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Systematic review

Effects of preoperative physical training on functional capacity in esophageal surgery: a systematic review

Efeitos do treinamento físico pré-operatório na capacidade funcional em cirurgia esofágica: revisão sistemática

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ABSTRACT

Introduction: Physical training is essential to improve cardiorespiratory function and muscle strength, directly impacting patients' functional capacity. Esophageal surgery, often performed in cases of cancer, is associated with high risks of morbidity and mortality. **Objective:** To summarize evidence on the effects of physical training on the functional capacity of individuals in the preoperative period of esophageal surgery. **Methods:** Systematic review in the Pubmed, VHL, EBSCOhost, Scielo and PEDro databases. Two independent reviewers carried out the search and selection of studies using the terms "Preoperative", "Esophageal" and "Surgery Training". Randomized clinical trials focused on physical training programs for patients in the preoperative period of esophageal surgery were included. The risk of bias of the studies was assessed using the PEDro scale. **Results:** The initial search identified 188 articles, of which three were considered eligible, covering a total sample of 149 patients, with 71.71% being men. The exercise programs ranged from inspiratory muscle training to aerobic and neuromuscular exercises, lasting 2 to 3 weeks. The majority of patients undergoing esophageal surgery had been diagnosed with cancer. Analysis of the studies indicated a moderate to low risk of bias. **Conclusion:** The evidence suggests that physical training in the preoperative period of esophageal surgery can improve functional capacity, muscle strength and cardiorespiratory function. In addition, these benefits may contribute to a reduction in pulmonary complications, reintubations and length of hospital stay.

Keywords: functional status; exercise therapy; esophageal neoplasms

RESUMO

Introdução: O treinamento físico é fundamental para melhorar a função cardiorrespiratória e a força muscular, impactando diretamente a capacidade funcional dos pacientes. A cirurgia esofágica, frequentemente realizada em casos de câncer, está associada a altos riscos de morbidade e mortalidade. **Objetivo:** Sumarizar evidências sobre os efeitos do treinamento físico na capacidade funcional de indivíduos no pré-operatório de cirurgia esofágica. **Métodos:** Revisão sistemática nas bases de dados Pubmed, BVS, EBSCOhost, Scielo e PEDro. Dois revisores independentes realizaram a busca e seleção dos estudos usando os termos "Preoperative", "Esophageal" e "Surgery Training". Foram incluídos ensaios clínicos randomizados focados em programas de treinamento físico para pacientes no pré-operatório de cirurgia esofágica. O risco de viés dos estudos foi avaliado pela escala PEDro. **Resultados:** A busca inicial identificou 188 artigos, dos quais três foram considerados elegíveis, abrangendo uma amostra total de 149 pacientes, com 71,71% sendo homens. Os programas de exercícios variaram entre treinamento muscular inspiratório, exercícios aeróbicos e neuromusculares, com duração de 2 a 3 semanas. A maioria dos pacientes submetidos à cirurgia esofágica tinha diagnóstico de câncer. A análise dos estudos indicou um risco de viés de moderado a baixo. **Conclusão:** As evidências sugerem que o treinamento físico no pré-operatório de cirurgia esofágica pode melhorar a capacidade funcional, força muscular e função cardiorrespiratória. Além disso, esses benefícios podem contribuir para a redução de complicações pulmonares, reintubações e tempo de internação hospitalar.

Palavras-chave: estado funcional; terapia por exercício; neoplasias esofágicas

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Introduction

Esophageal surgery (ES) is a complex procedure associated with high risks of morbidity and hospital mortality [1]. Its importance in clinical practice is indisputable, and it is often used for both curative and palliative treatment of various conditions, especially esophageal cancer. In 2016, the National Cancer Institute (INCA) estimated the occurrence of 10,810 new cases of esophageal neoplasia in Brazil, predominantly in older individuals, especially in the 6th and 7th decades of life [2]. Among the main risk factors are alcohol consumption, hot drinks and smoking [3].

In the clinical scenario, people with esophageal involvement usually present with symptoms such as dysphagia and significant weight loss, which significantly reduces their functional and metabolic reserves. Furthermore, in the post-operative period of esophagectomy, a further decline in cardiovascular, pulmonary and muscular function can be observed, resulting in a marked decrease in functional capacity (FC) and quality of life. These events make it urgent to identify therapeutic strategies for the recovery and rehabilitation of the public in question [4-7].

In this sense, physical training (PT) in the preoperative period has been shown to be a promising intervention to increase the functional reserve of patients who will undergo ES. Studies indicate that exercise training can bring significant benefits from pre- to post-surgery, helping to improve muscle and cardiopulmonary function [8,9]. Physiologically, PT improves FC by promoting adaptations in the muscular and respiratory systems [10]. These effects are particularly noticeable in the increase in maximum oxygen consumption (VO_2 peak) and in the strengthening of the inspiratory muscles, which translates into improvements in peripheral O_2 extraction, dyspnea and quality of life [1,11-12].

However, despite the biological plausibility and possible clinical benefits, there is still a significant gap in knowledge about the specific effects of exercise training in the preoperative period of ES. Understanding these effects is crucial for the development and adoption of strategies aimed at optimizing the recovery and rehabilitation of these patients. Therefore, this study aimed to summarize evidence on the effects of preoperative physical exercise on the functional capacity of individuals undergoing esophagogastric cancer surgery.

Methods

Type of study

This study is a systematic review, based on the criteria established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses - PRISMA [13], to answer the PICO question: "What are the effects of physical training on functional capacity during the preoperative period of esophageal surgery?". The study was registered with PROSPERO under opinion: CRD42021229289.

Eligibility criteria

In order to carry out this systematic review, specific inclusion and exclusion criteria were established to ensure the selection of relevant, high-quality studies.

Inclusion criteria: We only included randomized clinical trials. We considered studies that investigated the effects of preoperative physical training programs, such as aerobic, resistance or combined programs. The population of interest included hospitalized adult patients (≥18 years) who were preparing for esophagogastric cancer surgery, covering both esophageal and gastric cancer. The interventions were to be carried out exclusively in the preoperative period, i.e. before surgery, to focus on the specific effects of physical training during this crucial phase. We considered studies that evaluated outcomes related to functional capacity, such as VO_2 max and the six-minute walk test, as well as the incidence of postoperative complications and recovery time. There were no restrictions on language or publication period, allowing the inclusion of studies from any year and language to provide a comprehensive view of the available evidence.

Exclusion criteria: We excluded studies involving participants under the age of 18, as physiology and response to exercise training can differ significantly between adults and children. We also excluded studies that included additional associated clinical procedures in the preoperative period, such as concomitant chemotherapy or radiotherapy, to avoid confounding the results attributed exclusively to physical training. Theses, master's or doctoral dissertations and other academic papers that were not published in peer-reviewed scientific journals were also excluded, to ensure that only studies that had undergone a rigorous review process were considered. In addition, studies that did not report the outcomes of interest, such as functional capacity, postoperative complications or recovery time, were excluded, as these data are essential for answering the review question. Finally, duplicate studies or those with insufficient data for extraction and analysis were excluded to maintain the integrity of the review and avoid bias.

Outcome of interest

Functional capacity (FC) is defined in terms of abilities and independence to perform certain activities. For the purpose of this study, FC is considered in relation to the performance of the individual's cardiopulmonary and muscular functions [14].

Search strategy

The searches were carried out in the Pubmed, VHL, EBSCOhost, SCielo and PEDro databases, by two independent authors [C.P.S] and [V.A.G], between June and November 2022. We used a combination of descriptors selected from the Medical Subject Headings (MeSH), Health Sciences Descriptors (DeCS) and keywords: "Preoperative", "Esophageal", "Surgery" and "Training", as well as their respective sy-

nonyms. The specific cross-references for each database were carried out using the Boolean operators [AND] and [OR], as detailed in Chart 1.

Chart 1 - Search strategies for the selected databases

PUBMED	"Preoperative" AND "Esophageal" AND "Surgery Training"
Portal BVS	"Preoperative" AND "Esophageal" AND "Surgery Training"
EBSCOhost	Preoperative AND Esophageal AND Surgery Training
SCielo	"Preoperative" AND "Esophageal" AND "Surgery Training"
PEDro	Preoperative Esophageal* Surgery Training*

Study selection and data extraction

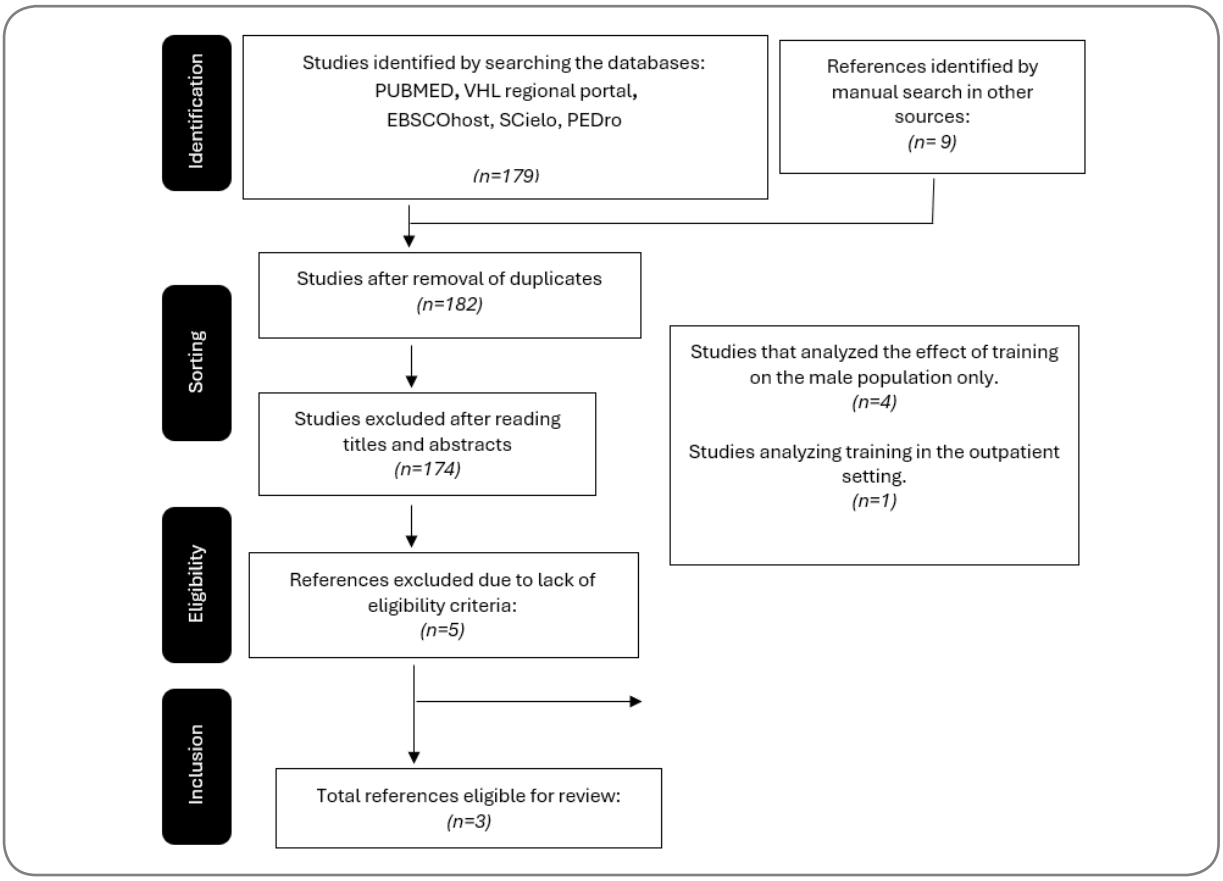
The studies were selected by two independent authors [C.P.S] and [V.A.G]. In the event of disagreements, a third reviewer [R.M.B] was consulted. Initially, a thorough reading of the titles and abstracts was carried out, selecting those that met the previously established eligibility criteria for the final analysis. As shown in Table I, the eligible studies were subjected to a complete reading in order to assess the selection criteria and retrieve the following data: a) Author and year of publication of the study; b) Main objectives of the study; c) Characteristics of the population (population sample); d) Intervention protocols (methods of the control and intervention groups); e) Main results obtained by the studies. The references reviewed and included in this review were analyzed in order to identify potential studies not detected in the initial searches in the selected electronic databases. Figure 1 summarizes the strategies for selecting the studies that make up the scope of this systematic review.

Methodological quality

The quality of the studies was assessed using the PEDro (Physiotherapy Evidence Database) scale, based on the Delphi list. The PEDro scale consists of 10 items, each contributing 1 point (except item 1, which is not scored), resulting in a total score ranging from 0 to 10. This scale assesses the methodological quality of randomized controlled clinical trials, focusing on two main aspects: internal validity (credibility of the observations and results in relation to the reality studied) and the amount of statistical information sufficient for interpretation. The scale does not assess the external validity, significance or magnitude of the treatment effect. The classification of the articles was carried out independently by two evaluators familiar with the scale. Divergences in the PEDro classification were discussed between the evaluators and resolved by consensus, establishing the final score for the studies (Table II). The cut-off point for distinguishing between studies of high and low methodological quality was defined as <6 (low quality) or ≥6 (high quality) on the PEDro scale [15].

Results

The search strategies and manual analysis of the references returned a total of 188 articles. After the initial review by authors [C.P.S] and [V.A.G], 6 articles were eliminated due to duplication, leaving 182 studies. Next, during screening based on the eligibility criteria, 177 studies were excluded after analyzing titles and abstracts, leaving 5 articles for full reading. Subsequently, two (2) of these studies were excluded because they performed physical training in the preoperative period of esophageal surgery in an outpatient setting. Finally, three (3) studies met the eligibility criteria and were included in the review, as summarized in Figure 1 [15-17].



Source: authors
Figure 1 – Flowchart for screening and selecting articles

As shown in Table I, the included studies aimed to investigate the effects and aspects of physical training in the preoperative period of esophageal surgery (ES) [15-17]. The total sample of these studies included 145 individuals, of whom 71 were men and 28 women [15,16]. It is worth noting that the study by Christensen *et al.* [17] did not differentiate the sample by sex, so it was not included in the gender distribution. Of these, 68 individuals were allocated to the intervention groups and 77 to the control groups.

Table I - Characteristics of the selected studies

Author/ year	Objective	Population characteristics	Intervention Protocol		Main results
			CG	IG	
Guinan *et al.* **2018 [15]**	To evaluate the effects of IMT in patients undergoing esophageal surgery on the development of postoperative pulmonary symptoms.	Patients with carcinoma, over 18 years old, both sexes 42 men and 18 women. GI: 28 participants CG: 32 participants	He carried out moderate-intensity activities for 2 weeks.	≥2 weeks preoperatively, performing 30 breaths, twice a day, using a resistive conical flow inspiratory loading device (K3, POWER breatheR). Training began at 60% of baseline (MIP) and progressed by 5% when the participant's reported rate of perceived exertion (RPE) < 7 (RPE scale 1-10).	-Improves preoperative active MIP. No improvement in pre- or post-operative physical functioning or post-operative reactive mobilization after esophagectomy.
Adrichem *et al.* **2014 [16]**	- Primary objective: To examine the effect of preoperative IMT-HI on PPCs compared to preoperative IMT-E in EC patients awaiting esophagectomy. - Secondary objective: To investigate the effect on ICU length of stay, number of reintubations, MIP and preoperative lung function, and to examine the feasibility of both training modalities	Aged between 18 and 85, of both sexes 29 men and 10 women, with esophagectomy for esophageal cancer. GI: IMT-HI: 20 participants. GC: IMT-E: 19 participants	IMT-E was based on the Hulzebos *et al.* 3-week program and contained seven training sessions per week, three supervised and four unsupervised (performed at home). Each session consisted of 20 min of breathing using an inspiratory breathing threshold-loading device (Threshold-IMT ®, Respironics) at 30% of the MIP measured before the first session. Train-loading was increased by 5% when a Borg score of \5 was achieved. To perform TMI at home, patients received instructions and kept a training log (intensity, experience, and perceived exertion).	- IMT-HI: 3 weeks and contained three supervised training sessions per week. Six cycles of six inspiratory maneuvers on a threshold inspiratory loading device (Respifit S, Biegler GmbH, Mauerbach, Austria). The rest time between cycles was progressively reduced from 60 to 45, 30, 15 and 5s. MIP was measured weekly to adjust the intensity accordingly. Initial intensity: 60% of MIP and 80% during the first week of training was 80% of MIP and increased by 5% if a Borg score for perceived exertion 5 was achieved.	- The median MIP (IQR) in cmH2O: IMT--HI: showed a significant increase of 12%. - IMT-HI proved to be a promising and effective intervention reducing PPCs in patients undergoing esophagectomy.
Christensen *et al.* **2018 [17]**	Examine SAEs. Adherence to exercise prescription, involving frequency rate, number of exercise interruptions and modifications, and changes in aerobic fitness, muscle function and body composition were also determined.	Cancer patients of both sexes over the age of 18, a total of 46 participants, 90% were men. GI: 20 participants CG: 26 participants	He didn›t report on the training carried out.	High-intensity aerobic and resistance exercises, twice-weekly sessions of approximately 75 min. 10 min warm-up on an exercise bike, 21-28 min of high-intensity interval training consisting of 4 x 4 min with 3 min of low-intensity active, high-intensity recovery. Resistance exercises: bench press, leg press, lateral pull and knee extension session, with a warm-up set followed by three sets of 8-12 repetitions.	Improvement in estimated peak VO_2; muscle strength for leg press, knee extension, chest press and seated rowing.

CG = Control Group; IG = Intervention Group; Min = Minutes; MIP = Passive Inspiratory Musculature; PPCs = Postoperative pulmonary complications; IMT = Inspiratory Muscle Training; IMT-E = Inspiratory Muscle Training – Endurance; IMT-HI = Inspiratory Muscle Training - High Intensity; SAEs = Serious adverse event rates; VO_2peak: peak oxygen consumption

The methods applied in the control groups varied over periods of 2 to 3 weeks, with moderate intensity activities and endurance inspiratory muscle training (IMT--E) [15,16]. In the intervention group, inspiratory muscle training (IMT) was performed using devices such as the conical flow resistor and the inspiratory loading device (K3, POWER breathe®) [15], or through high-intensity inspiratory muscle training (IMT-HI) [16]. The duration of these interventions was approximately 2 to 3 weeks. In contrast, one study [17] implemented the intervention with a program of high-intensity aerobic training and resistance exercises, with sessions held twice a week.

The main results indicate that preoperative physical training for patients undergoing esophageal surgery provides significant benefits for the inspiratory muscles [15,16], improved VO_2 peak and increased muscle strength [17]. It is important to note that all the individuals undergoing oesophageal surgery in the studies reviewed had been diagnosed with oesophageal cancer [15-17].

Regarding the risk of bias, the eligible articles ranged between 5 and 8 points on the PEDro scale, out of a possible 10 points. In the quality classification, one of the included studies was assessed as "low quality" [17], while two studies were classified as "high quality" [15,16]. The average quality of the studies in this review was 7 points on the PEDro scale. Table II presents a qualitative summary of the original studies included in this review.

Table II - Risk of Bias Analysis (PEDro Scale)

Author/Year	2	3	4	5	6	7	8	9	10	11	Total
Guinan *et al.* **2018 [15]**	YES	YES	YES	YES	NO	NO	YES	YES	YES	YES	8
Adrichem *et al.* **2014 [16]**	YES	YES	YES	YES	YES	YES	NO	NO	YES	YES	8
Christensen *et al.* **2019 [17]**	NO	NO	YES	NO	NO	NO	YES	YES	YES	YES	5 (mean: 7)

2. Were the subjects randomly assigned to groups (in a crossover study, the subjects were randomly assigned to groups according to the treatment they received)? 3. Was the allocation of subjects secret? 4. Were the groups initially similar with regard to the most important prognostic indicators? 5. Did all the subjects participate in the study in a blinded manner? 6. Did all the therapists who administered the therapy do so in a blinded manner? 7. All evaluators who measured at least one key outcome did so in a blinded manner?; 8. Measurements of at least one key outcome were obtained in more than 85% of the subjects initially allocated to the groups?; 9. All subjects from whom outcome measurements were presented received the treatment or control condition as allocated or, when this was not the case, the data was analyzed for at least one of the key outcomes by "intention to treat"?; 10. Have the results of the inter-group statistical comparisons been described?; 11. Does the study present both precision and variability measures for at least one key outcome?

Discussion

The main results of this study suggest that physical training (PT) during the preoperative period of esophageal surgery promotes a significant improvement in functional capacity, positively influencing outcomes such as cardiopulmonary function and muscle strength. In addition, the main condition leading to esophagectomy is esophageal cancer [15-17].

Previous studies have shown that this neoplasm is highly aggressive and is considered the sixth leading cause of cancer death worldwide [2,19,20]. Patients with this disease often have difficulty swallowing, which can result in weight loss, anemia and dehydration [21-23]. In addition, there are reductions in cardiopulmonary function, physical fitness and the ability to perform activities of daily living [5,24,25].

A previous review indicated that TF can optimize patients' vital and inspiratory capacity [25]. This was also observed in the studies included in this review, which found an improvement in inspiratory muscle function, peak VO_2 and muscle strength [15-17]. One study in particular suggested that intervention with high-intensity inspiratory muscle training (HI-IMT) may be promising and effective, capable of reducing the negative impacts of the postoperative period in patients undergoing esophagectomy, such as pulmonary complications, reintubations and length of hospital stay, when compared to endurance inspiratory muscle training (E-IMT). Both training methods showed a significant increase in maximum inspiratory pressure (MIP) and lung function [16].

Corroborating these findings, one of the included studies suggested that IMT can improve the patient's inspiratory muscle strength, expiratory strength and ventilatory function preoperatively, thus reducing the risk of pulmonary complications after esophagectomy [26]. In contrast, another study [15] showed that, despite the gains in MIP with the IMT intervention in the preoperative period, there was no significant influence on the improvement in functional capacity, which can be explained by the short period of the intervention, despite the intensity used (60% MIP). Monitoring the interventions by means of training diaries and weekly phone calls compromised the ability to accurately assess training adherence and possible problems in carrying out the interventions.

It is interesting to note that the changes observed may be associated with specific subgroups of patients, such as those over 70 who have undergone invasive or open surgical procedures, patients with chronic obstructive diseases and those with inspiratory muscle strength of less than 70 cmH2O [15]. Based on this hypothesis, it is plausible to suggest that intrinsic factors, such as age and comorbidities, and extrinsic factors, such as the type of surgical procedure, can influence the effect of preoperative physical training.

Another possible training strategy for this population involves continuous moderate-intensity aerobic exercise and resistance training [27]. These strategies have been shown to improve the functional capacity of individuals, as measured by their performance in the 6-minute walk test [27]. In addition, other exercise prescription strategies can influence the development of physical fitness, strength and quality of life, such as aerobic training and high-intensity resistance exercises, performed with a focus on gaining muscle strength using equipment such as leg presses, knee extensions, bench presses and seated rowing [17]. It is worth noting that some studies show that regular exercise can prevent the development of certain types of cancer [26], probably due to important anti-cancer mechanisms associated with this practice [27].

Furthermore, another relevant finding is that the highest prevalence of esophageal surgery occurs in men [15,16]. This can be explained by the higher consumption of tobacco, hot drinks and alcohol by this population [3,18,28]. Although it was not measured in this study, factors related to age, family history and genetic predisposition may also be associated with the development of oesophageal cancer [29].

Based on the data presented, there is a need to implement policies aimed at caring for patients undergoing oesophagectomy, considering the high prevalence of morbidity and mortality in this subgroup of the population. Physical training in the preoperative period can increase functional capacity, improve quality of life and potentially have an impact on longevity.

Clinical implications

The findings of this systematic review have important clinical implications for the management of patients undergoing esophageal surgery for resection of esophageal cancer. Preoperative physical training has been shown to improve patients' functional capacity, which can translate into faster recovery and a reduction in postoperative complications. Integrating physical training programs into preoperative preparation can be a valuable strategy to optimize patients' physical status before surgery, especially considering the high complexity and risks associated with esophagectomy. Furthermore, the adoption of these interventions can contribute to a more holistic and patient-centered approach, improving quality of life and surgical results. Healthcare professionals, including surgeons, physical therapists, and rehabilitation teams, should consider including exercise training regimens into standard clinical practice for patients with esophageal cancer. This proactive approach can not only improve the immediate outcomes of surgery, but also contribute to the overall health and longevity of patients.

Limitations

The limitations of this systematic review should be considered when interpreting the results. First, the data are specific to patients undergoing esophageal surgery for cancer resection, limiting generalizability to other populations or surgeries. Furthermore, the limited number of studies included may affect the robustness of the conclusions. The heterogeneity of the training modalities analyzed also complicates the comparison of results, as different approaches can generate varied responses. Monitoring training adherence, carried out through diaries and phone calls, can introduce measurement biases due to dependence on participant accuracy. Finally, the included studies generally had small sample sizes, which may limit the detection of significant effects. Despite these limitations, the results are consistent with existing literature, indicating benefits of preoperative physical training in complex esophageal surgeries.

Conclusion

The findings of this research demonstrate that physical training in the preoperative period of esophageal surgery promotes an improvement in functional capacity, muscle strength and cardiopulmonary function. This can lead to a reduction in pulmonary complications, the risk of reintubations and the length of hospital stay. However, further studies with greater methodological rigor are needed to confirm these results in this population.

Interest conflicts
No conflicts of interest

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Authors' contributions
Conception and design of the research: Santos CP, Barbosa RM, Moura RF, Gomes VA, Santos ACN, Petto J; Data collection: Santos CP, Barbosa RM, Moura RF, Gomes VA, Santos ACN, Petto J; Data analysis and interpretation: Santos CP, Barbosa RM, Moura RF, Gomes VA, Santos ACN, Petto J; Data collection: Santos CP, Barbosa RM, Moura RF, Gomes VA, Santos ACN, Petto J; Manuscript writing: Santos CP, Barbosa RM, Moura RF, Gomes VA, Santos ACN, Petto J; Data collection: Santos CP, Barbosa RM, Moura RF, Gomes VA, Santos ACN, Petto J, Santos WC, Santos LO; Critical review of the manuscript for important intellectual content: Santos CP, Barbosa RM, Moura RF, Gomes VA, Santos ACN, Petto J; Data collection: Santos CP, Barbosa RM, Moura RF, Gomes VA, Santos ACN, Petto J, Santos LO, Santos WC

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