ACPRC scoping review of post-operative physiotherapy in people undergoing cardiac surgery

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Keywords | In-patient, mobilisation, post-operative, respiratory physiotherapy, cardiac surgery.

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Abstract

Introduction
This scoping review was produced by the ACPRC editorial board. Surgery was considered one of five key priorities for review and was subsequently separated into surgical 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 cardiac surgery.

Inclusion criteria
Studies with adult patients undergoing cardiac surgery, requiring post-operative physiotherapy intervention, as part of the recovery process, and published between 2014 and 2021 were included.

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.

Results

Initially, 2795 articles were retrieved, 41 articles were included in this scoping review. The most frequent study methodologies were randomised control trials (*n* = 21), observational studies (*n* = 8), systematic reviews (*n* = 3) and qualitative studies (*n* = 2). The sample sizes tended to be small and single centred.

Included studies explored mobilisation (*n* = 18), respiratory physiotherapy (*n* = 12), sternal wound precautions (*n* = 7), staff or patient experience (*n* = 3) and adverse events (*n* = 1). Targeted respiratory physiotherapy may be beneficial for patients who are at high-risk of developing or have developed post-operative complications. Early mobilisation shows good evidence to reduce length of stay. Allowing patients more liberal use of their upper-limbs has also been shown to expedite recovery and reduce care needs on discharge without increasing sternal wound breakdown, infection or pain.

Conclusion

The literature showed positive outcomes for physiotherapy interventions involving early mobility and allowing an increase in upper-limb usage. Respiratory physiotherapy techniques are beneficial when used with appropriate patients. Cost effectiveness analysis should be undertaken. There is scope for an increase in qualitative studies to be undertaken to focus on patient experience and patient reported outcomes.

Introduction

The ACPRC editorial board is comprised of respiratory physiotherapy clinicians and academics. 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 surgery as a priority area for guidance. This was subsequently separated into cardiac, thoracic, and upper-gastrointestinal surgery.

For the purpose of this scoping review, cardiac surgery included valve replacements, valve repairs, coronary bypass grafts, and other invasive cardiac procedures requiring a large incision such as median sternotomy. The rationale for this, is that physiotherapy recovery pathways are comparable between surgeries.

There has been a decline in the number of cardiac surgery operations performed in the U.K. This has decreased from 41,586 procedures performed in 2008 and 2009 to 34,000 in 2019. Mortality rates are low at 2.59%, and average post-operative length of stay is 7.8 days (1). During this time there has been an increase in less invasive procedures such as percutaneous coronary interventions. Consequently, patients undergoing surgery have an increased age, co-morbidities and more complex surgery (2).

Systematic reviews have been undertaken for cardiac surgery and physiotherapy, and have either incorporated other types of surgery, for example, thoracic and abdominal surgery (3) or focussed solely on mobilisation after cardiac surgery (4, 5).

The aim was to undertake a scoping review to identify all types of post-operative physiotherapy research, to provide a comprehensive representation of available evidence (6–8).

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 cardiac surgery.

Scoping review question

The primary scoping review question is:

- *What evidence exists for the post-operative physiotherapy management of people who have undergone cardiac 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 cardiac 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 an unregistered member of the physiotherapy team.

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

Mobilisation – to support and encourage patients to move. This may be to mobilise out-of-bed, to march on the spot or walking.

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, active cycle of breathing techniques, resistive training, positive and negative pressure devices, and adjuncts.

Eligibility criteria

Participants

Inclusion criteria

- Adult patients undergoing invasive cardiac surgery requiring access through a chest wound, for example, sternotomy, and that requires a post-operative hospital stay.
- Study includes acute post-operative physiotherapy.

- Study published between 2014 and 2021. The start date of 2014 was chosen, as it allowed a slight overlap in studies captured within published systematic reviews identified by the scoping review search.
- Article written in English.

Exclusion criteria

- Animal studies.
- Paediatrics – defined as children less than 18-years-of-age.
- Day case surgery.
- Cardiology interventions such as percutaneous coronary intervention, transcatheter aortic valve implantation.
- Physiotherapy intervention prior to admission, for example prehabilitation and intervention after hospital discharge, for example out-patient follow up.

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 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 (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), observational studies including prospective and retrospective cohort studies, case-control studies and analytical cross-sectional studies. Other designs included systematic reviews, descriptive observational study designs including case series, individual case reports and descriptive cross-sectional studies. Qualitative studies that focused on qualitative data, 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 (9). Initially, 2795 articles were retrieved from the database searches (n = 2736) and clinical trial registers (n = 59). Following removal of 53 duplicate records, one reviewer screened the titles and abstracts against the inclusion criteria. This process excluded 2602 studies as they did not fulfil inclusion criteria. Full texts were retrieved for 140 articles, with 19 being unavailable. Each full-text article was screened by two reviewers, and of the 121 full text articles reviewed, 80 were excluded due to a lack of focus on physiotherapy specific treatment, or the intervention was conducted in the pre-operative or post-discharge phases of care. Subsequently, 41 studies were selected for inclusion into the scoping review.

Any ambiguity was discussed with the topic lead. The results are presented in Figure 1 the *Preferred Reporting Items for Systematic Reviews and Meta-analyses Extension for Scoping Review* (PRISMA-ScR) flow diagram (10).

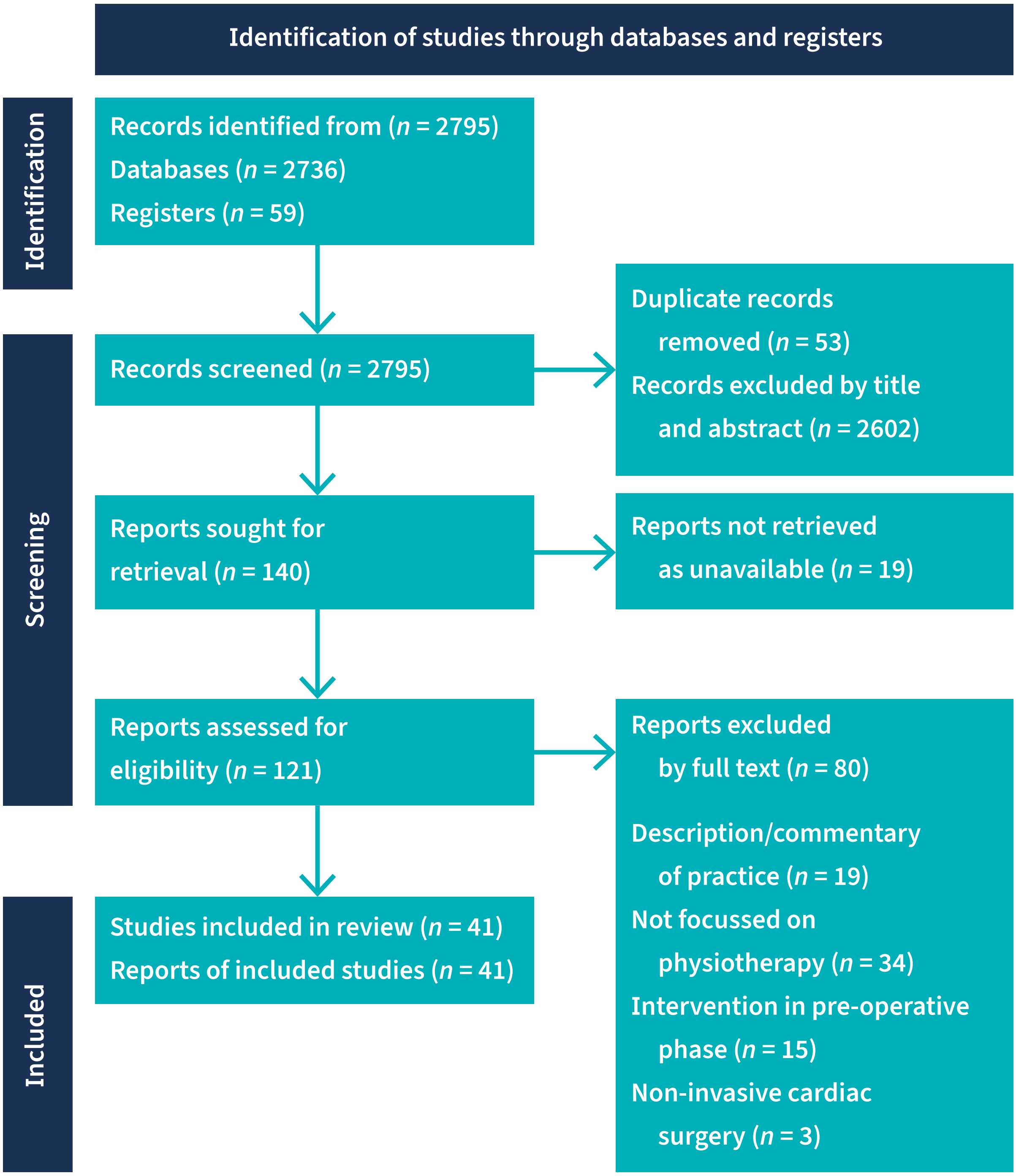

Figure 1: PRISMA-ScR flow chart.

Data extraction

All articles were reviewed by two independent reviewers and data was extracted and collated. Study quality was assessed using appropriate Critical Appraisal Skills Programme (11) or Joanna Briggs Institute (12) tools. An appraisal tool template was completed for each study, and submitted to the topic lead.

Results

Number of studies and research methodologies

In total, 41 studies researching the post-operative physiotherapy management of people who had undergone cardiac surgery and required a hospital stay were included in this scoping review. This included a total of 7824 participants, ranging from 13 participants (13) to 1419 participants (5). This did not include the number of participants in the systematic review by Sullivan et al. (3) as it was not possible to differentiate participant numbers between cardiac, thoracic and abdominal surgery. The most frequent types of study design were RCTs ($n = 21$) of which three were pilot RCTs, observational studies ($n = 8$) and systematic review ($n = 3$). Two qualitative studies were included for review. The methodology types and number of studies can be seen in Figure 1.

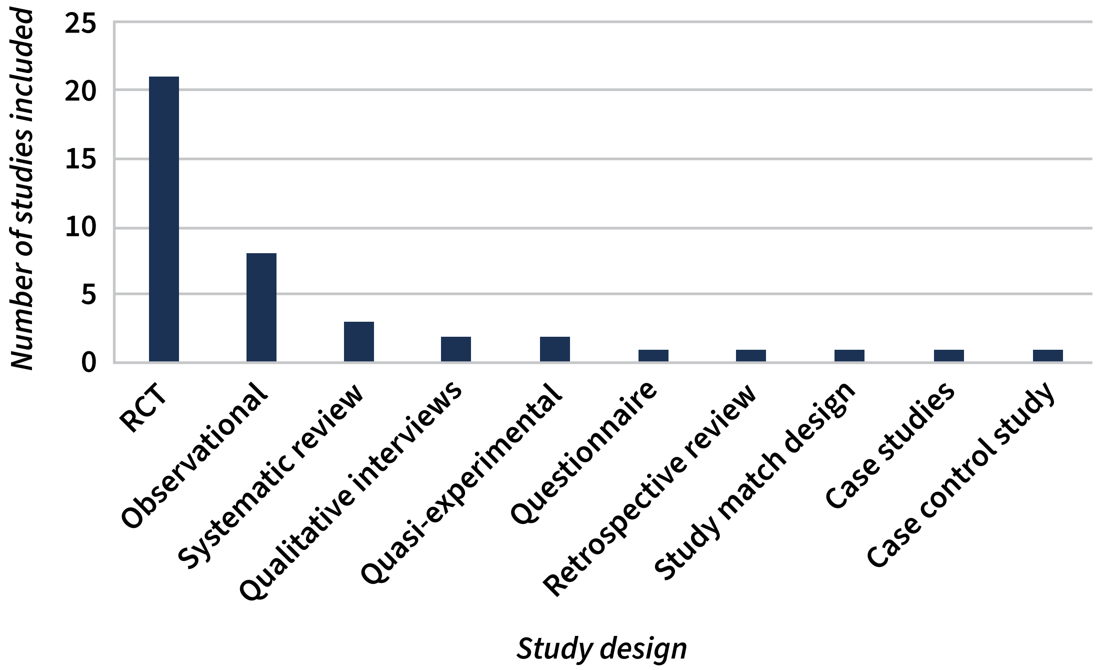

Figure 2: Methodology types and number of studies included.

The 41 studies were categorised by type of physiotherapy intervention. This included 18 studies (45%) investigating post-operative mobilisation, 12 studies (29%) reviewing respiratory physiotherapy and respiratory interventions, seven studies (17%) exploring sternal wound precautions and associated pain, three studies (7%) investigating staff and patient experience and one study (2%) reporting adverse events during physiotherapy. See Figure 2.

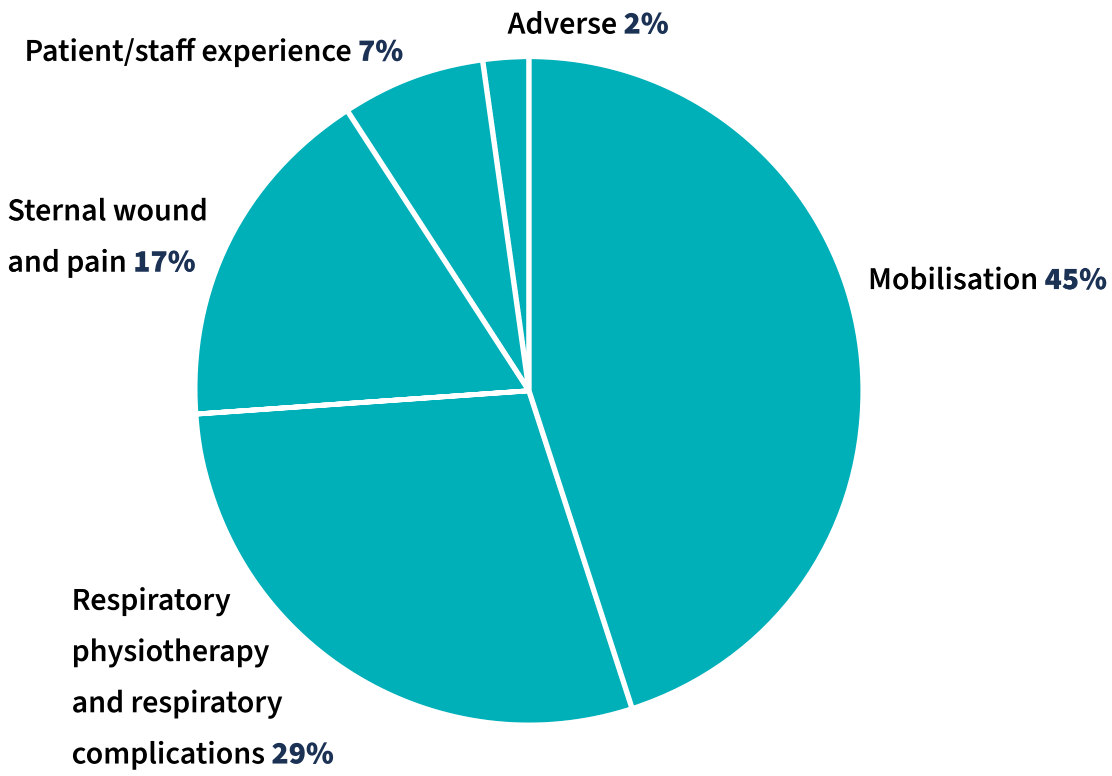

Figure 3: Methodology types and number of studies included.

Quality of research

Many of the studies (with some exceptions) had small sample sizes and were based in single centres. For the RCTs, blinding was inconsistent across studies resulting in potential risk of bias within the methods. The participants were appropriately selected and accounted for through the pathway of the studies and the study protocols were outlined in nearly all studies. The outcome measures were largely easily replicable and appropriate to the patient groups being investigated, however overall, there was little consideration of cost-benefit analysis.

Study findings

A detailed summary of the studies is presented in the literature review table (Appendix 2).

The themes identified were respiratory physiotherapy, mobilisation and sternal wound precautions.

Respiratory physiotherapy

Research relating to respiratory physiotherapy covered a range of interventions. Three studies (14–16) looked at positive pressure interventions alongside early mobilisation following cardiac surgery. Kamisaka et al. (14) found that delivering pressure support may have a role in improving dyspnoea in early mobilisation. Dholaki et al. (15) compared Bi-level positive airway pressure and high-flow nasal oxygen (HFNO) on ambulation and found both groups doubled the distance mobilised with ventilatory support. Pantoni et al. (16), found continuous positive airway pressure (CPAP) on ambulation demonstrated increased exercise tolerance, tidal volumes, and oxygen saturation, as well as reduced dyspnoea in comparison to the control group.

Three studies (17–19) investigated positive expiratory pressure (PEP) devices. They found no benefit of PEP (17) or Acapella® (18) over conventional physiotherapy on pulmonary function, post-operative pulmonary complications (PPCs), radiological changes or length of hospital stay (17–18). Petterson et al. (19) found deep breathing exercises performed with bubble PEP demonstrated significantly higher SpO_2 in standing versus sitting.

Incentive spirometry has been investigated with mixed results. In a systematic review, Sullivan et al. (3) reported that incentive spirometry alone did reduce PPCs. However, a pilot RCT concluded that there was no statistically significant difference in lung function tests, at post-operative day (POD) seven or on six-minute walk distance (6MWD) in incentive spirometry versus diaphragmatic breathing (20).

Wu et al. (21) found the use of mechanical insufflation:exsufflation post-operatively, had significantly improved lung function, but patients reported significantly more pain compared with the Intermittent Positive Pressure Breathing Group. There was no difference in PPCs between groups.

Zochios et al. (22) found that prophylactic use of HFNO in patients with pre-existing respiratory conditions resulted in lower hospital length of stay and reduced intensive care unit (ICU) readmissions in comparison to a standard care control group.

Cargnin et al. (23) found the use of post-operative inspiratory muscle training demonstrated significant improvement in maximal inspiratory pressure and non-significant improvement in 6MWD, with no difference in length of stay, lung function or quality of life. Another study found that ACBT did not lead to physiological improvements compared to routine physiotherapy (24).

Mobilisation

Studies have established that early mobilisation is beneficial compared to bedrest, but there was no evidence of the optimal exercise prescription, or definition of *early mobilisation* (5, 25).

Early mobilisation significantly reduced hospital length of stay (LOS) in five studies (26–30), but not in other studies that reported no significant difference in LOS (4, 31–32). Intensive care LOS was shown to have been significantly reduced by Afxonidis et al. (26), and was also reported to be reduced, but not significantly by Chen et al. (4).

Four studies (29, 31, 33–34) all found no significant difference in 6MWD between control and intervention groups whereas one study (35) showed a significant improvement in 6MWD in their small sample intervention groups. Kubitz et al. (36) reported that 80% of patients fully adhered to their post-operative mobility protocol. Outcomes of supervised exercise are variable, with one study showing a significant increase in step count when supervised by physiotherapists (37), but another showed no significant difference between orderly led ambulation (31).

Physiological measures showed no significant differences following the interventions of cycle ergometry (34). However, Tariq et al. (28) showed a significant improvement in SpO_2 following mobilisation and respiratory physiotherapy within four hours of extubation. Studies found no significant difference in left ventricular ejection function (29), respiratory muscle strength (35) or lung function (35, 38) between an exercising intervention group and the control group.

Miwa et al. (30) and Floyd et al. (32) showed no differences between control and intervention groups, and the incidence of adverse events. Takei et al. (39) reported an incidence of 18% of physiological abnormalities or potential safety events during physiotherapy, but only 2% requiring treatment. The main adverse effects reported were altered blood pressure and vertigo. The study by Sousa et al. (40) found the majority of physiological abnormalities or adverse events were mild or near misses occurring more so with mechanically ventilated patients.

Other interventions reporting positive impact on recovery are targeted exercise and education (41) and distance walked based on wall art (42). There was a significant reduction in costs in an early rehabilitation (<8 days) intervention group compared to the control or delayed (>8 days) intervention group (29).

Sternal wound precautions

Work reviewing the long-established practice of strict sternal wound precautions has been compared to modified sternal precautions, such as *Keep your Move in the Tube* (KYMITT) (43–45). KYMITT is a post-sternotomy protocol that allows load bearing movement through the upper-limbs whilst avoiding excessive stress to the sternal wound. This is achieved by keeping upper-limbs at close range to the trunk, or as if you were placed in a tube. Both Gach et al. (43) and Radfar et al. (44) found that implementing KYMITT was associated with an increased proportion of cardiac surgery patients discharged home, opposed to inpatient rehabilitation or nursing facilities. The use of KYMITT did not increase wound complication or readmission rates. Katjjahbe et al. (45) study showed substantial improvement with KYMITT, but no significant difference at weeks four and 12. LaPier et al. (46) found the majority of physiotherapists would implement wound support immediately after median sternotomy to reduce pain and to protect sternal healing. Restrictions related to the arms lifting weights and heights were commonly employed but varied greatly in degree and duration.

Thoracic exercises showed a significant reduction in early (0–6 weeks) sternal pain post cardiac surgery. However, there was no difference at three months (47). A systematic review of continuous local anaesthetic in post-cardiac surgery patients (48) found no significant differences in pain scores, distance walked, or for time to physiotherapy discharge.

Boitor et al. (49) found hand massage in the critically ill cardiac surgery patients significantly reduced pain immediately post intervention compared to active and passive control groups, but they were unable to assess longer term benefit.

The qualitative studies explored patient's experiences following cardiac surgery (13, 50). They concluded that cardiac surgery causes both physical and emotional disturbance. Relationships developed with healthcare professionals built safe spaces for discussion, to prepare patients and families adequately for discharge.

Discussion

This scoping review outlines research published in key areas of physiotherapy and post cardiac surgery management. There is a variety of respiratory treatment techniques and interventions studied which makes concluding the impact of respiratory physiotherapy more difficult. There is some evidence that initiating positive pressure such as CPAP or HFNO in the early phase of care does positively impact patient recovery. However, physiotherapy delivered pressure treatment such as PEP and incentive spirometry are less likely to improve outcome in the absence of PPCs. In patients who do not develop PPCs or have pre-operative respiratory conditions, physiotherapy adjuncts do not expedite recovery and that these treatment options should not be routinely delivered.

Research supports that mobility provides a multi-faceted impact on recovery including enhancing re-ambulation, cardiovascular improvement and contributes towards prevention of PPCs.

There is strong evidence for early mobilisation, in reducing ICU and hospital LOS. However, the optimal timings and frequency of mobility remains unanswered. There is evidence to support that staff and a culture dedicated to mobilisation impacts step count and frequency of mobility. These findings support the more holistic post-operative recovery approach, involving patient experience and patient accountability for their care, in addition to physiological recovery.

The pioneering work around sternal precautions has been a significant change in post-operative cardiac care, over the past few years. Due to the increasing age and frailty of patients, the inability to use the upper-limbs to facilitate bed transfers, and aid sit-to-stand has an impact on recovery, hospital length of stay and ongoing care needs on discharge. Evidence provides assurance that the KYMITT approach does not lead to an increase in sternal wound breakdown, infection or pain (51). It would be interesting to assess adoption of this practice in cardiac centres.

The literature includes mainly quantitative research, however qualitative consideration of the impact of staff and patient experience in recovery after cardiac surgery was included. Additional consideration for further research would be multi-centred trials to enable greater sample sizes, and cost-benefit analysis in terms of both hospital and patient benefit would allow for greater weight for supporting change in practice.

A limitation to this scoping review was that the search criteria excluded prehabilitation and post-discharge exercise prescription such as cardiac rehabilitation programmes. Further scoping reviews would be beneficial to identify studies relating to these areas.

Conclusion

In conclusion, the objective of this scoping review was to report the extent and methodological type of evidence associated with post-operative physiotherapy in people who undergo cardiac surgery.

The initial search returned 2795 articles and following screening 41 studies were included in the scoping review. A variety of different research methodologies were included in the review which demonstrates diversity of evidence available.

The literature showed positive outcomes for physiotherapy interventions involving early mobility, a culture that supports holistic post-operative recovery and allowing increased use of the upper-limbs. It is more difficult to conclude which respiratory intervention provides the most benefit, and targeted use in patients with respiratory compromise appears to be better than routine application. Cost effectiveness analysis needs to be undertaken. There is scope for an increase in qualitative studies to be undertaken to focus on patient experience and reported outcomes.

In addition to this cardiac scoping review, the editorial board has published separate gastrointestinal and thoracic scoping reviews and plan to publish a combined ACPRC surgical position statement.

Acknowledgements

Thanks to Becky Scott, Royal Papworth Hospital library services, 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.

Appendix 1 – search strategy

Search 1

Heart.

Cardiac.

Aortic.

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 mobilize or mobilise).

OR (exercis* or physical activity or fitness).

OR ambulat# OR walk# OR recovery.

Appendix 2 – cardiac surgery and physiotherapy literature summary

First author	Source origin	Aim/purpose	Design/ methodology	Sample size	Comparison	Outcome measures	Key findings
Respiratory physiotherapy and respiratory complications							
Alaparthi, 2021	India	Effect of different breathing techniques on PFTs after valve surgery.	Pilot RCT.	*n* = 30, IG1, *n* = 10, mean age 63, male 70%. IG2, *n* = 9, mean age 62, male 78%. IG3, *n* = 10, mean age 54, male 90%.	IG1 – flow-oriented incentive spirometry. IG2 – volume-oriented spirometry. IG3 – diaphragmatic breathing. In addition to airway clearance and progressive mobility and stairs.	PFTs, 6MWT, functional difficulty.	No statistically significant difference in PFTs at POD7 except FVC in IG3 ($p = 0.024$). No statistically significant difference in 6MWT. Volume spirometry group (IG2) scored statistically significantly better on the functional difficulty questionnaire when compared to the IG3 group ($p = 0.001$) but not when compared to IG1 ($p = 0.04$).
Sullivan, 2021	Canada	Use of IS in cardiac, thoracic and abdominal surgery.	SR.	9 cardiac studies *n* = ? – unable to differentiate cardiac, thoracic and abdominal patients.	IS versus respiratory PT.	PPCs, mortality, hospital LOS.	IS alone compared with other strategies did not reduce PPCs (95% *CI* 0.80–1.43; $p = 0.64$, mortality (95% *CI* 0.04–3.17, $p = 0.36$, $Z = 0.91$), or hospital LOS (95% *CI* -1.42–1.20, $p = 0.87$, $Z = 0.17$).

First author	Source origin	Aim/purpose	Design/ methodology	Sample size	Comparison	Outcome measures	Key findings
Wu, 2021	Taiwan	Compare effect of MI:E versus IPPB on lung function after cardiac surgery.	Retrospective observational study.	$n = 51$, MI:E group $n = 21$, mean age 64, male 67%. IPPB group $n = 20$, mean age 63, male 57%.	Selection based on availability of device. Treatment for 5 days MI:E group. IPPB group.	PFTs, PPCs.	The post-operative percentage of predicted FVC (58.4 ± 4.74 versus $46.0 \pm 3.70\%$, $p = 0.042$), and FEV_1 (62.4 ± 5.23 versus $46.8 \pm 3.83\%$, $p = 0.017$) were significantly less in IPPB group. Statistically significant higher reported chest pain in MI:E group (61.9% versus 16.7%; $p = 0.002$). No statistically significant difference in PPCs; pneumonia (95% *CI* 0.12–16.86; $p = 0.777$), atelectasis (95% CI 0.20–1.91; $p = 0.402$), pleural effusion (95% *CI* 0.46–4.43; $p = 0.544$).
Pieczkoski, 2020	Brazil	Effect of PEP in patients after cardiac surgery.	RCT.	$n = 48$. IG1 $n = 16$, mean age 61, male 69%. IG2 $n = 16$, mean age 65, male 69%. CG $n = 16$, mean age 67, male 100%.	IG1 – PEP blow bottle device. IG2 – Expiratory positive airway pressure. CG – conventional physiotherapy.	Compared pre-op and POD3: PFTs, Respiratory muscle strength, CXR changes, pulmonary. complications, ICU and hospital LOS.	No difference between groups in PFTs, MIP and MEP, pain, PPCs, ICU or hospital LOS. Unable to statically compare CXR changes due to small sample size.

First author	Source origin	Aim/purpose	Design/ methodology	Sample size	Comparison	Outcome measures	Key findings
Cargnin, 2019	Brazil	Does IMT after heart valve replacement improve recovery.	RCT.	$n = 25$. IG $n = 13$, mean age = 62, male = 69%. CG = 12, mean age = 60, male = 50%.	IG – IMT 2 × day from POD3 to 4 weeks post op. CG – IMT placebo group.	Lung function, MIP, functional capacity, QoL measured pre-op and at 4 weeks post-op.	Significantly improved MIP in IG ($p = 0.005$), improvement in 6MWD for IG compared with CG ($p = 0.019$). Correlation between MIP and 6MWD ($r = 0.72$; $p = 0.001$). Significant association between MIP and lung function test (FEV_1 $p = 0.003$; FEV_1/FVC $p = 0.38$). No difference between groups in lung function or QoL.
Derakhtanjani, 2019	Iran	Comparison of ACBT and routine PT on pain and respiratory parameters.	RCT.	$n = 70$. IG $n = 35$, mean age = 53, male = 74%. CG $n = 35$, mean age = 52, male = 74%.	IG – ACBT 1 × day in addition to early mobility. CG = chest wall vibration and manual percussion in addition to early mobilisation.	PaO_2, HR, RR, pain score.	No significant difference in PaO_2, SaO_2, RR and pain between groups.
Dholakia, 2018	USA	Does transport BiPAP or HFNO impact mobility, PPCs, and short-term morbidity and mortality.	Retrospective review abstract.	$n = 20$, Group 1 $n = 8$, Group 2 $n = 12$ No demographic details available.	Group 1 – Transport BiPAP. Group 2 – HFNO.	Distance mobilised, reintubation rate.	Both groups doubled their mobility distance with additional respiratory support. No numerical data or statistical analysis was presented in the abstract. No detail on control group or previous ability.

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First author	Source origin	Aim/purpose	Design/ method-ology	Sample size	Comparison	Outcome measures	Key findings
Zochios, 2018	U.K.	Effect of HFNO on hospital LOS in cardiac surgery patients with pre-existing respiratory disease.	RCT.	$n = 100$. IG $n = 51$, mean age – 67, male – 61%. CG $n = 49$, mean age – 69, male – 62%.	IG – HFNO for the first 24 hours. CG – standard oxygen therapy.	Hospital LOS, ICU readmission, 6MWD, PFTs, PROMs.	Mean hospital LOS lower in IG (95% *CI* 11–44%; $p = 0.004$). Risk of prolonged stay higher in CG (38%) versus IG (18%) ($p = 0.03$). IG had fewer ICU readmissions ($p = 0.02$). No difference in ICU LOS, 6MWD, lung function tests, PROMs between groups.
Naswa, 2017	India	Comparing ACBT and Acapella® on PPC incidence following cardiac valve surgery.	RCT.	$n = 30$, male = 60%. IG $n = 15$, mean age = 33. CG $n = 15$, mean age = 31.	IG = Acapella® × 10 breaths for 15 minutes or until tired. CG = ACBT for 15 minute or until tired.	CXR, hospital LOS.	No significant difference in CXR appearance or hospital LOS, 3 patients in CG developed pneumonia. (Note- young mean age).
Kamisaka, 2016	Japan	Does mechanical ventilatory support reduce dyspnoea during walking after cardiac surgery.	Prospective case series.	$n = 56$. Mean age – 68, male – 73%.	Walked without VA (session A), followed by walking with VA (HFNO to 3 cm H_2O) (session B), or in reverse order. Classed as dyspnoea group if Borg increased by 1 point.	Dyspnoea, leg fatigue, ventilatory parameters, lung function, physical function, CXR.	35 patients (63%) reported dyspnoea on first walk. 18 (51%) of these patients responded to VA support by demonstrating a reduction in dyspnoea on walking.

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First author	Source origin	Aim/purpose	Design/ methodology	Sample size	Comparison	Outcome measures	Key findings
Pantoni, 2016	Brazil	Effect of CPAP on POD_1 mobility.	RCT.	*n* = 27. IG *n* = 13, mean age – 58, male – 38%. CG *n* = 14, mean age – 57, male – 71%.	IG – as CG plus CPAP 10–12 cm H_2O) during all exercises. CG – early mob, respiratory exercises.	Breathing pattern variables, exercise time, dyspnoea, SpO_2.	Statistical improved outcomes in IG in some respiratory parameters; V_T ($p = 0.001$), minute ventilation ($p = 0.005$); exercise time ($p = 0.04$), dyspnoea ($p = 0.008$), SpO_2 ($p = 0.016$). No difference for leg effort scores.
Pettersson, 2015	Sweden	Evaluate if DBEs are better performed in sitting or standing.	RCT.	*n* = 189. IG *n* = 94 mean age – 65, Male -79%. CG *n* = 95 mean age – 67, Male – 87%.	IG- 3 × 10 deep breaths with PEP device in standing. CG – 3 × 10 deep breaths with PEP device in sitting.	SpO_2, subjective breathing ability, BP, HR, pain at rest, pain on deep breathing.	Significantly higher SpO_2 in standing group directly after exercises ($p = 0.0001$) and 15 minutes after ($p = 0.027$). IG able to take a deeper breath ($p = 0.004$). No significant difference in HR, BP, pain at rest or on deep breathing.
Mobilisation/enhancement of physical ability							
Afxonidis, 2021	Greece	Effect of early and enhanced PT after cardiac surgery.	RCT.	*n* = 78. IG *n* = 39, mean age 64, male 87%. CG *n* = 39, mean age 65, male 80%.	IG as CG plus additional session of PT POD0–3. CG – conventional PT 2 × day. DBE, IS, chest percussion, chest binder, coughing, progressive mobility.	ICU LOS. Hospital LOS. Haemodynamics and lab tests; sodium, potassium, calcium, glucose, haemoglobin, lactate.	Mean number of treatment sessions: IG 16.6 ± 1.2, and 12.3 ± 0.8. LOS statistically significant less in IG group (8.1 days versus 8.9; 95% *CI* 0.6–1 days, $p < 0.001$) ICU LOS statistically significant less in IG (23.2 hrs versus 25 hrs; 95% *CI* 1.3–3.2 hours; $p = < 0.001$).

First author	Source origin	Aim/purpose	Design/ method-ology	Sample size	Comparison	Outcome measures	Key findings
Chen, 2021	China	SR and meta-analysis of effect of early mobilisation after cardiac surgery.	SR and meta-analysis.	*n* = 652, 5 studies (one study pre-op).		ICU LOS, hospital LOS, physical function, adverse events.	3 of 5 studies demonstrated beneficial effect of early mobilisation on ICU LOS (95% *CI* -2.01–0.04) however overall effect not significant ($p = 0.06$). 3 of 5 studies demonstrated beneficial effect of intervention on hospital LOS is beneficial (95% *CI* -3.96–0.71) however overall effect not significant ($p = 0.17$).
Pizzorno, 2020	Italy	Early post-op rehabilitation in patient >75 years old.	Retrospective case control study.	*n* = 160. Early rehabilitation *n* = 80, mean age 79, male 56%. Delayed rehabilitation *n* = 80, mean age 79, male 53%.	Both group: aerobic, flexibility, resistance, neuromotor training. Early rehabilitation = <8 days from cardiac procedure. Delayed rehabilitation = >8 days from cardiac procedure.	6MWT, LVEF, LOS, cost.	No significant difference between groups for 6MWT, LVEF or post-op complications. Early rehabilitation group had a significantly lower LOS (25.8 days versus 34.1 days; $p < 0.0001$) compared to the delayed rehabilitation group. Early rehabilitation group also showed significant reduction in costs ($p < 0.0001$).

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First author	Source origin	Aim/purpose	Design/method-ology	Sample size	Comparison	Outcome measures	Key findings
Ribeiro, 2020	Brazil	Impact of different PT protocols on heart rate variability and LOS after CABG.	RCT	*n* = 48, CG *n* = 16, mean age 60, male 69%. IG1 *n* = 15, mean age 58, male 87%. IG2 *n* = 17, Mean age 62, Male 59%.	Protocols from POD1–3 CG – respiratory PT and ankle exercises. IG1 – early mobilisation group – cycle ergometry and ambulation. IG2 – virtual reality group – as IG1 plus 2 × Wii games to increase UL strength and cardiovascular fitness.	Heart rate variability, hospital LOS.	IG1 and IG2 demonstrated improved autonomic response on POD_4 than CG ($p < 0.05$). LOS shortest in IG2 (8.1 days), versus IG1 (10.2 days), versus CG (16 days) (p 0.03). Note – 28 patients lost to follow up. Initial *n* = 76, data analysed for 48 patients.
Kubitz, 2020	Germany	ERAS in minimally invasive heart valve surgery.	Retrospective observational study.	*n* = 50, mean age 52, male 76%.	Protocol POD0 – PT 3 hours after Sx, aim to mobilise POD1 – 4 × PT mobility sessions POD2 – Stairs or cycling POD3 & 4 – Independent exercise.	Adherence to protocol, post-operative complications.	47 patients undertook mobilisation 3 hours after surgery on POD_0. Full adherence to protocol in 80% patients. Non adherence due to nausea/vomiting, arrythmia, pain, neurological events. Post-operative complications impacting early phase of the ERAs project; disabling pain (30%), nausea and vomiting (35%), compared with 7% each by late phase of the ERAS project.

First author	Source origin	Aim/purpose	Design/ methodology	Sample size	Comparison	Outcome measures	Key findings
Zanini, 2019	Brazil	Outcomes of different rehabilitation protocols after CABG.	RCT.	*n* = 40. G1 *n* = 10 mean age 58, male 90%. G2 *n* = 10, mean age – 57 male 70%. G3 *n* = 10 mean age – 59, male 60%. G4 *n* = 10, mean age – 61, male 70%.	Conventional PT plus G1 – active UL & LL exercises, early ambulation, IMT. G2 – active UL & LL exercises, early ambulation G3 – IMT G4/ CG – conventional PT (DBEs, EPAP, chest clearance), encouraged to walk from POD_2. All groups seen 2× day for 6 days.	6MWT, CPET variable, PFTs, respiratory muscle strength.	G3 & G4 had greater impairment in functional capacity (6MWD) immediately post-op compared to baseline vs G1 & G2 ($p = <0.001$). 30 days post op – G4 had least amount of recovery. G1,2 3 had significant improvement in post-op 6MWD compared to pre-op baseline ($p = <0.001$). No significant difference between groups in lung function (FVC $p = 0.18$; FEV_1 $p = 0.055$) or respiratory muscle strength (MIP $p = 0.90$, MEP $p = 0.68$). Mean ICS LOS longer in CG ($p < .05$), no difference in hospital LOS across the 4 groups.
Borzou, 2018	Iran	Effect of inpatient cardiac rehabilitation on patient self-efficacy.	RCT.	*n* = 60. IG *n* = 30, mean age 62, male 53%. CG *n* = 30, mean age 58, male 53%.	IG – 3 sessions (education and exercise) commenced 72 hours after surgery until discharge. CG – routine care.	Self-efficacy questionnaire.	At discharge and 1 month after discharge feeling of general self-efficacy, feeling self-efficacy, exercise self-efficacy and total self-efficacy significantly better in IG ($p = <0.001$).

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Cerqueira, 2018	Brazil	Effect of NMES after cardiac valve surgery.	RCT.	$n = 59$. IG $n = 26$, mean age 42, male 69%. CG $n = 33$ mean age 42, male 70%.	IG – received twice daily NMES in additional to regular PT. Total of NMES sessions. CG – usual physiotherapy 2 × day.	6MWT.	No statistical difference between groups 6MWD (95% *CI* -64.87–65.97) and walking speed (95% *CI* -0.55–0.57).
Miwa, 2017	USA	Effect of ambulation orderlies following cardiac surgery.	Quasi-experimental prospective design.	$n = 925$. Post – implementation $n = 478$, mean age 69 Male 69%. Pre-implementation $n = 447$, mean age 67, male 67%.	Post. implementation – ambulation orderlies mobilised patients 1–4 × day for 3–10 minutes. Pre-implementation – encouraged to walk by ward team, no set guidelines, ambulation not recorded.	LOS, mortality, readmission rates, discharge location, hospital. complications.	The implementation of ambulation orderlies showed a statistically significant reduction in LOS by 1 day (median and mean) ($p = 0.001$). No statistically significant difference in discharge location, hospital readmission rate, hospital complications or mortality.
Mungovan, 2017	Australia	Determine amount of physical exercise undertaken immediately after cardiac surgery.	Prospective observational study.	$n = 83$. Mean age 66, male 70%.	Twice daily PT sessions; respiratory, musculoskeletal movement, walking up to 10 mins per session.	Step count, physical activity intensity in metabolic equivalents, 6MWD.	PT supervised 50% of physical activity. Significant increase in step count from POD_1 to POD5 ($p = <0.001$).
Pack, 2017	USA	Evaluation of ambulation orderlies on recovery.	RCT pilot.	$n = 36$. IG $n = 18$, mean age 62, male 72%. CG $n = 18$, mean age 69, male 78%.	IG – ambulation orderly directed ambulation. 4 × day for 3–10 minutes. CG – usual care, nurse directed (no mention of PT involvement).	Average daily steps, 6MWD, LOS.	No statistical significance between groups for average daily steps, 6MWD, LOS. IG noted to have more preferable baseline characteristics.

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First author	Source origin	Aim/purpose	Design/ method-ology	Sample size	Comparison	Outcome measures	Key findings
Santos, 2017	Brazil	Effects of early mobilisations after cardiac surgery.	SR	9 studies included Total *n* = 1419.			Lack of definition on early mobility, however early mobilisation is beneficial compared with bed rest. No evidence of optimal prescription.
Takei, 2017	Brazil	Is PT safe in early post op cardiac surgery patients.	Conference abstract of observational study.	*n* = 258.	698 PT interventions observed.	HR, BP, SpO_2, temperature, RR, Haemoglobin.	18% of interventions had physiological abnormality or potential safety events (95% *CI* 15–21%), these occurred most commonly during ambulation (40%) and NIV (37%). The main adverse events were altered BP, and vertigo. Only 2% (95% *CI* 1–4%) required additional treatment.

First author	Source origin	Aim/purpose	Design/method-ology	Sample size	Comparison	Outcome measures	Key findings
Tariq, 2017	Pakistan	Effects of early exercise after cardiac surgery.	RCT.	*n* = 174, mean age – 52, male 76%. IG *n* = 87. CG *n* = 87.	IG – mobilised to chair on POD0 (within 4 hours of extubation) and chest PT. CG – as IG but starts on POD_1.	HR, BP, SpO_2, RR, temperature, dyspnoea, PPCs.	POD0: Following exercise, the IG showed significant improvement in SpO_2 (p = <0.001) and reduced RR (p = <0.001) compared to the CG. POD1: Following exercise, the IG demonstrated significant reduction in HR (p = <0.001) and the CG showed significant improvement in SpO_2 (p = <0.001). Reduced ICU LOS in IG (no *p* value; ICU LOS at 5 days IG 31% versus CG 2%).
Borges, 2016	Brazil	Effect of aerobic exercise after CABG.	RCT.	*n* = 34. IG *n* = 15 Mean age – 63 Male 80%. CG *n* = 19 Mean age – 73 Male 53%.	IG – aerobic exercise (cycle ergometery) in addition to conventional PT. CG – conventional PT. DBEs, UL and LL exercises, progressive ambulation.	PFTs, respiratory muscle strength, 6MWT. Assessed pre-op and at hospital discharge.	Both groups experienced significant reduction post-op PFTs (p = 0.001–0.27) but no difference between IG & CG. Both groups maintained MIP (p = 0.14–0.16), but reduction in MEP (p = 0.004–0.006). 6MWD maintained in IG (p = 0.06), but reduced in CG (p = 0.01). Statistically significant difference between both groups at discharge (p = 0.03).

First author	Source origin	Aim/purpose	Design/ method-ology	Sample size	Comparison	Outcome measures	Key findings
Floyd, 2016	USA	Evaluate effectiveness of progressive mobility protocol on PROM related to immobility.	Retrospective study matched design.	$n = 30$. IG $n = 15$, mean age 65, male 87%. CG $n = 15$, mean age 67, male 80%.	IG – progressive mobility protocol. CG – no standard activity protocol for post-op therapy.	ICU LOS, ICU readmission, pressure ulcers, DVT.	Results not statistically significant for hospital LOS ($p = 0.502$), ICU readmission ($p = 0.301$) or DVT ($p = 0.492$) or pressure ulcer ($p = 0.313$). Note – some results combined cardiac and thoracic surgery.
Monte-leone, 2015	Italy	Assessment of ability post cardiac and thoracic surgery and recovery.	Prospective observational study.	$n = 375$. Mean age 66 Male 63%.	Introduction of rehabilitative protocol. No CG.	Assessment of post op disability and impact of rehabilitative protocol.	25% patients had no post-op disability, 63% patients classed as simple deconditioning and 12% as complex deconditioning. Number of PT sessions received was associated with severity of deconditioning ($p = 0.01$).

First author	Source origin	Aim/purpose	Design/ method-ology	Sample size	Comparison	Outcome measures	Key findings
Trevisan, 2015	Brazil	Use of cycle ergometer in post CABG recovery.	RCT.	*n* = 24. IG *n* = 14 Mean age – 58 Male 71% CG *n* = 10 Mean age – 63 Male 80%.	IG – as CG but substituting walking with cycle ergometery. CG – POD3. Chest PT, POD4–7 addition of mobility, POD5 stairs. 2 × 20 mins per day.	6MWT.	IG non statistically significant longer distance walked in 6MWT (312.2 ± 80.6 versus 249.7 ± 61.4; $p = 0.06$) No statically significant difference in HR, SpO_2, and Borg.
Sternal wound and pain							
Gach, 2021	USA	KYMITT impact on discharge.	Before and after observational study.	n = 1104. IG *n* = 477, mean age 63, male 69%. CG *n* = 627, mean age 67, male 71%.	IG – adoption of KYMITT. CG – sternal precautions to avoid pushing, pulling, lifting for 6–8 weeks.	Discharge location, incidence of sternal wound complications, functional status at discharge.	IG more independent at discharge for bed mobility (49% versus 11%) and transfers (66% versus 35%) ($p = 0.001$). Significantly more IG patients were discharged home ($p = 0.001$), with decrease in referrals to inpatient rehabilitation or nursing facilities. No significant difference in LOS ($p = 0.97$). No significant difference in sternal wound complications between the groups ($p = 0.68$; 95% *CI* 0.52–3.09).

First author	Source origin	Aim/purpose	Design/ methodology	Sample size	Comparison	Outcome measures	Key findings
Radfar, 2019	USA	Examine if KYMITT impacts LOS following surgery.	Abstract of retrospective observational study.	$n = 856$. Pre implementation of KYMITT $n = 356$. Post implementation of KYMITT $n = 509$.	Standard sternal restrictions versus KYMITT.	Case mixed index, length of stay.	Decrease in LOS by 0.10 days (no information on statistical significant).
Boitor, 2018	Canada	Evaluate the effectiveness of hand massage on pain and anxiety following cardiac surgery.	RCT.	$n = 60$. IG1 $n = 20$ Median age 64 Male 70%. IG2 $n = 19$ Median age 68 Male 84%. CG $n = 21$ Median age 63 Male 77%.	IG1–2 × 20 mins hand massage. IG2–2 × 20 mins hand holding. CG – standard care with 20 rest period.	Pain intensity, pain unpleasantness, anxiety, muscle tension, vital signs.	Pain intensity ($p = 0.011$), pain unpleasantness ($p = 0.009$), anxiety ($p = 0.015$) and muscle tension ($p = 0.053$) significantly lower immediately after hand massage, compared with hand holding and standard care. No difference between hand holding and control group. No difference between groups after 30 minutes or POD1. No changes in vital signs.
Katijjahbe, 2018	Australia	Comparison of standard restrictive sternal precautions and modified sternal precautions following sternotomy.	RCT.	$n = 72$. IG $n = 36$, mean age – 63, male – 86%. CG $n = 36$, mean age – 64, male – 94%.	IG = modified sternal precautions for 4–6 weeks. CG = usual restrictive sternal wound precautions.	SPPB, upper-limb function, pain, kinesiophobia, QoL, sternal stability and adherence at week 0, 4 and 12.	No significant difference between groups SPPB at week 4 (95% *CI* -0.2–2.3) or week 12 (95% *CI* -0.9–1.6), nor secondary outcomes. Both groups measurements improved with time after surgery. No difference in sternal complications.

First author	Source origin	Aim/purpose	Design/ method-ology	Sample size	Comparison	Outcome measures	Key findings
LaPier, 2018	USA	Survey physio-therapists application of sternal precautions.	Question-naire.	$n = 29$.	NA.	Descriptive questionnaire; type of sternal precautions, RoM restriction, weightlifting restriction, duration of restrictions, occurrence of dehiscence, sternal instability and pain.	Sternal precautions are commonly prescribed to patients following sternotomy, their application is highly variable.
Hong, 2017	Australia	Does a continuous local anaesthesia improve pain control and walking distance post CABG.	RCT.	$n = 75$. IG $n = 26$ Mean age 60 Male 81%. Sham group $n = 25$. Mean age 62 Male 80%. CG $n = 24$ Mean age 58 Male 83%.	IG – received 0.5% Ropivacaine solution via two tunnelled parasternal catheters. Sham group – as above with saline solution. CG – standard pain therapies (PCA and oral analgesia).	Pain VAS score, walking distance, proportion of patients discharged on POD_4.	No differences in pain before or after PT from POD1–4 ($p = 0.110$). No difference in distance walked between groups ($p = 0.230$). No difference in number of patients discharged from PT on POD4 ($p = 0.510$).
Sturgess, 2014	Australia	Do thoracic exercises improve pain, RoM and HRQoL following cardiac surgery.	RCT (pilot).	$n = 38$. IG $n = 23$, mean age – 63, male – 74%. CG $n = 15$ mean age – 59, male – 93%.	IG = individualised thoracic exercise programme plus walking programme. CG = 2 × daily walking programme.	Shoulder and thoracic ROM, pain, HRQoL.	At 4 weeks IG group reported statistically significant less sternal pain ($p = 0.03$; 95% *CI* -0.28–0.0). No difference at 3 months ($p = 0.79$). IG perceived home PT contributed more to recovery ($p = 0.04$; 95% *CI* -2.1–0.0).

First author	Source origin	Aim/purpose	Design/ methodology	Sample size	Comparison	Outcome measures	Key findings
Patient and staff experience							
Chang, 2017	Taiwan	Early illness experiences of unexpected heart surgery.	Qualitative descriptive Semi structured interviews.	*n* = 13.	NA.	NA.	Themes: symptoms, physical and emotional disturbances, establishing new life and support after surgery. MDT input and education should be initiated as soon as possible to facilitate recovery.
Lapum, 2016	Canada	Facilitation and barriers to discharge post heart surgery.	Narrative account via 2 interviews.	*n* = 17, 10 patients 7 nurses.	NA.	NA.	Cognitive ability post-op impeded so pre-op education optimal time for education. Recommend group and scenario based education. Support needed at home post discharge.

First author	Source origin	Aim/purpose	Design/ method-ology	Sample size	Comparison	Outcome measures	Key findings
Bowen, 2015	USA	Does visual art displayed on walls motivate patients to walk more frequently and further distances.	Quasi-experimental design.	$n = 86$ (included lower extremity. revascular-isation). CG1 $n = 34$, mean age – 61, male – 80%, cardiac surgery – 47%. CG2 $n = 25$, mean age – 63, male – 63%, cardiac surgery 96%. IG $n = 31$, mean age – 63, male – 76%, cardiac surgery 100%.	CG1 – usual hospital artwork on walls. CG2 – no artwork on walls. IG – artwork created by hospital staff on walls.	Distance walked, frequency walked, art experience.	Statistically significant difference in distance walked on day 1 in IG ($p = 0.052$). No difference in frequency walked. No statistically significant difference in LOS. Statistically significant IG walked further on POD1 (median 370 feet), than CG1 and CG2 (median 270 feet) ($p = 0.052$). No statistical significance difference in number of times walked per day. No statistically significant difference was found in total mood disturbance among the three groups at discharge ($p = 0.78$). Patients in IG reported higher positive art experience compared to CG1 ($p < 0.05$).

First author	Source origin	Aim/purpose	Design/ method-ology	Sample size	Comparison	Outcome measures	Key findings
Adverse events							
Sousa, 2021	Brazil	Adverse events during PT in ICU after cardiac surgery.	Prospective observational study.	*n* = 323 patients, mean age – 59, male 57%.		Assessed against 12 physiological abnormalities or adverse events, plus severity rating.	935 PT sessions observed 46% of patients had at least 1 adverse event. 20% incidence (95% *CI* 18–23%). Incidence of adverse events: suction 44%, walking 40%, NIV 37%, sitting on edge of bed 28%, IPPB 26%. Type of adverse events: 74% haemodynamic changes, most rated as near miss or mild severity.

6MWD = six minute walk distance, 6MWT = six minute walk test, ACBT = active cycle of breathing techniques, BiPAP = bilevel positive airway pressure, BP = blood pressure, CABG = coronary artery bypass graft, CG = control group, CPAP = continuous positive airway pressure, CPET = cardiopulmonary exercise test, CXR = chest XRay, DBEs = deep breathing exercises, DVT = deep vein thrombosis, EPAP = expiratory positive airway pressure, ERAS = enhanced recovery after surgery, FEV_1 = forced expiratory volume in the first second, FVC = forced vital capacity, HFNO = high flow nasal oxygen, HR = heart rate, HRQoL = health related quality of life, ICU = intensive care unit, IG = intervention group, IMT = inspiratory muscle training, IPPB = inspiratory positive pressure breathing, IS = incentive spirometry, KYMITT = Keep your move in the tube, LL = lower limb, LOS = length of stay, LVEF = left ventricle ejection fraction, MI:E = mechanical insufflation:exsufflation, MIP = maximal inspiratory pressure, MEP = maximal expiratory pressure, NIV = non-invasive ventilation, NMES = neuromuscular electrical stimulation, PCA = patient controlled analgesia, PEP = positive expiratory pressure, PFT = pulmonary function test, POD = post operative day, PPC = post operative pulmonary complications, PROMs = patient reported outcome measures, PT = physiotherapy, QoL = quality of life, RCT = randomised control trial, RoM = range of movement, RR = respiration rate, SpO_2 = peripheral oxygen saturation, SPPB = short performance physical battery, SR = systematic review, UL = upper limb, VA = ventilator assistance, VAS = visual analogue scale, V_T = tidal volume.

References

1 National Institute for Cardiovascular Outcomes Research. *National Adult Cardiac Surgery Audit (NACSA). 2020 Summary Report (2016/17–2018/19 data).* 2020. https://www.nicor.org.uk/wp-content/uploads/2020/12/National-Adult-Cardiac-Surgery-Audit-NACSA-FINAL.pdf.

2 Specialty Advisory Committee and Society for Cardiothoracic Surgery in Great Britain and Ireland. *U.K. Cardiothoracic Surgery Workforce Report.* 2019. https://scts.org/_userfiles/pages/files/sctsworkforcereport2019.pdf.

3 Sullivan KA, Churchill IF, Hylton DA, Hanna WC. Use of Incentive Spirometry in Adults following Cardiac, Thoracic, and Upper Abdominal Surgery to Prevent Post-Operative Pulmonary Complications: A Systematic Review and Meta-Analysis. *Respiration.* 2021;100(11):1114–1127. https://doi.org/10.1159/000517012.

4 Chen B, Xie G, Lin Y, Chen L, Lin Z, You X, Xie X, Dong D, Zheng X, Li D, Lin W. A systematic review and meta-analysis of the effects of early mobilization therapy in patients after cardiac surgery. *Medicine (Baltimore).* 2021 Apr 16;100(15):e25314. https://doi.org/10.1097/md.0000000000025314.

5 Ramos Dos Santos PM, Aquaroni Ricci N, Aparecida Bordignon Suster É, de Moraes Paisani D, Dias Chiavegato L. Effects of early mobilisation in patients after cardiac surgery: a systematic review. *Physiotherapy.* 2017;103(1):1–12. https://doi.org/10.1016/j.physio.2016.08.003.

6 Peters M, Godfrey C, McInerney P, et al. Chapter 11: Scoping Reviews. In: Aromataris E, Munn Z (Editors). JBI Manual for Evidence Synthesis, JBI. 2020. Available from https://synthesismanual.jbi.global. https://doi.org/10.46658/JBIMES-20-12.

7 Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic Review or Scoping Review? Guidance for Authors When Choosing Between a Systematic or Scoping Review Approach. *BMC Med Res Methodol.* 2018;18(1):143. Published 2018 Nov 19. https://doi.org/10.1186/s12874-018-0611-x.

8 Khalil H, Peters M, Godfrey CM, McInerney P, Soares CB, Parker D. An Evidence-Based Approach to Scoping Reviews. *Worldviews Evid Based Nurs.* 2016 Apr;13(2):118–23. https://doi.org/10.1111/wvn.12144.

9 Clarivate Analytics. *Endnote software.* 2021. Available at https://endnote.com. Accessed Jan–March 2021.

10 Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, Moher D. The PRISMA 2020 statement: an updated

guideline for reporting systematic reviews. *BMJ.* 2021 Mar 29;372:n71. https://doi.org/10.1136/bmj.n71.

11 Critical Appraisal Skills Programme. *CASP Checklist.* 2020. Available at: https://casp-uk.net/casp-tools-checklists/. Accessed: January–March 2021.

12 Joanne Briggs Institue (JBI). *Critical Appraisal Checklist for Systematic Reviews and Research Syntheses.* https://jbi.global/critical-appraisal-tools. Accessed: January–March 2021.

13 Chang YL, Tsai YF. Early Illness Experiences Related to Unexpected Heart Surgery: A Qualitative Descriptive Study. *Aust Crit Care.* 2017;30(5):279–285. https://doi.org/10.1016/j.aucc.2016.11.005.

14 Kamisaka K, Sakui D, Hagiwara Y, et al. Mechanical Ventilatory Assistance May Reduce Dyspnea During Walking Especially in Patients With Impaired Cardiopulmonary Function Early After Cardiovascular Surgery. *J Cardiol.* 2016;67(6):560–566. https://doi.org/10.1016/j.jjcc.2015.08.003.

15 Dholakia K, Hemli J, Gill H, et al. Transport Bipap and High-Flow Nasal O_2 During Early Mobility Accelerate Recovery Aafter Cardiac Surgery. *Critical Care Medicine.* 2018;47(1): 1138.

16 Pantoni CB, Di Thommazo-Luporini L, Mendes RG, et al. Continuous Positive Airway Pressure During Exercise Improves Walking Time in Patients Undergoing Inpatient Cardiac Rehabilitation After Coronary Artery Bypass Graft Surgery: A Randomized Controlled Trial. *J Cardiopulm Rehabil Prev.* 2016;36(1):20–27. https://doi.org/10.1097/hcr.0000000000000144.

17 Pieczkoski SM, de Oliveira AL, Haeffner MP, Azambuja ACM, Sbruzzi G. Positive expiratory pressure in postoperative cardiac patients in intensive care: A randomized controlled trial. *Clin Rehabil.* 2021;35(5):681–691. https://doi.org/10.1177/0269215520972701.

18 Naswa S, Tuteja R, Gupta VP, et al. Comparison of Acapella Versus Active Cycle of Breathing Technique in Post-Operative Pulmonary Complications After Valve Replacement Surgeries [With Consumer Summary]. *Indian Journal of Physiotherapy and Occupational Therapy.* 2017;11(2):24–29.

19 Pettersson H, Faager G, Westerdahl E. Improved Oxygenation During Standing Performance of Deep Breathing Exercises With Positive Expiratory Pressure After Cardiac Surgery: A Randomized Controlled Trial. *J Rehabil Med.* 2015;47(8):748–752. https://doi.org/10.2340/16501977-1992.

20 Alaparthi GK, Amin R, Gatty A, et al. Contrasting effects of three breathing techniques on pulmonary function, functional capacity and daily life functional tasks in patients following valve replacement surgery – A pilot randomized clinical trial. *Heliyon.*

2021;7(7):e07643. Published 2021 Jul 22. https://doi.org/10.1016/j.heliyon.2021.e07643.

21 Wu MF, Wang TY, Chen DS, et al. The Effects of Mechanical Insufflation-Exsufflation on Lung Function and Complications in Cardiac Surgery Patients: A Pilot Study. *J Cardiothorac Surg.* 2021;16(1):350. Published 2021 Dec 9. https://doi.org/10.1186/s13019-021-01738-x.

22 Zochios V, Collier T, Blaudszun G, et al. The Effect of High-Flow Nasal Oxygen on Hospital Length of Stay in Cardiac Surgical Patients at High Risk For Respiratory Complications: A Randomised Controlled Trial. *Anaesthesia.* 2018;73(12):1478–1488. https://doi.org/10.1111/anae.14345.

23 Cargnin C, Karsten M, Guaragna JCVDC, Dal Lago P. Inspiratory Muscle Training After Heart Valve Replacement Surgery Improves Inspiratory Muscle Strength, Lung Function, and Functional Capacity: A Randomized Clinical Trial. *J Cardiopulm Rehabil Prev.* 2019;39(5):E1–E7. https://doi.org/10.1097/hcr.0000000000000409.

24 Salehi Derakhtanjani A, Ansari Jaberi A, Haydari S, Negahban Bonabi T. Comparison the Effect of Active Cyclic Breathing Technique and Routine Chest Physiotherapy on Pain and Respiratory Parameters After Coronary Artery Graft Surgery: A Randomized Clinical Trial. *Anesth Pain Med.* 2019;9(5):e94654. https://doi.org/10.5812/aapm.94654.

25 Monteleone S, Dalla Toffola E, Emiliani V, et al. Recovery of Deambulation After Cardiothoracic Surgery: A Single Center Experience. *Eur J Phys Rehabil Med.* 2015;51(6):763–771.

26 Afxonidis G, Moysidis DV, Papazoglou AS, et al. Efficacy of Early and Enhanced Respiratory Physiotherapy and Mobilization After On-Pump Cardiac Surgery: A Prospective Randomized Controlled Trial. *Healthcare (Basel).* 2021;9(12):1735. Published 2021 Dec 15. https://doi.org/10.3390/healthcare9121735.

27 Ribeiro BC, Poça JJGD, Rocha AMC, et al. Different physiotherapy protocols after coronary artery bypass graft surgery: A randomized controlled trial. *Physiother Res Int.* 2021;26(1):e1882. https://doi.org/10.1002/pri.1882.

28 Tariq MI, Khan AA, Khalid Z, Farheen H, Siddiqi FA, Amjad I. Effect of Early ≤3 Mets (Metabolic Equivalent of Tasks) of Physical Activity on Patient's Outcome After Cardiac Surgery. *J Coll Physicians Surg Pak.* 2017;27(8):490–494.

29 Pizzorno M, Desilvestri M, Lippi L, et al. Early Cardiac Rehabilitation: Could t Improve Functional Outcomes and Reduce Length of Stay and Sanitary Costs In Patients Aged 75 Years or Older? A Retrospective Case-Control Study. *Aging Clinical and Experimental Research.* 2020. https://doi.org/10.1007/s40520-020-01589-x.

30 Miwa S, Visintainer P, Engelman R, et al. Effects of an Ambulation Orderly Program Among Cardiac Surgery Patients. *Am J Med.* 2017;130(11):1306–1312. https://doi.org/10.1016/j.amjmed.2017.04.044.

31 Pack QR, Woodbury EA, Headley S, et al. Ambulation Orderlies and Recovery After Cardiac Surgery: A Pilot Randomized Controlled Trial. *J Clin Exerc Physiol.* 2017;6(3):42–49. https://doi.org/10.31189/2165-6193-6.3.42.

32 Floyd S, Craig SW, Topley D, Tullmann D. Evaluation of a Progressive Mobility Protocol in Postoperative Cardiothoracic Surgical Patients. *Dimens Crit Care Nurs.* 2016;35(5):277–282. https://doi.org/10.1097/dcc.0000000000000197.

33 Fontes Cerqueira TC, Cerqueira Neto ML, Cacau LAP, et al. Ambulation Capacity and Functional Outcome in Patients Undergoing Neuromuscular Electrical Stimulation After Cardiac Valve Surgery: A Randomised Clinical Trial. *Medicine (Baltimore).* 2018;97(46):e13012. https://doi.org/10.1097/md.0000000000013012.

34 Trevisan MD, Lopes DG, Mello RG, Macagnan FE, Kessler A. Alternative Physical Therapy Protocol Using a Cycle Ergometer During Hospital Rehabilitation of Coronary Artery Bypass Grafting: a Clinical Trial. *Braz J Cardiovasc Surg.* 2015;30(6):615–619. https://doi.org/10.5935/1678-9741.20150085.

35 Zanini M, Nery RM, de Lima JB, Buhler RP, da Silveira AD, Stein R. Effects of Different Rehabilitation Protocols in Inpatient Cardiac Rehabilitation After Coronary Artery Bypass Graft Surgery: A Randomized Clinical Trial. *J Cardiopulm Rehabil Prev.* 2019;39(6):E19–E25. https://doi.org/10.1097/hcr.0000000000000431.

36 Kubitz JC, Schulte-Uentrop L, Zoellner C, et al. Establishment of An Enhanced Recovery After Surgery Protocol in Minimally Invasive Heart Valve Surgery. *PLoS One.* 2020;15(4):e0231378. Published 2020 Apr 9. https://doi.org/10.1371/journal.pone.0231378.

37 Mungovan SF, Singh P, Gass GC, Smart NA, Hirschhorn AD. Effect of Physical Activity in The First Five Days After Cardiac Surgery. *J Rehabil Med.* 2017;49(1):71–77. https://doi.org/10.2340/16501977-2165.

38 Borges DL, Silva MG, Silva LN, et al. Effects of Aerobic Exercise Applied Early After Coronary Artery Bypass Grafting on Pulmonary Function, Respiratory Muscle Strength, and Functional Capacity: A Randomized Controlled Trial. *J Phys Act Health.* 2016;13(9):946–951. https://doi.org/10.1123/jpah.2015-0614.

39 Takei M, Nozawa E, Sousa ML, et al. Physiotherapy Intervention Is Safety in Early Postoperative Patients After Cardiac Surgery? *European Respiratory Journal.* 2017;50(61). https://erj.ersjournals.com/content/50/suppl_61/PA2560.

40 Sousa MLA, Coimbra VRM, Takei MT, Melo CCA, Feltrim MIZ, Nozawa E. Physiological abnormalities and adverse events during physical therapy in the intensive care unit after cardiac surgery: A prospective observational study. *Braz J Phys Ther.* 2021;25(5):623–631. https://doi.org/10.1016/j.bjpt.2021.04.001.

41 Borzou SR, Amiri S, Salavati M, Soltanian AR, Safarpoor G. Effects of the First Phase of Cardiac Rehabilitation Training on Self-Efficacy among Patients Undergoing Coronary Artery Bypass Graft Surgery. *J Tehran Heart Cent.* 2018;13(3):126–131.

42 Bowen MG, Wells NL, Dietrich MS, Sandlin V. Art to Heart: The Effects of Staff-Created Art on the Postoperative Rehabilitation of Cardiovascular Surgery Patients. *Medsurg Nurs.* 2015;24(5):349–355.

43 Gach R, Triano S, Ogola GO, et al. 'Keep Your Move in The Tube' Safely Increases Discharge Home Following Cardiac Surgery. *PM R.* 2021;13(12):1321–1330. https://doi.org/10.1002/pmrj.12562.

44 Radfar J, Fuchs L, Cahalin LP. An Alternative Approach to Sternal Precautions Improves Length of Stay After Median Sternotomy. *Cardiopulmonary Physical Therapy Journal.* 2019.

45 Katijjahbe MA, Granger CL, Denehy L, et al. Standard Restrictive Sternal Precautions and Modified Sternal Precautions Had Similar Effects in People After Cardiac Surgery Via Median Sternotomy ('Smart' Trial): A Randomised Trial. *J Physiother.* 2018;64(2):97–106. https://doi.org/10.1016/j.jphys.2018.02.013.

46 LaPier T, Perilli P, Solly K, et al. Physiotherapists' Descriptions and Perceptions of Wound Protection and Arm Activity Restrictions Following Median Sternotomy: An International Perspective. *Cardiopulmonary Physical Therapy Journal.* 2018.

47 Sturgess T, Denehy L, Tully E, et al. A Pilot Thoracic Exercise Programme Reduces Early (0–6 Weeks) Sternal Pain Following Open Heart Surgery [With Consumer Summary]. *International Journal of Therapy and Rehabilitation.* 2014;21(3):110–117.

48 Hong SS, Alison JA, Milross MA, Robledo K, Dignan R. Does Continuous Infusion of Local Anaesthesia Improve Pain Control and Walking Distance After Coronary Artery Bypass Graft Surgery? A Randomised Controlled Trial. *Physiotherapy.* 2017;103(4):407–413. https://doi.org/10.1016/j.physio.2017.02.002.

49 Boitor M, Martorella G, Maheu C, Laizner AM, Gélinas C. Effects of Massage in Reducing the Pain and Anxiety of the Cardiac Surgery Critically Ill: A Randomized Controlled Trial. *Pain Med.* 2018;19(12):2556–2569. https://doi.org/10.1093/pm/pny055.

50 Lapum JL, Fredericks S, Liu L, et al. Facilitators and Barriers of Heart Surgery Discharge: Patients' and Nurses' Narrative Accounts. *J Cardiovasc Nurs.* 2016;31(4):350–356. https://doi.org/10.1097/jcn.0000000000000253.

51 El-Ansary D, LaPier TK, Adams J, et al. An Evidence-Based Perspective on Movement and Activity Following Median Sternotomy. *Phys Ther.* 2019;99(12):1587–1601. https://doi.org/10.1093/ptj/pzz126.