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Breathing exercises in upper abdominal surgery: a systematic review and meta-analysis

Exercícios respiratórios em cirurgia abdominal alta: revisão sistemática e metanálise

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Abstract

Background: There is currently no consensus on the indication and benefits of breathing exercises for the prevention of postoperative pulmonary complications (PPCs) and for the recovery of pulmonary mechanics. **Objective:** To undertake a systematic review of randomized and quasi-randomized studies that assessed the effects of breathing exercises on the recovery of pulmonary function and prevention of PCCs after upper abdominal surgery (UAS). **Method:** Search Strategy: We searched the Physiotherapy Evidence Database (PEDro), Scientific Electronic Library Online (SciELO), MEDLINE, and Cochrane Central Register of Controlled Trials. Selection Criteria: We included randomized controlled trials and quasi-randomized controlled trials on pre- and postoperative UAS patients, in which the primary intervention was breathing exercises without the use of incentive inspirometers. Data Collection and Analysis: The methodological quality of the studies was rated according to the PEDro scale. Data on maximal respiratory pressures (MIP and MEP), spirometry, diaphragm mobility, and postoperative complications were extracted and analyzed. Data were pooled in fixed-effect meta-analysis whenever possible. **Results:** Six studies were used for analysis. Two meta-analyses including 66 participants each showed that, on the first day post-operative, the breathing exercises were likely to have induced MEP and MIP improvement [treatment effects of 11.44 mmH_2O (95%CI 0.88 to 22) and 11.78 mmH_2O (95%CI 2.47 to 21.09), respectively]. **Conclusion:** Breathing exercises are likely to have a beneficial effect on respiratory muscle strength in patients submitted to UAS, however the lack of good quality studies hinders a clear conclusion on the subject.

Keywords: postoperative complications; breathing exercises; systematic review.

Resumo

Contextualização: Não existe um consenso quanto à indicação e benefícios dos exercícios respiratórios na prevenção das complicações pulmonares pós-operatórias (CPPs) e na recuperação da mecânica pulmonar nesses pacientes. **Objetivo:** Realizar uma revisão sistemática de ensaios controlados aleatorizados e ensaios controlados quasi-aleatorizados que avaliaram os efeitos de exercícios respiratórios na recuperação da função pulmonar e prevenção da CPPs após CAA. **Método:** Estratégia de busca: Os artigos foram pesquisados nas seguintes bases de dados: *Physiotherapy Evidence Database* (*PEDro*), *Scientific Electronic Library Online* (*SciELO*), *MEDLINE* e *Cochrane Central Register of Controlled Trials*. Critérios de seleção: Foram incluídos, nesta revisão sistemática, somente ensaios controlados aleatorizados e ensaios controlados quasi-aleatorizados envolvendo pacientes submetidos à CAA que também tinham sido submetidos a exercícios respiratórios, como intervenção primária, sem uso de inspirômetros de incentivo. Coleta de dados e análise: A qualidade metodológica dos estudos incluídos foi avaliada pela escala PEDro. Foram analisados dados referentes à pressão inspiratória máxima (PImáx), pressão expiratória máxima (PEmáx), espirometria, mobilidade diafragmática e CPPs. Os dados foram agrupados em uma metanálise modelo *fixed effect*, quando possível. **Resultados:** Seis estudos foram analisados. Duas metanálises, incluindo 66 participantes cada, demonstraram que, no primeiro dia de pós-operatório, os exercícios respiratórios provavelmente induziram melhoras na PEmáx e PImáx [tamanho de efeito de 11,44 mmH_2O (IC95% 0,88 a 22) e 11,78 mmH_2O (IC95% 2.47 a 21.09), respectivamente]. **Conclusão:** Exercícios respiratórios provavelmente apresentam efeitos benéficos na força muscular respiratória em pacientes submetidos à CAA, no entanto a falta de estudos de boa qualidade comprometeu uma conclusão mais categórica sobre o assunto.

Palavras-chave: complicações pós-operatórias; exercícios respiratórios; revisão sistemática.

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Introduction

It is known that surgical procedures in the upper abdominal area promote changes in pulmonary function and respiratory mechanics, leading to postoperative pulmonary complications (PPCs)[1]. Some of the main changes that lead to PPCs are: (a) decreased diaphragm mobility; (b) depressed central nervous system; (c) changes in the ventilation-perfusion ratio; (d) reduced cough efficacy; (e) increased respiratory rate; and (f) reduced pulmonary volumes and capacities[2-4]. The most common complications due to these changes are atelectasis, hypoxemia, and pneumonia, which can affect up to 80% of patients submitted to upper abdominal surgery (UAS)[3,5-7], increasing the length of hospital stay and treatment costs and contributing significantly to mortality[8-10].

Respiratory physical therapy has been widely used to reverse or minimize the development of PPCs[11]. Several techniques are employed, however there is no consensus among researchers on the most efficient technique for the recovery of PPCs and respiratory mechanics in these patients[11-13]. A systematic review by Overend et al.[14] analyzed the use of incentive inspirometers for PPC prevention and found that only one of the analyzed studies compared three different techniques: incentive inspirometers, deep breathing, and intermittent positive pressure breathing. This review concluded that the techniques were equally effective and that they are more beneficial than the non-prevention of PPCs after abdominal surgery.

Routinely used by physical therapists in clinical practice, breathing exercises involve breathing patterns that can be combined with upper limb and trunk movements, as well as thoracic cage maneuvers. These exercises aim to improve the patient's breathing pattern and increase lung expansion, respiratory muscle strength, functional residual capacity, and inspiratory reserve volume, thus preventing or treating PPCs[15]. Understanding the effect of these exercises is of fundamental importance to physical therapists as this knowledge will help them to select the best interventions for patients submitted to UAS. Nevertheless, the effectiveness of breathing exercises is rarely investigated. Thus, the objective of the present study was to undertake a systematic review of randomized and quasi-randomized studies that assessed the effects of breathing exercises on the recovery of pulmonary function and prevention of PCCs after UAS.

Method

Inclusion criteria

The present review included randomized controlled trials and quasi-randomized controlled trials with patients assessed before and after UAS. The UAS was defined as a surgery involving an incision above or extending above the umbilicus, therefore including hernia repair, gall bladder removal, large bowel removal, exploratory laparotomy, and other interventions in the abdominal cavity performed by conventional laparotomy or laparoscopy. The patients should have the following characteristics: (a) age above 18 years; (b) non-obese; (c) without heart, pulmonary and/or neuromuscular disease; (d) who had not been on mechanical ventilation and/or in intensive care for more than 48 hours. The primary intervention of the studies had to be breathing exercises, defined as respiratory strategies, encompassing diaphragm exercise, pursed-lip breathing, changes in body posture to favor ventilation, and active upper and lower limb exercises combined with breathing, applied without the use of incentive inspirometers or other breathing equipment such as CPAP (Continuous Positive Airway Pressure) and BIPAP (Bilevel Positive Airway Pressure). The studies also had to analyze at least one of the following variables: (a) maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP); (b) spirometry (vital capacity=VC, forced vital capacity=FVC, forced expiratory volume=FEV, forced inspiratory volume=FIV, forced expiratory volume in 1 second=FEV_1, and FEV_1/FVC ratio); (c) diaphragm mobility; and (d) number of PPCs. There were no language restrictions on the search, and all retrieved studies where translated when possible and necessary.

Search strategies to identify studies

The searches were conducted by an independent researcher in PEDro (Physiotherapy Evidence Database; www.pedro.fhs.usyd.edu.au) on May 20, 2011; SciELO (Scientific Electronic Library Online; http://www.scielo.br) on May 26, 2011; MEDLINE on May 17, 2011; and the Cochrane Central Register of Controlled Trials via OVID on May 27, 2011. Search filters developed by the Scottish Intercollegiate Guidelines Network (SIGN, http://www.sign.ac.uk/methodology/filters.html) to identify randomized studies were combined with a strategy to identify studies on UAS and breathing exercises. This strategy was used in all databases, with adaptations when required. The keywords used for the search included those to identify "breathing exercises", "randomized controlled trials", and "upper abdominal surgery". The full detailed search strategy, with all terms and truncations used, is shown in the Appendix 1. Also, a manual search was performed in the references of the included articles. There were no date restrictions for the searches.

Study selection and methodological quality

Two raters analyzed the search results independently to find potentially eligible studies. First, the studies were separated according to title, then the abstracts were analyzed, and only the potentially eligible studies were re-selected. Based on the abstracts, articles in full were acquired for full review and considered for analysis. In case of disagreement between raters, a third rater made a decision concerning the eligibility of the study in question.

The methodological quality of the studies was rated according to the PEDro scale[16,17], an 11-item scale designed to rate the methodological quality (internal validity and statistical information) of randomized controlled trials. With the exception of the first item, each item satisfied is worth one point toward the final overall rating (0 to 10 points)[16,17]. When this rating was not available in the PEDro database website, two raters analyzed the study independently and attributed a rating. Discrepancies between raters were resolved by a third rater.

Data extraction and analysis

Data extraction and analysis were conducted by at least two of the authors. When there was apparent qualitative homogeneity between participants, intervention, assessment moment, and variables, a meta-analysis was conducted. For statistical analysis of homogeneity among studies, we used the value of I^2, as suggested by Higgins et al.[18]. Whenever possible, the mean and standard deviation were extracted from each study and converted into weighted mean differences (treatment effect) and 95% confidence intervals (95%CI). Meta-analyses (of continuous outcomes) were performed with a fixed effect model to pool findings across studies as most I^2 values were under 25%. Meta-analyses were conducted using the software MIX (Meta-analysis Made Easy)[19].

Results

A total of 1486 articles were identified in the search (Figure 1), 50 of which were selected according to title and had their respective abstracts reviewed. Based on the abstracts, 22 articles were eligible for a full review, and a total of six articles[20-25] that fulfilled all of the inclusion criteria were selected (Table 1).

The PEDro scale was used to rate the quality of the included studies. The PEDro scale has 11 items that are used to assess the methodological internal validity of the studies. It converts the quality of the study into a final score that can vary from 0 to 10, 0 being the worst possible score and 10 being the best possible score. The first item of the scale is not considered for the

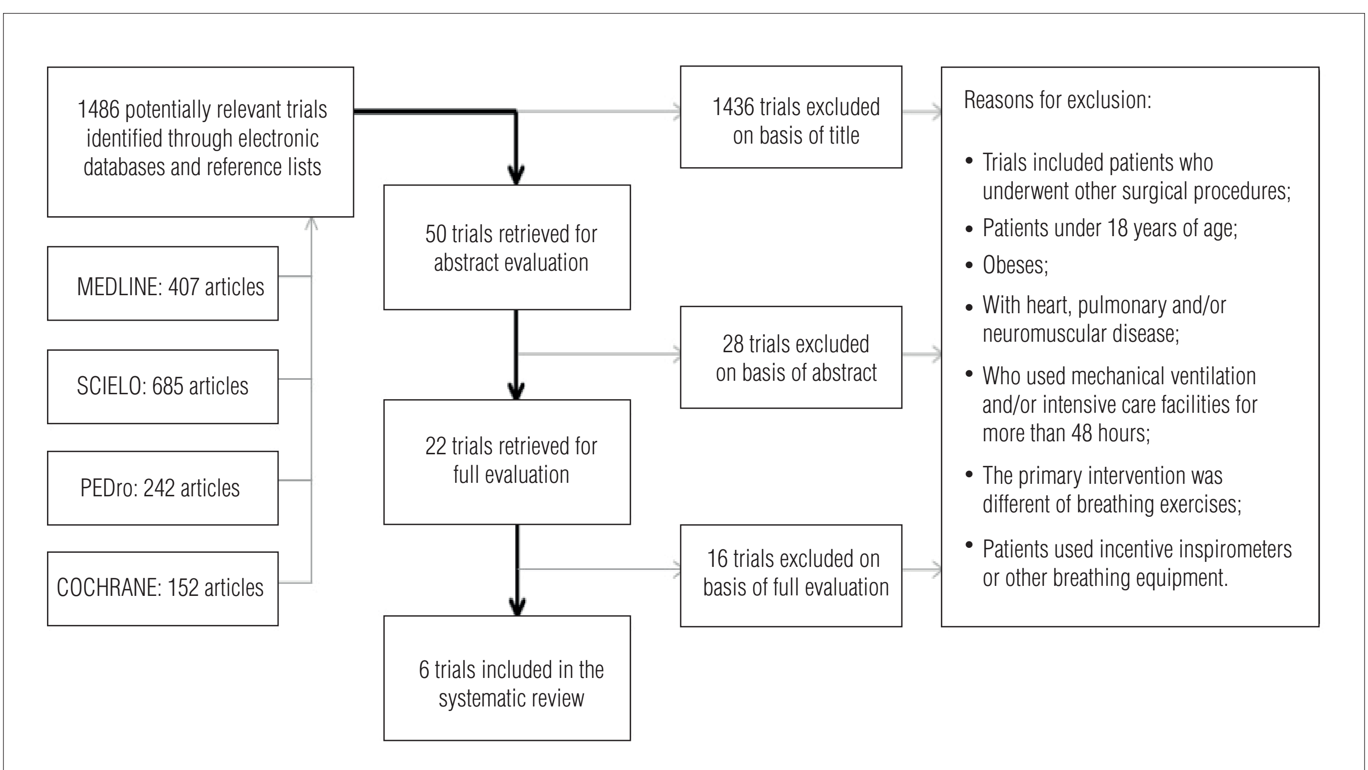


Figure 1. Flow chart of the search process.

Table 1. Description of the studies included in the present review.

Author, year and sample	Assessment	Variables	Time of intervention	TG	CG	Results regarding between group comparisons as presented by the studies
Hallböök et al.[20] n=137 Open cholecystectomy	Preop and day 3 PO	VC, FEV, FEV_1, FIV, FIV_1, PEF, X-ray, clinical signs of PPC and arterial blood gas analysis, length of hospital stay	Day 1 to day 3 PO	Early mobilization, breathing exercises, self-assisted coughing, and postural drainage twice a day	Instructions on breathing exercises and coughing. Patients were mobilized and performed upper limb exercises and walking twice a day	No difference between groups for all variables
Manzano et al.[21] n=31 UAS	Preop and day 2 PO	FVC, FEV_1, FEV_1/FVC and PEF, SpO2, anamnesis, VAS, time of surgery, length of hospital stay and PPC.	Immediate PO	30 min of passive and localized breathing exercises, deep diaphragm breathing, and thoracic cage expansion exercises	No treatment	↑ oxyhemoglobin saturation after physical therapy ($p<0.03$) in TG. No between-group differences for the variables pain, breathing complications.
Roukema et al.[22] n=153 UAS	Preop, immediate PO and days 1 to 5 PO	Clinical assessment, arterial blood gas analysis, temperature, chest x-ray, VC and FEV_1	Preop, immediate PO, days 1 to 5 PO	Diaphragm breathing, deep inspiration, forced expiration, and coughing	No treatment	Incidence of PPC greater in the CG (60%) than the TG (19%) ($p<0.01$)
Ribeiro et al.[23] n=30 UAS	Preop, days 1, 3 and 5 PO	MIP, MEP, FVC, FEV_1, FEV_1/FVC, PEF, and saturation	Non-specific	Diaphragm breathing, sustained inspiration, and fractional inspiration (3x10 each), 5 min walk, and coughing (30 min total)	20 min of walking (10 min in the morning and 10 min in the afternoon) and assisted coughing (30 min total)	No significant difference between groups for all variables in day 1, 3 and 5PO.
Gastaldi et al.[24] n=36 Laparoscopic cholecystectomy	Preop and days 1 to 6 PO	MIP, MEP, VC, FVC, EFV, FEV_1, FEV_1/FVC, and PEF	Preop and days 1 to 6 PO	Diaphragm breathing, sustained maximal inspiration, and fractional inspiration (3x20 each)	No treatment	↑ MIP and MEP for TG when compared to CG from day 3 to 6 PO
Forgiarini Junior et al.[25] n=36 UAS	Preop and day 1 PO	FVC, FEV_1, FEV_1/FVC, MIP, MEP, time in recovery room	TG: started in the recovery room and continued in the hospital room CG: started in the hospital room	Diaphragmatic proprioception, varied inspiration exercises, forced expiration maneuvers, assisted couch, and early ambulation	Same as treatment groups, however it only started after the patients were transferred to the hospital room	↑ FVC, FEV_1, MEP for TG ($p<0.05$)

TG=treatment group; CG=control group; UAS=upper abdominal surgery; PO=postoperative; Preop=preoperative; VC=vital capacity; FVC=forced vital capacity; FEV=orced expiratory volume; FIV=forced inspiratory volume; FEV_1=forced expiratory volume in 1 second; FEV_1/FVC ratio; PEF=peak expiratory flow; SpO2=pulse oxygen saturation; PPCs=postoperative complications; VAS=visual analog scale; MIP=maximal inspiratory pressure; MEP=maximal expiratory pressure.

final score as it relates to external validity. Of the six included studies, one had a final PEDro score of 1, one had a final score of 3, two had a final score of 5, one had a final score of 6, and one had a final score of 7 (Table 2). The overall quality of the included studies was low, with the exception of the studies by Forgiarini et al.[25] (score 7) and Gastaldi et al.[24] (score 6; Table 2).

Among the included studies, the one by Hallböök et al.[20] divided the participants into three intervention groups: mobilization, thoracic physical therapy, and thoracic physical therapy plus bronchodilator. For the analysis of the results, we considered the mobilization group as the control group and the thoracic physical therapy group as the treatment group. Also, in the study by Forgiarini Junior et al.[25], the participants were divided into two groups: patients submitted to physical therapy in the postoperative recovery room and, subsequently, in the hospital room; and patients first submitted to physical therapy in the hospital room. For the analyses at 1PO, we considered the group that received physical therapy only in the hospital room as the control group. However, we also analyzed the data without including the study by Forgiarini Junior et al.[25] as it did not specify how much physical therapy (if any) the control group received prior to the assessment at day 1 PO. For all other included studies there was a clear intervention group and a control group (Table 1). As expected, the studies did not report data on all the variables considered in the present study. Among the variables considered for analysis, diaphragm mobility was the only variable not assessed by any of the studies.

Respiratory muscle strength

Three studies presented data showing that breathing exercises have a positive effect on respiratory muscle strength. Ribeiro, Gastaldi and Fernandes[23] and Gastaldi et al.[24] assessed the MEP and MIP (mmH_2O) on day 1 postoperative (PO), and the meta-analysis of these two studies (Figure 2A and 2C) found treatment effects (95%CI) of 11.44 mmH_2O (0.88 to 22) and 11.78 mmH_2O (2.47 to 21.09) for these variables, respectively. Forgiarini Junior et al.[25] also assessed the MEP and MIP (mmH_2O) on day 1 PO, however in their study, the treatment group started the treatment in the recovery room and the control group in the hospital room. Because it was unclear whether the control group received any treatment prior to the assessment at day 1 PO, we decided to present a subsequent meta-analysis that includes data from the study by Forgiarini Junior et al.[25] (Figure 2B and 2D). The meta-analysis with these three studies[23–25] showed a treatment effect (95%CI) of 12.8 mmH_2O (7.47 to 18.2) for MEP (Figure 2B) and 5.6 mmH_2O (0.61 to 10.51) for MIP (Figure 2D).

Although Ribeiro, Gastaldi and Fernandes[23] reported that there were no differences between the groups in their ANOVA analysis, when we applied their data to the meta-analysis procedures adopted in this study, we found a positive treatment effect for MIP favoring breathing exercises (treatment effect of 17.70 mmH_2O and 95%CI 1.70 to 33.70) on 3 PO. However there was no difference between groups for MEP (treatment effect 15.40 mmH_2O and 95%CI-2.90 to 33.70). On day 5 PO, the treatment effect (95%CI) was 17.70 mmH_2O (-2.30 to 37.70) and 21.30 mmH_2O (1.40 to 41.20) for MIP and MEP, respectively. Gastaldi et al.[24] assessed pressures up to day 6 PO, however they presented only the means for the pressures of the groups for each day without the standard deviations.

Spirometry

FVC, measured in liters (L), was assessed in four studies[21,23-25], and a meta-analysis was conducted with the data from two of

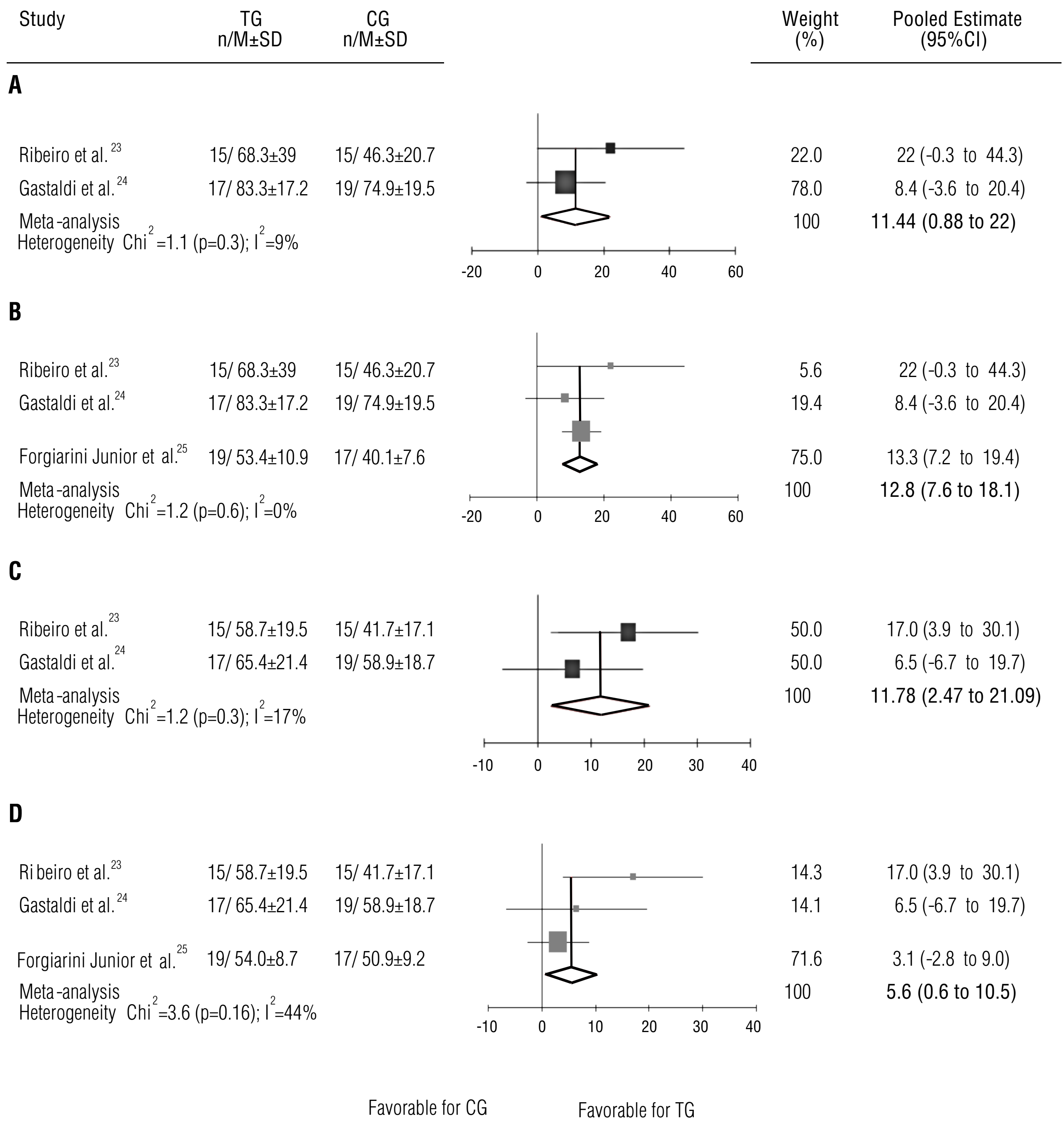
Table 2. Methodological classification of studies.

PEDro	Hallböök et al.[20]	Manzano et al.[21]	Roukema et al.[22]	Ribeiro et al.[23]	Gastaldi et al.[24]	Forgiarini Junior et al.[25]
Eligibility criteria*	no	yes	yes	yes	yes	yes
Randomized/randomly selection	yes	yes	no	yes	yes	yes
Concealed allocation	yes	no	no	no	yes	yes
Pretreatment homogeneity	yes	yes	no	no	yes	yes
Blind subjects	no	no	no	no	no	no
Blind therapists	no	no	no	no	no	no
Blind assessors	no	no	no	yes	yes	yes
Appropriate monitoring	no	no	no	no	no	yes
Intention to treat	no	yes	no	no	no	no
Comparisons between-groups	yes	yes	yes	no	yes	yes
Point measures and measures of variability	yes	yes	no	yes	yes	yes
TOTAL	5/10	5/10	1/10	3/10	6/10	7/10

*The item Eligibility criteria is not added to the final score.

the studies[23,24] without significant results. The meta-analyses were conducted for the assessments on days 1, 3, and 5 PO. The results showed the following treatment effects (95%CI): 0.15 L (-0.18 to 0.48), 0.14 L (-0.20 to 0.48), and 0.13 L (-0.17 to 0.43), to days 1, 3, and 5 PO respectively. One of the studies[24] also assessed days 2, 4, and 6 PO and found treatment effects of 0.10L (-0.40 to 0.60) for day 2 PO and 0.20 L (-0.30 to 0.60) for days 4 and 6 PO.

Data from Forgiarini Junior et al.[25] were again only included in a post-hoc analysis for day 1 PO, and the meta-analysis including this study found treatment effect (95%CI) of 0.2L (-0.08 to 0.48). The study by Manzano et al.[21] assessed day 2 PO, however the results were expressed in percentage (%). This study found a treatment effect (95%CI) of 16.30% (0.60 to 32.00), showing a positive effect.



(A) meta-analysis for maximal expiratory pressure; (B) meta-analysis for maximal expiratory pressure including data from forgiarini junior et al.[25].; (C) meta-analysis for maximal inspiratory pressure; (D) meta-analysis for maximal inspiratory pressure including data from forgiarini junior et al.[25]. N=sample size; m=mean; sd=standard deviation; ci=confidence interval; cg=control group; tg=treated group.

Figure 2. Meta-analysis for Maximal Expiratory and Inspiratory Pressures (mmHg) on day 1 postoperative.

Three studies assessed VC[20,22,24], but only Gastaldi et al.[24] described and analyzed the data. Thus, a meta-analysis could not be conducted. The study by Gastaldi et al.[24] assessed VC in liters from day 1 to day 6 PO, and the treatment effect (95%CI) for breathing exercises was 0.10 L (-0.50 to 0.30) on day 1 PO, 0.10 L (-0.30 to 0.50) on day 2 PO, 0.20 L (-0.30 to 0.70) on day 3 PO, and 0.30 L (-0.20 to 0.80) on days 4, 5, and 6 PO. In these cases, there was no positive effect of breathing exercises.

FIV and the FEV were only assessed by one study[20], with no significant difference between groups, and the data were not presented in the respective study. All studies compared FEV_1 (liter) between treatment and control groups, however only two studies[23,24] could be compared because of the time of assessment. Three meta-analyses were conducted based on the data obtained, with no significant difference. The treatment effect (95%CI) for breathing exercises was 0.01L (-0.26 to 0.28) on day 1 PO, 0.1 L (-0.25 to 0.45) on day 3 PO, and 0.13 L (-0.16 to 0.43) on day 5 PO. Data from Forgiarini Junior et al.[25] were again subsequently added to the meta-analysis on day 1 PO, and the results showed a treatment effect (95%CI) of 0.1 L (-0.16 to 0.28). One of the studies[24] also assessed days 2, 4, and 6 PO with the following results: 0.00 L (-0.50 to 0.50), 0.10 L (-0.40 to 0.60), and 0.20 L (-0.30 to 0.70), respectively, showing that there was no benefit from breathing exercises in these cases. Unlike previous studies that assessed FEV_1 in liters, Manzano et al.[21] presented the results of the assessment conducted on day 2 PO in percentages and could not be compared to the other studies for a more detailed analysis. The remaining studies[20,22] did not describe their findings.

The FEV_1/FVC ratio (%) was verified in three studies[21,23,24] and four meta-analyses were conducted with the data from these studies, however none of the meta-analyses found a positive treatment effect for breathing exercises. Two studies[21,24] assessed days 1, 3, and 5 PO and found the following treatment effects (95%CI): 0.43% (-3.41 to 4.26), -1.69% (-6.33 to 2.93), and 2.78% (-1.09 to 6.67), respectively. Two studies[23,24] analyzed day 2 PO and obtained a treatment effect (95%CI) of -3.4% (-8.67 to 1.87).

Postoperative pulmonary complications

Two studies[20,21] compared the length of hospital stay of the treatment group and the control group, however none of them found a significant difference between groups. One of the studies[20] obtained a treatment effect (95%CI) of 1.20 days (-0.10 to 2.50). The other study did not present the findings.

Two articles[20,22] compared the findings for chest X-rays, however there was no inferential analysis for any of the studies. The first[20] did not mention the data and values for the findings, and the second[22] mentioned the number of patients that developed changes and specified them, but did not provide sufficient data to allow a statistical analysis.

The studies that assessed temperature[20,22] did not describe the data. In the study by Hallböök et al.[20], only one patient from the treatment group had an increase in body temperature. Overall, the data provided were insufficient for statistical comparison.

The development of PPCs was observed by two studies[20,21]. However, the incidence of breathing complications did not differ between the groups.

Discussion

Patients submitted to UAS usually develop a restrictive lung pattern, with changes to pulmonary mechanics in the first days PO[4,26]. This can cause a reduction in inspiratory capacity, total inspiratory time, and ventilation at the lung bases, leading to a high risk of developing PPCs[4,27]. For adequate pulmonary ventilation to occur, it is fundamental that the forces that act on the respiratory system favor the thoracic and abdominal movements, especially the respiratory muscle strength that is compromised after UAS.

The present review found a significant improvement for maximal respiratory pressures in patients who performed breathing exercises. Interestingly, these findings are related to breathing exercises without resistance commonly used in muscle training, therefore the increase in respiratory pressures may be related to the characteristics of the exercises. In the studies that found improved MIP and MEP in the groups that performed breathing exercises, the programs consisted of diaphragm breathing, sustained maximal inspiration, and fractional inspiration aimed at increasing diaphragm mobility, improving respiratory muscle synergism, and maintaining muscle trophism by using the diaphragm and reducing the action of accessory muscles[28-30]. It is routine in many hospitals to administer respiratory exercises to patients submitted to abdominal surgery despite the lack of studies showing the benefits of respiratory exercises in these conditions. The findings of the present systematic review corroborate the use of respiratory exercises in these patients in order to improve their respiratory muscle strength. There is indication that the breathing exercises could have an effect on the quality of the hospital stay and recovery of these patients.

Among the analyzed variables in the pulmonary function test, FVC is the most important to diagnose respiratory disorders. Pulmonary function tests can also be used to indirectly verify diaphragm activity because good results in pulmonary function tests indicate effective pulmonary mechanics, which requires the use of the diaphragm muscle to its full capacity[31]. In the study by Manzano et al.[21] that found a positive effect of breathing exercises on FVC, the treatment group was submitted to a protocol of localized breathing exercises combined with manual pressure applied by the physical therapist to the patient's thoracic cage during expiration, deep diaphragm breathing, and thoracic cage expansion exercises such as fractional inspiration. The aims of the exercises were to increase flow volume, decrease the respiratory rate, and consequently promote lung expansion[28-30]. It seems that these breathing exercises were able to improve pulmonary mechanics and lead to a beneficial effect on FVC, however that was the only study that found such a positive result. Further high-quality studies should be conducted before a final conclusion can be drawn.

The fact that the other analyzed variables did not show significant improvement as a result of breathing exercises may be related to the methodological quality of the studies. According to the rating, articles with scores between 10 and 5 are considered good, 5 and 4 are intermediate, and below 4 are poor. In the present review, only one article was rated as good, 2 as intermediate, and 2 as poor.

Besides the methodological quality of the studies, the concept of breathing exercise may also have been a limitation of the present review. Breathing exercises, recently described as respiratory strategies, encompass diaphragm exercise, pursed-lip breathing, changes in body posture to favor ventilation, and active upper and lower limb exercises combined with breathing[32]. The lack of standardization of the types of exercises, number of series, repetitions, intervals, frequency, and times may have influenced the outcome of the studies.

In the literature, there are instruments that can assess the risk of developing pulmonary complications after general surgery[33] and after UAS[7], however there is no consensus on how to classify these complications or how to measure them. The diagnosis of PPCs is based on the analysis and establishment of certain parameters related to clinical, laboratory, and imaging tests. Nevertheless, the majority of these parameters are subjective and prone to interpretation error, and often they have not been predetermined or well-defined in the studies.

Based on the present review, three studies[23–25] of good and moderate quality (scores 5 to 7) showed that breathing exercises are likely to have a beneficial effect on MIP and MEP of patients in the post-UAS phase. However the lack of well-designed studies may have hindered a more complete analysis of the effects of breathing exercise on these patients. Special emphasis must be given to the establishment of assessment, classification, and treatment programs that are specific, reliable, and methodologically adequate so that future studies can be well analyzed and compared. The accomplishment of this task would help to confirm the findings on MIP, MEP, and perhaps pulmonary function of the present study. It would also better clarify when and how breathing exercises should be used to prevent and/or treat PPCs in patients submitted to UAS.

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Appendix 1. Search filters - Scottish Intercollegiate Guidelines Network.

MEDLINE (OVID WEB)
1 Randomized controlled trials as Topic/
2 Randomized controlled trial/
3 Random allocation/
4 Double blind method/
5 Single blind method/
6 Clinical trial/
7 exp Clinical Trials as Topic/
8 or/1-7
9 (clinic$ adj trial$1).tw.
10 ((singl$ or doubl$ or treb$ or tripl$) adj (blind$3 or mask$3)).tw.
11 Placebos/
12 Placebo$.tw.
13 Randomly allocated.tw.
14 (allocated adj2 random).tw.
15 or/9-14
16 8 or 15
17 Case report.tw.
18 Letter/
19 Historical article/
20 review.pt.
21 or/17-20
22 16 not 21
23 (abdom* adj4 surger*).tw.
24 abdomen/
25 laparotomy/
26 postoperative complications/
27 Surgical Procedures, Operative/
28 or/23-27
29 (breath* adj3 strateg*).tw.
30 (breath* adj3 exercis*).tw.
31 (respirat* adj3 mechanic*).tw.
32 (respirat* adj3 physiot*).tw.
33 Respiratory Mechanics/
34 Respiratory Therapy/
35 Physical Therapy Modalities/
36 Respiration/
37 Breathing Exercises/
38 exp "Physical Education and Training"/
39 or/29-38
40 22 and 28 and 39

PEDro
Strategy 1:
In the *Title/abstract* field: surg*,
In the *Therapy* field: respiratory therapy
In the *Method* field: clinical Trial

Strategy 2
In the *Title/abstract* field: *operat*
In the *Therapy* field: respiratory therapy
In the *Method* field: clinical trial

*In both strategies, the search terms were reached in association ("AND")

SCIELO
Cirurgi* [*all indexes*] and respira* [*all indexes*] or diafragm* [*all indexes*]