Association of Chartered Physiotherapists in Respiratory Care scoping review: Post-operative physiotherapy in people undergoing thoracic surgery

Allaina Eden[1], Nikki Gilbert[1], Amy Bendall[2], Izzie Easton[3], Agnieszka Lewko[4], Alicia Page[1], Chloe Tait[5] and Una Jones[2]

Abstract

Introduction

This scoping review was produced by the ACPRC editorial board. Following a preliminary scoping day, surgery was considered 1 of 5 key priorities for review. Surgery was subsequently separated into specialities.

Objective

The objective of this scoping review was to report the extent and methodological type of evidence associated with post-operative physiotherapy in people who underwent thoracic surgery.

Inclusion criteria

Studies with adult patients undergoing thoracic surgery and published between 2014 and 2020 were included. The thoracic procedure undertaken required post-operative physiotherapy intervention as part of the recovery process.

Method

Searches were undertaken in PEDro, CINAHL, EMBASE, MEDLINE, PubMed, Google Scholar and the Clinical Trials Registry. Article titles and abstracts were screened by one reviewer, and full text articles appraised by two reviewers.

Quality was assessed and data was extracted using the relevant tools dependent on study methodology.

Results

Initially, 1809 articles were retrieved from which 28 articles were included in this scoping review, including a total of 6265 participants. Studies were randomised

Author details

[1]Royal Papworth Hospital, Cambridge, CB2 0AY, U.K.

[2]Cardiff University, School of Healthcare Sciences, Heath Park, Cardiff, CF14 4XN, U.K.

[3]University of Essex, School of Sport, Rehabilitation and Exercise Sciences, Wivenhoe Park, Colchester, CO4 3SQ, U.K.

[4]Kingston University and St. George's University of London, 6th Floor, Hunter Wing, Cranmer Terrace, London, SW17 0RE, U.K.

[5]Blackpool Teaching Hospitals NHS Foundation Trust, U.K.

Keywords

In-patient, mobilisation, post-operative, respiratory physiotherapy, thoracic surgery.

Correspondence author

Allaina Eden. Email: allaina.eden@nhs.net.

Go to contents page

control trials (n = 10), observational studies (n = 7) and systematic review or meta-analysis (n = 5).

The quality of the articles was good with the studies having structured protocols and blinding of subjects where appropriate, however there were some methodical flaws, including being underpowered. The variability in clinical physiotherapy practice between countries was highlighted.

Included studies explored respiratory physiotherapy (n = 13), mobilisation (n = 10), combined respiratory and mobilisation (n = 3), kinesiology taping (n = 1) and outcomes (n = 1). Early and intensive mobilisation as part of an ERAS programme demonstrated statistically significant reduction in length of stay, post-operative pulmonary complications, and morbidity. The level of patients' pre-operative mobility impacted on their post-operative outcomes and risk of developing post-operative pulmonary complications (PPC).

Conclusion

The scoping review included 28 studies with a range of methodologies providing evidence that supports post-operative physiotherapy intervention in people who undergo thoracic surgery. Future research should aim to clarify which respiratory physiotherapy techniques impact recovery and expand the diversity of methodologies to include more qualitative research.

Introduction

The ACPRC editorial board is comprised of respiratory physiotherapy clinicians and academics who volunteered through their ACPRC membership to be a representative on the board. The purpose of the board is to lead scoping, commissioning, co-ordination and delivery of all new ACPRC guidance documents and resources, to facilitate knowledge sharing and drive improvements in the quality of care for people with respiratory conditions. A preliminary scoping day in March 2018 identified topics relevant to respiratory physiotherapy that required guidance. The editorial board first met in May 2019 and confirmed the initial topics to be explored would be surgery, chest wall trauma, lung ultrasound, sputum retention in ventilated patients, and mechanical insufflation/exsufflation.

The topic of surgery was subsequently separated into cardiac, thoracic, and upper gastro-intestinal (GI) surgery. Members of the editorial board were nominated to be the scoping review team leads and team members, and other respiratory physiotherapists were also approached to be part of each team.

Patients undergoing thoracic surgery, more specifically lung resection, is an important patient group as 5,843 patients in the United Kingdom underwent this type of surgery in 2015, a 4.9% year-on-year increase from 2014 (Royal College of Physicians, 2017). With planned government investment in cancer diagnosis and treatment outlined in the *NHS Long Term Plan*, it is expected the number of lung resections will continue to increase (NHS, 2019).

Systematic reviews and meta-analyses have been undertaken for physiotherapy and thoracic surgery, and have either incorporated other types of surgery, for example thoracic and abdominal surgery (Castellino et al., 2016; Narayanan et al., 2016) or focused on one type of physiotherapy intervention, for example exercise training (Crandall et al., 2014; Li et al., 2017), breathing exercises (Wang et al., 2019), incentive spirometry (Narayanan et al., 2016), high flow nasal therapy (Wu et al., 2018), inspiratory muscle training (Kendall et al., 2017; Ge et al., 2018), and also cover the pre-operative phase to after hospital discharge. The editorial board's aim was to undertake a scoping review to identify all types of post-operative physiotherapy research, to provide a comprehensive review of available evidence (Kahlil et al., 2016; Munn et al., 2018; Peters et al., 2020).

Objective

The objective of this scoping review is to report the extent and type of evidence associated with post-operative physiotherapy in people who undergo thoracic surgery.

Scoping review question

The primary scoping review question is:

- *What evidence exists for the post-operative physiotherapy management of people who have undergone thoracic surgery that require a hospital stay?*

The secondary scoping review questions are:

- *What number of studies and research methodologies have been carried out in relation to post-operative physiotherapy in adults undergoing thoracic surgery?*
- *What is the quality of the research carried out?*
- *What are the findings of the studies?*

Definition of key terms

Physiotherapy intervention – treatment that is prescribed or carried out by a registered physiotherapist or a member of the physiotherapy team (for example, rehabilitation or therapies assistant).

Surgical intervention – invasive surgery that requires admission to hospital, not performed as a day case.

Hospital stay – patient remains an in-patient in a hospital facility following surgery.

Mobilisation – to support and encourage patients to move. This may be to mobilise out of bed, to march on the spot or to walk. This may be performed independently or with assistance.

Respiratory physiotherapy – physiotherapy interventions aimed to mobilise and remove airway secretions, increase lung volume, reduce breathlessness and work of breathing. This may include: physical exercise, thoracic expansion exercises, forced expiratory techniques, cough, active cycle of breathing techniques, inspiratory muscle training, inspiratory spirometry, positive and negative pressure devices, and adjuncts, for example Acapella®, Flutter, and oscillating positive expiratory pressure (OPEP).

Eligibility criteria

Participants

Inclusion criteria

- Adult patients undergoing thoracic surgery that require a post-operative hospital stay.
- Study includes acute post-operative physiotherapy.
- Study published between 2014 and 2020. The start date of 2014 was chosen as it allowed a slight overlap in studies captured within published systematic and narrative reviews and studies identified by the scoping review search.

Exclusion criteria

- Animal studies.
- Paediatrics – defined as children less than 18 years of age.
- Day case surgery.
- Physiotherapy intervention prior to admission, for example pre-habilitation, and intervention after hospital discharge, for example out-patient follow up.
- Chest wall surgery.

Concept

Procedures that require post-operative physiotherapy intervention as part of the recovery process.

Context

The context is in-patient, hospital-based surgery, based in any country of origin, within state or privately funded healthcare.

Method

The scoping review objective was developed and agreed by the ACPRC editorial board. The scoping team was formed, and the inclusion criteria outlined above were agreed by the scoping team.

Search strategy

The search strategy was developed and agreed by the scoping team, with input from local hospital and university library services (see Appendix 1). A full search was undertaken of PEDro, CINAHL, EMBASE, MEDLINE, PubMed, and Google Scholar. The Clinical Trials Registry was also searched for any unpublished literature. All articles with search strategy terms contained in the titles and abstracts were shortlisted. The search strategy, including all identified keywords and index terms, were adapted for each database.

Types of sources

The scoping review considered all available evidence using experimental and quasi-experimental study designs including randomised controlled trials (RCT), non-randomised controlled trials. Observational studies including prospective and retrospective cohort studies, case-control studies and analytical cross-sectional studies were also considered for inclusion. Other designs that were considered included systematic reviews, descriptive observational study designs including case series, individual case reports and descriptive cross-sectional studies.

Qualitative studies that focus on qualitative data including, but not limited to, designs such as phenomenology, grounded theory, ethnography, qualitative description, and action research were considered, as were text and opinion papers.

Source of evidence Selection

Following the search of databases and registries, all identified citations were uploaded into web-based Endnote (Clarivate Analytics, 2021). Initially, 1809 articles were retrieved from the database searches (*n* = 1789) and clinical trial registers (*n* = 20). Following removal of 18 duplicate records, one reviewer screened the titles and abstracts against the inclusion criteria. This process excluded 1661 studies as they did not fulfil inclusion criteria. Full texts were retrieved for 129 articles, with one being unavailable. Each full text article was screened by two reviewers and of the 129 full text articles reviewed, 101 were excluded due to a lack of focus on physiotherapy specific treatment or were not during the in-patient phase of care. Subsequently, 28 studies were selected for inclusion into the scoping review.

Any ambiguity to the relevance of title, abstract or full text was discussed with the topic lead. The results of the search and the study inclusion process are presented in the preferred reporting items for systematic reviews and meta-analyses extension for scoping review (PRISMA-ScR) flow diagram (Page et al., 2021).

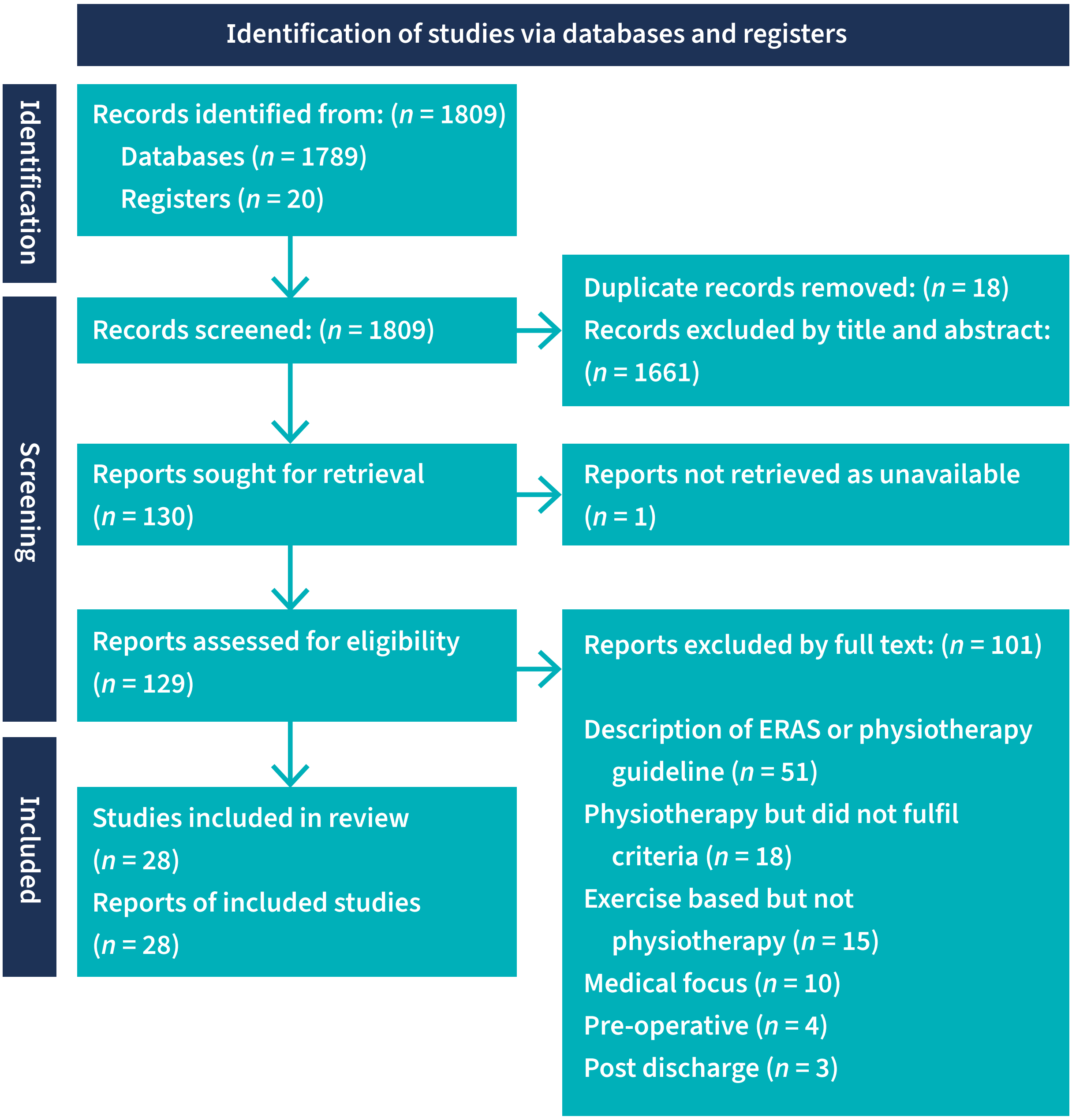

Figure 1: PRISMA-ScR flow chart.

Data extraction

All articles were reviewed by 2 independent reviewers and data were extracted, collated and are presented in tabular form in Appendix 2. Data extraction included the aim of the study, design/methodology, sample details (number of participants, mean age, gender ratio), comparison of groups, outcome measures, and key findings relevant to the scoping review questions. The quality of the study was assessed using appropriate Critical Appraisal Skills Programme (CASP) or Joanna Briggs Institute (JBI) tools dependent on study methodology. CASP appraisal tools were used for RCTs, systematic reviews and cohort studies, and JBI tools were used for quasi-experimental and cross-sectional studies. An appraisal tool template was completed for each study and submitted to the topic lead.

Results

Number of studies and research methodologies

In total, 28 studies researching the post-operative physiotherapy management of people who had undergone thoracic surgery and required a hospital stay were included in this scoping review. In the majority of studies, patients required thoracic surgery for lung resection. This included a total of 6265 participants, ranging from 21 participants (Santos et al., 2016) to 1270 participants (Wang et al., 2019). The most frequent types of study design were RCTs ($n = 10$), observational studies ($n = 7$) and systematic review or meta-analysis ($n = 5$). No qualitative studies were included for review. The methodology types and number of studies can be seen in Figure 2.

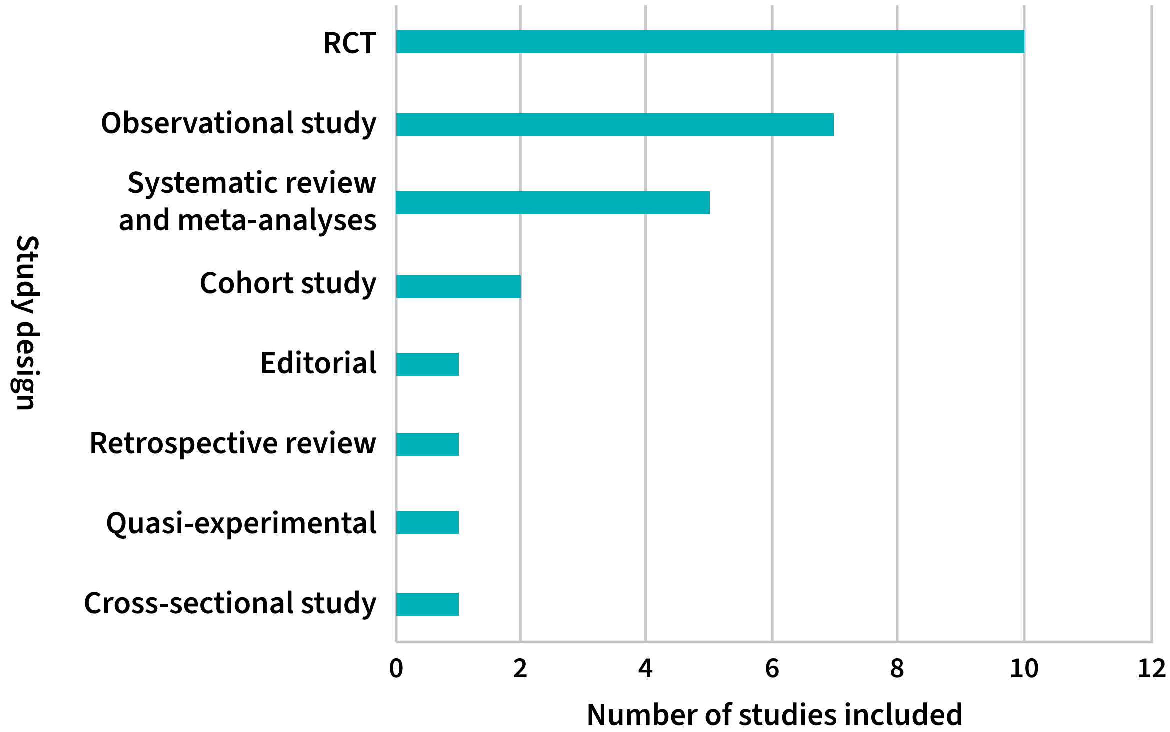

Figure 2: Methodology types and number of studies included.

The 28 studies were categorised by type of physiotherapy intervention. This included 13 studies exploring the effect of respiratory physiotherapy, 10 studies investigating mobilisation, 3 studies looking at physiotherapy that included both mobilisation and respiratory physiotherapy as combined treatment, 1 study reviewing the effect of kinesiology taping, and 1 study investigating outcomes, see Figure 3.

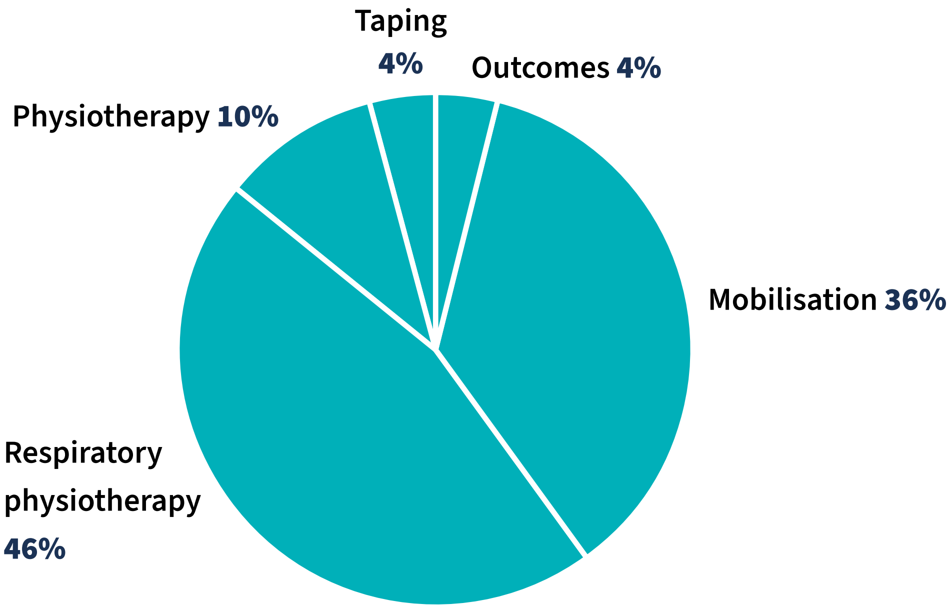

Figure 3: Types of physiotherapy intervention in studies.

Quality of research

The quality of the studies was assessed and the strengths of the RCTs were that all the studies ran for the planned duration and were not stopped early, they had clear study protocols, and in most studies all participants were accounted for. In most studies the participants in each group had comparable baselines and some studies blinded their participants. Both groups of participants received the same level of baseline care (with the addition of the experimental intervention).

Limitations were that some of the RCTs had a small sample size and, at times, studies were underpowered (Arbane et al., 2014; Brocki et al., 2016; Brocki et al., 2018). Although there was blinding of some participants there was an absence of blinding of researchers and assessors. Valid and reliable outcomes were used, however additional outcome measures were suggested by the reviewers (for example, duration of physiotherapy, compliance/adherence to treatment and patient satisfaction) and collecting pre-operative data would enable pre- and post-operative comparison of activity levels. The reviewers felt that cost analysis would have improved the RCTs as this would support business planning and economic implications of implementing evidence-based practice. It was noted in one study undertaken in China (Zhou et al., 2019) that time to extubation following thoracic surgery was between 3 and 7 days, this is considerably different to practice in the U.K., which highlighted the variability in clinical practice between countries.

Within the observational studies the positive aspects included that the prospective studies ran for the full expected duration and generally used large sample size, although this was not the case for all studies (Monteleone et al., 2015; Santos et al., 2016). The studies also had clear inclusion and exclusion criteria and relevant outcomes measures with definitions for respiratory complications when captured. The control and intervention groups were comparable, compounding factors identified, propensity score matching was used in some studies and loss of participants were accounted for.

The negative aspects of the retrospective observational studies investigating enhanced recovery after surgery (ERAS) was that it was not possible to control differences in ERAS protocols and how these were implemented. Some of the studies assessed a range of physiotherapy interventions therefore it was difficult to identify which intervention was impactful. As the participants were not blinded, some bias may occur particularly with self-reported activity levels, and where monitoring devices were worn. Some articles reported observational studies for abdominal, cardiac and thoracic surgery, within these studies it was difficult to extract the thoracic specific information, and the thoracic specific sample size tended to be smaller than the other surgical populations (Monteleone et al., 2015).

The systematic reviews varied between single surgery RCTs and combined abdominal, cardiac and thoracic surgery with a small number of studies being included in each systematic review and the thoracic surgery sample sizes often being small (Castellino et al., 2016). In multi-surgery systematic reviews, it was difficult to extract the independent thoracic information. Within the systematic review the quality assessment was not consistently reported on.

Study findings

A detailed summary of the study findings is presented in the literature review table (Appendix 2). Reasons for physiotherapy referral following thoracic surgery were reduced mobility, oxygen desaturation, loss of lung volume and sputum retention (Agostini et al., 2020).

Reviewing the study findings by theme, ERAS studies with robust methodology demonstrated statistically significant reduced length of stay (LOS) and post-operative pulmonary complications (PPCs) (Glogowska et al., 2017; Shiono et al., 2019), reduced morbidity (Rogers et al., 2018), an increase in distance walked post-operatively and a reduction in length of physiotherapy input (Baddeley, 2016). Studies that were unable to conclude favourable outcomes were underpowered (Arbane et al., 2014; Castellino et al., 2016) or had insufficient evidence following a systematic review (Li et al., 2017).

The impact of pre-operative mobility (Santos et al., 2016) and post-operative pain (Agostini et al., 2014; Imperatori et al., 2016) on outcomes were explored.

Studies focusing on respiratory physiotherapy reported that different types of respiratory treatments had a positive impact on a range of outcomes including PPCs, lung function, clinical observations LOS and physical activity. This included thoracic expansion exercise (Rodriguez-Larrard et al., 2016; Wang et al., 2019), respiratory muscle training (Brocki et al., 2016; Brocki et al., 2018; Taskin et al., 2020) and respiratory muscle function (Refai et al., 2014).

The use of adjuncts and respiratory support was explored, with the use of the Acapella® having favourable outcomes (Cho et al., 2014; Zhou et al., 2019). Two studies found no benefit from adding incentive spirometry to routine physiotherapy (Narayanan et al., 2016; Malik et al., 2018). The use of continuous positive airway pressure (CPAP) (Palleschi et al., 2018) and high flow nasal oxygen (HFNO) (Wu et al., 2018) were found to reduce PPCs.

Discussion

The literature showed positive outcomes for physiotherapy interventions. The quality of the research was generally good with consistent rigour across methodology types and some limitations to consider when interpreting the results. The studies pertinent to physiotherapy intervention were all quantitative in nature, focusing on physical results and pathway related outcomes. This scoping review has highlighted that in the absence of qualitative data, there is a lack of patient voice. Insight into reasons for levels of adherence to protocols and patient's priorities for recovery would provide more information on patient's experience to this body of knowledge.

Patients were referred for physiotherapy for pre- and post-operative respiratory and mobility issues. Studies reviewing the impact of ERAS consistently reported that early and intensive mobilisation were linked to a reduction in PPCs and LOS. These outcomes were shown to be impacted by pre-operative fitness and post-operative pain control. There were more variable outcomes on recovery with the addition of adjuncts such as airway clearance devices, HFNO and IMT. There is not overwhelming evidence to support implementation of one particular device, as only one or two studies per device were reviewed.

The clinical relevance for this scoping review is that physiotherapy as part of an ERAS is beneficial, and intensive mobilisation is linked to improved recovery and reduced length of stay. Pre-operative fitness is shown to improve post-operative outcomes; however pre-habilitation was not explored as part of this scoping review. Adjuncts and other oxygen delivery methods may improve recovery, but positive outcomes depended on which measurements were taken, therefore this may be more appropriate for specific patient groups.

A limitation to this scoping review was that the search criteria excluded pre-habilitation and therefore further work needs to be carried out in order to reflect changing clinical practices.

Conclusion

This scoping review identified 28 studies with 6265 participants that investigated post-operative management of people who had undergone thoracic surgery. Study design included RCT, observational studies and systematic reviews, and interventions included mobility and respiratory physiotherapy. Robust ERAS studies demonstrated statistically significant reductions in LOS, PPCs and morbidity with increased walking distance in intervention groups. Pre-operative fitness was shown to improve post-operative outcomes. Future research should aim to provide more conclusive impact of specific respiratory physiotherapy treatment and associated training and adjuncts. These should be RCTs and observational studies with cost effectiveness analysis. However, there was also a lack of qualitative studies, so a focus on patient experience and patient reported outcomes should also be prioritised.

Acknowledgements

Thanks to Becky Scott and Rebecca Rowe, Royal Papworth Hospital library services.

Funding

There was no funding provided in this scoping review. All participants gave their time voluntarily.

Conflicts of interest

There are no conflicts of interest with the authors listed on this manuscript.

References

Agostini, P., Lugg, S. T., Adams, K., Smith, T., Kalkat, M., Rajesh, P. B., Steyn, R. S., Naidu, B., Rushton, A., & Bishay, E. (2020). Video-assisted thoracoscopic lobectomy: Which patients require postoperative physiotherapy? *Physiotherapy*, *106*, 87–93. https://doi.org/10.1016/j.physio.2019.01.001.

Agostini, P. J., Naidu, B., Rajesh, P., Steyn, R., Bishay, E., Kalkat, M., & Singh, S. (2014). Potentially modifiable factors contribute to limitation in physical activity following thoracotomy and lung resection: A prospective observational study. *Journal of Cardiothoracic Surgery*, *9*, 128. https://doi.org/10.1186/1749-8090-9-128.

Ansari, B. M., Hogan, M. P., Collier, T. J., Baddeley, R. A., Scarci, M., Coonar, A. S., Bottrill, F. E., Martinez, G. C., & Klein, A. A. (2016). A randomized controlled trial of high-flow nasal oxygen (Optiflow) as part of an enhanced recovery program after lung resection surgery. *The Annals of Thoracic Surgery*, *101*(2), 459–464. https://doi.org/10.1016/j.athoracsur.2015.07.025.

Arbane, G., Douiri, A., Hart, N., Hopkinson, N. S., Singh, S., Speed, C., Valladares, B., & Garrod, R. (2014). Effect of postoperative physical training on activity after curative surgery for non-small cell lung cancer: A multicentre randomised controlled trial. *Physiotherapy*, *100*(2), 100–107. https://doi.org/10.1016/j.physio.2013.12.002.

Baddeley R. A. (2016). Physiotherapy for enhanced recovery in thoracic surgery. *Journal of Thoracic Disease*, *8(Suppl 1)*, S107–S110. https://doi.org/10.3978/j.issn.2072-1439.2015.12.02.

Brocki, B. C., Andreasen, J. J., Langer, D., Souza, D. S., & Westerdahl, E. (2016). Postoperative inspiratory muscle training in addition to breathing exercises and early mobilization improves oxygenation in high-risk patients after lung cancer surgery: A randomized controlled trial. *European Journal of Cardio-Thoracic Surgery*, *49*(5), 1483–1491. https://doi.org/10.1093/ejcts/ezv359.

Brocki, B. C., Andreasen, J. J., & Westerdahl, E. (2018). Inspiratory muscle training in high-risk patients following lung resection may prevent a postoperative decline in physical activity level. *Integrative Cancer Therapies*, *17*(4), 1095–1102. https://doi.org/10.1177/1534735418796286.

Castelino, T., Fiore, J. F., Jr, Niculiseanu, P., Landry, T., Augustin, B., & Feldman, L. S. (2016). The effect of early mobilization protocols on postoperative outcomes following abdominal and thoracic surgery: A systematic review. *Surgery*, *159*(4), 991–1003. https://doi.org/10.1016/j.surg.2015.11.029.

Cho, Y. J., Ryu, H., Lee, J., Park, I. K., Kim, Y. T., Lee, Y. H., Lee, H., Hong, D. M., Seo, J. H., Bahk, J. H., & Jeon, Y. (2014). A randomised controlled trial comparing incentive spirometry with the Acapella® device for physiotherapy after thoracoscopic lung resection surgery. *Anaesthesia*, *69*(8), 891–898. https://doi.org/10.1111/anae.12750.

Clarivate Analytics. (2021). Endnote software. https://endnote.com.

Crandall, K., Maguire, R., Campbell, A., & Kearney, N. (2014). Exercise intervention for patients surgically treated for non-small cell lung cancer (NSCLC): A systematic review. *Surgical Oncology*, *23*(1), 17–30. https://doi.org/10.1016/j.suronc.2014.01.001.

Critical Appraisal Skills Programme (2020). CASP checklist. https://casp-uk.net/casp-tools-checklists/.

Ge, X., Wang, W., Hou, L., Yang, K., & Fa, X. (2018). Inspiratory muscle training is associated with decreased postoperative pulmonary complications: Evidence from randomized trials. *The Journal of Thoracic and Cardiovascular Surgery*, *156*(3), 1290–1300.e5. https://doi.org/10.1016/j.jtcvs.2018.02.105.

Glogowska, O., Glogowski, M., & Szmit, S. (2017). Intensive rehabilitation as an independent determinant of better outcome in patients with lung tumors treated by thoracic surgery. Archives of Medical Science, *13*(6), 1442–1448. https://doi.org/10.5114/aoms.2016.60706.

Imperatori, A., Grande, A., Castiglioni, M., Gasperini, L., Faini, A., Spampatti, S., Nardecchia, E., Terzaghi, L., Dominioni, L., & Rotolo, N. (2016). Chest pain control with kinesiology taping after lobectomy for lung cancer: Initial results of a randomized placebo-controlled study. *Interactive Cardiovascular and Thoracic Surgery*, *23*(2), 223–230. https://doi.org/10.1093/icvts/ivw110.

Joanne Briggs Institue. (JBI). *Critical appraisal checklist for systematic reviews and research syntheses.* https://jbi.global/critical-appraisal-tools.

Jonsson, M., Ahlsson, A., Hurtig-Wennlöf, A., Vidlund, M., Cao, Y., & Westerdahl, E. (2019). In-hospital physiotherapy and physical recovery 3 months after lung cancer surgery: A randomized controlled trial. *Integrative Cancer Therapies*, *18*, 1534735419876346. https://doi.org/10.1177/1534735419876346.

Kendall, F., Oliveira, J., Peleteiro, B., Pinho, P., & Bastos, P. T. (2018). Inspiratory muscle training is effective to reduce postoperative pulmonary complications and length of hospital stay: A systematic review and meta-analysis. *Disability and Rehabilitation*, *40*(8), 864–882. https://doi.org/10.1080/09638288.2016.1277396.

Khalil, H., Peters, M., Godfrey, C. M., McInerney, P., Soares, C. B., & Parker, D. (2016). An evidence-based approach to scoping reviews. *Worldviews on Evidence-Based Nursing*, *13*(2), 118–123. https://doi.org/10.1111/wvn.12144.

Li, J., Guo, N. N., Jin, H. R., Yu, H., Wang, P., & Xu, G. G. (2017). Effects of exercise training on patients with lung cancer who underwent lung resection: A meta-analysis. *World Journal of Surgical Oncology*, *15*(1), 158. https://doi.org/10.1186/s12957-017-1233-1.

Malik, P., Fahim, C., Vernon, J., Thomas, P., Schieman, C., Finley, C. J., Agzarian, J., Shargall, Y., Farrokhyar, F., & Hanna, W. C. (2018). Incentive spirometry after lung resection: A randomized controlled trial. *The Annals of Thoracic Surgery*, *106*(2), 340–345. https://doi.org/10.1016/j.athoracsur.2018.03.051.

Monteleone, S., Dalla Toffola, E., Emiliani, V., Ricotti, S., Bruggi, M., Conte, T., D'Armini, A. M., Orlandoni, G., & Petrucci, L. (2015). Recovery of deambulation after cardiothoracic surgery: A single center experience. *European Journal of Physical and Rehabilitation Medicine*, *51*(6), 763–771.

Munn, Z., Peters, M., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology*, *18*(1), 143. https://doi.org/10.1186/s12874-018-0611-x.

Narayanan, A. L., Hamid, S. R., & Supriyanto, E. (2016). Evidence regarding patient compliance with incentive spirometry interventions after cardiac, thoracic and abdominal surgeries: A systematic literature review. *Canadian Journal of Respiratory Therapy*, *52*(1), 17–26.

NHS. (2019). *The NHS long term plan.* https://www.longtermplan.nhs.uk/publication/nhs-long-term-plan/.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuinness, L. A., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ (Clinical research ed.)*, *372*, n71. https://doi.org/10.1136/bmj.n71.

Palleschi, A., Privitera, E., Lazzeri, M., Mariani, S., Rosso, L., Tosi, D., Mendogni, P., Righi, I., Carrinola, R., Montoli, M., Reda, M., Torre, M., Santambrogio, L., & Nosotti, M. (2018). Prophylactic continuous positive airway pressure after pulmonary lobectomy: A randomized controlled trial. *Journal of Thoracic Disease*, *10*(5), 2829–2836. https://doi.org/10.21037/jtd.2018.05.46.

Peters, M., Godfrey, C., McInerney, P., Munn, Z., Tricco, A., & Khalil, H. (2020). Chapter 11: Scoping reviews. In E. Aromataris, & Z. Munn (Eds.). *JBI Manual for Evidence Synthesis.* https://synthesismanual.jbi.global.

Refai, M., Pompili, C., Salati, M., Xiumè, F., Sabbatini, A., & Brunelli, A. (2014). Can maximal inspiratory and expiratory pressures during exercise predict complications in patients submitted to major lung resections? A prospective cohort study. *European Journal of Cardio-Thoracic Surgery*, *45*(4), 665–670. https://doi.org/10.1093/ejcts/ezt440.

Rodriguez-Larrad, A., Vellosillo-Ortega, J. M., Ruiz-Muneta, C., Abecia-Inchaurregui, L. C., & Seco, J. (2016). Postoperative Respiratory Exercises Reduce the Risk of Developing Pulmonary Complications in Patients Undergoing Lobectomy. *Archivos de Bronconeumologia*, *52*(7), 347–353. https://doi.org/10.1016/j.arbres.2015.11.017.

Rogers, L. J., Bleetman, D., Messenger, D. E., Joshi, N. A., Wood, L., Rasburn, N. J., & Batchelor, T. (2018). The impact of enhanced recovery after surgery (ERAS) protocol compliance on morbidity from resection for primary lung cancer. *The Journal of Thoracic and Cardiovascular Surgery*, *155*(4), 1843–1852. https://doi.org/10.1016/j.jtcvs.2017.10.151.

Royal College of Physicians. (2017). *Lung cancer clinical outcomes publication 2017 (for surgical operations performed in 2015).* https://www.rcplondon.ac.uk/projects/outputs/lung-cancer-clinical-outcome-publication-2017-audit-period-2015.

Santos, B. F., Souza, H. C., Miranda, A. P., Cipriano, F. G., & Gastaldi, A. C. (2016). Performance in the 6-minute walk test and postoperative pulmonary complications in pulmonary surgery: An observational study. *Brazilian Journal of Physical Therapy*, *20*(1), 66–72. https://doi.org/10.1590/bjpt-rbf.2014.0119.

Shiono, S., Endo, M., Suzuki, K., & Hayasaka, K. (2019). Impact of enhanced recovery after surgery on outcomes of elderly patients undergoing open thoracic surgery. *General Thoracic and Cardiovascular Surgery*, *67*(10), 867–875. https://doi.org/10.1007/s11748-019-01099-2.

Sihoe, A. D., Yu, P. S., Kam, T. H., Lee, S. Y., & Liu, X. (2016). Adherence to a clinical pathway for video-assisted thoracic surgery: Predictors and clinical importance. *Innovations (Philadelphia, Pa.)*, *11*(3), 179–186. https://doi.org/10.1097/IMI.0000000000000279.

Taşkin, H., Telli Atalay, O., Yuncu, G., Taşpinar, B., Yalman, A., & Şenol, H. (2020). Postoperative respiratory muscle training in addition to chest physiotherapy after pulmonary resection: A randomized controlled study. *Physiotherapy Theory and Practice*, *36*(3), 378–385. https://doi.org/10.1080/09593985.2018.1488189.

Topcu, S. Y., Rızalar, S., Önüt, F., Işıklı, A. G., & Ünver, S. (2016). Relations between patients' breathing practices and mobilisation after lung resection surgery. *International Journal of Caring Sciences*, *9*(2), 653–657.

Wang, Y. Q., Liu, X., Jia, Y., & Xie, J. (2019). Impact of breathing exercises in subjects with lung cancer undergoing surgical resection: A systematic review and meta-analysis. *Journal of Clinical Nursing*, *28*(5–6), 717–732. https://doi.org/10.1111/jocn.14696.

Huang, H. W., Sun, X. M., Shi, Z. H., Chen, G. Q., Chen, L., Friedrich, J. O., & Zhou, J. X. (2018). Effect of High-Flow Nasal Cannula Oxygen Therapy Versus Conventional Oxygen Therapy and Noninvasive Ventilation on Reintubation Rate in Adult Patients After Extubation: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Journal of Intensive Care Medicine*, *33*(11), 609–623. https://doi.org/10.1177/0885066617705118.

Zhou, Z., Zhao, B., Zha, M. & Meng, X. (2019). Analysis of the effect of acapella in the rapid rehabilitation of thoracoscopic lung cancer. *Acta Medica Mediterranea*, *35*(1), 205–209.

Appendices

Appendix 1: Search strategy

Search 1

- Thoracic.
- Pulmonary resection.
- Pulmonary.
- Lung.
- Thoracotomy.
- VATS/Video-assisted thoracoscopic surgery.

Search 2

- operat#.
- OR surg#.
- OR (postoperative or post operative or post-surgery or post-surgical).

Search 3

- (physiotherap# or physical therap# or rehabilitati*).
- OR (mobilisation or mobilization or mobilise or mobilise).
- OR (exercis* or physical activity or fitness).
- OR ambulat# OR walk# OR recovery.

Appendix 2: Thoracic surgery literature review table

First author	Year	Source origin	Aim/purpose	Design/methodology	Sample	Comparison	Outcome measures	Key findings
Mobilisation								
Shiono	2019	Japan	Assess the impact of ERAS on the post-operative recovery of elderly patients	Observational study	*n* = 535. IG *n* = 130. Mean age 70. Male 66%. CG *n* = 405. Mean age 70. Male 68%.	IG – ERAS. CG – usual care.	• Postoperative complications. • Chest tube duration. • Hospital LOS. • Re-admission rate. • Mortality rate.	Before matching: statistically significant post-op complications (p 0.022), chest drain duration (p 0.006) and shorter LOS (p <0.001), in ERAS group. No difference in readmission or mortality between groups. After matching: statistically significant post-op complications (p 0.167), chest drain duration (p 0.029) and shorter LOS (p <0.001) in ERAS group. No difference in readmission or mortality.
Li	2017	China	Effects of exercise training on people undergoing lung resection	Systematic review	6 RCTs. *n* = 438. IG *n* = 218, mean age 65.6. CG *n* = 220. Mean age 65.8. Gender ratio not reported.		• Post-op complications. • 6MWD. • FEV1. • QoL.	Unable to conclude exercise training will improve QoL, exercise capacity, lung function or reduce PPCs due to insufficient evidence.
Rogers	2017	U.K.	Impact of ERAS on morbidity following resection for lung cancer	Prospective cohort study	*n* = 422. Detail not reported.		• PPCs. • LOS.	ERAS compliance associated with significant reduction in morbidity (OR, 0.72; 95% CI, 0.57–0.91; p <0.01). Early mobility significant independent associated with LOS (OR, 0.25; 95% CI, 0.16–0.40, p <0.01).
Baddeley	2016	U.K.	Physiotherapy for enhanced recovery in thoracic surgery	Editorial				Audit indicated an increase in distance walked and reduction in physiotherapy LOS after implementation of ERAS.

First author	Year	Source origin	Aim/purpose	Design/methodology	Sample	Comparison	Outcome measures	Key findings
Castellino	2016	Canada	To what extent do early mobilisation protocols impact upon postoperative outcomes in comparison to standard care?	SR	4 studies. *n* = 283. IG *n* = 133. Mean age 63.6. Male 49.6%. CG *n* = 150. Mean age 67.2. Male 60.1%.	IG – Mobilisation protocol. CG – unsupervised walking/ usual care without ambulation encouragement.	• Post-op complications. • PFTs. • Physical activity. • PROs. • LOS.	Variation in mobility protocols between studies. Unable to report *p* values. No difference in post-op complications, functional testing, or PROs. Reduced hospital LOS in IG.
Sihoe	2016	China	Assessment of adherence to clinical pathway for VATs	Retrospective review of prospectively collected data	*n* = 136 Mean age 61 Male 56%		• Adherence to the clinical pathway was assessed for each post-op day.	83 patients (61%) adhered to the clinical pathway for less than 50% of the duration of their in-hospital stay. Predictors of poor adherence: male (*p* 0.047), smokers (*p* 0.011), pain (*p* 0.016).
Glogowska	2015	Poland	Is intensive rehabilitation as an independent determinant of better outcome in patients with lung tumours treated by thoracic surgery	Prospective observational study	*n* = 402. IG *n* = 215. Mean age 59. Male 53%. CG *n* =187. Mean age 55. Male 55%.	IG – intensive PT until discharge. CG – historical scheme.	• Postop complications. • Need for bronchoscopy 72 hours post-op. • LOS.	Rehabilitation reduced post-op complications by 43% (OD, 0.57; 95% CI, 0.323–0.988; *p* 0.045). IG had reduced need for bronchoscopy (5.6% v. 16%; *p* 0.0006). IG has significantly shorter hospital LOS (median IG 7 v. CG 8 days; *p* 0.004).
Monteleone	2015	Italy	Assessment of post-op disability in patients following cardiothoracic surgery	Prospective observational study	*n* = 42. Mean age 64. Male 57%.	IG – Individual rehabilitation protocol.	• Ability at discharge.	At discharge: 36 (85.7%) patients able to walk independently, 2 (4.8%) patients walk with assistance and 2 (4.8%) unable to walk. 2 (4.8%) patients died.

Go to contents page

First author	Year	Source origin	Aim/purpose	Design/methodology	Sample	Comparison	Outcome measures	Key findings
Agostini	2014	U.K.	Determine how physical activity patients are following major thoracic surgery, and identify any contributing factors	Prospective observational study	*n* = 99. Lower active patients = 50. Mean age 71. Male 54%. Higher activity group = 49. Mean age 66. Male 46%.		• Motion sensors to measure physical activity. • PPCS. • LOS.	Significant increase in step count from POD2 to POD3 (p 0.008). Pain was the primary limiting factor (p 0.014 on POD2, p 0.004 on POD3). Significant increased LOS (p 0.013) and PPCs (p 0.028) in less active patients.
Arbane	2014	U.K.	The effect of hospital plus home exercise programme on physical activity	RCT	*n* = 131. IG *n* = 64. Mean age 67. Male 45%. CG *n* = 67. Mean age 68. Male 64%.	IG – Hospital and home exercise plan plus usual care. CG – usual care.	• Post-op complications. • Physical activity/exercise tolerance. • Quadriceps strength. • HRQOL. • Hospital LOS.	No significant difference in physical activity (95% CI, -20.2–44.1), LOS (p >0.05), HRQoL (p 0.85–0.01). In patients with airflow obstruction: IG had statistically significant improvement in quadricep strength (95% CI, 0.18–0.20; p 0.04), and HRQoL on SF-36 (p 0.04–0.01).
Respiratory physiotherapy								
Taskin	2020	Turkey	Effectiveness of intensive RMT in addition to chest PT after pulmonary resection	RCT	*n* = 40. IG *n* =20. Mean age 53. Male 75%. CG *n* = 20. Mean age 57. Male 65%.	IG = Respiratory muscle training and chest physiotherapy. CG = chest physiotherapy.	• Respiratory muscle strength (PImax and PEmax). • Exercise capacity (6MWT). • Pain and fatigue (VAS). • Hospital LOS.	Significant difference between the IG and CG on discharge for PImax (p 0.045), PEmax(p 0.006), hospital LOS (p 0.002), and 6MWT (p 0.037). No difference in VAS.

First author	Year	Source origin	Aim/purpose	Design/methodology	Sample	Comparison	Outcome measures	Key findings
Zhou	2019	China	Effect of Acapella in recovery of thoracoscopic lung cancer	RCT	*n* = 100. IG *n* = 50, Mean age 60. Male 42%. CG *n* = 50. Mean age 58. Male 44%.	IG = Acapella from POD1 and usual care. CG = usual care (including post-op breathing exercises, percussion and aerosol inhalation).	• Sputum index. • White blood cell count. • Extubation time. • Hospital LOS.	The addition of using the Acapella significantly increased sputum expectoration on POD3 (p <0.05) and at discharge (p <0.05) but not on POD 1 (p >0.05) and 2 (p >0.05). Significant difference in white cell index at discharge (p <0.05) in IG. Statistically significantly shorter time of extubation (IG 3.84 ± 1.56 v. CG 7.21 ± 2.10 days; p <0.05). Note- long extubation time in each group. Statistically significantly shorter hospital LOS (IG 8.68 ± 2.56 v. CG 11.84 ± 3.08; p <0.05).
Brocki	2018	Denmark	Description of postoperative self-reported physical activity level and assess the effects of 2 weeks of postoperative IMT in patients at high risk for postoperative pulmonary complications following lung resection	Observational study	*n* = 68. IG *n* = 34. Mean age 70. Male 59%. CG *n* = 34. Mean age 70. Male 56%.	IG = Inspiratory muscle training and standard care. CG = standard care.	• Perceived physical activity. • QoL.	A significant percentage of the IG reported less sedentary activity 2 weeks post-op compared with CG (p 0.006). No difference in QoL between groups, but QoL significantly lower at 2 weeks post-op (p <0.0001) for both groups.

First author	Year	Source origin	Aim/purpose	Design/methodology	Sample	Comparison	Outcome measures	Key findings
Malik	2018	Canada	Whether the addition of IS to routine physiotherapy following lung resection results in a lower rate of PPC, as compared with physiotherapy alone	RCT	*n* = 387. IG *n* = 195. Mean age 66. Male 47%. CG *n* = 192. Mean age 68. Male 53%.	IG = IS and routine physiotherapy. CG = routine physiotherapy.	• PPCs. • Hospital LOS. • Re-admission rates.	No significant differences in the incidence of PPCs (*p* 0.879), hospital LOS (*p* 0.342) or re-admission to hospital (*p* 1.0) between the groups.
Palleschi	2018	Italy	Does prophylactic application of CPAP following pulmonary lobectomy reduce postoperative complications	RCT	*n* = 163. IG *n* = 81. Mean 67. Male 56%. CG *n* = 82. Mean age 66. Male 72%.	IG = CPAP and physiotherapy. CG = usual care.	• Postoperative complications. • Hospital LOS.	Significantly lower rate of one or more post-op complications (*p* 0.009) and shorter hospital LOS (6 v. 7 days, *p* 0.031) in IG.
Wang	2018	China	Breathing exercises in patients undergoing surgical resection for lung cancer	SR	16 RCTS. *n* = 1270.		• PPC. • Pulmonary function. • 6MWD. • LOS.	Significant reduction in PPCs (95% CI, 0.21–0.49; *p* <0.00001), predicted FEV1 (95% CI, 4.66–11.78; *p* <0.00001), predicted FVC% (95% CI, 6.14–10.29, *p* <0.00001), FVC (95% CI, 0.17–0.86, *p* 0.004), and FEV1/ FVC ration (95% CI 3.37–11.73, *p* 0.0004) except FEV1 (*p* 0.20), and LOS (95% CI, -3.84–2.36, *p* <0.00001). No significant difference in 6MWD (95% CI, -24.05–55.27; *p* 0.44).

Go to contents page

First author	Year	Source origin	Aim/purpose	Design/methodology	Sample	Comparison	Outcome measures	Key findings
Wu	2018	China	Comparison of HFNO v. conventional oxygen therapy in people post cardiothoracic surgery	Meta – analysis of RCTs	4 studies *n* = 154.	HFNO v. conventional O_2 therapy.	• Escalation of respiratory support. • Pulmonary complications. • Re-intubation rate. • ICU LOS. • Hospital LOS.	HFNO associated with a significant reduction in the escalation of respiratory support (OR = 0.44; 95% CI, 0.29–0.66; p <0.001) and pulmonary complications (OR 0.28; 95% CI, 0.13–0.6; p 0.001). No significant difference in reintubation rate (p 0.34), length of ICU stay (p 0.14) or hospital LOS (p 0.36).
Brocki	2016	Denmark	Does post-operative IMT in addition to breathing exercises and early mobilisation preserve respiratory muscle strength, compared with a control group not performing IMT in high risk patients post lung cancer surgery	RCT	*n* = 68. IG *n* = 34. Mean age 70. Male 59%. CG *n* = 34. Mean age 71. Male 56%.	IG – standard PT plus 2× day IMT for 2 weeks CG – standard PT.	• Change in inspiratory muscle strength. Secondary: • PPC. • Lung volumes. • Physical performance. • Dyspnoea. • Oxygen saturations.	Nil significant difference in respiratory muscle strength (MIP p 0.22; MEP p 0.26), lung volume (FVC% pred. p 0.57; FEV1 pred. p 0.14; FEV1/FVC p 0.35), 6MWT (p 0.21), 6MWT dyspnoea (p 0.34) between the groups. Postoperative hypoxaemia significantly lower in IG (p 0.04). Pneumothorax was more common in IG but not statistically significant (53% v. 35%, p 0.14). Higher incidence of pneumonia in CG, but not statistically significant(21% v. 6%, p 0.14).
Narayanan	2016	Malaysia	Exploring the evidence on compliance with incentive spirometry post abdominal, cardiac and thoracic surgery	SR	36 RCTs. *n* = 279. IG *n* = 141. CG *n* = 138.		• Compliance with IS prescription.	There is a scarcity and inconsistency of evidence on compliance with IS.

First author	Year	Source origin	Aim/purpose	Design/methodology	Sample	Comparison	Outcome measures	Key findings
Rodriguez-Larrard	2016	Spain	Evaluate the effects of an intensive postoperative physiotherapy program focused on respiratory exercises in patients undergoing lobectomy	Quasi-experimental study	*n* = 208 . IG *n* = 106. Mean age 63. Male 73%. CG *n* = 102. Mean age 66. Male 78%.	IG – CG with individualised respiratory PT intervention. CG – IS hourly post op.	• Incidence of PPC. • LOS.	PPC incidence was significantly reduced in the IG (20.6% v. 6.6%, *p* 0.003). LOS was reduced in IG (14 CG v. 12 IG, *p* 0.017).
Ansari	2015	U.K.	Does prophylactic use of HFNO in patients after lung resection surgery improve early functional outcome compared with patients treated with standard low-flow oxygen	RCT	*n* = 59. IG *n* = 28. Mean age 68. Male 50%. CG *n* = 31. Mean age 66. Male 45%.	IG – ERAS and HFNO. CG – ERAS and standard O_2 therapy.	• Pre and post-op 6MWT. Secondary: • PFTs. • PROs. • LOS.	No significant difference in 6MWT (95% CI, -37.9–66.5; *p* 0.58) and FEV1 (95% CI, -0.12–0.28; *p* 0.42) between groups. Significantly higher patient reported satisfaction (*p* 0.046) and reduced LOS in IG (95% CI, 0.48–0.86; *p* 0.03).
Cho	2014	U.S.A.	Does Acapella enhance pulmonary function and provide more comfort than conventional chest physiotherapy after thoracoscopic lung resection	RCT	*n* = 78. IG *n* = 39. Mean age 56. Male 56%. CG *n* = 39. Mean age 57. Male 54%.	IG = Acapella. CG = IS.	• FEV1 on POD3. Secondary outcomes: • Oxygenation. • Comfort and patient preference.	No significant difference in lung function (FEV1) on POD3 (mean (SD) 53%(16%) v. 59%(18%); *p* 0.113) or oxygenation (graphically represented in article). IG reported significantly higher comfort scores (*p* <0.001) and preference (*p* <0.001).

Go to contents page

First author	Year	Source origin	Aim/purpose	Design/methodology	Sample	Comparison	Outcome measures	Key findings
Refai	2014	Italy	Are PImax and PEmax before stair climbing associated with complications post lung resection?	Prospective cohort study	*n* = 283. Mean age 67.		• PImax and PEmax pre and post stair climbing. • Post-op complications.	Patients with complications had a greater reduction in their PImax compared with non-complicated patients (8.7% v. 2.1%; *p* 0.03).
Physiotherapy								
Agostini	2019	U.K.	Observe frequency of problems potentially amenable to physiotherapy following VATS lobectomy, and to identify associated baseline factors of patients in whom physiotherapy may be beneficial	Prospective observational study	*n* = 287. No issues *n* = 76. Mean age 64. Issues identified *n* = 209. Mean age 69.	Those who did and didn't require physio treatment	• Metres walked pre-operatively. • PPC. • Assessment by PT for treatment on POD1.	27% of patients didn't require PT. These patients had a shorter HDU LOS (*p* 0.004) and hospital stay (*p* <0.001) reflecting a speedy, uncomplicated recovery. 73% of patients required PT; referred for reduced mobility or oxygen desaturation. 23% required treatment for volume loss, and 8% for sputum retention. 7% PPC rate. Predictive factors for PT: age (OR 1.0, 95% CI, 1.0–1.1; *p* <0.001), COPD (OR 2.3; 95% CI 1.1–4.7; *p* 0.02), BMI >30 (OR 2.2; 95% CI, 1.0–4.6; *p* 0.04), pre-op mobility <400m (OR 2.0; 95% CI, 1.0–4.1; *p* 0.05).

First author	Year	Source origin	Aim/purpose	Design/methodology	Sample	Comparison	Outcome measures	Key findings
Jonsson	2019	Sweden	Examine the effect of in-hospital physiotherapy on post-operative physical capacity, physical activity, and lung function among patients undergoing lung cancer surgery	RCT	*n* = 107. IG *n* = 54. Mean age 69. Male 54%. CG *n* = 53. Mean age 68. Male 34%.	IG = pre- and post-operative in-hospital physiotherapy treatment. CG = No in-hospital physiotherapy.	• 6MWT. • PFTs. • Dyspnoea. • Pain.	IG significantly more physically active during hospital stay (95% CI, 3–30). Self reported physical activity higher in IG from pre-op to 3 months after surgery (*p* 0.047), but no objective difference in activity recorded (*p* 0.85). No difference in FEV_1 (*p* 0.92) or dyspnoea (*p* 0.56), or pain (*p* 0.49) at 3 months. No difference between hospital activity levels and physical activity at 3 months (*p* 0.42).
Topcu	2016	Turkey	Examine the relation between patients' frequency and duration of mobilisation and practices of pulmonary physiotherapy after lung resection surgery	Cross sectional relational study	*n* = 74. Mean age 57. Male 70%.		• Frequency of mobilising. • Frequency of breathing exercises, coughing & IS.	Frequency of breathing exercises was statistically significant related to frequency and duration of mobilisation across all PODS (*r* = 0.292–0.555; *p* 0.024–0.000). Frequency of coughing was statistically significant related to frequency and duration of mobilisation across all PODS (*r* = 0.252-0.682; *p* 0.108–0.000). Frequency of using spirometry was statistically significant related to frequency and duration of mobilisation across all PODS (*r* = 0.156-0.607; *p* 0.235–0.000).
Imperatoria	2016	Italy	Chest pain control with kinesiology taping (KT) after lobectomy	RCT	*n* = 92. IG *n* = 46. Median age 65. Male 72%. CG *n* = 46. Median age 66. Male 67%.	IG – KT applied to shoulder and chest wall. CG – no tape.	• Pain VAS.	Significant reduction of pain in the IG group on POD5 (*p* <0.01), POD8 (*p* <0.05) and at POD30 (*p* 0.03). Not significant at POD1 (*p* 0.92), POD2 (*p* 0.63), POD9 (*p* 0.17).

First author	Year	Source origin	Aim/purpose	Design/methodology	Sample	Comparison	Outcome measures	Key findings
Outcomes								
Santos	2016	Brazil	Can functional capacity assessed by pre-op 6MWT predict which patients will develop PPCs following pulmonary surgery	Observational study	*n* = 21. Group without PPC *n* = 9. Mean age 59. Male 33%. Group with PPC *n* = 12. Mean age 61. Male 58%.	Patients with and without PPCs	• Pre-op 6MWT. • PPCs.	57% of patients developed PPC. The group without PPC had a significantly higher 6MWD (OR 22.0; 95% CI, 1.86–260.65; *p* 0.01) than the group with PPC, therefore, lower than expected 6MWD is associated with increased risk of PPC.

6MWD = 6 minute walk distance; 6MWT = 6 minute walk test; BMI = body mass index; CI = confidence interval; CG = control group; CPAP = continue positive airway pressure; ERAS = enhanced recovery after surgery'; FEV1 = forced expiratory volume in 1 second; FVC = forced vital capacity; HFNO = high flow nasal oxygen; HRQoL = health related quality of life; IG = intervention group; IMT = inspiratory muscle training; IS = incentive spirometry; LOS = length of stay; MEP = maximum expiratory mouth pressure; METs = metabolic equivalent of task; MIP = maximal inspiratory mouth pressure; OR = odds ratio; PE_{max} = maximal expiratory mouth pressure; PI_{max} = maximal inspiratory mouth pressure; PFTs = pulmonary function testing; Post-op = post-operative; POD = post-operative day; PPCs = post-operative pulmonary complications; PROs = patient reported outcomes; PT = physiotherapy; QOL = quality of life; *r* = correlation coefficient; RCT = randomised control trial; RMT = respiratory muscle training; SR = systematic review; VAS = visual analogue scale; VATs = video assisted thoracoscopic surgery.