, English and Spanish. Two independent evaluators screened studies that used breathing exercises and IMT in children with asthma.

Results: Of a total of 312 titles, eight studies were included, of which six are randomized clinical trials and two are observational studies All the studies included breathing exercises, with the objective of adjusting breathing patterns and pulmonary ventilation, reducing pulmonary hyperinflation, bronchospasm and sensation of dyspnea. However, as these exercises were not performed solely, the effects of this intervention could not be verified. Two studies performed IMT and showed an increase in maximal respiratory pressure.

Conclusion: Breathing exercises are widely used in clinical practice as part of the management of asthma in children; however it is not possible to measure the effects in this population. IMT seems to improve inspiratory and expiratory muscle strength, but its indication in the pediatric population is not a standard procedure.

Keywords: asthma, breathing exercise, child.

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Authors summary

Why was this study done?
This study was designed to gather information about the effects of the IMT and breathing exercises in the pediatric population diagnosed with asthma. The importance and benefits of these interventions in adults are already known,
and although they are widely used in pediatric clinical practice, the effects are not yet clear.

What did the researchers do and find?
A systematic review was carried out, as this type of study is at the top of the pyramid of scientific evidence, in order to identify the studies that used these interventions (IMT and breathing exercise). However, only eight studies were included, which presented a variety of intervention methods and protocols, with associated application of techniques, making it difficult to generalize the results and to identify the effects of IMT respiratory exercises.

What do these findings mean?
There is a lack of evidence in scientific literature about the efects and possible benefits of IMT and breathing exercises in children with asthma. These interventions deserve further investigation, since they are quite widespread in clinical practice.

INTRODUCTION

The Global Initiative for Asthma defines asthma as a heterogeneous disease characterized by chronic inflammation of the airways, with a history of respiratory symptoms, such as wheezing, dyspnea, chest tightness, cough and variable airflow limitation[1]. Currently, it affects people of different age groups and is the most common chronic disease among children[1,2].

According to the World Health Organization, approximately 235 million people worldwide suffer from asthma[3], and in Brazil Barreto *et al.*[4] found a high prevalence of asthma symptoms among schoolchildren. There is a progressive increase in all age groups[5] and in deaths at home, with asthma being responsible for 5-10% of these cases[6]. Asthma is therefore considered a public health problem and a major concern to governmental authorities and healthcare professionals globally[6].

The disease is triggered by multiple allergenic and non-allergenic stimuli, such as infectious, emotional and hormonal factors, food, gastroesophageal reflux, as well as hypersensitivity reactions to drugs and chemicals. Among school children, physical exercise is the most frequently cited precipitating factor[7,8], and this may also be a limiting factor[9] in patients with the disease, given the presence of dyspnea due to respiratory and peripheral muscle weakness[10,11]. As a consequence, asthma can lead to fatigue and irritability and reduce tolerance to physical exercise and patients may suffer from side effects associated with the use of asthma medication[11]. When exercise deprivation occurs, it is possible to note underdeveloped musculature, lack of motor coordination and exercise tolerance[10,11]. However, there is evidence of benefits provided by physical activities, especially combined with breathing exercises; and it is therefore indicated as a non-pharmacological treatment option as well as physiotherapy[12].

The treatment of asthma includes respiratory physiotherapy, which consists of resources and techniques taught and applied to the patient to allow removal of secretion from airways, alleviate the sensation of respiratory discomfort, improve respiratory muscle strength and function, and promote cardiorespiratory conditioning[13]. In addition, they can prevent deformities and postural changes influenced by inadequate breathing.

Along these lines, several respiratory physiotherapy programs including inspiratory muscle training (IMT) and breathing exercises were the objects of study in patients with asthma as complementary therapies to drug treatment[10]. These programs are widely used in clinical practice, but do not follow a standard protocol regarding frequency, duration and application of their resources.

Thus, the present study is justified by the need to collect information from the scientific literature on the application of these physiotherapy approaches. It aims to describe the effects of 1) inspiratory muscle training and 2) breathing exercises in children with asthma through a systematic literature review.

METHODS

This is a systematic review of the literature, which was based on the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[14].

Search Strategy

At first, the literature search started with the definition of the guiding question, using the PICO framework: What are the effects of inspiratory muscle training and breathing exercises on children with asthma? Next, the search proceeded with descriptors using the DeCS system (Health Sciences Descriptors) in Portuguese, English and Spanish. Three blocks with descriptors were selected using the following keywords: asthma, inspiratory muscle training, breathing exercises and children. Boolean operators AND and OR were also used for combination of terms.

The electronic search was conducted in February 2019, using the Cochrane, PubMed, Scopus and Web of Science databases.

Selection Criteria

For this systematic review, randomized clinical trials or observational cross-sectional studies that answered the guiding question were included. They included children and adolescents up to 15 years old diagnosed with asthma, who underwent physical therapy intervention, namely IMT or breathing exercises. The date of publication was not an inclusion criterion for the selection of the articles; and only publications in English and Portuguese were considered. The following articles were excluded: case studies and case

series, review articles and studies with populations with syndromes, cognitive deficits and associated neurological deficits.

Study Selection and Methodological Evaluation

The articles were screened by two independent evaluators, who performed the search in the databases. At first, they read the titles and selected potential articles for further analysis of the abstracts. After screening the abstracts, the evaluators listed the articles that met previously established criteria to be read in full. Disagreements regarding the selection of studies were resolved through discussion between the evaluators. The methodological quality of the selected studies was also assessed using the PEDro scale[15].

RESULTS

The search in the databases identified 342 articles, and after excluding the duplicates, 312 titles were read. The abstracts of 98 studies were read, of which 32 were considered eligible for full analysis of the article. Of the eligible articles, only eight were included in the present review (Figure 1), for a total sample size of 288 children with asthma. Of the total studies included, six are randomized controlled trials and two are observational studies. The methodological quality was evaluated using the PEDro scale, as shown in table 1.

There was great variability in the physical therapy intervention protocols used in patients with asthma, but all studies included breathing exercises and only two studies reported inspiratory muscle training. About five studies compared intervention groups with control groups; two studies divided the sample into groups that received intervention, without a control group; and one study applied the intervention protocol to all participants. The main outcome under investigation was lung function, specifically spirometry parameters. These data are summarized in table 1.

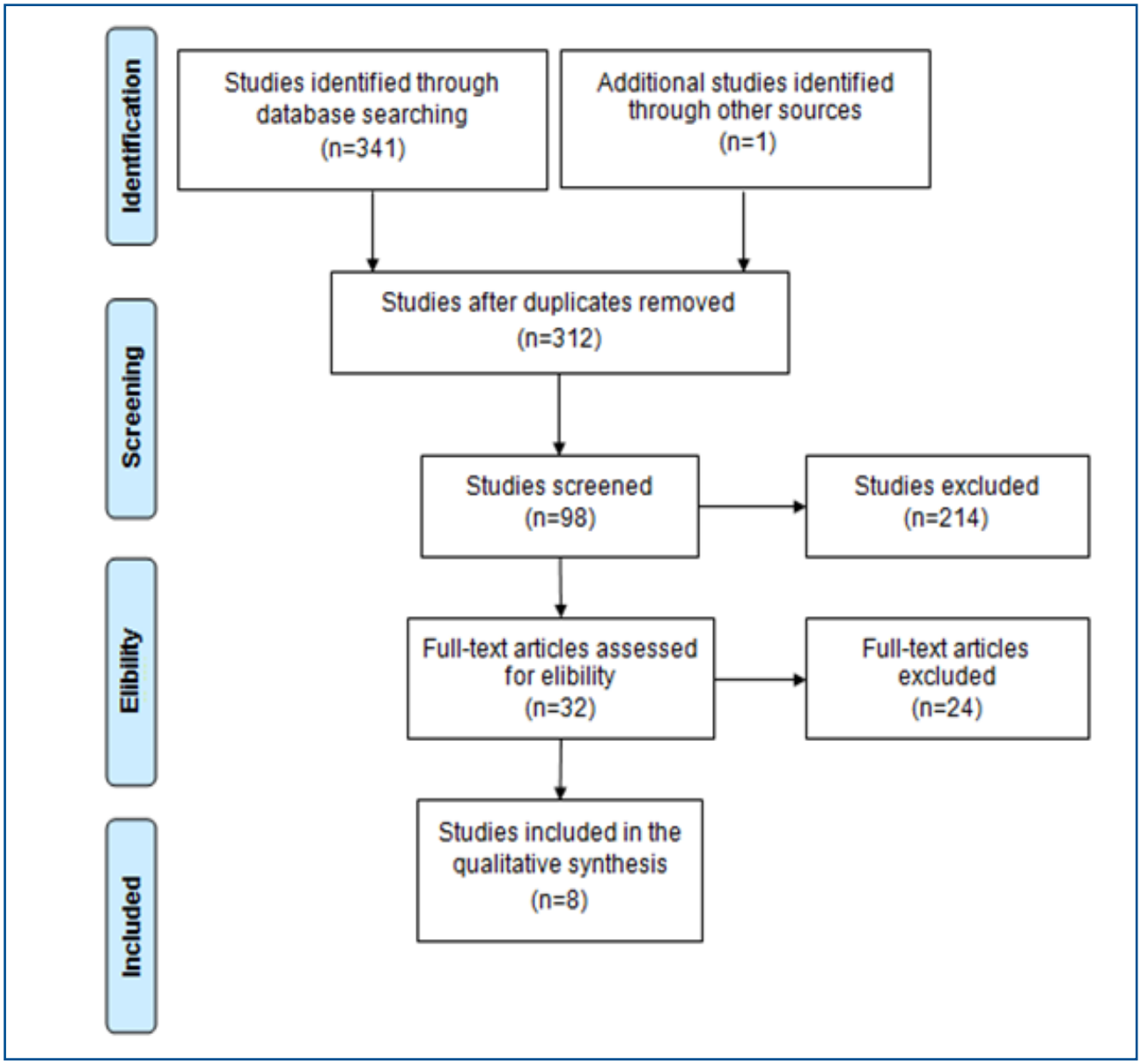

Figure1: Flowchart showing section of studies for literature review.

Table 1: Description of the selected studies that used inspiratory muscle training and/or breathing exercises in children with asthma, and the score of the assessment of methodological quality according to the PEDro scale.[15]

Authos/ year	Age group	PEDro	Type of study	Study Design	oucomes	conclusion
Seligman et al. 1970[26]	Not mentioned	0/10	Observ.	(n=18) A training program was carried out, which consisted of: relaxation, diaphragmatic breathing, exercises to improve chest and trunk mobility as well as to develop exercise capacity. The training program was conducted for 1.5 hours, 1x/week during 8 weeks.	Lung function, expiratory capacity and chest mobility.	There was an increase in predicted percentage values for expiratory capacity and chest mobility. Lung function showed no statistical difference before and after the treatment period.
Asher et al.1990[25]	6-13	6/10	RCT	(n=34) Physiotherapy in children hospitalized due to asthma exacerbation. CG – drug treatment and visits (for 20 minutes) by a volunteer with training in emotional support. IG – drug treatment and physiotherapy for 20 to 30 minutes. Physiotherapy intervention included techniques for secretion removal, relaxation and breathing exercises (diaphragmatic breathing and lateral costal breathing). Each child received 4 treatments during the 2-day hospital stay.	FVC, FRC, RV, TLC, PFE, FEV1, $FEF^{25-75\%}$.	Values were presented as a percentage of predicted. There was no statistically significant difference between baseline values and values at the end of the study, and between the two groups.
Ceugniet et al. 1994[29]	12-18	5/10	RCT	(n=24) The study investigated whether the voluntary control of the IT/ET ratio, during and after physical exercise reduces decline in lung function, preventing exercise-induced asthma. Only boys were included, who underwent two exercise tests 24 hours apart. G. without instructions - in the second test, a spontaneous breathing pattern was performed. G. IT/ET equal to 1 - in the second test, they performed 1/1 or 2/2 breathing pattern during and after the exercise. G. IT/ET equal 1/3 - in the second test, they performed 1/3 breathing pattern during and after the exercise.	VFC and FEV_1	There was no statistical difference in ΔVEF_1 and FVC between the first and the second test and between groups. Voluntary control of the IT/ ET ratio did not prevent exercise-induced asthma.

Continuation - Table 1: Description of the selected studies that used inspiratory muscle training and/or breathing exercises in children with asthma, and the score of the assessment of methodological quality according to the PEDro scale.[15]

Authos/ year	Age group	PEDro	Type of study	Study Design	oucomes	conclusion
Karakoç et al. 2000[30]	Mean (10.8±2.3) rehabilitation group/ (10.2±2.4) control group	3/10	RCT	(n= 28) Randomization in control group and pulmonary rehabilitation group. Pulmonary rehabilitation consisted of relaxation exercises, endurance exercises, breathing exercises and rhythmic mobilization, performed for 30 days at home.	Symptom and medication scores, quality of life and lung function.	There was a reduction in symptom and medication scores, as well as an increase in quality of life and lung function, after the treatment period in the rehabilitation group. There was no statistical difference in these outcomes before and after 30 days in the control group.
Lima et al.2008[19]	8-12	4/10	RCT	(n=50) IMT and breathing exercises in children with asthma. CG – medical follow-up and educational material about asthma. IG – diaphragmatic breathing, fractional breathing and pursed-lips breathing (10 sets of each exercise in the seated and supine positions), training with Treshold IMT (40% of MIP), 2x/ week during 7 weeks.	PFE, MIP, MEP.	IG showed an increase in PEF, MIP and MEP, which were maintained even after the end of the treatment program.
El-Kader2011[28]	8-15	4/10	Observ.	(n=40) All children performed aerobic exercise (60-70% of maximal heart rate) for 30 minutes and pursed-lips breathing for 10 minutes, 3x / week for 2 months. Group A – aerobic exercise + pursed-lips breathing. Group B – aerobic exercise + pursed-lips breathing + laser acupuncture (points connected to the respiratory system).	Number of asthma attacks per week, FEV_1, FVC, $FEF^{75-85\%}$, $FEF^{50\%}$.	In both groups there was an improvement in pulmonary function parameters and a reduction in the number of asthma attacks per week after treatment. After the treatment period, there was a difference between the groups, with group A showing a more significant improvement than group B.

Continuation - Table 1: Description of the selected studies that used inspiratory muscle training and/or breathing exercises in children with asthma, and the score of the assessment of methodological quality according to the PEDro scale.[15]

Authos/ year	Age group	PEDro	Type of study	Study Design	oucomes	conclusion
Bignall et al.2015[17]	12-17	6/10	RCT	(n=30) African-American adolescents diagnosed with asthma were randomized into two groups. The subjects were evaluated twice in a period of 30 days. CG – disease education. IG – disease education + respiratory training with three techniques: diaphragmatic breathing, mental exercise to visualize the airways (visualizing the airways open) and muscle relaxation. Participants received material with exercises to practice at home.	Asthma control scale, quality of life, anxiety scale, FEV_1 and peak flow.	There was an improvement in the asthma control scale in both groups one month after the intervention, but the intervention group reported better asthma control than the control group. There was no change in quality of life and anxiety scale before and after one month of study, or between groups. FEV_1 and peak flow also showed no significant difference.
David et al.2018[20]	4-16	8/10	RCT	(n=64) All participants performed 10 one-hour sessions, 2x/week. In the first 20 minutes: diaphragmatic breathing exercises, pursed-lips breathing and fractional breathing, 3x10 repetitions, in the supine and sitting positions. G.1 – breathing exercises and 40 minutes of CPAP (8 cmH_2O). G.2 – breathing exercises and 30 minutes of IMT (starting with 30% of inspiratory muscle strength and 40% after five sessions). G.3 – breathing exercise and 40 minutes of BiPAP (MIP = 12cmH_2O, MEP = 8cmH_2O).	Pulmonary inflammation (FeNO), clinical control of asthma, MIP, MEP, lung function, exercise test with bronchoprovocation.	Improved asthma control for all children and reduced lung inflammation only in the CPAP and BiPAP groups. MIP increased in all groups and MEP only in the IMT group. In the CPAP and BiPAP groups there was an improvement in the bronchial response to the bronchial challenge test.

Note: RCT – randomized clinical trial; Obser. – observational study; PEDro – evaluation of methodological quality using the PEDro scale; IMT – inspiratory muscle training; CG – control group; IG – intervention group; MIP – maximal inspiratory pressure; MEP – maximal expiratory pressure; PEF – peak expiratory flow; FEV_1 – forced expiratory volume in the first second; FVC – forced vital capacity; FRC – functional residual capacity; RV – residual volume; TLC – total lungl capacity; IT/ET – relationship between inspiratory time and expiratory time; CPAP – Continuous Positive Airway Pressure; BiPAP – BI-level Positive Airway Pressure; $FEF^{75-85\%}$ – forced expiratory flow of 75% to 85% of FVC; FEF50% – forced expiratory flow of 50% of FVC; FeNO – fractional exhaled nitric oxide.

DISCUSSION

Inspiratory muscle training (IMT)

Pulmonary hyperinflation is a pathophysiological manifestation commonly observed in respiratory diseases that lead to airway obstruction. It causes the lowering of the diaphragmatic dome, which becomes a mechanical disadvantage, thus leading to weakness of the respiratory muscles[16,17]. Therefore, it is of utmost importance to maintain adequate respiratory muscle strength in individuals with asthma.

Training of respiratory muscles, more specifically of inspiratory muscles, is recommended as part of the pulmonary rehabilitation program and its use is well-established in some conditions such as chronic obstructive pulmonary disease (COPD)[18]. However, a standard protocol is not available for individuals with asthma, especially for the pediatric population.

In the present review, two studies included IMT in children with asthma[19,20]. Both performed a similar intervention protocol, in which the participants used the Threshold IMT device (© Philips Respironics) at loads of 30% to 40% of the maximal inspiratory pressure during 25 to 30 minutes. There was an increase in the values for maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP). Detailed information about the intervention protocol is shown in table 1.

Lima *et al.*[19] also identified improvement of respiratory symptoms, activities of daily living, as well as reduction in the frequency of asthma attacks and use of medications in the intervention group. However, David *et al.* [20] did not observe clinical changes in the participants of the group who underwent IMT, and who were assessed with the Asthma Control Questionnaire (ACQ6).

In a systematic review on inspiratory muscle training in adults with asthma conducted by Silva et al.16 five randomized clinical trials with varied intervention protocols were included, with a load of 40% to 60% of MIP, which is greater than the load reported by Lima *et al.*[19] and David *et al.*[20]. A meta-analysis was carried out, which was in favor of increasing MIP during IMT. Additionally, other outcomes were analyzed, such as MEP, lung function, asthma symptoms and use of medication; but the results of the studies were controversial.

Breathing exercises

The indication of breathing exercises is a strategy that is part of the management of asthma, which has been recommended as an adjunctive treatment for adults with uncontrolled asthma[21] and the pediatric population. These exercises aim to maintain an adequate breathing pattern and pulmonary ventilation as well as to reduce pulmonary hyperinflation, bronchospasm and sensation of dyspnea[10,22,23].

In the most severe cases of asthmatic attacks with bronchospasm and subsequent limitation of expiratory flow, the implementation of breathing exercises to favor expiration has been discussed[12,24]. To our knowledge, Asher *et al.*[25] published the only study with breathing exercises in children who were hospitalized due to asthma exacerbation. However, no differences in lung function were observed before and after the intervention period and between the control and intervention groups. This outcome may be explained by the fact that the physical therapy intervention involves other physiotherapy resources, including techniques for secretion removal and muscle relaxation, in addition to breathing exercises, which were applied according to the needs of each patient.

Among different types of breathing exercises, diaphragmatic breathing was the most used technique in the studies in this review[19,20,25-27]. Other exercises were pursed-lips breathing[19,20,28] fractional breathing,[19,20] voluntary control of inspiratory and expiratory time (IT/ET)[29] and lateral costal breathing[25] the latter did not include its form of application.

As previously mentioned, breathing exercises still do not have a standard protocol regarding frequency, duration and specific exercise for asthma. In the present review, only the studies conducted by Lima *et al.*[19] and David *et al.*[20] described the frequency and duration of each exercise, and yet Karakoç et al.[30] did not describe which breathing exercises were used and how they were applied.

The studies included in this review did not use breathing exercises solely: they were one element of a more complex intervention protocol, including aerobic exercises, muscle relaxation, disease education, among other interventions. Therefore, the real effects of each resource or technique of the respiratory physiotherapy could not be identified and isolated. Nonetheless, it can be noted that breathing exercises are well-established techniques for the management of asthma in children and their importance has been recognized in the scientific community.

In the case of the pediatric population, breathing exercises should be associated with games and playful activities[31]. Notably, McCaully[24] had already described playful breathing exercises for children with asthma, especially through fun blowing games. However, none of the studies in the current review described the use of breathing exercises in a playful manner.

Although IMT and breathing exercises are widely used in patients with asthma, there is still insufficient scientific evidence on these physiotherapy approaches, especially in children. Thus, further studies are needed to identify the effects and benefits of these interventions among children with asthma.

CONCLUSION

It has been shown that IMT in children with asthma can improve the strength of inspiratory and expiratory muscle. But, the clinical improvement after treatment is still uncertain given the dearth of scientific literature about this intervention in the pediatric population.

Breathing exercises are widely used, both in clinical practice and in the scientific environment, and they are well-established techniques for the management of asthma. However, in this review, none of the studies used breathing exercises solely and a standardized protocol could not be identified; therefore, their effects on children with asthma cannot yet be measured.

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Resumo

Introdução: Asma é caracterizada por estreitamento e inflamação dos brônquios, com sintomas de dispneia, fadiga e limitação aos exercícios. O tratamento fisioterapêutico engloba treinamento muscular inspiratório e exercícios respiratórios, pois o aumento da força e resistência da musculatura inspiratória podem melhorar os sintomas da doença.

Objetivo: Descrever os efeitos do treinamento muscular inspiratório (TMI) e dos exercícios respiratórios na criança com asma.

Método: Revisão sistemática da literatura conduzida nas bases de dados Cochrane, PubMed, Scopus e Web of Science. Utilizou-se os descritores: asma, treinamento muscular inspiratório, exercícios respiratórios e criança e seus correlatos em inglês e espanhol. Dois avaliadores independentes elencaram estudos que realizaram intervenção com exercícios respiratórios e TMI na criança com asma.

Resultados: De um total de 312 títulos, foram incluídos oito estudos, dos quais seis são ensaios clínicos randomizados e dois observacionais. Todos os trabalhos incluíram exercícios respiratórios, com o objetivo de adequar o padrão respiratório e a ventilação pulmonar, reduzir a hiperinsuflação pulmonar, o broncoespasmo e a sensação de dispneia, porém como não foram realizados de forma isolada, comprometeu a verificação dos efeitos dessa intervenção. Dois estudos realizaram TMI e evidenciaram aumento nas pressões respiratórias máximas.

Conclusão: Exercícios respiratórios são muito utilizados na prática clínica como parte do manejo da criança com asma, entretanto ainda não é possível mensurar seus efeitos nessa população. O TMI parece melhorar a força muscular inspiratória e expiratória, mas sua indicação na população pediátrica ainda não é rotineira.

Palavras-chave: asma, exercício respiratório, criança.