Supplementary

Table S1 Baseline data of the included articles for the meta-analysis

Author	Year	Country	Study design	Group and treatment
Brocki (25)	2016	Denmark	RCT	Control 34; study 34 Lung tomour and at high risk of developing PPC; pulmonary resections were performed either by VATS or by the open technique; pain management
Brocki (26)	2018	Ditto		
Jonsson (29)	2019	Sweden	RCT	Control 53; study 54 Lung cancer; pulmonary resections were performed either by VATS or by the open technique; pain management
Kendall (27)	2020	Portugal	RCT	Control 22, IMT 22, EMT 22, Combined 22 Lung tumor; pulmonary resection by posterolateral thoracotomy; all patients were treated by the same surgical team and received the same anaesthetic and analgesic protocol
Wang (39)	2020	China	RCT	Control 34; study 31 Patients with NSCLC who received surgical treatment; undergoing video-assisted thoracic surgery
Lu (40)	2021	China	RCT	Control 30; study 30 Lung cancer and pneumonectomy
Du (30)	2022	China	RCT	Control 60, study 60 Lung cancer and pneumonectomy; pain management
Chen (31)	2023	China	RCT	Control 109; study 109 Lung cancer and pneumonectomy
Lu (28)	2023	China	RCT	Control 36; study 36 NSCLC; receive video-assisted thoracic surgery; pain management
Qiu (32)	2023	China	RCT	Control 40; study 40 Lung cancer and pneumonectomy

RCT, randomized controlled trial; NSCLC, non-small cell lung cancer.

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Table S2 Clinical characteristics of patients included for the meta-analysis

Author	Gender (male, %) and age (years)		BMI (kg/cm^2)		Smoking (never/former smoker and smoker)		COPD (yes, %)	
	Control	Intervention	Control	Intervention	Control	Intervention	Control	Intervention
Brocki (25)	56%, 70.5±7.5	59.0%, 69.7±7.9	50%	38.2%	12%/88%	3%/97%	28±5.7	25.7±4.3
Jonsson (29)	53.7%, 68.7±7.4	34.0%, 68.4±8.3	13%	11%	18.9%/81.1%	24.1%/75.9%	25±4	26±4
Kendall (27)	63.2%, 63.42±9.38	IMT 76.9%, 62.31±8.66; EMT 61.5%, 60.00±13.02; Combined 50%, 64.06±5.81	NR	NR	smoking relapse: 10.5%	smoking relapse: IMT 7.7% EMT 0% Combined 11.1%	25.38±2.92	IMT 25.59±3.49 EMT 24.92±3.41 Combined 26.15±2.31
Wang (39)	32.35%, 46.75–63.25	35.48%, 52–62	55.9%	48.3%	73.5% / 26.5%	74.2% / 25.8%	23.63 (22.48–26.04)	22.27 (20.02–24.03)
Lu (40)	46.6%, 59.3±1.92	56.6%, 60.4±1.64	NR	NR	NR	NR	22.28±2.21	22.87±2.40
Du (30)	73.33%, 5.23±11.21	76.66%, 65.21±11.21	NR	NR	NR	NR	24.40±3.11	24.41±3.21
Chen (31)	62.4%, 73.8±0.31	49.5%, 73.1±0.31	NR	NR	68.8%/31.2%	68.8%/31.2%	NR	NR
Lu (28)	38.26%, 58.38±7.40	52.78%, 56.67±8.21	35.29%	47.22%	41.2%/58.8%	47.2%/52.8%	22.84±2.04	22.16±1.87
Qiu (32)	62.5%, 62.18±10.39	60%, 62.76±1.43	NR	NR	NR	NR	23.52±3.68	23.47±3.97

BMI, body mass index; COPD: chronic obstructive pulmonary disease; IMT, inspiratory muscle training; EMT, expiratory muscle training; NR, not recorded.

Table S3 Summary of interventions

Author	Control group	Study group	Length of intervention	Outcomes	Time measured
Brocki (25)	Standard physiotherapy: breathing exercises, coughing techniques and early mobilization	Standard physiotherapy; IMT: twice daily with 2×30 breaths on a target intensity of 30% of maximal inspiratory pressure, in addition to standard postoperative physiotherapy	2 weeks postoperatively	Inspiratory muscle strength; physical capacity (6MWT), incidence of PPC, lung volumes, physical performance, dyspnoea levels and oxygen saturation	The day before surgery and again 3–5 days and 2 weeks postoperatively
Brocki (26)	Ditto			Activity levels; general health status	
Jonsson (29)	Standard care: by the nursing staff regarding pain management and general nursing	Standard care; Preoperative substance therapy education; Postoperative treatment: individually adapted early mobilization, deep breathing exercises, exercises for thoracic and shoulder range of motion. Delivered once or twice per day (10–30 minutes per session) on all days except Sundays	3 months postoperatively	Physical capacity (6MWT); physical activity, lung function assessed by spirometry, dyspnea, and pain	Day of admission and 3 months postoperatively
Kendall (27)	Outpatient physiotherapy: pulmonary expansion exercises, bronchial clearance and general exercises—usual care	Outpatient physiotherapy; IMT: receive inspiratory muscle training EMT: received expiratory muscle training Combined: received inspiratory muscle training plus expiratory muscle training. performed six days a week, for fifteen minutes each session	8 weeks postoperatively	Pulmonary and respiratory muscles function; physical fitness (6MWT); daily PA	Day of admission and 8 weeks postoperatively
Wang (39)	Routine pre- and post-surgery care: smoking cessation and abstinence, pre-operative in-hospital education, postoperative drainage tube management, pain management, nutritional counseling, and postoperative cough and expectoration guidance	Routine pre- and post-surgery care; Breathing exercises: abdominal breathing training, pursed-lips breathing, incentive spirometry exercises and blow balloon training; breathing exercises twice daily for 5–10 min on each occasion	From admission to 1 day before surgery, the first day after surgery until discharge from hospital	Dyspnea (mMRC) and IC; 6MWT, anxiety and depression	The day of admission (T0), the day before surgery (T1), the first day after operation (T2), and performed again when the patients discharge from hospital (T3)
Lu (40)	Routine nursing and routine pulmonary rehabilitation exercises: stair climbing, pursed lip breathing, balloon blowing, and effective cough training were also performed	Routine nursing and routine pulmonary rehabilitation exercises; Breathing exercises: acapella training instrument. 3 to 4 times a day, each time lasting 15 to 20 minutes	30 days postoperatively	Lung function (FVC, FEV1, and PEF)	Before and 30 days after operation
Du (30)	Conventional nursing methods: general breathing exercises in the hospital; medical pain management; exercise and psychological care	Conventional nursing methods; Preoperative substance therapy education; Continuous nursing care in the form of a questionnaire; New breathing exercise nursing: 3–4 sets daily	60 days postoperatively	Reconstruction condition of respiratory function; Incidence of pulmonary symptoms and complications; Improvement of self-efficacy and emotions; Evaluation of sleep quality	After operation and 60 days
Chen (31)	Standard care	Standard care; Breathing exercises: approximately 30-minutes	3 weeks	FEV1, FVC, FEV1 /FVC%, MVV, the postoperative complication rate, and the postoperative quality of life during the baseline and end-line assessments	The baseline and end-line assessments
Lu (28)	Usual preoperative and postoperative care: smoking cessation, pain management, nutritional counseling, cough and expectoration techniques, and early ambulation after surgery	Usual preoperative and postoperative care; Yoga breathing exercise: two 20-minute sessions were delivered each day: Dirga pranayama (3-part breathing), Kapalbhati (rapid abdominal breathing), Nadi shodhana (alternate nostril breathing). Length of intervention time is 9 to 14 days	NR	Dyspnea, exercise capacity (6MWT), anxiety and depression, days of chest drainage tube indwelling	Admission (T0), the day before surgery (T1), and at discharge (T2)
Qiu (32)	Conventional nursing and health education: conventional health education, perioperative nursing, dietary guidance after discharge, medication guidance, and daily nursing guidance were given to the patients	Conventional nursing and health education; Respiratory function exercise: pursed-lip breathing; abdominal breathing; balloons can be used for blowing for 15 min 3–4 times a day; Postural nursing; Effective cough and expectoration exercise	3 months	Pulmonary function tests; blood gas analysis; respiratory symptoms; complications; compliance; nursing satisfaction	Data of 3 months post-intervention were measured at patients' follow-up

IMT, inspiratory muscle training; EMT, expiratory muscle training; 6MWT, 6-minute walking test; mMRC, modified medical research council; IC, inspiratory capacity; FEV1, forced expiratory volume in one second; FVC, forced vital capacity; MVV, maximum voluntary ventilation; HRQL, health-related quality of life; PA, physical activity.

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Table S4 Extracted data for systematic review

Indicator	Control group (mean)	Study group (mean)	Average improvement of Study group	P value
FVC%	0.26	1.99	1.73	*
FEV1%	1.11	3.26	2.15	*
MVV (L/min)	2.15	9.73	7.58	**
MIP (cmH_2O)	5.98	6.93	0.95	*
Anxiety score	−4.55	−7.97	−3.42	*
Depression score	−3.92	−6.06	−2.14	*
SEDPA (min/day)	579.93	599.83	19.9	*
LIGPA (min/day)	201.33	211.25	9.92	*
MVPA (min/day)	28.03	26.1	−1.93	*

"−" means down. *, P<0.05; **, P<0.01. VC, forced vital capacity; FEV1, forced expiratory volume in one second; MVV, maximum voluntary ventilation; MIP, maximal inspiratory pressure; SEDPA, sedentary physical activity; LIGPA, light physical activity; MVPA, moderate to vigorous physical activity.

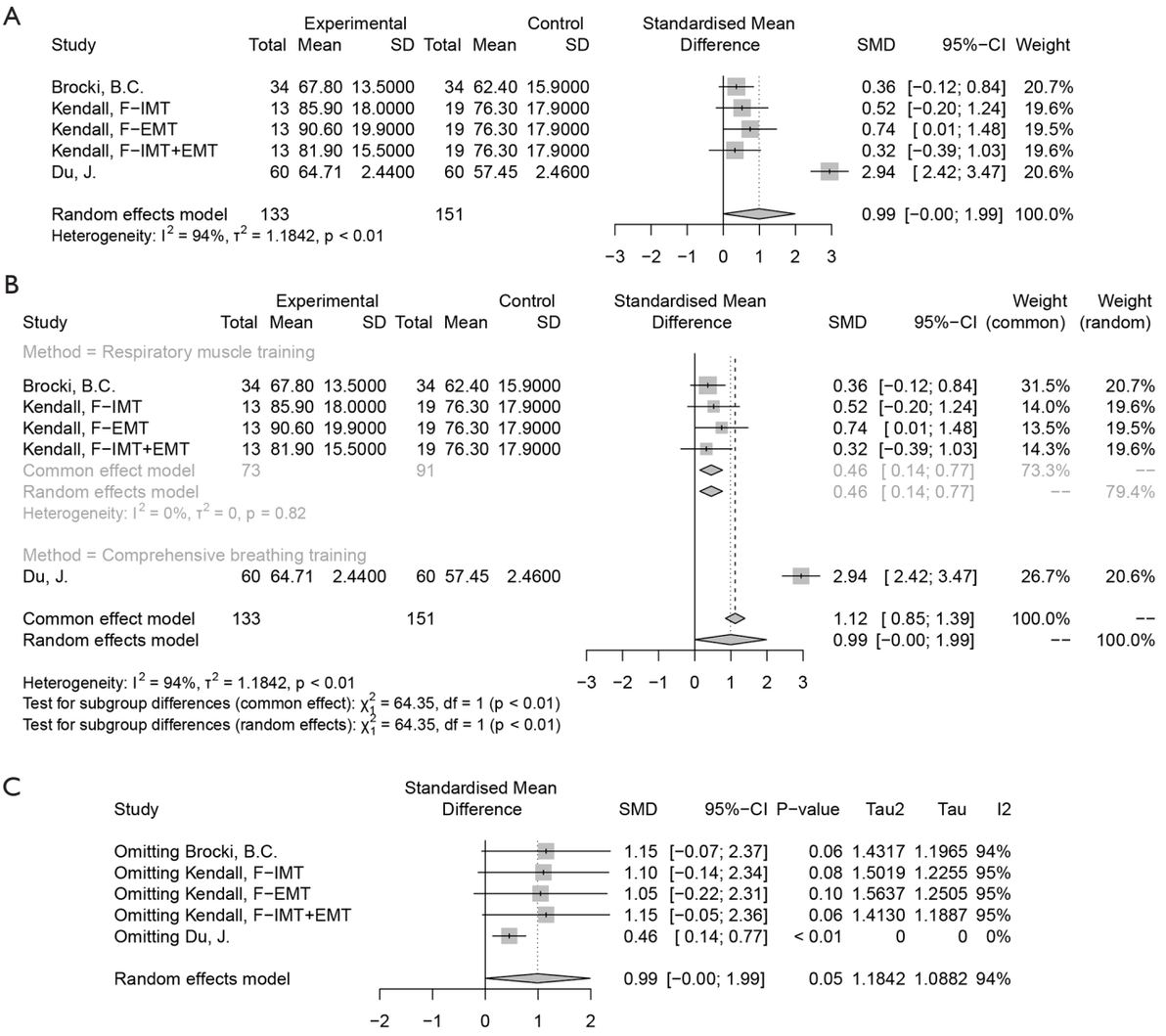

Figure S1 Meta-analysis of pulmonary function related indicators. (A) Forest plot of FEV1% variation. The vertical line in the middle of the graph represents the null line, meaning SMD =0, indicating no statistical association between the studied factor and the outcome. Each horizontal line represents the 90% CI of a study, and the small square in the middle of the line represents the point estimate of the MD value, with the square's size reflecting the study's weight. If the horizontal line of a study's 95% CI does not cross the null line (i.e., 95% CI does not include 0), it suggests a statistical association between the studied factor and the outcome. (B) Comparison between the control group and intervention group in each subgroup (breathing exercises method) for FEV1% data. (C) Sensitivity analysis results using one-study-removed method. FEV1%, forced expiratory volume in one second percentage; SMD, standard mean difference; CI, confidence interval; SD, standard deviation; IMT, inspiratory muscle training; EMT, expiratory muscle training.

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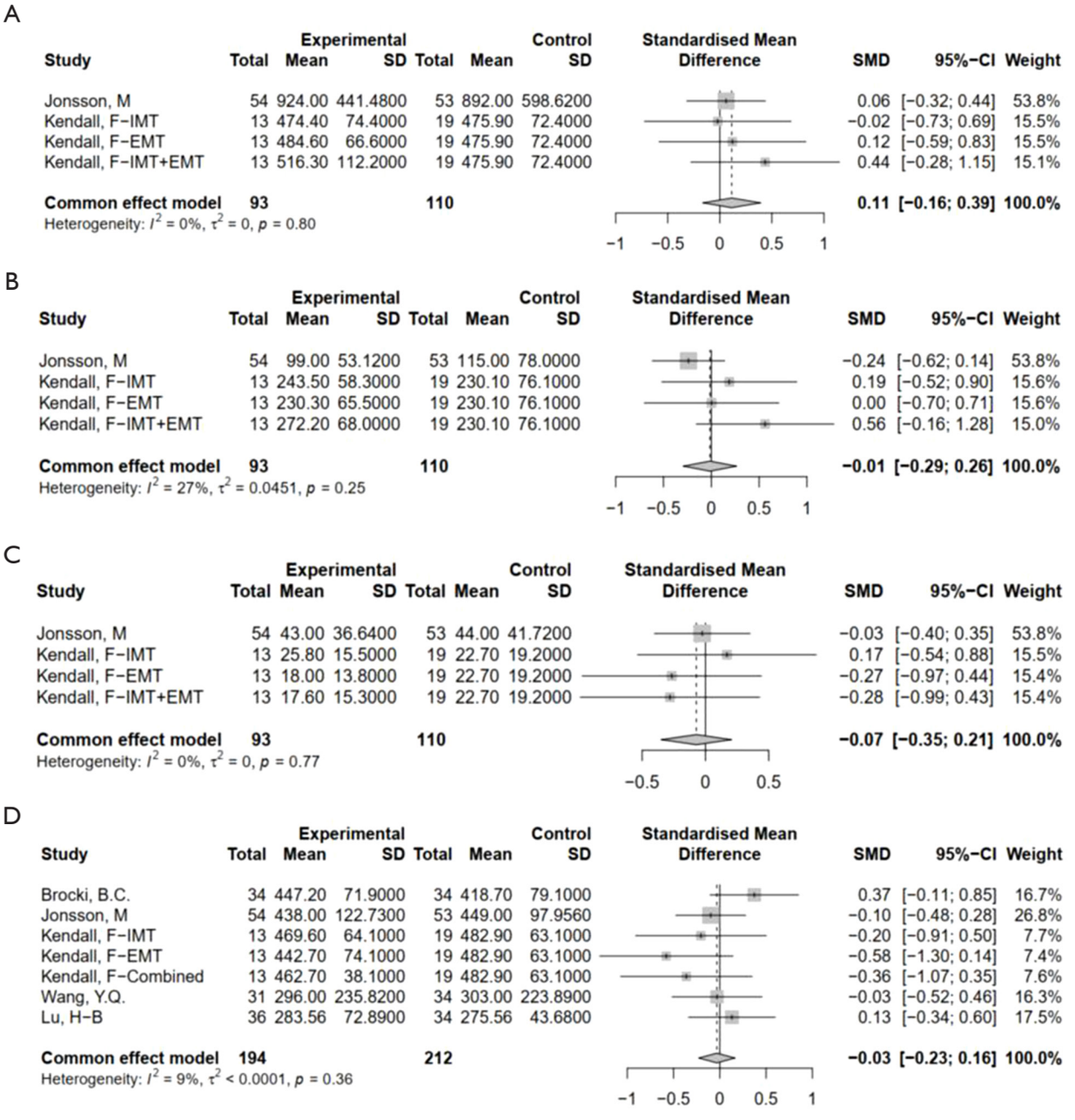

Figure S2 Meta-analysis of postoperative physical activity indicators in lung cancer patients. (A) Forest plot of sedentary time variation. The vertical line in the middle of the graph represents the null line, meaning SMD =0, indicating no statistical association between the studied factor and the outcome. Each horizontal line represents the 90% CI of a study, and the small square in the middle of the line represents the point estimate of the MD value, with the square's size reflecting the study's weight. If the horizontal line of a study's 95% CI does not cross the null line (i.e., 95% CI does not include 0), it suggests a statistical association between the studied factor and the outcome; (B) Forest plot of light activity time variation. (C) Forest plot of moderate or vigorous activity time variation. (D) Forest plot of 6MWT measurement data variation. SEDP, sedentary time; LIGPA, low-intensity physical activity time; MVPA, moderate to vigorous physical activity; 6MWT, 6-minute walk test; SMD, standard mean difference; CI, confidence interval; SD, standard deviation; IMT, inspiratory muscle training; EMT, expiratory muscle training.

References

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