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Prevention and Rehabilitation

Effects of therapeutic exercises in patients with lung cancer. A scoping review

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ABSTRACT

Introduction: Lung cancer is one of the most common malignancies worldwide and the leading cause of cancer-related death. Smoking is one of the main risk factors associated with this cancer. Treatment will depend on the form of cancer and its stage, existing many therapeutic possibilities. In this regard, therapeutic exercise plays an important role in lung cancer care, as well as the pulmonary rehabilitation and respiratory physical therapy.
Purpose: To review the current scientific literature about the effects of therapeutic exercise in lung cancer.
Method: A search was carried out in CINAHL, MEDLINE, PubMed, Scopus y Web of Science using de terms "Exercise Therapy" and "Lung Neoplasms". 141 studies were obtained, but only 19 were selected by adjusting to the inclusion and exclusion criteria. 10 of them were randomized controlled trials with a Jadad score between 2 and 3.
Results: These works performed a large variety of interventions based on therapeutic exercise, classified in preoperative, postoperative, during treatment, post treatment and combination. Most focused on aerobic exercise, muscle strength and respiratory exercises. **Conclusion**: therapeutic exercise seems to be positive and obtain significant improvements in patients with lung cancer, regardless the moment of intervention and the type of exercise performed.

1. Introduction

Lung cancer (LC) is one of the most common malignancies worldwide and the leading cause of cancer-related death (M. Sommer et al., 2018). It most frequently affects men between 50 and 60 years old, with smoking being the risk factor most commonly associated with the development of this type of cancer (Amorín Kajatt, 2013). There are two main forms of LC: small-cell lung cancer (SCLC) or microcytic lung cancer, which represents approximately 20% of LCs, and non-small-cell lung cancer (NSCLC) or non-microcytic lung cancer with stages I, II, III and IV representing the remaining 80% (Mehta et al., 2015). An early diagnosis of LC would dramatically increase the chances of treatment success. However, it rarely gives specific symptoms at this stage. Therefore, the tumor is diagnosed at an advanced stage in most cases, showing symptoms such as cough, dyspnea, chest pain, dysphonia and hemoptysis in general, which makes it a very aggressive pathology(-Mehta et al., 2015).

Treatment will depend on the type of LC and its stage, and there are many therapeutic possibilities. Thus, surgical resection is the most consistent and successful option for early stages; concurrent chemotherapy and radiotherapy is the preferred option for some locally advanced stages; and palliative chemotherapy is the best option for metastatic stages (Molina et al., 2009). Physical exercise plays an important role in LC care, as inactivity contributes to increased cancer-associated mortality, decreased quality of life, and increased burden of symptoms. Physical exercise interventions in patients with LC have shown improvements in oxygen consumption, activity tolerance, quality of life, and overall burden of symptoms. Likewise, the use of respiratory physiotherapy or pulmonary rehabilitation in the palliative, preoperative and postoperative phases provides benefits in terms of functional capacity

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Table 1
Databases and search equations.

Databases	Search equations
CINAHL	(MH "Therapeutic Exercise") AND (MH "Lung Neoplasms")
MEDLINE	(MH "Exercise Therapy") AND (MH "Lung Neoplasms")
PubMed	("Exercise Therapy"[Mesh]) AND "Lung Neoplasms"[Mesh]
Scopus	TITLE-ABS-KEY ("exercise therapy" AND "lung neoplasms")
WOS	TEMA: ("exercise therapy") AND TEMA: ("lung neoplasms")

and quality of life for patients with LC (Bade et al., 2018). Therefore, prescription of physical exercise should be fundamental in addressing cancer treatment (Saz-Peiró, 2016).

Considering that the knowledge in health sciences is constantly changing and specifically the investigation around cancer, the purpose of this study is to review and analyze the current scientific literature about the effects of therapeutic exercise in patients with LC.

2. Methods

2.1. Search and information sources

Between January and February 2020, a review of the current scientific literature was performed in Cinhal, Medline, PubMed, Scopus and Web of Science (WOS) databases by two independent investigators. The following Medical Subject Headings (MeSH) terms from Index Medicus 'Exercise Therapy' and 'Lung Neoplasms' were used, and the search equations from the different databases could be consulted in Table 1. On CINAHL, since it has its own thesaurus, the term 'Therapeutic Exercise' was used, while the absence of a thesaurus on Scopus and WOS forced the search using the terms between quotation marks in sections TITLE-ABSTRACT-KEYWORD and SUBJECT, respectively. This search provided 339 results, filtered by the following eligibility criteria.

2.2. Eligibility criteria

Regarding criteria used in the search, publications between 2015 and 2020 written in English were included, while meta-analyses, bibliographic reviews, protocols, publications without access to the text and case studies were excluded. These criteria were applied by two independent investigators and, in case of disagreement, a third investigator analyzed the study. Thus, Fig. 1 shows a flow diagram specifying the search process and valid articles established after applying these criteria.

Methodological quality.

Randomized clinical trials (RCTs) included were evaluated by JADAD methodological quality scale, which was developed and validated in order to independently assess the quality of these studies. This scale gives the study a point if it is described as randomized, as double-blind, if the procedures are described and appropriate, and if a description of dropouts/losses is reported. Thus, a study may receive a score between 0 and 5 (Bhogal et al., 2005).

3. Results

The main features of the 19 selected studies are set out below in various tables so as to facilitate analysis and comparison. In Table 2 (Cavalheri et al., 2017; Edvardsen et al., 2015; Hashmi et al., 2017; Hoffman et al., 2017; Janssen et al., 2017; Karenovics et al., 2017; Lai et al., 2017; Licker et al., 2017; Messaggi-Sartor et al., 2019; Molassiotis et al., 2015; Olivier et al., 2018; Quist et al., 2015, 2018;

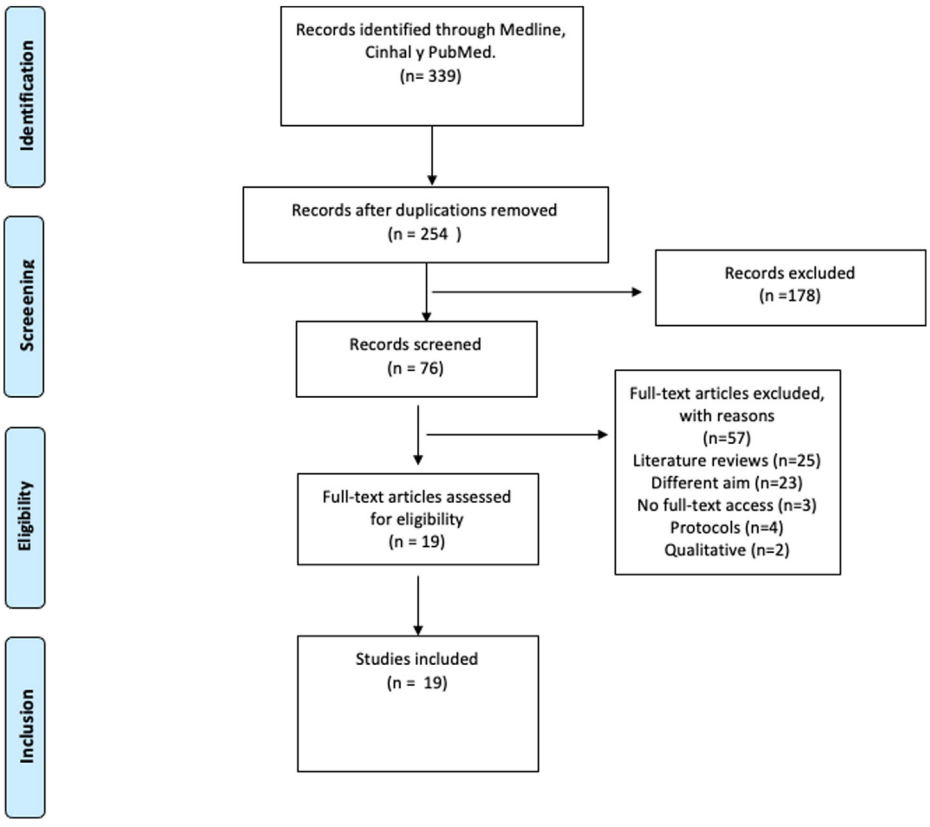

Fig. 1. Flow diagram according to PRISMA.

Table 2
Participants' characteristics.

Author	Sample	Age (years)	Sex (female/male)	Lost	Inclusion criteria	Exclusion criteria
(Edvardsen et al., 2015)	**61** CG: 31 IG: 30	IG: 64,4 CG: 65,9	33/28	18	- 80 years - Diagnosis of LC. - Accepted for surgery.	- Not able to perform the test
(Quist et al., 2015)	**114** IG: 114	66	57/57	43	- >18 years. - stage IIIB-IV y SCLC-ED. -Immunotherapy.	-Metastasis -Cardiac disease
(Quist et al., 2018)	**211** G1: 110 G2: 101	G1: 65 G2: 66	117/94	78	- >18 years. -stage I-IIIA and accepted for surgery.	–
(Zhang et al., 2016)	**91** CG: 44 IG: 47	62,8	23/68	17	- ≥18 years. -Diagnosis of LC. - Immunotherapy. - Performance 0 to 3.	-Contraindications for exercise
(Janssen et al., 2017)	**50** IG: 50	67	20/30	7	−6 weeks after surgery.	-Contraindications for exercise
(Sebio García et al., 2016)	**9** IG: 9	68,5	1/8	–	–	–
(Sebio García et al., 2017)	**22** CG: 12 IG: 10	CG: 69,4 IG: 70,9	2/20	3	- ≥18 years. - Diagnosis of LC. - At least one: FEV1⩽80%; BMI ⩾30; age⩾75 years	-Contraindications for exercise
(Olivier et al., 2018)	**71** IG: 71	60,6	17/54	24	- ≥18 years. -Diagnosis of LC -Immunotherapy	-Contraindications for exercise
(Salhi et al., 2015)	**70** CG: 24 GERC: 24 GVCT: 22	CG: 64 GERC: 63 GVCT: 60	19/51	12	- 18−80 years. -Stage I-III. - Initial hemoglobin 8 g/dl.	-Contraindications for exercise
(Lai et al., 2017)	**60** CG: 30 IG: 30	CG: 71,6 IG: 72,5	26/34	4	- Diagnosis of LC. -No surgery contraindications. -Accepted the preoperative therapy.	-Contraindications for exercise
(Licker et al., 2017)	**151** CG: 77 IG: 74	64	60/91	5	-Diagnosis of LC.	–Contraindications for exercise
(Karenovics et al., 2017)	**151** CG: 77 IG: 74	64	60/91	37	-Diagnosis of LC.	-Contraindications for exercise
(M. S. Sommer et al., 2016)	**40** IG_1+IG_3: 18 IG_2+IG_4: 22	68	24/16	11	- 18 years -Accepted for surgery. -Performance from 0 to 2 (WHO)	-Metastasis -Contraindications for exercise
(M. S. Sommer et al., 2018)	**40** IG_1+IG_3: 18 IG_2+IG_4: 22	68	24/16	11	- 18 years -Diagnosis of LC. -Accepted for surgery -Performance from 0 to 2 (WHO).	-Metastasis -Contraindications for exercise
(Hashmi et al., 2017)	**42** CG: 26 IG: 16	CG: 73 IG: 74	29/13	0	-Diagnosis of LC. -FEV1<1,6L. -Surgery.	–
(Cavalheri et al., 2017)	**17** CG: 8 IG: 9	CG: 68 IG: 66	–	8	-Diagnosis of LC postoperative -Immunotherapy	-Neuromuscular limitations -Contraindications for exercise
(Messaggi-Sartor et al., 2019)	**37** CG: 21 IG: 16	CG: 64,8 IG: 64,2	11/26	13	- <80 years. -Diagnosis of LC.. -Surgery	-Other therapies -Contraindications for exercise
(Molassiotis et al., 2015)	**46** CG: 23 IG: 24	69,5	9/37	11	-Diagnosis of LC. -Dyspnea	-COPD -Cardiac disease or dyspnea -Contraindications for exercise
(Hoffman et al., 2017)	**72** CG: 35 IG: 37	IG: 67,4 CG: 65,6	40/32	15	- 21 years at least. -Diagnosis of LC after surgery.	-Metastasis -Contraindications for exercise

LC: lung cancer; **FEV1:** forced expiratory volume in 1 s; **CG:** control group; **IG:** intervention group; **WHO:** World Health Organization; COPD: chronic obstructive pulmonary disease.

Table 3
Results and characteristics of the preoperative intervention.

Author	Study	Evaluation	Intervention	Measurements	Results ($p < 0.05$)
(Sebio García et al., 2016)	Pilot study	- at the start of the study. - before surgery. - discharge day. - 3 months after surgery	HIIT with elastic bands and respiratory exercises.	-Functional capacity: 6MWT. -Muscular strength. - SF-36. -Intrahospital complications	-SFT increase between each moment -Decrease of the functional capacity - Decrease of quality of life
(Sebio García et al., 2017)	RCT	- at the start of the study. - discharge day. - 3 months after surgery	-CG: standard treatment. -IG: resistance training combined with elastic bands and home exercises.	-Exercise capacity: CPET. -Functional capacity: 6MWT. -Muscular strength: SFT and Curl test. - SF-36v2. -Dyspnea: modified Borg Scale -Intrahospital complications (Melbourne Group Scale).	-Increase the exercises capacity, strength and quality of life.
(Lai et al., 2017)	RCT	At the start and 1 week after	-CG: standard treatment -IG: aerobic training	-Functional capacity 6-MWT. - EORTC-QLQ-C30 y EORTC QLQ-LC13. -Intrahospital complications (Claven-Dindo).	- Increase in 6-MWT - Decrease of the hospital time
(Hashmi et al., 2017)	Retrospective	At the start of the study and 8 weeks later	-CG: No treatment -IG: Exercises therapy at home, respiratory exercises and psychosocial interventions	-Spirometry	-Increase FEV1

RCT: Randomized clinical trial; **EORTC QLQ-C30:** European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire Core 30; **EORTC QLQ-LC13:** European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire-Lung Cancer; **FEV1**: forced expiratory volume in 1 s; **CG:** control group; **IG:** intervention group; **HIIT:** High Intensity Interval Training; **6MWT:** 6-min walk test; **SF-36:** Short Form-36 Health Survey; **SF-36v2:** Short Form-36 Healthy Survey version 2; **SFT:** Senior Fitness Test.

Salhi et al., 2015; Sebio García et al., 2016, 2017; M. S. Sommer et al., 2016, 2018; Zhang et al., 2016), participant characteristics as per the total sample can be observed, namely age (mean), gender, inclusion and exclusion criteria that allow their participation or not in the relevant study and, finally, the losses produced.

On the other hand, Table 3 shows the characteristics of the preoperative intervention (Hashmi et al., 2017; Lai et al., 2017; Sebio García et al., 2016, 2017); Table 4 shows them during treatment (Cavalheri et al., 2017; Quist et al., 2015; Zhang et al., 2016), postoperative period (Edvardsen et al., 2015; Hoffman et al., 2017; Janssen et al., 2017; Messaggi-Sartor et al., 2019; Quist et al., 2018; Salhi et al., 2015) and/or post-treatment (Molassiotis et al., 2015; Olivier et al., 2018); lastly, Table 5 reflects a combination of preoperative and postoperative interventions (Karenovics et al., 2017; Licker et al., 2017; M. S. Sommer et al., 2016, 2018). All these tables focus on the study type, the duration of the intervention and the time for different evaluations, the description of the intervention carried out, variables measured and the instruments used for it, as well as statistically significant results ($p < 0.05$) obtained.

Table 6 shows the assessment of the methodological quality for RCTs with scores ranging from 3 points (Cavalheri et al., 2017; Edvardsen et al., 2015; Karenovics et al., 2017; Licker et al., 2017; Quist et al., 2018; Salhi et al., 2015; Sebio García et al., 2017; Zhang et al., 2016) to 2 points (Lai et al., 2017). Those achieving a minimum of 3 are considered to be acceptable with regard to quality.

4. Discussion

The results of this study after analyzing 19 investigations suggest that therapeutic exercise is beneficial for patients with LC, in terms of physical, but also psychological improvements. During cancer, patients receive many therapies with the aim of making the disease disappear, but maintain and increase parameters as quality of life and anxiety has been confirmed to be very important for the total recovery of the patient (Donado Gómez et al., 2015). A great diversity of therapeutic actions is observed in patients with LC, where a combination of different aerobic exercises, muscle strengthening workouts and respiratory exercises is performed to ensure the chances of success.

Cancer, and specially LC, has been largely studied as is one of the most prevalent (Borràs et al., 2008), however, the perspective of this study is less common, as the main purpose is to review the current scientific literature in order to come to a conclusion about therapeutic exercise in LC: is therapeutic exercise effective to prevent physical and psychological disorders related to this cancer?

First, studies included in this review are quite heterogeneous in terms of sample size, type of cancer and type of surgery, finding different interventions according to this. Therefore, results of this investigations should be understood in their context, since different surgeries such as thoracotomy (Hashmi et al., 2017; Hoffman et al., 2017; Karenovics et al., 2017; Lai et al., 2017; Licker et al., 2017; Messaggi-Sartor et al., 2019; M. S. Sommer et al., 2016, 2018), lobectomy (Cavalheri et al., 2017; Hoffman et al., 2017; Lai et al., 2017; Sebio García et al., 2016; M. S. Sommer et al., 2016, 2018), radical resection (Salhi et al., 2015), exploratory surgery for confirmation of diagnosis (Hoffman et al., 2017; Quist et al., 2018), video-assisted lobectomy (Hoffman et al., 2017; Karenovics et al., 2017; Lai et al., 2017; Licker et al., 2017; Messaggi-Sartor et al., 2019; Sebio García et al., 2016; M. S. Sommer et al., 2016, 2018), surgery with curative intent(Janssen et al., 2017; Quist et al., 2018), and others performing unspecified resection surgery (Edvardsen et al., 2015; Molassiotis et al., 2015; Sebio García et al., 2017) probably have a different impact on the post-surgical period. Previous studies reported that lung resections, video-assisted lobectomy and thoracotomy are equivalent in terms of postoperative complications(Rodríguez D et al., 2012; Sebastián et al., 2018), but a lower inflammatory response and shorter hospital stay have been described in video-assisted lobectomy, providing a faster patient recovery. However, according to several experts, these resections are usually performed in patients at early stages(Cao et al., 2014; Sebio García et al., 2017), and thus, interventions based on therapeutic exercise should be different taking this aspect into consideration. On the other hand, of the 19 studies included in this review 10 were RCT (refs) and after analyzing their methodological quality with Jadad scale, 8 achieve the minimum score to be considered high quality (3 points) and the other 2 achieve two points of 5. One

Table 4
Results and characteristics of the postoperative and during treatment interventions.

Author	Study	Evaluation	Intervention	Measurements	Results ($p < 0.05$)
(Edvardsen et al., 2015)	RCT	Pre and post-surgery	CG: standard treatment IG: warm up exercises, HIIT	- Spirometry -Borg Scale -Strength: global and hand -Functional capacity -SF-36 -Dyspnea: EORTC QLQ-C30.	- IG > functional capacity, dyspnea and quality of life
(Quist et al., 2018)	RCT	Pre surgery and after 14, 26 and 52 weeks	Resistance exercises, strength and respiratory exercises	-Exercise capacity: VO_2 - EORTC QLQ-C30 y EORTC QLQ-LC13. - FACT-L, SF-36. -HADS scale -Functional capacity: 6MWT. -Spirometry. -Strength	Improvements in functional capacity, exercise capacity and strength in both groups
(Messaggi-Sartor et al., 2019)	Pilot study	Pre surgery, post-surgery, after 8 weeks and after 2 years	-CG: standard treatment -IG: aerobic training	- Exercise capacity: VO_2 - Strength. -CVRS: EORTC QLQ-C30.	-Improve exercise capacity
(Zhang et al., 2016)	RCD	At the start and after 6 and 12 weeks	-CG: home exercises -IG: Tai Chi	-Fatigue: MFSI-SF	-Improve fatigue after 8 and 12 weeks
(Janssen et al., 2017)	Observational study	At the start and the last day	-IG: endurance training, relaxation and respiratory exercises	FACT-L, SF-36 y CRDQ. -Fatigue: FACT-F y CRDQ. -Exercise capacity: CPET.	Improve in fatigue and exercise capacity
(Olivier et al., 2018)	Pilot study	At the start and after 8 weeks	-IG: endurance training and home activities	- Exercise capacity: 6MWT y el 6MST. -Muscular strength: TUG and 10CS. -Dyspnea: 6MWT, 6MST, Borg.	Improvement in balance, strength and exercise capacity.
(Salhi et al., 2015)	RCT	At the start and after 12 weeks	-CG: standard treatment -IG1: aerobic training -IG2: aerobic training and vibration exercises	-Comorbidity: (Charlson). - Spirometry. - Exercise capacity:6MWT. -Strength - EORTC QLQ-C30 y PF. -Fatigue: FACT-F. -Dyspnea: Visual Analogical Scale.	Increase of 6MWT and strength
(Hoffman et al., 2017)	Pilot study	After 6 weeks	-CG: standard treatment. -IG: walk and balance with Nintendo Wii Fit Plus.	-Fatigue: Brief Fatigue Inventory. -PSE balance and walking -Functional capacity: 6MWT -Fatigue: Borg.	-Decrease of fatigue and improvements in functional capacity
(Molassiotis et al., 2015)	Pilot study	At the start and after 4, 8 and 12 weeks	-CG: standard treatment -IG: standard treatment + respiratory exercises	-Spirometry -Dyspnea Numerical Rating Scale. -RPE: Borg. - CRDQ -HADS scale	-Increase dyspnea and Borg Scale parameters, but improve the satisfaction with treatment.
(Quist et al., 2015)	Prospective study	At the start and after 6 weeks	-IG: cardiovascular exercises and stretching	-Functional capacity VO_2 and 6MWT. -Muscular strength: 1RM. -Spirometry -HADS scale	Increase of functional capacity Increase of strength
(Cavalheri et al., 2017)	RCT	At the start and after 8 weeks	-CG: standard treatment -IG: aerobic and endurance training	- Functional capacity: 6MWT. -CSF-36, FACT-L y EORTC QLQ-C30. -Fatigue: FACT-F. - Exercise capacity: CPET.	-Improvements in 6MWT

Table 4 (*continued*)

Author	Study	Evaluation	Intervention	Measurements	Results ($p < 0.05$)
				-Dyspnea: Borg. -HADS scale	

CRDQ: Chronic Respiratory Disease Questionnaire; **CRF:** cardiorespiratory fitness; **10CS:** 10 chair stands test; **CVRS:** Calidad de Vida Relacionada con la Salud; **RCT:** Randomised clinical trial; **EORTC QLQ-C30:** European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire Core 30; **EORTC QLQ-LC13:** Europeran Organisation for Research and Treatment of Cancer Core Quality of Life Questionnaire-Lung Cancer 13; **FACT-F:** Functional Assessment of Cancer Therapy-Fatigue; **FACT-L:** Functional Assessment of Cancer Therapy-Lung; **HADS**: hospital anxiety and depression scale**; CG:** control group; **IG:** intervention group; **HIIT:** High Intensity Interval Training; **6MST:** 6-min stepper test; **MVV:** maxima ventilación voluntaria; **6MWT:** 6-min walk; **SF-36:** Short Form-36 Healthy Survey; **TUG:** Up and Go Test; **VSRQ:** Visual Simplified Respiratory Questionnaire.

Table 5
Results and characteristics of the preoperative and postoperative intervention.

Author	Study	Evaluation	Intervention	Measurements	Results ($p < 0.05$)
(M. S. Sommer et al., 2016)	Pilot study	At the start and after 12 weeks, 6 months and a year	-IG_1: exercise pre surgery and exercise after 2 weeks of surgery -IG_2: exercise pre surgery and exercise after 6 weeks of surgery -IG_3: exercise after 2 weeks of surgery -IG_4: exercise after 6 weeks of surgery	-Exercise capacity: VO_2) -Functional capacity: 6MWT. -Muscular strength. -Spirometry. -FACT-L.	- Increase of the functional capacity and muscle strength after 12 weeks
(M. S. Sommer et al., 2018)	Pilot study	At the start and after 12 weeks, 6 months and a year	-IG_1: exercise pre surgery and exercise after 2 weeks of surgery -IG_2: exercise pre surgery and exercise after 6 weeks of surgery -IG_3: exercise after 2 weeks of surgery -IG_4: exercise after 6 weeks of surgery	- SF-36, FACT-L, EORTC QLQ-C30. -EORTC QLQ-LC13. -HADS scale	-Improvements in wellness and mental health.
(Licker et al., 2017)	RCT	At the start, pre surgery and at the end of intervention	-CG: standard treatment -IG: pre and postoperative exercise based on endurance training	-Exercise capacity: 6MWT -Spirometry	-Increase of exercise capacity and decrease of complications
(Karenovics et al., 2017)	RCT	At the start, pre surgery at the end of intervention and after 1 year	-CG: standard treatment -IG: pre and postoperative exercise based on endurance training	-Exercise capacity: VO_2 . -Dyspnea: Medical Research Council. -Spirometry	-Increase of exercise capacity

RCT: Randomized clinical trial; **EORTC QLQ-C30:** European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire Core 30; **EORTC QLQ-LC13:** Europeran Organisation for Research and Treatment of Cancer Core Quality of Life Questionnaire-Lung Cancer 13; **CG:** control group; **IG:** intervention group; **HIIT:** High Intensity Interval Training; **HADS**: hospital anxiety and depression scale**; 6MWT:** 6-min walk test; **SF-36:** Short Form-36 Healthy Survey.

Table 6
Methodological quality of randomized controlled trials (Jadad scale).

Author	Randomization	Method of randomization	Double blind	Blind method	Withdrawals	TOTAL
Edvardsen et al. (2015)	1	1	0	0	1	3
Quist et al. (2018)	1	1	0	0	1	3
Zhang et al. (2016)	1	1	0	0	1	3
Sebio-García et al. (2017)	1	1	0	0	1	3
Salhi et al. (2015)	1	1	0	0	1	3
Lai et al. (2017)	1	0	0	0	1	2
Licker et al. (2017)	1	1	0	0	1	3
Karenovics et al. (2017)	1	1	0	0	1	3
Cavalheri et al. (2017)	1	1	0	0	1	3

of the main reasons of these results could be the type of intervention based on exercise programs, which increase the difficulty in blinding the subjects and decrease the quality of the design of the study.

Regarding the measuring instruments used by authors to assess the quality of life, they are different but all validated (Carmona and Mendoza, 2011; García et al., 2004) so significant changes in this variable are consistent through the different investigations. Most investigations in this review concluded that therapeutic exercise improves the perception of the quality of life in patients with LC(Edvardsen et al., 2015; Janssen et al., 2017; Lai et al., 2017; Messaggi-Sartor et al., 2019; Molassiotis et al., 2015; Olivier et al., 2018; Quist et al., 2018; Salhi et al., 2015; Sebio García et al., 2017; M. S. Sommer et al., 2018), since this variable is considered as a clinical indicator of wellbeing and also as a guide for cancer progression and treatment efficacy(Martín-Ortiz et al., 2005). Likewise, other authors(Buscemi et al., 2004; Coyotl et al., 2015; Pérez et al., 2017; Vinaccia et al., 2005) link quality of life with fatigue and social support, but few articles focus their research on these variables.

According to the physiological parameters analyzed, most investigations studied lung function, muscle strength and exercise and functional capacity, finding significant improvements with the interventions based on therapeutic exercise. Specially, the measurement of peak of VO_2 is showed in most studies, since it is an indicator of exercise and functional capacity and moreover it is also

related with lung function, representing a predictor of complications after lung resections(Allison and Burdiat, 2010; Cid-Juárez et al., 2019). In addition, the 6MWT test was performed in order to measure the exercise and functional capacity in all the studies. This test has been validated and used largely for studying physiological parameters in patients with different pathologies(Enright, 2003).

About the psychological parameters studied, anxiety and depression have been the most analyzed ones, through the validated HADS scale in six studies (Cavalheri et al., 2017; Molassiotis et al., 2015; Olivier et al., 2018; Quist et al., 2015, 2018; M. S. Sommer et al., 2018) and finding significant differences with interventions based on therapeutic exercise. This is consistent with prior research, which shows that one of the main problem when dealing with cancer is the state of mind of the patients (López-Roig et al., 2000).

For these reasons, therapeutic exercise seems to be a good method when dealing with LC and the complications due to the treatment, surgical interventions and changes in wellbeing, as quality of life or disorders such as depression or anxiety, very frequent in cancer. Health care professionals in many disciplines could add therapeutic exercise to their interventions when treating patients with cancer, as it has been demonstrated to be an easy, affordable and useful tool to improve different complications in LC. However, the need of more studies analyzing bigger samples, and interventions based on therapeutic exercise with psychological therapy are remarkable, especially in other types of cancer with other treatments and thus other considerations. Future investigations should focus their research in analyzing other types of cancer, but also the underlying physiological implications of therapeutic exercise in the neoplasm processes.

5. Conclusion

Therapeutic exercise seems to be beneficial for patients with LC, improving lung function, muscle strength, exercise and functional capacity and psychological parameters.

Future research should consider the quality of the studies conducted, especially in terms of methodological quality and design of the study, in order to provide more accurate information and more consistent findings on the effects of therapeutic exercise in patients with lung cancer.

5.1. Clinical relevance

The results of this study can be used by health care professionals in the rehabilitation process of patients with lung cancer. Therapeutic exercise seems to be an appropriate tool to reduce the consequences of the lung cancer and its treatment, such as a decrease in pulmonary function or functional capacity. Moreover, psychological parameters improve with these interventions decreasing the levels of depression and anxiety and therefore enhancing a better mindset to cope with the disease. Finally, exercise is a healthy habit for the well-being of patients and it prevents them from cancer complications or other diseases.

CRediT authorship contribution statement

Lucía Romero-Ruíz: Software, Writing – review & editing, Conceptualization, Data curation. **Iria Da Cuña-Carrera:** Data curation, Writing – review & editing, Investigation, Methodology, Visualization. **Alejandra Alonso-Calvete:** Software, Writing – review & editing, Supervision. **Yoana González-González:** Investigation, Writing – review & editing, Supervision, Writing – original draft.

Declaration of competing interest

None declared.

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