Journal of the Association of Chartered Physiotherapists in Respiratory Care

Volume 54 • Issue 1 • 2022

www.acprc.org.uk

ACPRC

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Editor foreword

Welcome to volume 54 issue 1, which is our 1st publication of 2022. The fact that we have had 4 publications within the last year, is testament to the hard work of the authors and reviewers, our continued thanks to each one of you.

This edition of the journal continues to reflect the diversity of the areas in which respiratory physiotherapists work. The volume starts with Sheill et al. who report on a retrospective chart review on physiotherapy input and outcomes in patients hospitalised with COVID-19. Service evaluations are presented by Hubbard et al., who report on mechanical in-sufflation/exsufflation in acute cervical spinal cord injury, and Fang Tan et al. on physiotherapy-led early mobilisation protocol for neurosurgical patients with external ventricular drains in intensive care. The paper by Odebiyi et al. investigates the influence of age and gender on cardiovascular response to isometric exercise in healthy individuals, and a scoping review by Coleman et al. asks the question as to whether there is a link between the activity levels of parents and their children with cystic fibrosis. Weblin et al. report on a service evaluation on whether the incremental shuttle walk test predicts the development of pneumonia amongst elective oesophagectomy.

In this volume there is also an invited editorial by Ema Swingwood (outgoing ACPRC Chair) and Dr. Harriet Shannon (incoming ACPRC Vice-Chair) with the piece entitled *The future is bright and exciting, and it must involve research*. We are also extremely pleased to include a further output from the ACPRC editorial board, led by Dr. Una Jones. The editorial board is tasked with leading the scoping, commissioning, co-ordination, and delivery of all new ACPRC guidance documents and resources and in this publication, Eden et al. present a scoping review on post-operative physiotherapy in people undergoing thoracic surgery.

We hope that you enjoy reading this issue of the ACPRC journal, and that you are inspired to write up and submit your work. We have now made a change to the submission process, with 2 submission windows per year closing on the 1st April and 1st November followed by 2 publications per year. Submission guidelines are available on the ACPRC website www.acprc.org.uk and are due to undergo some updates, so please review them prior to submitting to the journal. Please remember that we also provide members with support through the research officer and as editors we are very happy to discuss any potential article ideas with you too.

Kind regards

Amy Bendall (MSc, MCSP) and Owen Gustafson (MSc Res, MCSP)

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Reviewers' acknowledgement

The journal editors and ACPRC committee would like to warmly thank the following 40 reviewers who reviewed manuscripts in 2021.

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Physiotherapy input and outcomes in patients hospitalised with COVID-19: A retrospective chart review

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Abstract

Objectives

The primary aim of this study was to profile the acute physiotherapy service provided to patients admitted to hospital with COVID-19.

Design

A retrospective observational chart review was completed on all patients admitted to an acute hospital with a confirmed diagnosis of COVID-19 between March and May 2020.

Participants

All patients admitted to hospital with a COVID-19 diagnosis receiving ICU and/or ward-based care were included in this study.

Main outcome measures

Baseline information (including demographic information and mobility status), physiotherapy treatment information, time to achieve functional mobility goals and discharge information (including length of stay, discharge destination and mobility status on discharge) was collected for each patient.

Results

A retrospective chart review of 171 charts was performed. Patients admitted for ward-based care (n = 130) were referred to physiotherapy on average 3 days post hospital admission (SD 4.45) with 72%

Note

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Keywords

Rehabilitation, physiotherapy, COVID-19, SARS-CoV-2.

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of patients documented as 'off pre-morbid mobility' on initial physiotherapy assessment. Of the 100 patients discharged from ward-based care, 86 (87%) of patients returned to baseline mobility status. All patients were referred for physiotherapy during their critical care stay (n = 41, range: 0–49 sessions). Of the 35 patients who survived an ICU stay, 26 (71%) patients had returned to baseline pre-morbidity mobility status on discharge home while 5 (14%) patients required increased aids/assistance with mobility when compared to baseline function. A further 4 patients (11%) were still receiving inpatient rehabilitation at the time of chart review. Factors such as older age and longer hospital length of stay were significant predictors of likelihood of referral to physiotherapy.

Conclusions

This chart review found a significant number of patients hospitalised with COVID-19 required physiotherapy input, particularly older patients and those with a longer hospital length of stay.

Introduction

Treating COVID-19 (SARS-CoV-2) infections has posed an enormous challenge to healthcare systems across the globe (Rothan & Byrareddy, 2020). While the number of recovered patients continues to increase, there are many unanswered questions regarding what recovery from COVID-19 infection entails, including the rehabilitation required to support the physical recovery of patients hospitalised with COVID-19 (Hosey & Needham, 2020; Sheehy, 2020).

Patients admitted to critical care with COVID-19 may require extensive rehabilitation in order to regain losses in muscle strength and physical function (Van Aerde et al., 2020; McWilliams et al., 2021). While it is known that critical care rehabilitation is safe and should be commenced as early as possible (Thomas et al., 2020), it is unknown if those hospitalised with COVID-19 infection recover in a predicted fashion and whether traditional mechanisms for rehabilitation meet the needs of this group (Bailey et al., 2007). Physical weakness may also occur in those admitted for ward-based care as a result of deconditioning caused by illness and inactivity during hospital admission (Townsend et al., 2020). As the effects of COVID-19 infection are more systemic than initially expected it is naive to assume a return to baseline function (pre-hospital admission mobility status) for all COVID-19 positive

survivors (Arentz et al., 2020; Townsend et al., 2021). Physiotherapists have a role in providing exercise, mobilisation and rehabilitation interventions to survivors of critical illness associated with COVID-19 in order to enable a functional return to home (Jose & Dal Corso, 2016; Thomas et al., 2020). Recent work has identified functional status as a strong predictor for discharge destination for patients with COVID-19 (Roberts et al., 2021). However, further information is needed to identify the impact of COVID-19 on the rehabilitation needs of patients post critical care or those admitted for ward-based care. There is an absence of studies addressing predictors for discharge destination and describing rehabilitation selection criteria for patients with COVID-19 (Wang et al., 2020; Ceravolo et al., 2020). More information on use of rehabilitation services, as well as objective descriptors of functional recovery and patient rehabilitation needs on hospital discharge, may provide valuable insight into the supportive services required to support patient discharge.

The primary aim of this study was to profile the acute physiotherapy service provided to patients admitted with COVID-19. Secondary aims were to examine patients' rehabilitation needs on hospital discharge and to examine the association between patient characteristics and likelihood of receiving a referral to physiotherapy, likelihood of returning to baseline mobility status and likelihood of discharge home.

Methods

A retrospective patient chart review was completed in September 2020 on all patients admitted to St James's Hospital with a confirmed diagnosis of COVID-19 between 16th March and 14th May, 2020. Exclusion criteria included the charts of patients who contracted and were diagnosed with COVID-19 during the course of their inpatient stay. St James's Hospital is the largest acute teaching hospital in Ireland and is partnered academically with Trinity College Dublin.

Data source

Data were obtained from the inpatient hospital databases: the electronic patient record (EPR) system for ward-based care, including rehabilitation, and ICU electronic patient record (the IntelliSpace Critical Care and Anaesthesia-ICCA, Phillips), allowing patients to be followed throughout their entire hospital stay.

Data collection

Each patient admitted with a positive SARS-CoV-2 RT-PCR was identified in the EPR and ICCA database. A standardised data collection tool was created for the collection of all data. Demographic information (including gender, age, medical history and ethnicity) and information regarding hospital stay (including admission to ICU or ward-based care, hospital length of stay) was collected for each patient by 2 members of the research team. Where differences between the 2 researchers' results were encountered, the chart was re-examined by both observers and results were recorded after an agreement was reached.

The standard of care for physiotherapy input in the study centre was:

1. Early rehabilitation in ICU facilitated by a blanket referral to physiotherapy for every patient on the day of ICU admission.
2. Needs based referrals to physiotherapy by the medical teams of patients admitted for ward-based care.

All physiotherapy input was delivered in the context of a multi-disciplinary care model (where physicians, nurses, physiotherapists, clinical pharmacists, and other staff members provide critical care as a team). Information on the physiotherapy rehabilitation received by each patient was collected, including information on referral to physiotherapy (yes/no), referral to other members of the multidisciplinary team, the number of days to referral to physiotherapy and the number and duration of each physiotherapy session. A pre-admission functional mobility status and functional mobility status on hospital discharge was recorded for each patient from inpatient physiotherapy documentation. Pre-admission mobility status was determined from documentation of the patient's subjective history on admission. For patients receiving ward-based care, time from physiotherapy referral until mobility away from bedside was collected. For patients admitted to ICU, information was collected on time from referral to physiotherapy until patients successfully achieved the following standardised functional milestones on the ICU mobility scale: independent sitting, independent transfers, independent mobility away from bedside and independent completion of stairs (Hodgson et al., 2014). Functional mobility status on hospital discharge was determined from the objective assessment of patient mobility prior to discharge. Discharge information recorded for all patients included discharge destination (transfer for further inpatient rehabilitation, home, home with community rehab, long-term care, death, remains inpatient in study centre) and referral to community-based physiotherapy on discharge (yes/no).

For patients admitted to ICU additional information was collected, including PaO_2/FiO_2 on admission, intubation (yes/no), tracheostomy (yes/no), ICU length of stay, the number of days on ventilation and any activity related desaturation during physiotherapy sessions.

Ethical consideration

The study was approved by the Tallaght St James's Research Ethics Committee (reference number: 2020-06, list 23).

Statistical analysis

Data were analysed using SPSS (2013). Descriptive statistics, namely percentage, mean, and standard deviation, were used for quantitative variables.

We compared factors (for example, patient characteristics, referral to physiotherapy) and patient outcomes (return to baseline function, hospital discharge destination) using the *t* test for means of continuous variables and the χ^2 test for categorical variables. Each factor was 1st tested individually, before all factors that showed an association in

the univariate model (p <0.10) were added to a multivariable model (Mudge et al., 2012). We used multivariable logistic regression analysis [backward stepwise selection (likelihood ratio) (PIN <0.05, POUT >0.10)] to determine the association between different factors (for example, length of stay) and referral to physiotherapy (yes/no). The Hosmer-Lemeshow goodness-of-fit test, was used to assess model fit. ANOVA was used to assess any association between patient characteristics (for example, age) and outcomes (for example, discharge destination). p values of <0.05 were considered to be statistically significant.

Results

A retrospective chart review of 171 charts was performed. The clinical characteristics of patients are described in Table 1. Patients admitted to ICU were significantly younger than patients admitted for ward-based care (mean 61 v. 65 years, $p = 0.045$). In total 98 patients (57%) received a referral for physiotherapy during their inpatient stay. Of the 135 patients alive at the time of data analysis, a total of 19 (14%) patients had not returned to baseline function (pre-hospital admission mobility status). 57% of patients ($n = 97$) receiving physiotherapy input had input from a mean of 2 other members of the multi-disciplinary team (MDT) (IQR 0–4) (including clinical nutrition, speech and language therapy, occupational therapy and social work).

Table 1: Patient demographics.

Characteristic	Total study cohort ($n = 171$) n (%)/mean ± SD	ICU patients ($n = 41$)	Ward patients ($n = 130$)
Male/female	106 (62)/65 (38)	32 (78)/9 (22)	74 (57)/56 (43)
Age (years)	64 ± 18.7	61 ± 11.7	65 ± 20
LOS (days)	17 ± 19.1	22 ± 13	16 ± 20
RIP, Yes	36 (21)	6 (15)	30 (23)
Medical history			
Cardiac history	76 (44)	22 (54)	54 (42)
Cancer	29 (17)	2 (5)	27 (21)
Respiratory (COPD and asthma)	41 (24)	12 (29)	29 (22)
Cognitive impairment	26 (15)	1 (2)	25 (19)
Race			
White	135 (79)	30 (73)	105 (81)
Asian	14 (8)	6 (15)	8 (6)
Black	9 (5)	3 (7)	6 (5)
Other/unknown	12 (7)	2 (5)	10 (8)

Characteristic	Total study cohort ($n = 171$) n (%)/mean ± SD	ICU patients ($n = 41$)	Ward patients ($n = 130$)
Baseline function			
Independent mobility	122 (71)	38 (93)	84 (65)
Independent mobility with aid	26 (15)	2 (5)	24 (18)
Assistance or supervision with a mobility aid	11 (6)	-	11 (8)
Hoist dependent	4 (2)	-	4 (3)
Unknown	9 (5)	1 (2)	8 (6)
Referred to physiotherapy	98 (57)	41 (100)	57 (44)
Time from admission to referral, days	3.44 ± 4.45	2 ± 4.5	4 ± 4
Active physiotherapy sessions (number of sessions)	9 ± 11.3	8.87 ± 9.34	8.96 ± 12.79
Time spend with physiotherapy (minutes)	195 ± 315	173 ± 230	211 ± 365
Hospital discharge destination			
Further inpatient rehab	6 (3.5)	1 (2)	5 (4)
Home	100 (58.5)	27 (66)	73 (56)
Home with community rehab	18 (10.5)	3 (7)	15 (12)
LTC	6 (3.5)	0 (0)	6 (5)
Death	36 (21)	6 (15)	30 (23)
Remains inpatient in study centre	4 (2.3)	4 (10)	0 (0)

LOS: length of stay; COPD: chronic obstructive pulmonary disease; LTC: long term care.

Physiotherapy service provided to patients admitted with COVID-19

Ward-based physiotherapy

A total of 130 patients received ward-based care only (Table 1). Patients admitted for ward-based care were referred to physiotherapy by their medical teams a mean of 3 days post hospital admission (*SD* 4.45). Amongst patients referred for physiotherapy, 72% of patients were documented as 'off baseline mobility function' upon initial assessment. Patients admitted for ward-based care mobilised away from the bedside on average 3 days after referral to physiotherapy (*SD* 6).

A total of 41 patients were admitted to ICU (Table 1), with 28 (68%) of these patients intubated. The mean PaO_2/FiO_2 on admission to ICU was 22.2 (*SD* 15.8). The mean duration of intubation was 13.2 days (*SD* 10.5, range 2–43 days), with 5 patients receiving a tracheostomy during their ICU stay. The mean ICU length of stay (ICU-LOS) was 15.8 days (*SD* 13.9, range 2–69 days). All patients were referred for physiotherapy during their critical care stay (range: 0–49 sessions). Patients began active rehabilitation sitting over the edge of the bed a mean of 9.9 days (range 2–38 days) after ICU admission and progressed to mobilise away from the bedside 12.96 days post ICU admission (range 1–33) (Figure 1). In total 20 (49%) participants experienced a documented oxygen desaturation during physical rehabilitation in ICU, the majority while transferring out of bed and mobilising (SpO_2 90–95% $n = 6$, SpO_2 85–90% $n = 8$, SpO_2 80–85% $n = 4$, SpO_2 75–80% $n = 2$).

A total of 38 (93%) patients had independent mobility before admission to ICU. Of the 35 patients who survived an ICU stay, 26 (71%) patients had returned to baseline mobility status on discharge home while 5 (14%) patients required increased aids/assistance with mobility when compared to baseline function. A further 4 patients (11%) were still receiving inpatient rehabilitation at the time of the chart review.

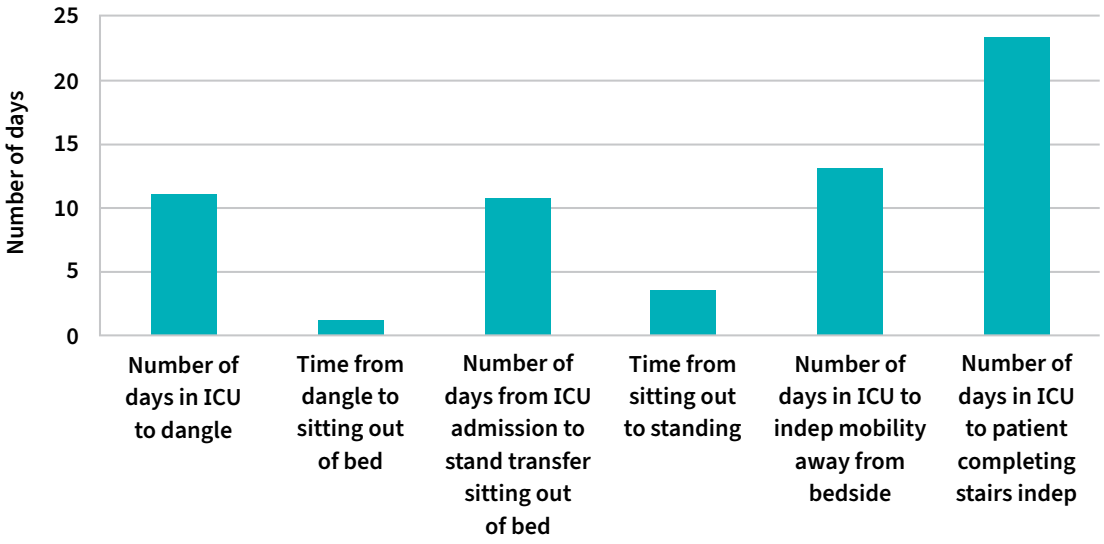

Figure 1: Functional mobility milestones in ICU.

Rehabilitation needs on hospital discharge

Of the 100 patients discharged from ward-based care, 86 (87%) of patients returned to their documented baseline mobility status. A total of 38 (93%) patients had independent mobility before admission to ICU. Of the 35 patients who survived an ICU stay, 26 (74%) patients had returned to baseline mobility status on discharge home while 5 (14%) patients required increased aids/assistance with mobility when compared to baseline function. A further 4 patients (11%) were still receiving inpatient rehabilitation at the time of the chart review. The chart review identified that 13% ($n = 17$) of the 131 patients discharged home had a documented onward referral for further physiotherapy input in the community.

Factors associated with referral to physiotherapy

Male patients were significantly more likely to be referred to physiotherapy than females ($p = 0.004$). Patients with a cardiac history were also more likely to be referred to physiotherapy ($p = 0.025$) however no association was found between a cancer history, respiratory history (COPD and asthma), cognitive impairment (a documented diagnosis of dementia or Alzheimer's disease) and likelihood of referral to physiotherapy. Patients were less likely to have independent mobility on hospital discharge if referred to physiotherapy ($p = 0.038$). Multivariate analysis demonstrated older patients and those with a longer length of stay were significant predictors of those more likely to be referred to physiotherapy ($p < 0.001$) (Table 2).

Table 2: Multiple logistic regression model for factors associated with referral to physiotherapy.

Variable	OR	95% *CI*	*p*-value
Patient gender	.433	0.158–0.708	0.105
Hospital length of stay	1.113	1.052–1.174	<0.001
Age	1.040	1.007–1.073	0.018
Cardiac history	.591	0.187–0.995	0.669

Factors associated with return to baseline function

Cardiac history and history of cognitive impairment were significantly associated with a lower likelihood of return to baseline function on discharge home ($p = 0.041$ and $p = 0.046$ respectively). A cancer history ($p = 0.113$), respiratory history ($p = 0.251$), gender ($p = 0.287$), ethnicity ($p = 0.988$) and an admission to ICU ($p = 0.572$) had no association with return to baseline function. Results of the ANOVA analysis found both patient's age and hospital length of stay were significantly associated with likelihood of return to baseline function (both $p < 0.001$). In addition, receiving a higher number or longer physiotherapy sessions was not found to increase the likelihood of returning to baseline function (Table 3).

Table 3: Results of ANOVA analysis: Factors associated with return to baseline function.

Factors associated with return to baseline function	η^2	Mean square	F	Sig.
Age	.344	4955.247	17.353	0.000
Hospital length of stay	.427	10241.372	28.530	0.000
ICU length of stay	.089	22.098	0.229	0.636
Number of physiotherapy sessions	.407	1697.003	13.665	0.000
Total physiotherapy treatment time	.394	1292180.683	12.865	0.001

Factors associated with discharge destination

A cardiac history and history of cognitive impairment were significantly associated with likelihood of discharge home ($p = 0.001$ and $p = 0.013$). There was no association between ICU admission and likelihood of discharge home ($p = 0.439$). No association was found between gender, cancer history, respiratory history and likelihood of discharge home. Results of ANOVA analysis found younger age, a shorter hospital length of stay, shorter ICU length of stay were all associated with an increased likelihood of discharge home ($p < 0.05$) (Table 4). A lower number of physiotherapy sessions and lower total physiotherapy treatment time were also associated with increased likelihood of discharge home ($p < 0.05$). Patients' functional status on discharge home was also associated with hospital discharge destination, with those achieving independent mobility significantly more likely to be discharged home (both $p < 0.001$).

Table 4: Results of ANOVA analysis: Factors associated with discharge home.

Factors associated with discharge home	η^2	Mean square	F	Sig.
Age	.119	6201.955	23.233	0.000
Hospital length of stay	.182	9757.460	27.047	0.000
ICU length of stay	.008	846.011	4.356	0.045
Number of physiotherapy sessions	.165	596.313	4.280	0.042
Total physiotherapy treatment time	.155	728639.215	6.814	0.011

Discussion

Findings of this study indicate that a significant number of patients hospitalised with COVID-19 require physiotherapy input. Once physiotherapy commenced, a large proportion of patients progressed quickly through functional mobility classifications to become independently mobile on discharge. A sub-set of patients included in the chart review required extensive inpatient physical rehabilitation following a critical care stay.

The patients admitted to critical care were of a similar age to those in our centre pre-pandemic and the national average of patients admitted to critical care (Hodalova et al., 2020). However, there was a lower proportion of females in this COVID-19 critical care cohort (22%) when compared to previous work in our centre (45%) and gender distribution internationally (40%) (Dwyer et al., 2018). This is in keeping with previous reports of sex differences in both hospitalisation and ICU admission rates in those with COVID-19 (Gomez et al., 2021). Additionally, the length of stay of patients admitted to critical care was lower than those in previous studies (22 ± 13 v. 34 ± 24.4 days) however the mortality rates of our COVID-19 critical care population were higher than predicted national mortality rates for ICU (15% v. 7%) (Dwyer et al., 2018).

This study found 72% of patients were off baseline function when referred to physiotherapy, demonstrating the high number of patients hospitalised with COVID-19 infection who require inpatient physiotherapy input. However, a large proportion (86%) of these patients returned to baseline function on discharge from hospital, possibly highlighting the important role of rehabilitation services during the pandemic. The large number of surviving patients that returned to baseline function is in contrast to the results of recent studies in populations recovering with COVID-19 where patients are discharged from hospital with persistent functional and cognitive deficits (Barker-Davies et al., 2020; Roberts et al., 2021). However, there are several possible explanations for this. Firstly, the quality of care and continuity of physiotherapy services in the study setting was high. For example, blanket orders are in place for physiotherapy in the ICU and physiotherapy referral on the ward is consistent with high acknowledgment of the contribution of physiotherapy along the continuum of care. In addition, while patients returned to baseline function, they may still have been experiencing common post COVID-19 symptoms such as fatigue and dyspnoea (Mahase, 2020; Carfì et al., 2020). Although patients regained their capacity to move, they may not have regained their pre-COVID-19 exercise tolerance or subjectively felt fully recovered on discharge from hospital. Indeed, a high number of patients in this study had a transient decrease in oxygen saturation during physiotherapy. While this is a common adverse event in acute rehabilitation (<1% incidence of activity related adverse events) there was a higher incidence of activity related adverse events in this COVID-19 population (Bailey et al., 2007). These, in some cases profound desaturations, resolved with rest and appeared to have no long term effects for the patient in their recovery (Adler & Malone, 2012). In keeping with previous work, this study highlights the importance of understanding the functional limitations of patients with COVID-19 and providing rehabilitation care for hospitalised patients with COVID-19 (Wang et al., 2020). The provision of physiotherapy care continued within the evolving hospital and national guidance throughout the pandemic, with levels of physical rehabilitation provision higher than those reported in similar work (Roberts et al., 2021). This involved careful planning to manage infection control and reduce risk to patients and staff by working in small teams. Information collected in this evaluation has been incorporated into continuous physiotherapy COVID-19 education and advocacy initiatives with healthcare staff at ward level.

A number of patients in this study were referred to community physiotherapy for further rehabilitation input following their hospital admission, reflecting the current evidence regarding the post-hospital rehabilitation needs for patients with COVID-19 (Carfì et al., 2020; Mandal et al., 2021; Taquet et al., 2021). Specific follow up clinics for COVID-19 patients may provide a way to assess patient needs for further rehabilitation resources and services. From the results of this study these services may benefit from including physiotherapy. Patients were less likely to have independent mobility on hospital discharge if referred to physiotherapy, possibly reflecting the complexity of the patient cohort in need of physical rehabilitation.

This study has some limitations. The extensive data collection using electronic records for information specific to physiotherapy means there is a possibility of human error in relation to the recording of study data. Data was recorded from clinical notes that were not specifically documented for research purposes and during urgent care transitions, documentation was occasionally unclear and required interpretation, contributing to potential misclassification bias. It is unknown how well/fit the individuals in this study were pre- SARS-CoV-2 infection. The recording of patients functional status provides only broad classifications of functional mobility pre-admission and on hospital discharge. In addition, it is possible that those patients who remain unwell experience the highest burden of long-term effects of COVID-19 and continue to receive inpatient based care. Further longitudinal follow up is required to identify the long-term trajectory of the rehabilitation required by patients admitted to hospital with COVID-19.

This study examines physiotherapy input only; to have a complete picture of the rehabilitation needs for this patient group other professions such as speech and language therapy, dietetics, occupational therapy and so on, would be required, however, this was beyond the scope of this study. Additonally, ward based patients relied on referral from the medical team or nursing staff for a referral to physiotherapy. As a result, there may have been patients in this review that needed but did not receive physiotherapy. The strengths of this paper include information on patients admitted for both ICU and ward-based care, a cohort with longitudinal analysis and the MDT appproach to patient care. The review highlights that recovery to baseline mobility is probable following COVID-19 infection. It attempts to provide expected markers of progress for physiotherapists treating inpatients with COVID-19. No attempt was made to link the reported longer term effects of COVID-19 infection with the physiotherapy input recevied as an inpatient. The data that has been presented from this institution post covid clinic, including this patient cohort, highlights that fatigue and exercise intolerance remain an issue in the medium term (Townsend et al. 2021). It is unknown whether a potential intervention at hospital discharge such as education and advice on fatigue management, paced exercise and recovery trajectory are benefical in longer term recovery.

Conclusion

This study found a significant number of patients hospitalised with COVID-19 required physiotherapy input. Older patients and those with a longer length of hospital stay were more likely to be referred to physiotherapy. A large proportion of patients returned to pre-morbidity mobility status at the time of hospital discharge however a sub-set of patients included in this chart review required extensive inpatient physical rehabilitation following a critical care stay.

Key points

- A large number of patients hospitalised with COVID-19 were found to be off baseline mobility levels on initial physiotherapy assessment.
- The majority of patients with COVID-19 patients discharged from hospital had returned to their baseline mobility.
- Older patients with COVID-19 and those with a longer length of hospital stay were more likely to be referred to physiotherapy.

Acknowledgements

We would like to thank all patients involved as well as the healthcare providers who cared for these patients throughout their illness, in particular the physiotherapy department in St James's Hospital.

Author contributions

GS and JD contributed to planning, conducting, design, data acquisition, analysis of data, and writing of the manuscript. NM, KOB, KC, BM, KN and GK contributed data acquisition and review of manuscript. LT, CB and IML contributed to planning, conduction, design, data acquisition and manuscript review.

Competing interests and funding support

- Funding: no funding.
- Conflict of interest: nothing to report.

Ethical approval

The study was approved by the Tallaght St James's Research Ethics Committee (reference number: 2020-06, list 23).

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Mechanical insufflation-exsufflation for the prevention and treatment of respiratory complications in acute cervical spinal cord injury: A retrospective service evaluation

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Abstract

Background

A cervical spinal cord injury (CSCI) is a life-changing event resulting in neurological weakness. Acutely, respiratory complications are the leading cause of mortality. Mechanical insufflation-exsufflation (MI-E) is used to augment cough and promote airway clearance in the prevention and treatment of respiratory complications in this population. The incidence of respiratory complications in subjects with CSCI who receive MI-E is not widely reported.

Objectives

To report on the incidence of respiratory complications and to evaluate the clinical application of MI-E in subjects with acute traumatic CSCI.

Methods

This was a retrospective case note review. Data was collected for subjects with a traumatic CSCI admitted to a U.K. major trauma centre between January 2017 and September 2018. The incidence of respiratory complications on admission and 3 weeks post-admission were collected. Where used, detail relating to MI-E clinical application was recorded.

Results

33 subjects were eligible for inclusion. The overall incidence of respiratory complications was 21% (7/33). There was no significant difference in occurrence of respiratory complications between those

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Keywords

Spinal cord injuries, cough, pulmonary atelectasis, pneumonia, respiratory insufficiency.

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who received MI-E and those who did not. There was a significant difference in the clinical application of therapeutic MI-E compared to prophylactic MI-E. The 'number of cycles' and 'exhale pressure' settings were found to be significantly greater in those receiving therapeutic treatment (p = <0.001; p = 0.002 respectively). Reporting of other MI-E parameters and treatment detail was poor.

Conclusion

Whilst the findings of this review may suggest that MI-E provides no additional benefit in the prevention of respiratory complications following acute traumatic CSCI, firm conclusions cannot be drawn due the small sample and poor treatment detail reporting. Further incidence reporting in a multi-site study, including those with thoracic injuries is warranted.

Introduction

A spinal cord injury (SCI) is a life-changing event caused by irreversible damage to the spinal cord (World Health Organisation, 2013). Approximately 45% of injuries occur in the cervical region (Singh et al., 2014). In cervical spinal cord injuries (CSCI), respiratory function may be severely compromised due to denervation of the primary inspiratory muscle, the diaphragm. As a result, CSCI results in lower forced vital capacity (FVC) and peak cough flow (PCF) measurements, severely impairing secretion clearance (Berlowitz et al., 2016).

Respiratory complications (RC) affect up to 80% of individuals with CSCI and are the leading cause of morbidity and mortality in the acute phase (Berlowitz et al., 2016). Atelectasis, pneumonia, and respiratory failure (RF) are the most commonly reported RC (Jackson & Groomes, 1994). Due to the progressive nature of paralysis, secondary to spinal shock, acute management is targeted at preventing respiratory deterioration by promoting airway clearance and reducing work of breathing (Sheel et al., 2018).

Mechanical insufflation-exsufflation (MI-E) is a cough augmentation technique utilised for those with reduced PCF (Chatwin et al., 2018). MI-E augments tidal volume by delivering a positive inspiratory pressure (insufflation), which promotes mobilisation of peripheral secretions and may improve atelectasis (Chatwin et al., 2018). Expiratory flow is enhanced by rapid switch to negative pressure on expiration (exsufflation), thereby improving cough efficiency and secretion clearance (Chatwin et al., 2018). Literature supports the instigation of treatment when PCF <160L/min (Chatwin et al., 2018).

Research of MI-E in subjects with CSCI has focused on investigating its efficacy for improving lung function (Reid et al., 2010). Both Lee et al. (2012) and Pillastrini et al. (2006) found MI-E effective in improving FVC, forced expiratory volume in 1 second and PCF. However, the role and impact of MI-E as a prophylactic adjunct to prevent RC in this population remains unknown. For those with acute CSCI, MI-E is currently implemented in line with best practice recommendations and expert opinion, rather than high quality research (Bott et al., 2009). Therefore, uncertainty exists of how best to utilise MI-E in CSCI.

Objectives of this service evaluation were to report the following in subjects admitted with traumatic CSCI:

1 The incidence of RC within the 1st 3 weeks following injury for those who did/did not receive MI-E.
2 MI-E parameters used and differences in those parameters between prophylactic and therapeutic use.

Methods

Ethical approval was not required as this study was deemed a service evaluation. The project was registered and approved by The Patient Safety, Assurance and Audit Service at the study site (application number: CE22662).

Study design

A single-centre retrospective case note review was undertaken.

Setting

The service evaluation took place at a regional major trauma and neurosurgical centre in Southwest England, U.K. Patients with suspected traumatic SCI are admitted directly from the scene or transferred from other hospitals. Those with confirmed CSCI are typically transferred to the intensive care unit for cardiorespiratory monitoring and/or support. However, some with less severe impairments may be suitable for ward-based care with outreach support. During normal working hours (Monday–Friday, 8:30–16:30), new patients are screened and assessed by a physiotherapist within 4 hours of admission. MI-E (E70 Philips Respironics, Pennsylvania, U.S.A.) is standardly used for the 1st 7 days, as advised by a tertiary spinal treatment centre. Patients who have evidence of or are symptomatic of RC receive treatment considered 'therapeutic' rather than 'prophylactic'. MI-E may be used in conjunction with other respiratory interventions, for example, manual assisted cough, manual techniques, and suction. FVC is assessed daily as part of nursing observations and MI-E is discontinued providing FVC is stable and >1 litre.

Sample

Potential subjects were identified through the Trauma Audit and Research Network database with the following criteria: 'spinal cord injury', admitted between 1st January 2017 and 30th September 2018. Subjects were screened for eligibility using inclusion and exclusion criteria outlined in Table 1.

Table 1: Subject inclusion and exclusion criteria.

Inclusion	Exclusion
Adults (≥18 years)	Paediatrics (age <18 years)
SCI diagnosis	No SCI diagnosis
Injuries C8 and above	Injuries T1 and below
Traumatic SCI	Non-traumatic SCI
International Standards for Neurological Classification of Spinal Cord Injury A–D	International Standards for Neurological Classification of Spinal Cord Injury E
Acute (0–4 weeks post injury)	Sub-acute or chronic (≥4 weeks post injury)
Self-ventilating, with own airway	Mechanically ventilated and those with tracheostomy

Outcome variables

Diagnostic criteria for RC utilised followed guidance specific to the study setting and supported by relevant literature (Ray et al., 2013; Davidson et al., 2016; Kalil et al., 2016; O'Driscoll et al., 2017) (Table 2).

Table 2: Diagnostic criteria for respiratory complications.

Respiratory complication	Criteria
Atelectasis	• Radiological reporting of atelectasis. *Or* evidence of any of the following on chest x-ray as documented in medical notes: • Increased opacification. • Displaced fissures. • Silhouette sign. • Elevation of hemi diaphragm. • Mediastinal displacement.

Respiratory complication	Criteria
Pneumonia	• Radiological reporting of pneumonia. *Or* evidence of any of the following on chest x-ray as documented in medical notes: • New diffuse or patchy infiltrates. • Consolidation. • Air bronchogram. *And* 1 or more of the following: • C-reactive protein >20mg/l. • Heart rate >90 bpm. • The need for/increasing supplementary oxygen.
Respiratory failure	• pH <7.35. • PaO_2 <60mmHg +/- $PaCO_2$ >49mmHg. *Or* • The need for mechanical ventilation (unless required for any other reason).

Data collection

The following data was collected for all included subjects: age, gender, neurological level of injury, International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) and medical management of SCI, in addition to respiratory status on admission. Furthermore, data was collected pertaining to MI-E set up. The incidence of RC were collected up to 14 days following MI-E discontinuation.

Data collection was completed between January 2019 and April 2019. Data was anonymised at point of collection by successive subject number allocation. The spreadsheet was piloted on five subjects prior to commencing data collection to assess the suitability of the RC diagnostic criteria. The pilot resulted in the inclusion of an additional criterion for pneumonia ('*the need for/increasing supplementary oxygen*').

Statistical analysis

Statistical analysis was carried out using IBM Statistical Package for the Social Science, version 26. Although normality of data was assessed, non-parametric tests were used for all variables for consistency. The Mann-Whitney U test was used to analyse differences in numerical variables. For categorical data, for samples >20 Chi-Square was used and <20, Fishers Exact was used. When comparing the proportions of 2 variables, odds ratios and their confidence intervals were calculated. Additionally, two-sided *p* values with a significance level <0.05 were used.

Results

A total of 33 subjects met the inclusion criteria (Figure 1). For the purpose of analysis, subjects were split into 2 cohorts; those who received MI-E prophylactically and/or therapeutically (MI-E cohort, *n* = 15) and those who did not (noMI-E cohort, *n* = 18). 1 subject who initially did not receive MI-E went on to develop pneumonia and received therapeutic MI-E. This subject was included in the noMI-E cohort.

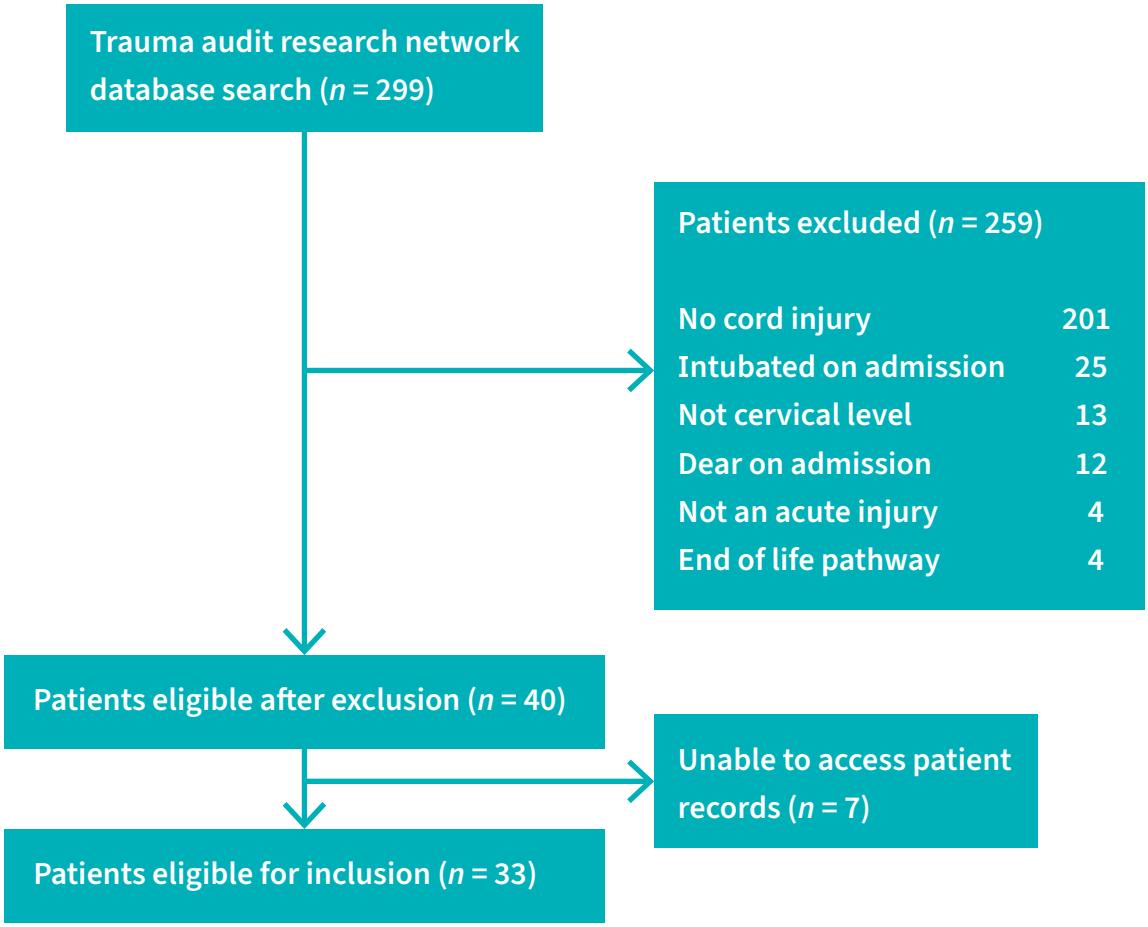

Figure 1: Inclusion flow chart.

Cohort characteristics

Characteristics for all cases and comparative characteristics between cohorts are summarised in Table 3. There was no statistical difference found in baseline characteristics between cohorts, except for gender. There were no statistically significant differences in baseline respiratory status between cohorts (Table 4).

Table 3: Subject characteristics for all cases and comparative characteristics within each cohort.

Variable	All cases *n* = 33	noMI-E *n* = 18	MI-E *n* = 15	Odds ratio	95% confidence interval		*p*
					Lower	Upper	
Age (years)[+]	69 (40–82)	70 (48–81)	68 (31–82)	-	21.0	-9.00	0.58
Gender				0.18	0.04	0.82	0.037*
Male	16/33	12/18	4/15				
Female	17/33	6/18	11/15				
Neurological level of injury				-	-	-	0.22
C2	1/30	0/16	1/14				
C3	2/30	0/16	2/14				
C4	8/30	6/16	2/14				
C5	10/30	4/16	6/14				
C6	8/30	5/16	3/14				
C7	1/30	1/16	0/14				
ISNCSCI classification				-	-	-	0.34
A	5/26	2/11	3/15				
B	0/26	0/11	0/15				
C	13/26	4/11	9/15				
D	8/26	5/11	3/15				
Medical management				2.75	0.63	12.0	0.28
Conservative	13/33	9/18	4/15				
Surgical	20/33	9/18	11/15				

*Denotes statistically significant $p < 0.05$ (2-sided test).

[+]Age is expressed as median and interquartile range. All categorical variables are expressed as proportion.

Where there is missing data, proportions are presented out of the number recorded.

Table 4: Baseline respiratory status on admission for all cases.

Variable	noMI-E *n* = 18	MI-E *n* = 15	Odds ratio	95% confidence interval		*p*
				Lower	Upper	
Smoker			-	-	-	0.35
Yes	3/13	1/11				
No	7/13	9/11				
Ex	3/13	1/11				
Pre-existing respiratory comorbidities	2/1	1/15	0.57	0.05	7.00	>0.99
Asthma	1/2	1/1				
Chronic obstructive pulmonary disease	1/2	0/1				
Associated chest wall injuries	4/18	2/15	0.54	0.08	3.45	0.67
Rib fractures	3/4	2/2				
Pneumothorax	1/4	0/2				
Respiratory complications on admission	1/18	1/15	1.21	0.07	21.2	>0.99

All categorical variables are expressed as proportions. Where there is missing data, proportions are presented out of the number recorded.

Incidence of respiratory complications

Overall, there were 7 episodes of RC reported in 5 subjects during the evaluation period (Table 5). This included 5 recorded 0–3 weeks post-injury and 2 recorded on admission. Subjects who developed more than 1 RC in the same episode (*n* = 2), were counted as 1 overall complication for that individual. The incidence of RC was higher in the noMI-E cohort, although this difference was not statistically significant. None of those who received MI-E prophylactically developed a RC during the evaluation period. The subject with pneumonia on admission received MI-E therapeutically, but still went on to develop an additional complication (RF).

Table 5: Overall incidence of respiratory complications in all cases.

Variable	noMI-E *n* = 18	MI-E *n* = 15	Odds ratio	95% confidence interval		*p*
				Lower	Upper	
Total number of subjects with respiratory complications[+]	4/18	1/15	0.25	0.03	2.53	0.35
Incidence of specific respiratory complications						
Atelectasis	1/18	0/15	0.94	0.84	1.06	>0.99
Pneumonia	4/18	1/15	0.25	0.03	2.53	0.35
Respiratory failure	0/18	1/15	1.07	0.94	1.23	0.46

[+]This includes recorded incidences on admission and during the evaluation period.

Clinical application and device set up

The MI-E cohort was further split into those who received MI-E prophylactically (MI-Ep) and those who received MI-E therapeutically (MI-Et). The majority received treatment prophylactically (*n* = 29). There was variation in the clinical application and set up of MI-E between prophylactic and therapeutic use (Table 6). Some data, specifically '*pause time*', '*cough trak*' and '*oscillation*', were missing in all cases.

Table 6: Comparison of MI-E application (therapeutic MI-E (MI-Et) v. prophylactic MI-E (MI-Ep)).

Variable	MI-Et treatment contacts *n* = 25	MI-Ep treatment contacts *n* = 76	95% confidence interval		*p*
			Upper	Lower	
MI-E settings					
Number of cycles	4.0 (3.0–5.8)	2.0 (2.0–3.0)	1.00	2.00	<0.001*
Number of insufflation breaths[+]	4.0 (3.0–4.5)	3.0 (3.0–4.0)	0.00	1.00	0.34
Inhale pressure (cm H_2O)	30.00 (30.00–30.00)	30.00 (25.00–30.00)	0.00	5.00	0.08
Inhale time (sec)	3.0 (3.0–3.0)	3.0 (3.0–3.0)	0.00	0.00	0.17
Exhale pressure (cm H_2O)	35.00 (31.25–35.00)	30.00 (30.00–35.00)	0.00	5.00	0.002*
Exhale time (sec)	1.0 (1.0–1.0)	(1.0–1.0)	0.00	0.00	0.14

All numerical variables are expressed as median and interquartile range.

[+]If used in manual mode.

*Denotes statistically significant $p < 0.05$ (2-sided test).

Discussion

This service evaluation aimed to describe the incidence of RC in those with traumatic CSCI, as well as detail the use of MI-E. To the authors knowledge, this is the first published service evaluation to do so in this specific population. Results suggest there is no difference in RC incidence for patients who do/do not receive MI-E. Additionally, variation in the clinical application of MI-E was observed.

The overall incidence of RC observed in this service evaluation is low compared to existing data. One study (Lemons & Wagner, 1994) found 62% (n = 39) of subjects with acute CSCI experienced RC, which is consistent with earlier studies by Fishburn et al. (1990) and Reines and Harris (1987) who reported incidences of 57% (n = 17) and 77% (n = 95) respectively. A possible explanation for differences observed might relate to the inclusion of a greater number of complete injuries in those studies. This is noteworthy since complete injuries often result in more defined impairments and little improvement potential (Harvey, 2016). The significance of this is reflected in the higher incidence of RC reported in complete injuries alone (69%) (Jackson & Groomes, 1994). Indeed, medical care improvements have seen a decline in the incidence of complete injuries (World Health Organisation, 2013), therefore the RC reported within this evaluation may reflect more accurately on the wider population.

Incidence of respiratory complications in noMI-E and MI-E cohorts

Since prophylactic MI-E is considered standard practice at the study location, it is surprising that over half of the cohort did not receive this. Despite its increasing popularity, a recent survey of MI-E use in an adult intensive care unit highlighted MI-E use in clinical practice as sporadic (Swingwood et al., 2020). Whilst there is inevitable variation in opinion and practice among clinicians, this survey highlighted lack of experience and training as barriers to MI-E's practical use (Swingwood et al., 2020). Although clinician demographics were not recorded in this study, level of experience and confidence in device use may have influenced whether MI-E was instigated prophylactically.

Though there was no statistically significant difference in neurological level of injury and ISNCSCI classification between cohorts, data for the latter was missing for 39% (n = 7) of subjects in the noMI-E cohort. It is possible that this cohort were less neurologically impaired and consequently may have had comparatively better respiratory function. Therefore, it is plausible these subjects were deemed at a lower risk of developing RC by the treating clinician.

While the results reveal the incidence of RC were higher in the noMI-E cohort, they did not reach statistical significance. Therefore, no firm conclusions can be drawn as to whether instigating prophylactic MI-E provides additional benefit in preventing RC. Whilst none of those receiving treatment prophylactically went on to develop a RC during the evaluation period, the small sample and confounding factors (for example, pre-existing respiratory co-morbidities and associated chest wall injuries) may limit extrapolation of results.

Clinical application of MI-E

There is a paucity of research reporting commonly used pressures for prophylactic MI-E for those with SCI, therefore direct comparisons cannot be made. However, artificial lung studies suggest to achieve inspiratory volumes of normal capacity (>3.6 litres), minimum insufflation pressures of +40cmH_2O are required (Volpe et al., 2018; Chatwin & Simonds, 2020). The median insufflation pressure used in this study was +30cmH_2O, which may be inadequate to achieve the desired physiological effect. Therefore, the finding of no significant difference between cohorts may be unsurprising.

The variation in clinical application between MI-Ep and MI-Et was anticipated. Clinicians used greater exhalation pressures in the presence of a complication, which corresponds with existing research favouring asymmetrical pressure settings to achieve adequate expiratory flow bias for sputum clearance (Chatwin & Simonds, 2020). Given that CSCI affects inspiratory and expiratory capacity, it is surprising that the same insufflation pressures were used for MI-Ep and MI-Et. In the presence of an acute RC, lung function measurements such as FVC have shown to decline by up to 70% (Nasher et al., 2014). Therefore, higher pressures may be required to achieve adequate lung volume increases and airway clearance. Notwithstanding this, whilst MI-E pressures should be individualised (Chatwin et al., 2018), ultimately tolerability will guide MI-E prescription (Spinou, 2020).

Device settings, *'pause time'*, *'cough trak'* and *'oscillation'*, were not recorded consistently by the treating clinician. The underutilisation of such settings may suggest sub-optimal MI-E implementation, thus limiting clinical effectiveness. However, it is possible these settings were not used as opposed to not recorded; particularly for those receiving prophylactic treatment.

Limitations

The absence of a comprehensive evaluation of potential confounders should be considered when interpreting results. The sample included only adults with a CSCI admitted to a single centre, which may affect the study's external validity. Whilst RC are most prevalent in CSCI, those with thoracic lesions are also at risk, therefore their inclusion may have been warranted. The overall sample was small, increasing the probability of a type II error when comparing cohorts (Banerjee et al., 2009). Additionally, 7 medical records were inaccessible, therefore potentially eligible subjects may have been missed.

Larger prospective studies are required to further establish the incidence of RC in patients with CSCI who receive MI-E post-injury. Multi-site data collection may allow for a larger sample and for prescription variability.

Conclusion

Whilst the findings of this service evaluation demonstrate a low incidence of RC in those receiving MI-E following CSCI, limitations exist that may restrict the application and confound the results. Current guidelines recommend MI-E is considered for those with

impaired respiratory function following SCI (Bott et al., 2009). Therefore, greater efforts are needed to ensure those at high risk (for example, complete injuries, those with pre-existing respiratory co-morbidities or additional respiratory complications) receive prophylactic treatment. There is a need to establish the incidence of RC in those with thoracic and CSCI who receive MI-E prophylactically. Emphasis should be placed on obtaining a sufficiently sized sample to produce clinically meaningful results.

Funding

This service evaluation was conducted as part of a master's research project and received financial assistance from the Private Physiotherapy Educational Foundation to cover tuition fees.

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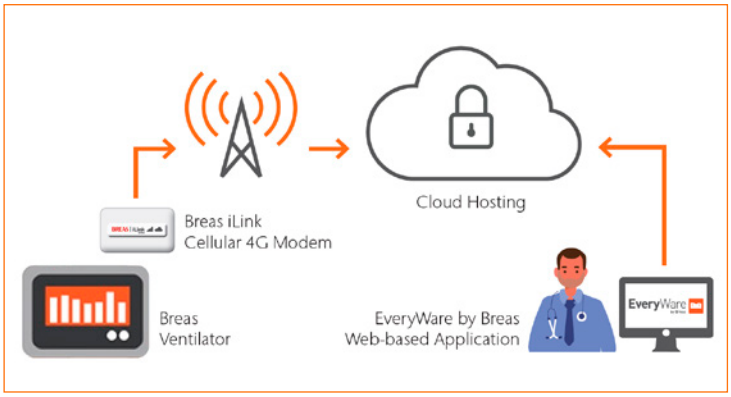

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A physiotherapy-led early mobilisation protocol for neurosurgical patients with external ventricular drains in intensive care: A service evaluation

Yi Fang Tan[1,2], Charlotte Pereira[2,3] and Harriet Shannon[2]

Abstract

Background

An external ventricular drain (EVD) is used to relieve elevated intracranial pressure in neurosurgical patients, and remains in place for an average of 8 days post-surgery. The presence of an EVD poses a major barrier to early mobilisation due to safety concerns. Eligibility criteria published in EVD mobilisation protocols only consisted of parameters related to the neurological system (Moyer et al., 2017; Young et al., 2019). Parameters pertaining to cardiovascular, respiratory and musculoskeletal systems deemed safe for mobilisation were not stated.

Aims

To determine the safety, feasibility and effectiveness of implementing an early mobilisation protocol, which included physiological parameters, in patients with EVDs.

Methods

A retrospective service evaluation was conducted in a neurological intensive care unit. Medical records were reviewed for 2 periods from October 2017 to March 2018 (pre-protocol period) and October 2019 to March 2020 (protocol period). Eligible patients for out-of-bed mobilisation were screened and identified by physiotherapists.

Results

After protocol implementation, there was a 64.8% increase in the proportion of patients with EVDs mobilised (95% CI, 35.9–82.1%, p <0.0001). Median time

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Keywords

External ventricular drain, EVD, early mobilisation, intensive care.

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from EVD placement to 1st mobilisation decreased from 14 to 3.5 days (p <0.0001). Moreover, the median intensive care and hospital length of stays were significantly reduced from 8 to 3.5 days (p = 0.037) and 38 to 22.5 days (p = 0.030) respectively. No adverse events were recorded in the protocol period.

Conclusion

The early mobilisation protocol for patients with EVDs enabled safe, feasible and effective mobilisation. Future prospective, controlled research studies are warranted.

Introduction

An external ventricular drain (EVD) is surgically inserted into the brain ventricles to drain cerebrospinal fluid (CSF) and is commonly seen in the neurological intensive care unit (ICU) (Muralidharan, 2015). It is used to relieve raised intra-cranial pressure (ICP) and treat acute hydrocephalus in patients with acquired brain injuries such as traumatic brain injury, intra-cerebral haemorrhage, subarachnoid haemorrhage and meningitis (Muralidharan, 2015), which would otherwise result in reduced cerebral perfusion and increased cerebral oedema (Hinson et al., 2010). This drain also enables clearing of intra-ventricular blood clots, monitoring of ICP and administering of medications.

Historically, patients with EVDs remain on bed rest for the duration of EVD placement (Moyer et al., 2017; Gaspari et al., 2018; Young et al., 2019) which averages 8 days (Albano et al., 2018). The presence of an EVD posed a major barrier to early mobilisation as there were safety concerns pertaining to bleeding and dislodgement during the process (Hale et al., 2013). In the event of EVD dislodgement, an emergency surgical procedure would be necessary for re-insertion (Gaspari et al., 2018). As the EVD is clamped to prevent inappropriate drainage of CSF during position changes, there is a potential risk of elevated ICP (Muralidharan, 2015). These factors could deter physiotherapists from encouraging mobilisation. Conversely, 8 days on bed rest could have significant negative consequences on the patient's musculoskeletal, cardiovascular and respiratory systems, further prolonging intensive care stay.

Several studies have proposed the use of a mobilisation protocol in the ICU, with eligibility criteria that provide specific safety recommendations to identify suitable patients (Bailey et al., 2007; Morris et al., 2008; Miranda Rocha et al., 2017). However, most of these were developed and introduced in the medical ICU (Conceição et al., 2017) with only 2 mobilisation protocols devised particularly for patients with EVDs in the neurological ICU (Moyer et al.,

2017; Young et al., 2019). These EVD mobilisation protocols only consisted of exclusion criteria and parameters related to the neurological system. Parameters related to cardiovascular, respiratory and musculoskeletal systems were not clearly stated. The lack of clarity on eligibility criteria could compromise safety and delay mobilisation.

In Tan Tock Seng Hospital (TTSH), Singapore, a physiotherapy-led early mobilisation protocol for neurological patients with EVDs was introduced in April 2018. The protocol contained specific eligibility criteria indicating the parameters for each aforementioned physiological system. The aim of this service evaluation was to determine whether the early mobilisation protocol, which included physiological parameters, was safe, feasible and effective in patients with EVDs.

Methods

Study design and ethical considerations

This was a retrospective service evaluation of an early mobilisation protocol for patients with EVDs in the neurological ICU. Medical records were reviewed for 2 comparable 6-month periods from October 2017 to March 2018 (pre-protocol period) and October 2019 to March 2020 (protocol period). The UCL Research Ethics Committee and Singapore's Domain Specific Review Board granted ethics exemption and waiver of informed consent. Service evaluation registration procedures within the hospital were followed.

ICU setting

Tan Tock Seng Hospital is the 2nd largest public tertiary hospital in Singapore. In the 18-bedded neurological ICU, a typical nurse-to-patient ratio is 1:2. A blanket referral system for physiotherapy is in place, and physiotherapists are allowed to screen and review patients. On weekdays, the workload is shared among 2 permanent senior physiotherapists and 2 rotating junior physiotherapists. They provide respiratory and rehabilitation therapy for the patients. On weekends, patients are reviewed by other physiotherapists who are rostered to work for the day, mainly for respiratory interventions.

Protocol

The EVD early mobilisation protocol was devised through discussion with physiotherapists, neurosurgeons and ICU consultants. The term 'early' mobilisation was determined from the time at which the patients were deemed physiologically stable following a set of inclusion and exclusion criteria, as shown in Tables 1 and 2 respectively. Patients with EVDs were evaluated by physiotherapists on a daily basis to determine their eligibility for mobilisation. As for the type of mobilisation activity performed and the level of assistance given, it was dependent on physiotherapy assessment on the day of therapy.

Table 1: Inclusion criteria.

Neurology system	• ICP ≤15mmHg (as measured using either Codman ICP transducer or EVD). • GCS of at least E3 and M6. • Left and right Lindegaard ratio (MCA/ICA mean flow velocity ratio) ≤3 (no vasospasm). • MCA mean flow velocity ≤120cm/s (no vasospasm). • RASS -1 to +1.
Respiratory system	• PEEP ≤8cmH_2O. • FiO_2 ≤0.5. • RR ≤24 breaths per minute. • SpO_2 ≥95%.
Cardiovascular system	• No new onset of arrhythmias or cardiac ischaemia within 12 hours. • No vasopressor and inotrope. • 40bpm ≤HR ≤120bpm. • MAP ≥65mmHg.
Musculoskeletal system	• Muscle strength ≥3/5 using manual muscle testing (at least one sided UL and LL).

bpm = beats per minute; EVD = external ventricular drain; FiO_2 = fraction of inspired oxygen; GCS = Glasgow Coma Scale; HR = heart rate; ICA = internal carotid artery; ICP = intracranial pressure; LL = lower limb; MAP = mean arterial pressure; MCA = middle cerebral artery; PEEP = positive end-expiratory pressure; RASS = Richmond Agitation Sedation Scale; RR = respiratory rate; SpO_2 = peripheral capillary oxygen saturation, UL = upper limb.

Table 2: Exclusion criteria.

Others	• Uncontrolled seizures.
EVD	• Active bleeding. • Blocked. • CSF leak. • Use of urokinase. • EVD height <+5cmH_2O. • Hourly drainage >100ml.

CSF = cerebrospinal fluid; EVD = external ventricular drain.

Mobilisation was defined as any active out-of-bed activity that consisted of sitting-on-edge-of-bed, sit-to-stand, sitting-out-of-bed, marching and ambulation. The flow chart used to guide mobilisation was modified from Moyer et al. (2017) and is illustrated in Figure 1.

The physiotherapist assisted the patient in mobilisation while a nurse managed the EVD. The EVD was clamped during mobilisation and levelled to the tragus of the ear to measure ICP before session, sitting-on-edge-of-bed and after session. For higher levels of mobilisation activity, ICP was not measured but vital signs and symptoms were monitored throughout by both the nurse and physiotherapist.

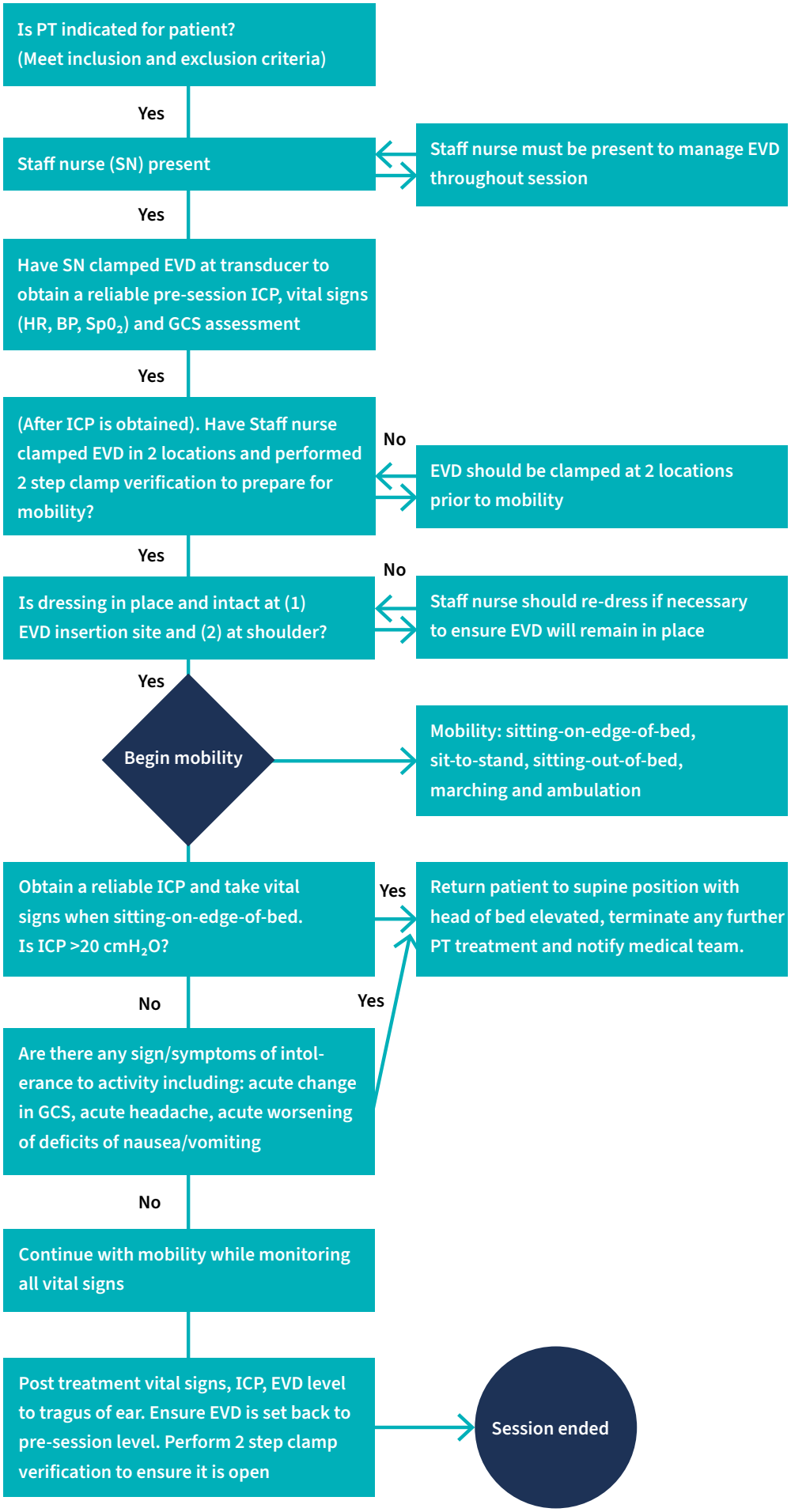

Figure 1: EVD mobilisation flow chart.

Service evaluation process

Relevant data for the studied time periods were extracted from the hospital's electronic system by the principal investigator and were de-identified. Data were stored in an encrypted Microsoft Excel file. For patients from the pre-protocol period, eligibility for mobilisation was determined by retrospectively reviewing their hourly physiological parameters in the ICU and comparing to the protocol's eligibility criteria. For patients deemed eligible for mobilisation, physiotherapy documentation was further scrutinised to find out whether they were, in fact, mobilised. Data entry was verified by a random check of 10% of patients with an independent physiotherapist who was not part of the project team.

Outcome measures

Outcome measures for safety, feasibility and effectiveness were collected. Safety was determined by the number and type of adverse events occurring during mobilisation. Adverse events were defined as events exceeding the established safety limits. Types of adverse events included elevated ICP (>20mmHg), EVD dislodgement or malfunction, haemodynamic events (orthostatic systolic blood pressure (BP) drop by ≥20mmHg; hypotension or hypertension depending on patient's baseline BP range and the targeted BP range set by neurosurgeons) and adverse symptoms (such as dizziness, emesis and headache). Adverse events that led to clinical deterioration and the need for medical intervention were termed as 'adverse events with consequences'. Feasibility was determined by the proportion of patients who were successfully mobilised in the neurological ICU. Effectiveness of the protocol was assessed using the following outcomes:

1. Time from EVD placement to first mobilisation in the hospital.
2. ICU length of stay (LOS).
3. Hospital LOS, in eligible patients.

Statistical analysis

Data were analysed using the SPSS (2013) Windows, version 25.0. Continuous variables were analysed using a 2-sample *t*-test for parametric data or Mann-Whitney U test for non-parametric data. Chi-Square test (n >20) or Fisher's exact test (n <20) was used for categorical variables. Level of significance was set at 0.05 for all tests. As significant differences in patient baseline characteristics may influence the outcomes of the protocol, a correlation test was conducted. A Pearson's correlation (r) for parametric data or Spearman's correlation (r_s) for non-parametric data was used for the correlation test.

Results

A total of 75 patients received EVDs during the pre-protocol period (Figure 2) and 42 patients underwent EVD placement in the protocol period (Figure 3). Their eligibility for mobilisation are summarised in Figures 2 and 3. The baseline characteristics of eligible patients for the 2 periods are shown in Table 3. There were similar baseline characteristics except for the Glasgow Coma Scale (GCS) on emergency department (ED) admission, which was significantly higher in the protocol group ($p = 0.023$).

Safety, feasibility and effectiveness of the early mobilisation protocol are shown in Table 4. After protocol implementation, the median time from EVD placement to 1st mobilisation decreased from 14 to 3.5 days ($p < 0.0001$) in eligible patients. The median ICU and hospital length of stays were also significantly reduced from 8 to 3.5 days ($p = 0.037$) and 38 to 22.5 days ($p = 0.030$) respectively. Correlation tests between the GCS on ED admission and LOS in both ICU and hospital showed either weak correlation ($r_s = 0.038$ to 0.070, $p > 0.05$) or a clinically unimportant relationship (multiple outliers). Hence, the GCS on ED admission may not influence LOS.

No adverse events were recorded for the 21 mobilisation sessions in the protocol period. The highest level of mobility achieved during each session was sitting-on-edge-of-bed (47.6%), followed by marching (23.8%), sit-to-stand (19.1%) and ambulation (9.5%). Only 1 out of 25 eligible patients was mobilised in the pre-protocol period, compared to 11 out of 16 patients in the protocol period. Reasons for the remaining 5 patients not mobilised are seen in Figure 3. This contributes to a 64.8% (95% CI, 35.9–82.1%, $p < 0.0001$) increase in the proportion of patients mobilised.

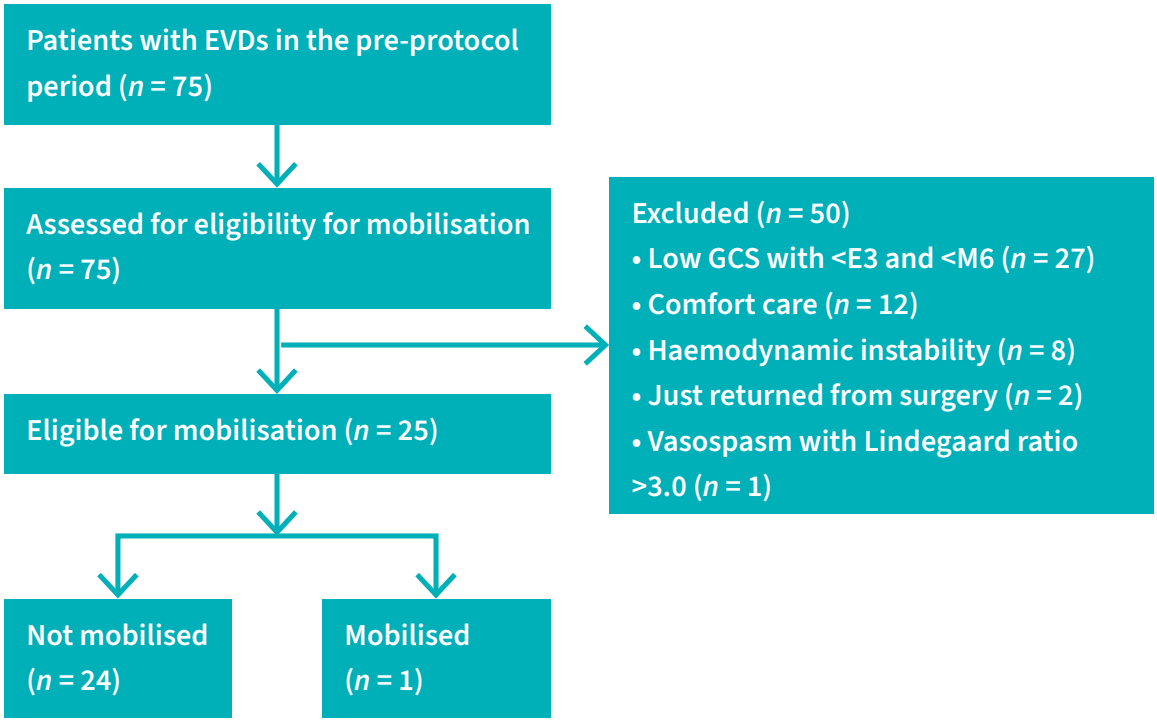

Figure 2: Flow chart for patients' eligibility for mobilisation in the pre-protocol period.

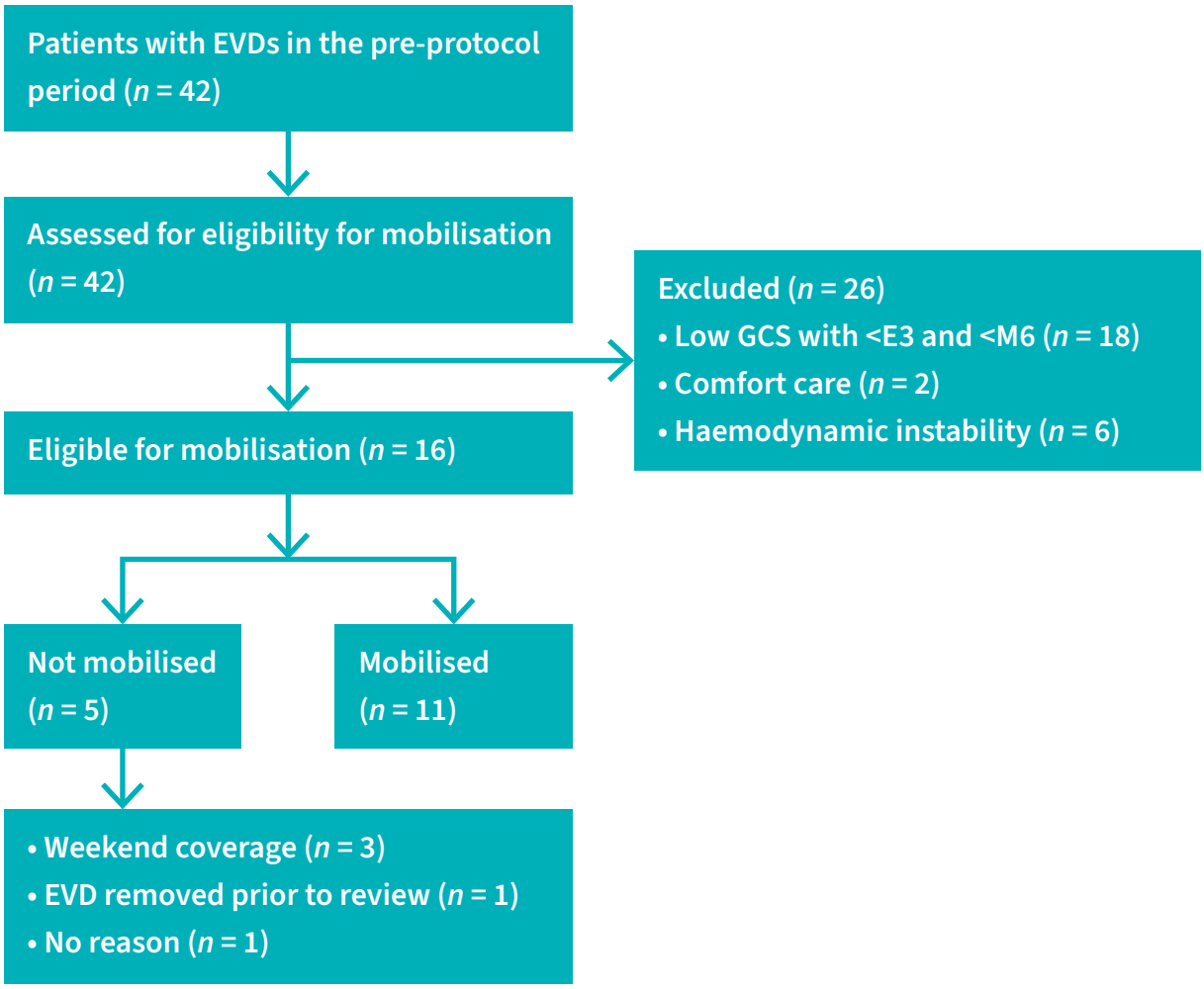

Figure 3: Flow chart for patients' eligibility for mobilisation in the protocol period.

Table 3: Eligible patient baseline characteristics.

	Patients eligible for mobilisation		
	Pre-protocol (*n* = 25)	**Protocol (*n* = 16)**	**Difference with 95% CI (protocol – pre-protocol), *p*-value**
Age (years)[1]	57.0 (46.0–65.5)	61.5 (53.8–65.8)	$p = 0.467$
Gender, *n* (%)[2]			
Male	17 (68%)	6 (37.5%)	$p = 0.105$
Female	8 (32%)	10 (62.5%)	
Diagnosis, *n* (%)[2]			
SAH	12 (48%)	9 (56.3%)	$p = 0.883$
ICH	7 (28%)	3 (18.8%)	
IVH	2 (8%)	1 (6.3%)	
Meningitis	1 (4%)	0	
Tumour	2 (8%)	3 (18.8%)	
TBI	1 (4%)	0	
GCS on ED admission[1]	10.0 (5.0–13.5)	14.0 (9.0–15.0)	$p = 0.023$***
Duration of EVD (days)[1]	13.6 (8.5–18.0)	12.0 (6.3–15.0)	$p = 0.320$
On ventilator	0	0	

CI = confidence interval; ED = emergency department; EVD = external ventricular drain; GCS = Glasgow Coma Scale; ICH = intra-cerebral haemorrhage; IVH = intra-ventricular haemorrhage; SAH = subarachnoid haemorrhage; TBI = traumatic brain injury.

***Level of significance $p < 0.05$.

[1]Mann-Whitney U test with median (25th–75th percentile).

[2]Fisher's exact test.

Table 4: Safety, feasibility and effectiveness of the early mobilisation protocol.

	Pre-protocol (n = 75)		Protocol (n = 42)	Difference with 95% CI (protocol – pre-protocol), p-value
Patients eligible for mobilisation, n (%)	25 (33.3%)		16 (38.1%)	
Eligible patients mobilised, n (%)[1]	1 (4%)		11 (68.8%)	64.8%, 95% CI (35.9%, 82.1%), p <0.0001***
Total number of therapy sessions	1		21	
Highest level of mobility achieved during each session	SOOB 1	SOEOB STS SOOB Marching Ambulation	10 (47.6%) 4 (19.1%) 0 5 (23.8%) 2 (9.5%)	
Number of adverse events	Information not available		0	
Time from EVD placement to first mobilisation in the hospital (days)[2]	14.0 (9.5–18.0)		3.5 (2.0–7.0)	p <0.0001***
ICU LOS (days)[2]	8.0 (4.0–10.0)		3.5 (2.0–9.0)	p = 0.037***
Hospital LOS (days)[2]	38.0 (24.5–54.5)		22.5 (17.8–39.0)	p = 0.030***

CI = confidence interval; EVD = external ventricular drain; ICU = intensive care unit; LOS = length of stay; SOEOB = sitting-on-edge-of-bed; SOOB = sitting-out-of-bed; STS = sit-to-stand.

***Level of significance p <0.05.

[1]Fisher's exact test.

[2]Mann-Whitney U test with median (25th–75th percentile).

Discussion

This service evaluation demonstrated that the physiotherapy-led early mobilisation protocol in patients with EVDs was safe, feasible and effective within TTSH. The time from EVD placement to 1st mobilisation, ICU LOS and hospital LOS were significantly reduced in eligible patients. A significantly greater proportion of patients with EVDs were also mobilised in the neurological ICU after protocol implementation, with no recorded adverse events.

In line with Moyer et al. (2017) and Young et al. (2019), the time from EVD placement to 1st mobilisation, as well as ICU and hospital lengths of stay were significantly reduced. While LOS is an important outcome, it is difficult to evaluate owing to many contributing factors and is likely not dependent on physiotherapy treatments alone (Gruenberg et al., 2006). Assessment of physical function in patients with EVDs could have provided data more directly associated with the intervention and could be a better outcome measure to examine the effectiveness of early mobilisation in the ICU.

Early mobilisation in patients with EVDs was found to be safe given that no adverse events were recorded. This was in contrast to studies with reported EVD mobilisation protocols in which adverse events, ranging between 0.8% and 5.9% occurred (Moyer et al., 2017; Young et al., 2019). The robust safety profile for mobilisation of patients with EVDs in this study may be due to more cautious eligibility criteria, or differing definitions of adverse events.

A systematic review by Conceição et al. (2017), suggested that early mobilisation of critically ill patients could be carried out with reference to specific safety criteria which can be broadly categorised into cardiovascular, respiratory, neurological and orthopaedic-related. In this study, the protocol clearly stated eligibility criteria pertaining to each of the above-mentioned physiological systems for initiation of early mobilisation in patients with EVDs. Having such definitive criteria eliminated any ambiguity for determining whether a patient was eligible for mobilisation. Coupled with the mobilisation flow chart that illustrated a step-by-step safety checklist, as well as the collaborative efforts between the nurse and physiotherapist in monitoring the patient's vital signs and symptoms throughout mobilisation, adverse events were avoided.

This study reported an increased in mobilisation rate during the protocol period. Titsworth et al. (2012) reported similar finding in the population admitted into the neurological ICU using the Progressive Upright Mobility Protocol Plus. Despite differences in the methods used in quantifying mobilisation rate in both studies, they demonstrated feasibility of introducing a mobilisation protocol within critical care.

This study was not designed as research, but to evaluate a specific service. Patient numbers were small, and data were analysed retrospectively from a single centre with no concurrent control group or randomisation process. Results would not be generalisable to the wider population, although this work provides some practice sharing and learning points. The accuracy of the reported adverse events was dependent on the quality of note-taking at

the time of the incident. Eligibility criteria applied retrospectively to the pre-protocol group may have flaws as the medical records may not have presented a full picture as to whether patients were appropriate for mobilisation.

The clinical implications of having a mobilisation protocol included developing greater confidence amongst physiotherapists and other healthcare professionals in mobilising patients with EVDs. Furthermore, it helped to promote a mobilisation culture within the ICU in this patient population, who traditionally would have been placed on bed rest.

Conclusion

A physiotherapy-led early mobilisation protocol for patients with EVDs enabled safe, feasible and effective mobilisation in 1 neurological ICU. Although these findings add to the current evidence supporting mobilisation among this patient population, a service evaluation cannot be generalised more widely. Future prospective, controlled research studies are warranted.

Acknowledgements

The author would like to thank the physiotherapy department and the neurocritical care team at TTSH for the support. Acknowledgements are also extended to the physiotherapists and nursing staff involved in mobilisation, as well as Dr. Vincent Ng Yew Poh and Dr. Wong Yu Lin for the collaboration in developing the protocol's eligibility criteria.

Funding

This service evaluation was undertaken as a fulfillment of the author's MSc research thesis. There was no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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Influence of age and gender on cardiovascular response to isometric exercise in apparently healthy individuals

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Abstract

Objective

Static exercises are an integral aspect of patient rehabilitation and are employed in advanced strength and endurance training programmes. Exercise is a form of self-induced stress leading to circulatory and respiratory changes, therefore, this study sought to determine the influence of age and gender on the cardiovascular responses of apparently healthy individuals to isometric/static exercises.

Methodology

Sixty apparently healthy individuals (30 males and 30 females) participated in this study. Their ages ranged between 21–50 years and were grouped into 21–30 years, 31–40 years and 41–50 years. Each participant carried out and maintained 30% of maximal isometric voluntary contraction (MIVC) using hand grip for 1, 2 and 3 minutes respectively, with 30-minutes rest period. Systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were measured and recorded, at rest, and during each of the sustained contractions.

Results

There was a statistically significant increase (p <0.05) in the mean SBP, DBP and HR at rest and with every increase in duration (that is, from 1 minute to 3 minutes) of static handgrip contraction, maintained at 30% MIVC in the 3 groups; except for HR for group one (that is, 21–30 years). There was no gender difference (p >0.05) in SBP and DBP of the participants within the 3 groups, although male participants, particularly in

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Keywords

Isometric exercise, cardiovascular response, sex.

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group 2 had higher SBP. There was also a statistically significant increase in the HR of female participants compared to the males in group 2. Isometric contraction for 3 minutes produced the greatest change (increase) in cardiovascular parameter across all the groups but more marked among participants in group 2 (that is, 31–40 years).

Conclusion

The study concluded that submaximal (30% MIVC) isometric upper limb exercise increase blood pressure and heart rate in both sexes, with greatest values when the exercise was sustained for 3 minutes. Hence, efforts should be made to monitor cardiovascular parameters prior to prescribing safe level of isometric exercise. Also, 3 minutes of static/isometric exercises may be avoided, particularly during the rehabilitation of patient with cardiovascular disease.

Introduction

Exercise, as defined by Awopetu (2014), is activity which requires physical effort and is conducted with the intention of sustaining or improving health and fitness. It is a form of self-induced stress to the body, capable of leading to changes in the cardiovascular and respiratory systems (Aldajah & Hariraja, 2015). It also impacts the metabolic system by leading to an increase in metabolic demand (Bhavsar et al., 2015). The magnitude of this change however depends on the type of exercise (for example, either static/isometric or dynamic/isotonic) being carried out. According to the literature, pure static contractions are observed only with in vitro models, however, isometric or static contraction has been described as a sustained muscle contraction (increase in tension) with no change in length of the involved muscle group (Mitchell & Wildenthal, 1974). Static or isometric exercise is an important therapeutic exercise modality employed by physiotherapists in patients' management, particularly in advanced strength and endurance training exercise programmes (Aldajah & Hariraja, 2015). It is quite different from isotonic or dynamic exercises, where there is a change in the muscle length with tension remaining the same (Clark, 2010). Hand grip exercise (HGE) is one of the most widely studied isometric training protocols with varying number of contractions and degrees of maximal isometric voluntary contraction (MIVC) or an equivalent electromyographic value (Ray & Carrasco, 2000; Wiles et al., 2010; Badrov et al., 2013).

Previous studies have confirmed the effects of isometric exercise on the cardiovascular system, and that the larger the muscle groups involved in the isometric exercise, the greater the resultant effect on the cardiovascular parameters (Mbada et al., 2007; Srikanth et al., 2013; Thimmaraju & Anandarao, 2014). Furthermore, Maan et al. (2014) stated that the intensity of the isometric exercise and the number of the muscles recruited for the exercise also affect the influence of isometric exercise, and that it may lead to increased metabolic demands of the exercising muscle, with consequent changes in the circulatory and respiratory system. The sympathetic system has been found to be responsible for these changes leading to increased cardiac output which results in raised heart rate and systolic blood pressure as well as increased peripheral resistance, which results in raised diastolic blood pressure (Muthusamy et al., 2015). Following this disproportionate rise in HR, SBP and DBP, a significant pressure load is imposed on the heart which is presumed to increase perfusion to the contracting muscles (Maan et al., 2014).

There are reports of an association between aging and the cardiovascular system in the literature with subsequent alterations in cardiovascular physiology. The changes occurring with age differ from person to person with varying rates. The changes associated with aging in the cardiovascular system include a decrease in elasticity and an increase in stiffness of the arterial system (North & Sinclair 2012; Maan et al., 2014). This leads to increased afterload on the left ventricle, an increase in systolic BP (SBP), left ventricular hypertrophy, and other changes in the left ventricular wall that prolong relaxation of the left ventricle in diastole. Although resistance exercise is part of the overall fitness programme designed for healthy older adults, an understanding of the effects of age and gender on cardiovascular response is crucial, prior to prescription of static exercise in a patient's rehabilitation. Age has been reported as the most important determinant of cardiovascular health (North & Sinclair, 2012). Advancing age has been shown to have a significant effect on the heart and arterial system, which may lead to increase in the susceptibility to cardiovascular disease including hypertension, atherosclerosis, myocardial infarction and stroke (Lakatta & Levy, 2003). Similarly, sex differences have also been identified in cardiovascular health. Researchers have opined that cardiovascular disease is widely considered as a man's disease and mortality from coronary heart disease and stroke remains higher among men than women until old age (Mosca et al., 2011; Bots et al., 2017).

Although a number of studies have been conducted on isometric exercise (Mbada et al., 2007; Bhavsar et al., 2015; Rajasekhar et al., 2015; Akintomide et al., 2016), a study on the influence of age and sex on the cardiovascular response of apparently healthy adults has not been fully studied in Nigeria. A study of this kind may provide adequate information on the effects of age and gender on the cardiovascular response to isometric exercise, and consequently enhance the rehabilitation, particularly patients with cardiovascular diseases. This study was therefore designed to determine the effect of age and sex on cardiovascular response to isometric exercise, using hand held dynamometer (HHD) at 30% MIVC.

Methodology

Participants

This cross-sectional analytical study involved 60 apparently healthy participants (30 males and 30 females). The participants were students and staff of a Federal University and Teaching Hospital in Nigeria. The study included apparently healthy individuals who are between 21 and 50 years old. Individuals with history of cardiovascular (heart) disease, hypertension, diabetes mellitus, and deformity or weakness (paralysis) of the upper limb were excluded from this study. Participants were selected using consecutive sampling and screened for eligibility based on the inclusion criteria. The participants were grouped into 3 groups (21–30 years, 31–40 years and 41–50 years). Each group consisted of 20 participants with 10 males and 10 females.

Ethical consideration

Prior to the commencement of this study, ethical approval was sought for and obtained from the Health Research and Ethics Committee of the Lagos University Teaching Hospital, Lagos state. Informed written consent was obtained from participants prior to the commencement of the study.

Instrumentation

A hand-held dynamometer (HHD) was used to carry out the static exercise, Sphygmomanometer (Honbrand Med, Germany) and a stethoscope (Wenzhous Kangju, China) were used to measure the blood pressure, a stop watch was used while counting the pulse rate of the participant. A portable weighing scale (Hana, China) graduated in kilograms with a maximum capacity of 120 kilograms was used to measure the participants' weight. A vertical scale made of steel and calibrated in inches and meters with a moveable wooden pointer attached which indicates the height of an individual was used to measure the height of the participants.

Research procedure

The procedure for the data collection was explained to the participants. Participants' weight and height were measured using the weighing scale and height-meter respectively. Thereafter, participants' cardiovascular parameters (SBP, DBP and HR) were measured and recorded in a sitting position. The blood pressure measurement, (for example, SBP and DBP) were obtained at the brachial artery from the arm not being used for contraction (for example, non-dominant arm). While heart rate measurement was obtained at radial artery of the arm not being used for contraction. Blood pressure and heart rate measurement were obtained during each of the sustained exercise protocols (for example, 1-minute, 2-minutes and 3-minutes).

Prior to the isometric exercise protocol, maximal isometric voluntary contraction (MIVC) was determined from the participant's best single voluntary contractions of three trials. 30% of the MIVC was employed in this study (that is, sub maximal exercise) for isometric

contraction, using the protocol described by Ray and Carrasco (2000). To obtain the 30% of MIVC, the maximal contraction of the participants was multiplied by 30% (0.3) (for example, dynamometer peak value for each participant × 30/100).

Data analysis

The data obtained were analysed using SPSS, version 20. Data was normally distributed following Shapiro Wilk Test for normality of data. Data was summarised using descriptive statistics of mean, standard deviation, frequency, percentages and charts. Independent *t*-test was used to compare the data of males and female participants while analysis of variance was used to compare the data across the 3 groups and 4 stages of assessment (rest, 1 min, 2 mins, and 3 mins). Level of significance was set at $p < 0.05$.

Table 1: Demographic characteristics of the participants.

Variables	21–30 years Mean ± *SD*	31–40 years Mean ± *SD*	41–50 years Mean ± *SD*	*f*-value	*p*-value
Age (years)	24.20 ± 3.24	35.20 ± 3.02	46.15 ± 2.88	258.61	0.001*
Body mass index (kg/m^2)	23.63 ± 4.51	24.48 ± 4.51	24.27 ± 5.18	0.17	0.840

*Significance: $p < 0.05$.

Table 2: Participants cardiovascular response to isometric exercise at rest and 3 exercise durations.

Variables	Rest Mean ± *SD*	1 minute Mean ± *SD*	2 minutes Mean ± SD	3 minutes Mean ± *SD*	*f*-value	*p*-value
21–30 (years)						
HR (bpm)	71.95 ± 6.84	71.35 ± 4.09	71.70 ± 3.58	72.20 ± 3.73	0.25	0.637
SBP (mmHg)	122.55 ± 6.89	124.00 ± 6.89	125.30 ± 6.16	126.05 ± 6.19	19.29	0.001*
DBP (mmHg)	69.40 ± 8.47	72.30 ± 3.46	72.15 ± 3.21	72.70 ± 3.48	7.82	0.001*
31–40 (years)						
HR (bpm)	70.50 ± 5.73	71.65 ± 5.42	71.80 ± 4.92	71.95 ± 5.01	5.92	0.005*
SBP (mmHg)	121.35 ± 7.79	124.20 ± 6.42	125.20 ± 6.70	125.90 ± 6.52	25.83	0.001*
DBP (mmHg)	68.00 ± 4.30	69.15 ± 3.61	70.05 ± 3.34	71.15 ± 3.91	11.69	0.001*
41–50 (years)						
HR (bpm)	71.20 ± 4.20	71.80 ± 3.90	72.50 ± 3.77	72.70 ± 3.79	5.78	0.010*
SBP (mmHg)	126.15 ± 7.57	127.75 ± 6.64	129.15 ± 5.68	130.30 ± 6.21	16.20	0.001*
DBP (mmHg)	73.25 ± 5.86	73.75 ± 5.10	73.80 ± 5.09	74.85 ± 4.33	10.67	0.004*

*Significance at $p < 0.05$.

HR = heart rate; SBP = Systolic blood pressure; DBP = Diastolic blood pressure.

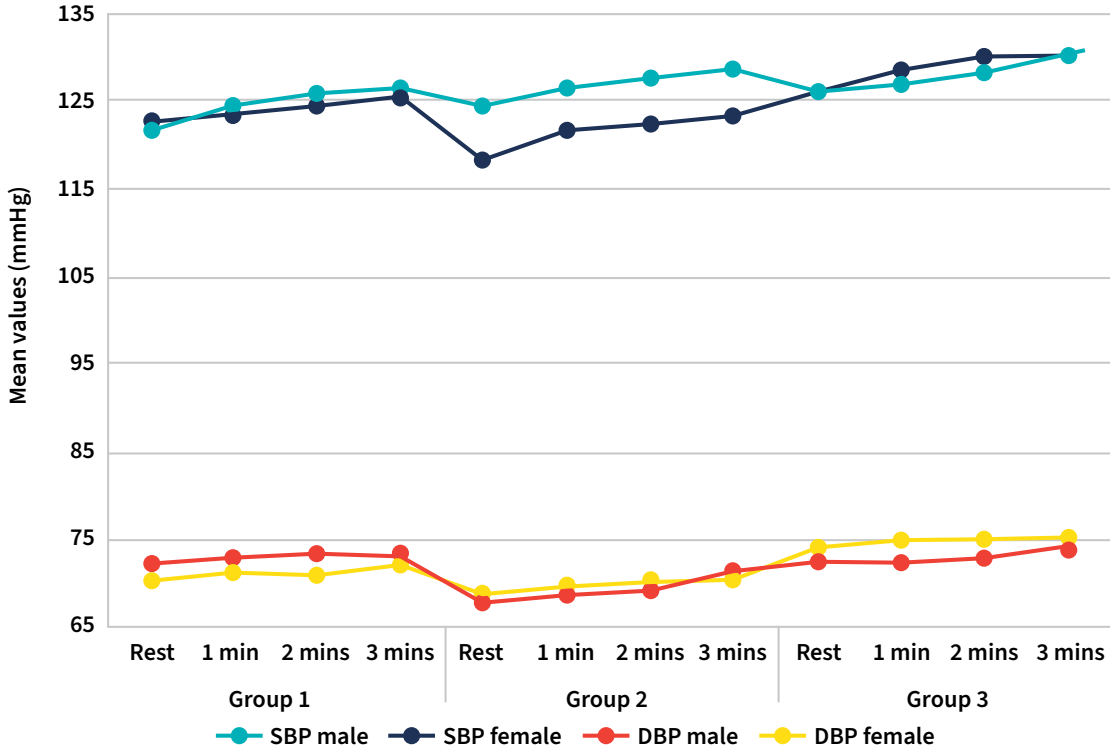

Figure 1: Systolic blood pressure (SBP) and diastolic blood pressure (DBP) of the participants across the 3 groups.

SBP = Systolic blood pressure (mmHg); DBP = Diastolic blood pressure (mmHg).

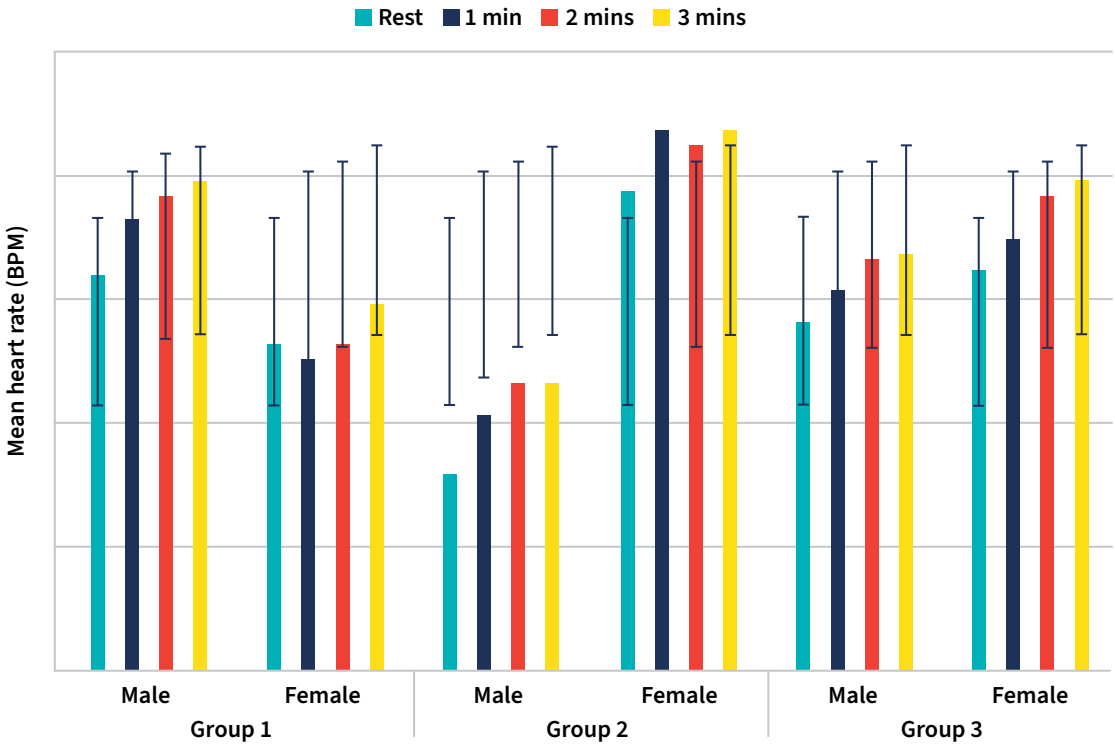

Figure 2: Heat rate (HR) response of the male and female of the participants across the groups.

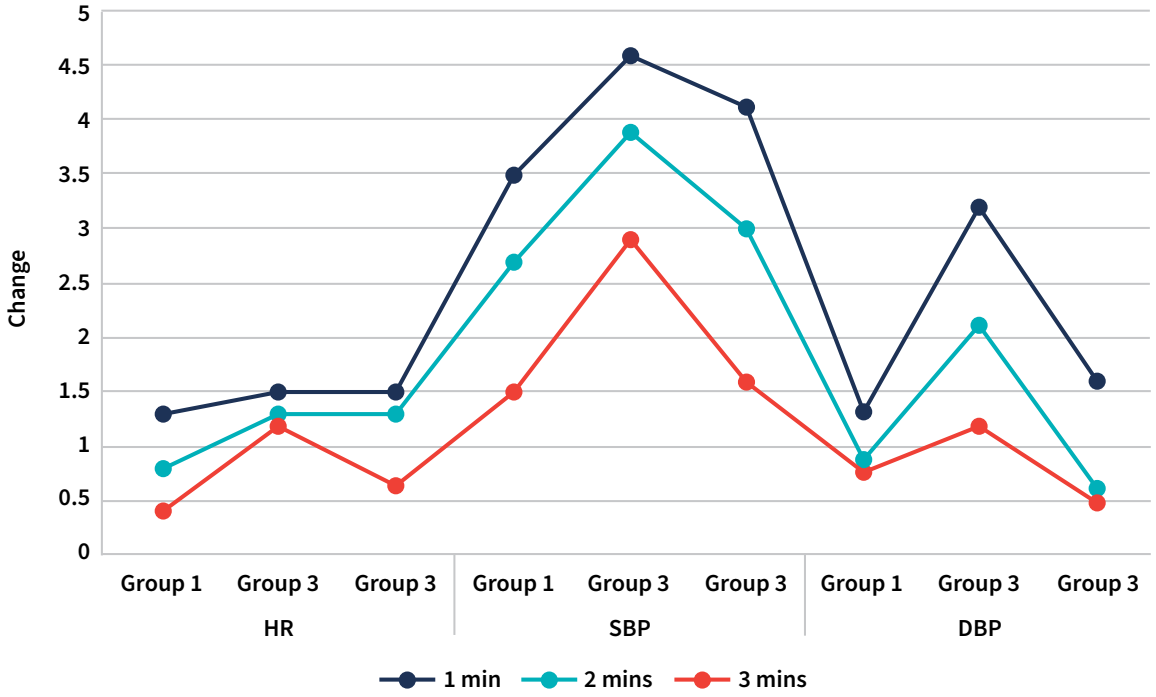

Figure 3: Change in cardiovascular response from rest to the end of 1 min, 2 mins and 3 mins of contraction.

Results

This study involved 60 participants. Each of the three age groups consisted of 10 males and 10 females. As expected, a statistically significant difference (p <0.05) was observed in the mean age across the three the groups but no statistically significant difference (p >0.05) was noted in the body mass index (BMI) (Table 1).

There was a statistically significant increase (p <0.05) in the mean SBP, DBP and HR with increase in duration of static handgrip contraction from 1 minute to 3 minutes in the three groups, except HR for group one, that is, 21–30 years (Table 2).

Following independent t-test, there was no gender difference (p >0.05) in SBP and DBP of the participants within the three groups, although males, particularly in group 2 had higher SBP (Figure 1). Also, for participants in group 2, there was a statistically significant increase in the HR of female participants compared to males (Figure 2). Figure 3 showed that isometric contraction for 3 minutes produced the greatest change (increase) in cardiovascular parameter across all the groups but this is more marked among participants in group 2, that is, 31–40 years.

Discussion

This study was carried out to evaluate the changes in cardiovascular response to static exercise across different age groups and gender. It sought to evaluate the systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) responses in male and female. Static exercise is considered to be an isometric contraction based on the fact it

causes increase in intramuscular tension without a change in muscle length (Gabriel, 2000; Gabriel et al., 2006).

The cardiovascular parameters increased in all the three group among both males and females following 3 minutes of sustained static exercise. The finding that there was a significant increase in the cardiovascular parameters after the isometric exercise is corroborated by the finding of earlier studies by Krzeminski et al. (2012), Akintomide et al. (2016) and Muthusamy et al. (2015). Increased systolic blood pressure often arises from the increased cardiac output which accompanies increasing rates of work in order to improve blood flow to the contracting muscles (Bhavsar et al., 2015). The increased cardiac output may stem from the activation of sympathetic adrenergic system, which was indicated by an increase in the plasma catecholamine level (Krzeminski et al., 2012). This rise in cardiovascular parameters, particularly for SBP were more marked in the males than females, for participants in group 2. This finding is consistent with the trend in the literature, and it agrees with the finding of Thimmaraju and Anandarao (2014), who in a study exploring the gender differences in cardiovascular response in apparently healthy individuals to upper limb isometric exercises, reported a highly significant increase in post exercise HR, SBP, DBP and RPP in males compared to females. Muthusamy et al. (2015) reported that the plasma levels of all three catecholamines are higher in males compared to the females. Although among the older population, females showed slightly higher SBP. However, it was observed that HR was higher among females compared to males particularly in group 2. This finding is also consistent with the literature as it has been established that women generally have higher heart rates than men (Prabhavathi et al., 2014); the reported gender difference in heart rate may be accounted for by the size of the heart, which is typically reported in females than males. Because of this small size of the heart, less blood is pumped in each minute, therefore the heart needs to beat at a faster rate to meets its demands.

The finding of this study also showed that cardiovascular parameters were highest in group 3 (which comprised the older population) at rest and throughout the exercise. Literature has established that cardiovascular parameters increase with increasing age (Pollock et al., 2000; Mann et al., 2014). The significant difference noted in blood pressure at the 1 and 3 minute/s durations, when the age groups were compared, agreed with the report of Mann et al. (2014) and has been suggested to be due to the increased stiffness and decreased elasticity of arterial tree that have reported at older age (Pollock et al., 2000). Furthermore, static contraction sustained for 3 minutes produced the highest increase in cardiovascular parameters. The fact that isometric exercises narrow the blood vessels, raising the total peripheral resistance may lead to increase pressure load on the heart, resulting in increased cardiovascular response. This knowledge may be useful in the management of the elderly and patients with cardiovascular disease. These categories of individuals may benefit more when they are gradually exposed to sub maximum isometric training in supervised cardiac rehabilitation programmes.

Conclusion and recommendation

The result of this study revealed that submaximal (30% MIVC) isometric upper limb exercise elicited increase in blood pressure and heart rate in both males and females and this was greatest when the exercise was sustained for 3 minutes. Hence, it is recommended that health care professionals, fitness instructors as well as coaches should measure the blood pressure before isometric exercise in order to prescribe safe level of exercise as prolonged isometric exercise further increases cardiovascular parameters.

Limitation of the study

The study sample size was 60 apparently healthy individuals, in the age group of 21–50 years. This may be a potential limitation. So, further study may be required using a larger sample, for more generalisable results.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

There is no potential conflict of interest associated with this study.

Acknowledgement

The authors acknowledged those consented to participant in this study.

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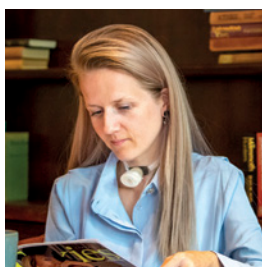

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Is there a link between the activity levels of parents and their children with cystic fibrosis? A scoping review

Kieren James Lock[1], Sam Coleman[1] and David Young[1]

Abstract

Background

Increased exercise levels result in decreased pulmonary exacerbations and hospitalisations in people with cystic fibrosis (CF). There is a clear link in the literature between parental activity levels and that of their children, though this not reported in CF.

Objective

To investigate whether there is a link between activity levels of parents and children with CF.

Method

A literature search was conducted to identify studies that evaluated the importance of parental activity and other behavioural factors on children's activity levels. Two investigators screened titles and abstracts to identify suitable studies using inclusion criteria. A third author reviewed discrepancies with eight articles selected for review. Relevant data was extracted from accepted studies using agreed criteria.

Discussion

A narrative synthesis was used. The data showed multiple outcome measures discussing adherence and treatment levels within children and young people with CF. Questionnaires were the most commonly used tool to establish activity levels. There were multiple psychosocial programmes effectively used in people with CF. There was limited evidence on the impact parents play on a child's activity levels or their adherence to treatment.

Conclusion

There is currently no clear link between parental activity levels and activity levels for children with CF,

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Keywords

Physical activity, children, parents, cystic fibrosis.

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or adherence to physiotherapy treatment in CF. Evidence shows that family-based interventions can increase a child's adherence to a variety of CF related treatments.

Limitations

There is limited research currently published in this area meaning that only eight studies were included for review. Selected studies used a range of methodologies making data analysis and synthesis challenging.

Introduction

Cystic fibrosis (CF) is a genetic condition affecting more than 10,500 people in the United Kingdom and is the most common lethal genetic disease in the Caucasian population (Sibley et al., 2006). People with CF have associated damage to the lungs which occurs from a build-up of viscous sputum. This indicates an importance in maximising the effectiveness of mucociliary clearance. There are various methods of airway clearance techniques (ACT) which are commonly used, including: exercise, manual techniques (such as percussions), breathing exercises, use of positive expiratory pressure (PEP) devices and the oscillatory versions of this (Cystic Fibrosis Trust, 2020).

There is evidence throughout the literature, including systematic and Cochrane reviews, that to maintain respiratory health, exercise and airway clearance are important (Flume et al., 2009; Patterson et al., 2019). Physical activity (PA) and exercise have shown a decrease in the number of pulmonary exacerbations and hospitalisations in the CF population, alongside improvements in cardiovascular endurance and quality of life in both children and adults (Rand & Prasad 2012; Patterson et al., 2019). The benefits of exercise have led to the question of whether exercise can be a replacement for ACT in people with CF, which would have implications for both research and clinical practice. Dwyer et al. (2019) found no significant difference in mucus clearance from the intermediate and peripheral lung regions when comparing treadmill exercise to PEP devices. When considering sputum clearance in central lung regions between PEP and exercise, however, there was a difference in expectoration indicating that exercise alongside traditional ACTs may be of greater benefit that ACTs alone. Although, this benefit may not be fully achieved due to issues with adherence.

Adherence is defined as the 'extent to which the patient's behaviour matches agreed recommendations from the prescriber' (NICE, 2007, p. 2). Modi and Quittner (2006) reported adherence to overall treatment to be below 50% in children with CF. Goodfellow et al. (2015) also found adherence to be low in this population with 49% of patients being low-adherers to chest physiotherapy. Adherence to exercise and ACTs is important, as poor adherence to

treatment has been linked to a decline in health outcomes, such as risk of hospitalisation for intravenous antibiotics and length of stay, which pose a significant burden on health outcomes and the National Health Service (NHS) in terms of costs (Eakin et al., 2011). Conclusions have been drawn that adherence to medication, exercise and chest physiotherapy in CF is an important research area and more is needed to better understand family barriers to adherence in order for clinicians to provide appropriate intervention (Goodfellow et al., 2015).

Research has shown a significant link between parental activity levels and that of their children in a healthy population. One study has showed that with an active mother, children were two times as likely to be active, with an active father they were three and-a-half times as likely to be active, and when both parents were active the child was almost six times as likely to be active (Moore et al., 1991). More recent studies, taking into account the change of environment in terms of technology and home/life balance have also found that children's activity level depends on their parents' levels of activity (Brzęk et al., 2018). A pilot study from Emirza et al. (2018) showed that this significant difference in activity levels for parents and children extended into the population with CF. This pilot study concluded that parents should be included in PA training programme as part of clinic reviews, which would be a change in the way paediatric CF clinics are historically run. It should be noted that this study was carried out on a small sample size of 13 patients. PA tends to be lower in parents of children with chronic conditions, including that of CF. These decreased activity levels are amplified during the child's inpatient stay (Vardar-Yagli et al., 2016).

Dempster et al. (2018) also showed how important parents are to a child's adherence to treatment. Parent's health beliefs were significantly related to children's adherence to ACTs; higher importance placed on healthy lifestyles were associated with better adherence to treatment. Family-centred psychoeducational intervention has been a potentially promising supportive strategy for children with CF (Goldbeck & Babka, 2001). Possible mechanisms for the relationship between parents and children's activity levels include the parents serving as role models, sharing of activities by family members, as well as enhancement and support by active parents of their child's participation in PA (Moore et al., 1991). Family centred interventions on health beliefs can help to increase PA levels in children with CF (Hovell et al., 2009).

Exercise is a particularly important part of a child's development in terms of cognition, general health and mental health (Biddle et al., 2019), as well as CF related health. Understanding the reasons for reductions in activity and the impacts these can have on patients is an important part of care for people with CF, to enable a practitioner to challenge and support in changing these behaviours.

To date this area has not been comprehensively reviewed. A scoping review has therefore been chosen to evaluate the current literature as it can be a particularly useful approach when the information on a topic has not been comprehensively reviewed or is complex and

diverse (Munn et al., 2018). The aim of this scoping review is to synthesise evidence regarding how much parental activity can influence children's activity levels and engagement in treatment amongst people with CF. The synthesis of evidence aims to explore this link as well as inform research, clinical practice and policy moving forwards.

Aims

The aims of the scoping review are to:

- Address whether there is a link between parent and child activity levels or adherence to treatment in CF.
- Understand whether family-based interventions exist to increase child adherence.
- Identify which outcomes measures have been used to determine any links.
- Identify areas of future research based on the current literature that is available within and around this topic.

Methods

Scoping reviews are a relatively new design of research and thus there are still inconsistencies with regards to its methodology. This scoping review methodology will be closely guided by the framework, following five steps, as proposed by Arksey and O'Malley (2005), and further developed by Levac et al. (2010).

Identify research question

The broad research question is to look at: *How are the activity levels and engagement in physiotherapy of children with cystic fibrosis affected by their parents' activity levels?*

As discussed by Levac et al. (2010) there is a need in a scoping review to define the concept, target population, and health outcomes of interest. This definition allows for clarification on the focus of the scoping study. To facilitate this, a PICOT (Population, Intervention, Comparison, Outcome, Time) design was used, as described by Riva et al. (2012).

Table 1: PICOT used in study.

(P) – Population:	Children with cystic fibrosis. Parents of children with cystic fibrosis
(I) – Intervention:	No specific intervention will be looked for
(C) – Comparison:	Both those with and without reference groups will be considered
(O) – Outcome:	Physical activity levels, lung function, health beliefs
(T) – Time:	Studies were not excluded based on time; all ages of paper will be accepted

In order to establish an effective search strategy, the researchers aimed to consider the rationale for summarising this area of research.

Identify relevant studies

In consultation with a medical librarian, a search strategy was developed to identify relevant research to help answer the above question. This was carried out on 16th December 2020 (see Table 2 for search terms). In order to complete a comprehensive search of the existing literature Medline, Applied Social Sciences Index and Abstracts (ASSIA), Global Health and Web of Science search engines were used, to identify studies for this scoping review. This resulted in a total of 128 studies being identified (20 results on Medline, 93 results on ASSIA, 0 results on Global Health and 15 results on Medline); all duplicate studies between the search engines were removed prior to moving on to the study selection stage. The search strategy then progressed to searching reference lists of relevant studies for further appropriate research in which one additional paper was found through citations.

Table 2: Search terms.

1	(mother* or father* or parent*)
2	('activity level*' or 'health belief*' or 'health attitude*' or 'physical activity' or 'sedentary behavio*')
3	('chest physiotherapy' or nebuli*)
4	child*
5	(adherence or compliance or comply)
6	'cystic fibrosis'

Study selection

Inclusion and exclusion criteria were discussed between the authors prior to the study selection period, as suggested by Levac et al. (2010). The article titles and abstracts found from the database searches were screened by two authors independently applying the inclusion and exclusion criteria to all citations (KL and SC). Inclusion criteria were: studies including patients with CF; studies in English; a focus on parents and/or children; behavioural change. Exclusion criteria were: studies not in English; studies focusing on adults; studies with long term conditions other than CF.

A third author (DY) then reviewed the screened studies to establish any discrepancies between the 1st two authors. When any disagreements occurred, they were discussed under consultation with the third reviewer until an agreement on the final studies to include was reached. Ultimately, 8 studies were accepted in the study selection, alongside 1 abstract. At this stage, full copies of relevant studies were downloaded from journals or ordered through the Hospital library (Figure 1).

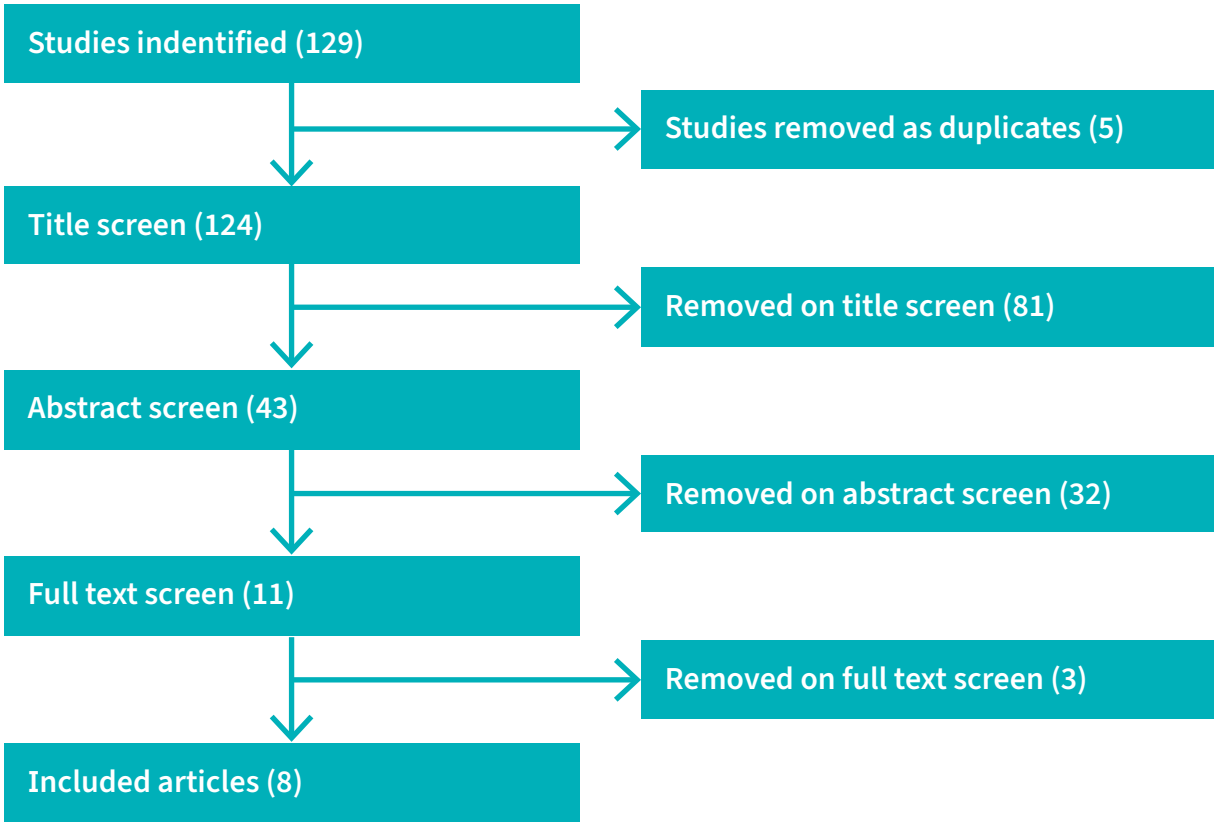

Figure 1: Study selection.

Studies were not taken through to full analysis if there was no full paper. However, the abstract by Emirza et al. (2018) was particularly relevant based on the title *Physical activity levels of children with cystic fibrosis and their parents: Pilot study* and will therefore be discussed in brief during the review.

Charting the data

A data-charting form was developed looking at variables that could be extracted to answer the research question. The following variables were chosen:

1. Title of the study.
2. Authors of the study.
3. Working hypothesis.
4. Outcome measures used.
5. Sampling method used.
6. Description of participants (age, sex, cognition, inclusion/exclusion criteria).
7. Confounding factors (if identified).
8. Quality of paper using the Mixed Methods Appraisal Tool (MMAT).
9. Implications for further research.
10. Overall implications.

A critical appraisal skills programme (CASP) tool was used to facilitate the appraisal of research quality and the extraction of data from the eight full studies isolated from the search (Brice, 2018). The Mixed Methods Appraisal Tool (MMAT) is a critical appraisal tool for

appraising during a systematic review of studies with mixed methods; it allows for appraising the methodological quality of both qualitative and quantitative data (Hong et al., 2018). The data variables used were chosen on review of previous scoping studies and altered over the process of the data extraction to allow researchers to become familiar with study data and model this into a meaningful format.

Collating, summarising and reporting the data

The full data collected is available in Appendix 1. The data collected was based on the variables chosen in the data charting section of the scoping review.

Results

Outcome measures

The identified studies included a mix of qualitative and quantitative methods, with quantitative studies generally looking for correlations between variables with no causal links discussed. The quantitative studies used a variety of designs, randomised control feasibility trial, pilot studies and cross-sectional studies. Forced expiratory volume in the 1st second (FEV1) was used as an outcome measure in two studies (Loutzenhiser & Clark 1993; Boucher et al., 1997) and PA questionnaires were used in three of the six quantitative studies (Loutzenhiser & Clark 1993; Hovell et al., 2009; Moola et al., 2017). Within the data set, a further quantitative questionnaire was used though it did not discuss PA, as well as a qualitative questionnaire.

There was no single outcome measure used to monitor PA. Whilst there was some evidence that physical activity monitoring devices appear to be an acceptable method for the objective assessment of PA (Shelley et al., 2018). Questionnaires were used most frequently, seen in three of the quantitative studies to review activity levels.

Population

There was no consensus on the age range throughout these studies. The minimum age was newly diagnosed children under one year of age, though this study focussed on parental knowledge (Goldbeck & Babka, 2001). Where children were engaged in questioning, six years old was the youngest age as seen in three of the studies. The maximum age appeared to vary dependent on the country in which the research was undertaken, though 19 was the eldest (Loutzenhiser & Clark, 1993); this appears to be in keeping with variations on strategies of transition from paediatric to adult care. Males and females were included in all of the selected studies. Inclusion and exclusion criteria also tended not to be discussed.

Confounding factors

Common confounding factors where discussed included: sample size and methodology, including sampling method. The majority of studies used convenience sampling. Two studies used randomised populations including that by Hovell et al. (2009), though in one case this was a randomised population from within one centre in a feasibility trial (Moola et al., 2017). In general, confounding factors were not discussed in these studies.

Critical evaluation of articles

The quality of studies again varied when using both the MMAT and CASP tools to examine them. The scores of the articles reviewed by the MMAT are stated in Table 3. The majority of studies have not stated how the findings support or will develop areas for future research.

Table 3: MMAT score.

MMAT score	Studies
2/5 yes	Shelley et al., 2018
3/5 yes	Loutzenhiser & Clark 1993; Boucher et al., 1997; Hovell et al., 2009; Moola et al., 2017
4/5 yes	Goldbeck & Babka, 2001
5/5 yes	Moola & Schneiderman, 2012; Dempster et al., 2018

Pilot study

The pilot study by Emirza et al. (2018) was particularly relevant to this study given its title. It was only presented as an abstract so limited information can be gained from it; however, its relevance warrants its review. The study used questionnaires to assess activity levels in both children and their parents. The total sample size was 13 patients and they concluded that there is a positive correlation between parental and children's activity levels in CF at both moderate and vigorous intensities, though not at low intensity. They also felt that parents should be included in PA training programmes as when parents are actively involved in treatment, its effectiveness is improved. On discussion with the authors, this was a presentation and unfortunately, no further information on the method was available. This will be briefly discussed in the summary and report of data, though a formal MMAT and CASP were unable to be performed on this.

Discussion

There were very few studies produced during a literature search with an open question, showing the small amount of research in how parental behaviours and activity can affect the activity levels and engagement in physiotherapy treatment in children with CF. The evidence that is available varies in quality when using both the CASP and MMAT critical evaluation tools, this likely represents the infancy of this area of research. Whilst understanding how to better engage patients who have CF with their treatment has become a more focussed area of research in recent years, there is still clearly a lack of evidence base in this specific aspect.

There appears to be no definitive inclusion criteria to be used when researching the paediatric CF population. There is variability with regards to age range, though where there is questioning of children, which may be answered by the parents, six years of age appears to be the youngest. All articles include both female and males. Convenience sampling tended

to be used throughout these studies with relatively low numbers of participants; this seems logical due to the relatively small numbers within local clinics but does affect the power of the studies. Individual centres tend to carry out their own research, which means that the majority of the research is specific to where this data was taken. A future approach may be to use multiple centres to improve the power and general acceptability of the studies.

Increasing the population size may also allow for confounding factors to be identified and discussed in more detail. The issues around the high number of confounding variables that come with convenience sampling, may be explained by convenience sampling as it is a non-randomised method of sampling that can lead to the under or over representation of specific groups inside the sample. The research methods used, alongside limitations with word counts may also contribute.

Understanding the complex psycho-social realities of living with a chronic illness is acknowledged across multiple studies. The psychological health of patients was seen to constrain PA and contribute towards reduced participation. Understanding this was important in developing educational and behavioural interventions to those with CF. Where this had been used to support and educate, it was reported to be a useful intervention. Though this does not discuss parental PA levels and its impact on children, the effective family behavioural interventions may be useful in this area if focussed on activity levels. Though there is limited value that can be taken from the pilot study by Emriza et al. (2018), as opposed to a fully powered randomised controlled trial, there is some evidence that exercise of parents has an association with the exercise levels of their children with CF.

Accelerometers are typically viewed as the gold standard in assessment of PA (Esliger & Tremblay, 2006), however, all of the studies that measured PA in this sample used questionnaires to measure this outcome. Questionnaires for measurement of activity levels have inconsistent results and often reporting errors, though are quicker, easier, and less expensive to use than accelerometers (Novak et al., 2020). The validity of this data is therefore in question, to improve this, accelerometers could be used in future studies. Whilst interventions and associations were reviewed in the studies measuring PA, parental activity levels were not one of these.

FEV1 was another outcome measure regularly used during these studies, though this is a better determinant of current health with no reports of long-term change in rates of decline in FEV1 in different exercise groups (Cheng et al., 2003). There is, however, an association when compared to a control, so FEV1 may be useful in the future as a supplementary outcome measure when reviewing parental and paediatric activity levels. There were no specific outcome measures with regards to physiotherapy used, such as adherence to physiotherapy questionnaires or the use of breath activated data logging nebulisers.

Individuals with CF engage in a variety of activities. CF was not perceived as a barrier to exercise per se, although participants acknowledged that they could be limited by their

symptoms (Shelley et al., 2018). Experiences of PA among children and young people with CF, was seen as largely comparable to their non-CF peers; this gives more weight to the correlation between parental and a child's activity levels seen by Moore et al. (1991) in the healthy population and its transition in people with CF. There is therefore more scope to investigate a link in activity levels of children with CF and their parents.

Study limitations

The variety of topics covered in selected studies make it challenging to select an appropriate outcome measure with which to review the evidence, collate and summarise it. The wide-range of study designs and methods used in the identified studies also made summarising data difficult. There were only eight full text studies found with which to review, this is a small body of work likely secondary to the lack of historical evidence and novelty of the area. A consultant stakeholder was not used as an optional additional stage of the study which could affect the ability of knowledge transfer and understanding of the evidence discovered.

Future research

A number of areas of research have been highlighted during this scoping review. Multiple studies noted a need for further development in PA assessment tools such as consumer level devices; they also recommended further research in validating paediatric specific PA tools. There are complex psycho-social realities in children with CF which act to constrain PA and contribute toward reduced participation; understanding these issues may allow for a better development of strategies to challenge non-adherence. Considering the initial question and lack of evidence around this, there is also a large scope for evidencing how parental activity levels are associated with a child's activity levels and engagement in physiotherapy and more broadly CF treatment as a whole. With the emergency of CF modulator therapy and a discussion between professionals of using PA as a main ACT, understanding how therapists can impact a patient's PA levels is particularly important.

Conclusion

In the literature at present there is no clear link between parental activity levels and child activity levels or adherence to treatment in those with CF. One pilot study, though in abstract form, is the beginnings of evidence to review this link. There appears to be a lack of evidence in the literature as to how activity levels are affected in children and young people with CF and the effect that the social aspect of the child's life plays in this. During the review of the literature, family-based interventions have shown an ability to increase child adherence. The importance of understanding how to increase activity levels in these children is evident and there is a large potential for future research to be carried out in this area.

Funding

There was no funding for this scoping review.

Conflict of interest

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

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Appendices

Appendix 1: Table used for data synthesis

Study number	Authors	Outcome measures	Participants	Summary of results
1	Boucher et al. (1997)	FEV1 and BMI	Defined population of CF children aged 6–16, but no defined area taken from	More emphasis should be put on the nutritional aspect of CF therapy, as increasing nutritional status may prevent a decrease in functional ability in those patients with air flow limitation
2	Moola et al. (2012)	Not applicable	14 children aged 11–17 participated, 10 females and 5 males. No other illnesses or disabilities. Majority Caucasian from middle class families	The findings call attention to how youths complex psycho-social realities, may operate in tandem with reduced physiological health to constrain physical activity and contribute toward reduced participation
3	Clark and Loutzenhiser (1993)	FVC, FEV1, VO_2 max, activity questionnaire	36 children, 6–19 years old, 19 female, 17 male. Midwestern suburb in U.S.A.	Allowing practitioners to have a better evidence base explaining their role in promoting exercise adherence, and how to do this
4	Moola et al. (2017)	Parents perceptions, questionnaires	8–18-year-olds in Winnipeg	Provides tentative evidence that physical that activity counselling is feasible and appears to increase PA among children with CF. Scope for further research
5	Hovell et al. (2009)	Bone mineral density, 24-hour physical activity recall	117 healthy children aged 10–13 years (58.1% female, 42.7% Hispanic, 40.2% White)	Exercise levels were lower in women. Education and support appeared to be useful in the cohort with the family intervention, though there were no confidence levels used

6	Shelley et al. (2018)	Not applicable	9 participants (5 female; mean age 12 ± 3 years)	PA monitoring devices appear to be an acceptable method for the objective assessment of PA among children and young people with CF. Wrist-worn devices that are unobtrusive and can display feedback are most acceptable for patients and clinicians. Experiences of PA among children and young people with CF are largely comparable to their non-CF peers. CF was not perceived as a barrier to exercise
7	Dempster et al. (2018)	Self-care inventory – cystic fibrosis, Health belief model scale – revised	33 children with CF 8–18 and a parent (range = 29–51 years); 45.5% were female. Caucasian (93.9%), 6.1% African Americans	There are significant relationships among health beliefs and adherence with functional differences by treatment and parent report. Practical variables, barriers and cues to action, were identified as early targets of intervention. Significant differences among perceptions of health beliefs for children and parents were present
8	Goldbeck and Babka (2001)	Questionnaires on knowledge of CF	0–12-year-old children with CF, their parents, and healthy siblings	Primary physician should provide information on motivating parents to engage in structured psychoeducational programmes, this may extend to exercise

FEV1 = forced expiration in 1 second; FVC = forced vital capacity; VO_2 max = maximum rate of oxygen consumption; PA = physical activity; CF = cystic fibrosis.

Does the incremental shuttle walk test predict the development of a hospital acquired pneumonia in patients undergoing elective oesophagectomy: A service evaluation

Jonathan Weblin[1], James Cuell[2] and David McWilliams[1]

Abstract

Introduction

Post-operative morbidity following oesophagectomy is high, with pulmonary complications, including hospital acquired pneumonia (HAP), the most commonly reported. Functional assessment to determine fitness for surgery is important to provide an individualised risk profile, helping to guide collaborative decision making around selection for surgery and post-operative care. The incremental shuttle walk test (ISWT) can be used to objectively measure functional capacity. Previous studies have demonstrated walking <350m on the ISWT is associated with significantly higher 30 day and 3-year mortality. The aim of this service evaluation was to assess if walking <350m on the ISWT correlated with the development of HAP.

Methods

Consecutive patients with oesophagogastric cancer listed for an elective oesophagectomy at a large U.K. tertiary hospital between December 2017 and February 2020 were included in analysis. All patients completed the ISWT at pre assessment clinic approximately 1 week prior to surgery. Primary outcome was incidence of HAP. Secondary outcomes included re-intubation rates, intensive care unit (ICU) re-admissions, ICU and hospital length of stay, and 30, 90 day and 12 month mortality.

Results

121 patients completed the ISWT and were included in analysis of which 25 (21%) walked <350m. Those walking <350m had significantly higher rates of

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Keywords

Hospital acquired pneumonia, oesophagectomy, incremental shuttle walk test, risk stratification.

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hospital acquired pneumonia (44% v. 11%, $p = 0.0003$) and spent significantly longer on ICU (5 v. 3 days, $p = 0.041$). Poor performance on ISWT had no significant effect on either 30, 90 day or 12 month mortality.

Conclusion

Walking less than 350 metres on the ISWT pre operatively was associated with a significant increase in the likelihood of developing HAP and longer stays in the ICU. The ISWT may therefore be a useful tool to help manage patient and clinician expectations, guide clinical decision making related to post-operative care, for example, high dependency unit vs ICU and direct post-operative resources like physiotherapy to patients most at risk.

Introduction

Oesophageal cancer is the 14th most common cancer in the U.K., accounting for 3% of all new cancer cases (Cancer Research U.K., 2020). Surgical resection via oesophagectomy remains the main stay of curative treatment, often in conjunction with neoadjuvant chemo/radiotherapy (Sjoquist et al., 2011; van Hagen et al., 2012). Despite advancements in surgical techniques and the implementation of enhanced recovery pathways, morbidity and mortality remains high in this cohort in comparison to other surgical populations (Takeuchi et al., 2014; Low et al., 2019). The national surgical quality improvement analysis identified patients undergoing an oesophagectomy having greater than five times the risk for developing pulmonary complications compared to those undergoing major abdominal surgery (Yang et al., 2015). Pulmonary complications, including hospital acquired pneumonia, are associated with longer hospital stays, increased cost of care, and substantial operative mortality (Shirinzadeh et al., 2011; Saeki et al., 2017).

The addition of preoperative neoadjuvant chemotherapy (NAC) has shown a 13% improvement in survival compared to surgery alone but side effects related to toxicity mean patients experience a reduction in cardiorespiratory reserve following treatment (Jack et al., 2014; Sinclair et al., 2016). As surgery places a significant metabolic demand on the body, those with a lower physiological reserve may be more susceptible to post-operative complications and higher rates of post-operative morbidity (Patel et al., 2019).

To improve clinical outcomes there is increasing focus on the assessment of patient's fitness for surgery during the pre-operative pathway (Paul et al., 2014). Assessment of cardiopulmonary fitness can provide an individualised risk profile, helping to guide collaborative decision-making and inform the consent process but also dictate the level of post-operative

care for example, high dependency unit/intensive care unit and provision of finite post-operative resources like physiotherapy. Whilst cardiopulmonary exercise testing is often seen as the gold standard for functional assessment, this is often time consuming and expensive, requiring specialist interpretation. Field tests to objectively measure functional capacity are therefore becoming of greater importance.

One such field test is the incremental shuttle walk test (ISWT) (Singh et al., 1992). An externally paced, maximal excursion test, the ISWT is a simple and easily reproducible test that is widely used within cardiac and pulmonary populations and shown to correlate well with VO_2 max VO_2 max on a cardiopulmonary exercise test (Pulz et al., 2008). Previous studies looking at the benefit of the ISWT in predicting post-operative outcomes within the oesophagastric population have demonstrated that walking less than 350 meters has been associated with significantly higher rates of mortality at 30 days (Murray et al., 2007) and 3 years (Whibley et al., 2018). The correlation between performance on ISWT and the development of hospital acquired pneumonia has not been previously investigated in this surgical population.

Objective

To assess whether walking <350 meters on an ISWT pre-operatively predicts the development of hospital acquired pneumonias following an elective oesophagectomy.

Method

Design

This was a single centre service evaluation conducted in a large tertiary level acute care hospital. This service evaluation was registered as an audit on the trusts clinical audit registration and management system (CARMS-14193).

Setting

The Queen Elizabeth Hospital Birmingham (QEHB) is part of the University Hospitals Birmingham NHS Foundation Trust (UHB) and a major tertiary upper gastrointestinal unit in Birmingham. Covering a population of 1.7 million, patients are referred both locally and from four district general hospitals (Walsall Manor Hospital, Sandwell and City Hospitals and Russells Hall Hospital Dudley). It performs approximately 80 oesophagectomys a year.

Participants

Consecutive patients with a diagnosis of oesophagogastric cancer listed for an elective oesophagectomy at a large U.K. tertiary hospital between December 2017 and February 2020 were included. Patients who were unable to complete an ISWT, deemed not fit for surgery or sustained a significant post-operative neurological event were excluded from the analysis.

Procedure

All patients were reviewed by a physiotherapist during their pre-assessment clinic one week prior to surgery to complete an incremental shuttle walk test (ISWT). The ISWT was

completed according to a standardised protocol and involved patients walking around two cones set up 9 metres apart. Patients were asked to cover the distance between the cones in time to auditory cues. Oxygen levels and heart rate were recorded during the assessment with the use of a portable pulse oximeter. The test was stopped when patients could no longer keep pace with the auditory cues or were too breathless to continue. The total distance mobilised was recorded.

Post-operatively all patients received standard care as normally provided in our institution. This consists of an enhanced recovery program which includes daily reviews by a physiotherapist for the provision of respiratory care (for example, deep breathing exercises, secretion clearance techniques) and progression of mobility.

Outcomes

Primary outcome was the incidence of hospital acquired pneumonias as defined by U.S. centres for Disease Control (Jammer et al., 2015). The specific criterion used is presented in Figure 1. Secondary outcomes included re-intubation rates, ICU readmissions, ICU and hospital length of stay. We also recorded 30 and 90 day and 12 month mortality.

Two or more serial chest radiographs with at least one of the following (1 radiograph is sufficient for patients with no underlying pulmonary or cardiac disease):

1. New or progressive and persistent infiltrates.
2. Consolidation.
3. Cavitation.

AND at least one of the following:

a. Fever (>38°C) with no other recognised cause.
b. Leucopaenia (white cell count <4 × 109/L) or leucocytosis (white cell count >12 × 109/L).
c. For adults >70 years old, altered mental status with no other recognised cause.

AND at least two of the following:

a. New onset of purulent sputum or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements.
b. New onset or worsening cough, or dyspnoea, or tachypnoea.
c. Rales or bronchial breath sounds.
d. Worsening gas exchange (hypoxaemia, increased oxygen requirement, increased ventilator demand.

Figure 1: U.S. Centres for Disease Control definition of pneumonia (Jammer et al., 2015).

Data collection

Data was collected prospectively throughout the evaluation period using patient noting and electronic databases. Baseline demographics included age, BMI, and charlson co-morbidity index (CCI). Patients were screened daily for the development of a HAP by the physiotherapist completing their daily treatment. ICU and hospital LOS and ICU re-admission data was obtained from electronic databases and mobility levels via patients notes.

Statistical analysis

Descriptive statistics were used to summarise the data; results are reported as medians and interquartile ranges or means and standard deviations, as appropriate. Categorical variables were summarised as counts and percentages. A non-parametric approach was employed, with data reported as medians and interquartile ranges (IQR), and comparisons between groups made using Mann–Whitney tests. For categorical variables, Fisher's exact tests were used. Analysis was performed with IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

Results

138 patients were reviewed by the physiotherapist in pre assessment clinic during the observation period and completed a pre-operative ISWT. Of the 138 patients, 121 were included in the analysis. Patients were excluded because they were not deemed fit for surgery by the multidisciplinary team based on ISWT outcomes ($n = 10$), were inoperable ($n = 6$) or had a myocardial infarction during induction ($n = 1$) (See Figure 2 – flow diagram).

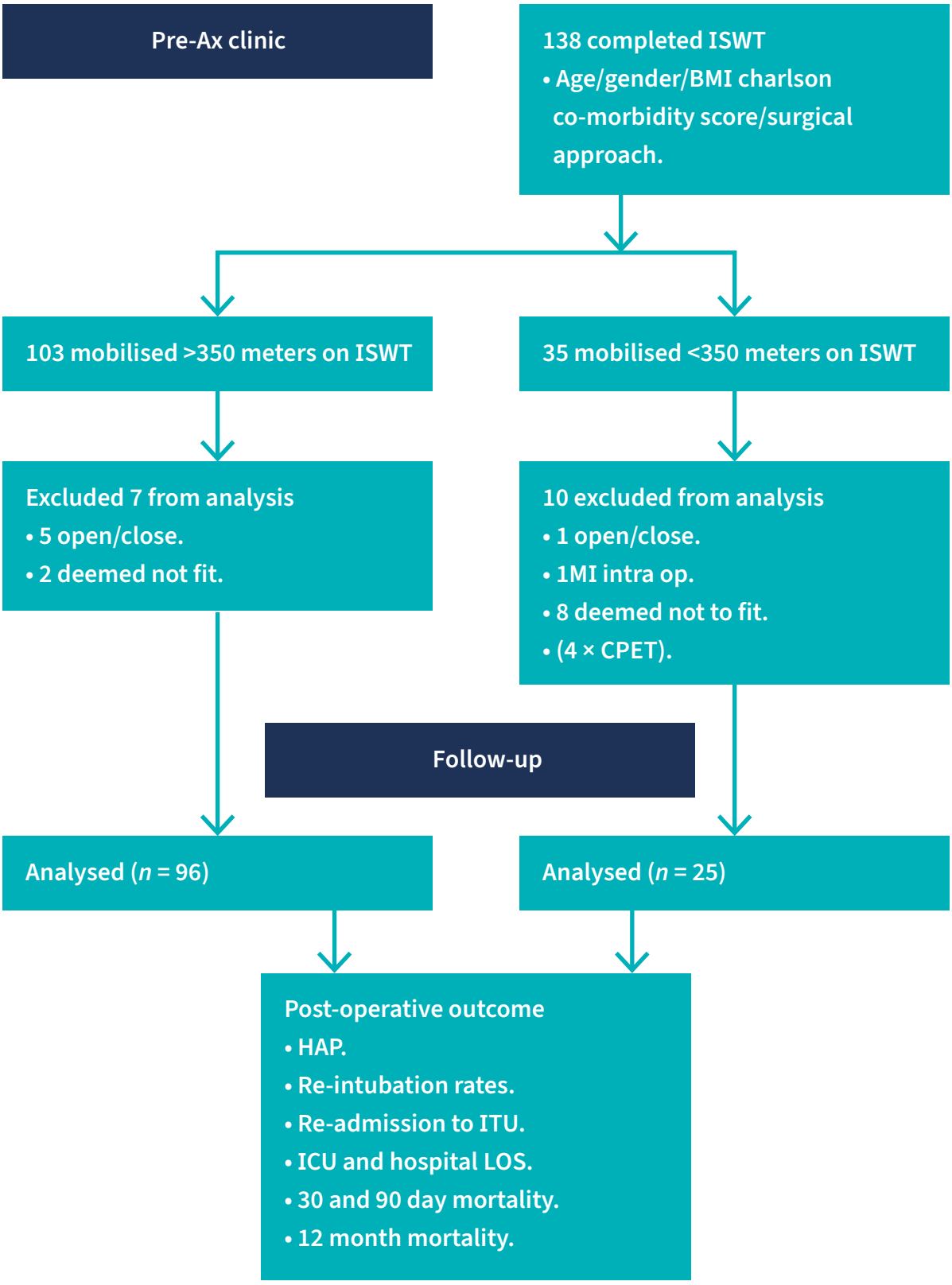

Figure 2: Flow diagram.

Of the 121 patients included in the analysis, 96 (79%) mobilised ≥350 metres and 25 (21%) <350 metres. Those mobilising <350 metres were significantly older (70 v. 65 years, *p* 0.044) and had a trend towards higher CCI (see Table 1).

Table 1: Patient demographics.

Distance mobilised on ISWT (meters)	>350	<350	*p* value
No patients	96	25	
Age (IQR)	65 (59–72)	70 (65–74)	0.044
Gender male *n* (%)	82 (85%)	18 (72%)	0.140
BMI	26.5 (24.6–29.9)	27.2 (24.9–33.3)	0.275
Charlson Comorbidity index	5 (4–6)	5 (5–7)	0.109
Surgical approach			
MIO	13 (14%)	4 (16%)	
Hybrid	62 (65%)	13 (52%)	
Open	21 (22%)	8 (32%)	

*Data is reported as *n* (%), with *p* values from Fishers exact test or as median (interquartile range) with *p* values from Mann-Whitney tests. Bold *p* values are significant $p < 0.05$. BMI = body mass index, MIO = minimally invasive oesophagectomy.

The incidence of hospital acquired pneumonias was significantly higher in individuals mobilising <350m (*p* 0.0003). Patients mobilising <350m also had a significantly longer ICU LOS (*p* 0.041). No significant difference in re-intubation rates, ICU re-admissions, hospital LOS and 30 and 90 day or 12 month mortality was observed between groups.

Table 2: Post-operative outcomes.

Distance mobilised on ISWT (meters)	>350	<350	*p* value
n	96	25	
Actual distance mobilised on ISWT (meters)	505 (430–630)	280 (240–330)	
HAP	10 (11%)	11 (44%)	0.0003
Re-intubation rate	13 (14%)	5 (20%)	0.527
Re-admission to ICU	4 (4%)	2 (8%)	0.602
ICU LOS	3 (2–5)	5 (3–7.75)	0.041
Hospital LOS	11 (9–17.5)	14 (11–23.5)	0.07
30 day mortality	0 (0%)	2 (8%)	0.108
90 day mortality	1 (1%)	2 (8%)	0.108
12 month mortality	16 (17%)	5 (20%)	0.69

**Data is reported as *n* (%), with *p* values from Fishers exact test or as median (interquartile range) with *p* values from Mann-Whitney tests. Bold *p* values are significant $p < 0.05$. HAP = hospital acquired pneumonia, ICU = intensive care unit, LOS = length of stay.

Discussion

This single centre service evaluation demonstrated the ISWT was an effective predictor for the development of HAP in patients undergoing oesophagectomy, with those patients walking <350 metres significantly more likely to develop a HAP and spend longer on ITU. There was also a trend towards patients walking <350 meters spending longer in hospital although this was not statistically significant. Patients mobilising less than 350 metres were significantly older, although no differences were observed with regards to comorbidities between groups. This is reflective of data published by other authors who also reported age as an independent risk factor for the development of post-operative pulmonary complications (PPCs) following oesophagectomy (Law et al., 2014) but would warrant further investigation to evaluate the impact of age and fragility on HAP. Age may therefore be utilised by clinicians as an indicator for triaging patients to pre-operative services for advanced medical investigations and assessments of functional capacity to determine fitness for surgery, as well guiding the level of post-operative care for example, HDU v. ICU.

Previous trials assessing the longer-term predictive value of the ISWT demonstrated significantly higher rates of mortality at both 30 days and 3 years post operatively in those walking <350 meters, with Murray et al. (2007) reporting a mortality rate of 63% at 30 days. Despite the significant difference in HAP rates in our study, we found no significant differences in mortality at either 30 or 90 days or at 12 months. Our mortality rate of 8% in the <350 meter cohort was considerably lower than that those in the study by Murray and colleagues (Murray et al., 2007). This may be reflective of the improvements in surgical screening and peri-operative care in the form of ERAS pathways over the past decade, resulting in more favourable outcomes for patients (Huang et al., 2020). Despite this, the 8% mortality in those walking <350 metres is still considerably higher than national 30 and 90 day mortality rates reported as 2.4% and 3.9% respectively (The Royal College of Surgeons of England et al., 2019) suggesting this still represents a higher risk population.

Our service evaluation has a number of notable limitations. Firstly, this is a single centre experience with small patient numbers and therefore may not be reflective of the entire oesophageal cancer population. Results were also open to bias as the physiotherapist assessing for HAPs was not blinded to ISWT outcomes. Additionally, time constraints in pre-assessment clinic meant patients only performed 1 ISWT. Previous studies have demonstrated a learning affect with this field test, recommending patients complete it twice to account for this. Therefore some of the patients who mobilised <350 meters may have improved their walking distance had the test been repeated.

Conclusion

This is a simple, low cost, easily reproducible risk stratification tool. Although no significant difference in mortality, patients walking less than 350 meters were more likely to get a HAP and spend longer on ITU. The ISWT may therefore help manage patient and clinician

expectations, guide clinical decision making relating to post-operative care for example, HDU v. ICU and direct post-operative resources like physiotherapy to those most at risk of HAPs. If completed early enough in the patient pathway it may also highlight individuals who would benefit from prehabilitation in this high-risk cohort.

Key messages

- Patients undergoing esophagectomy who walked <350 on the ISWT pre-operatively had significantly higher rates of post-operative hospital acquired pneumonia.
- Patients walking <350 meters also spent significantly longer on ICU.
- The ISWT may therefore help manage patient and clinician expectations, guide clinical decision making relating to post-operative care for example, intensive care v. high dependency unit and direct post-operative resources like physiotherapy to patients most at risk of HAPs.

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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

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Keywords

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

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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 gastrointestinal (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).

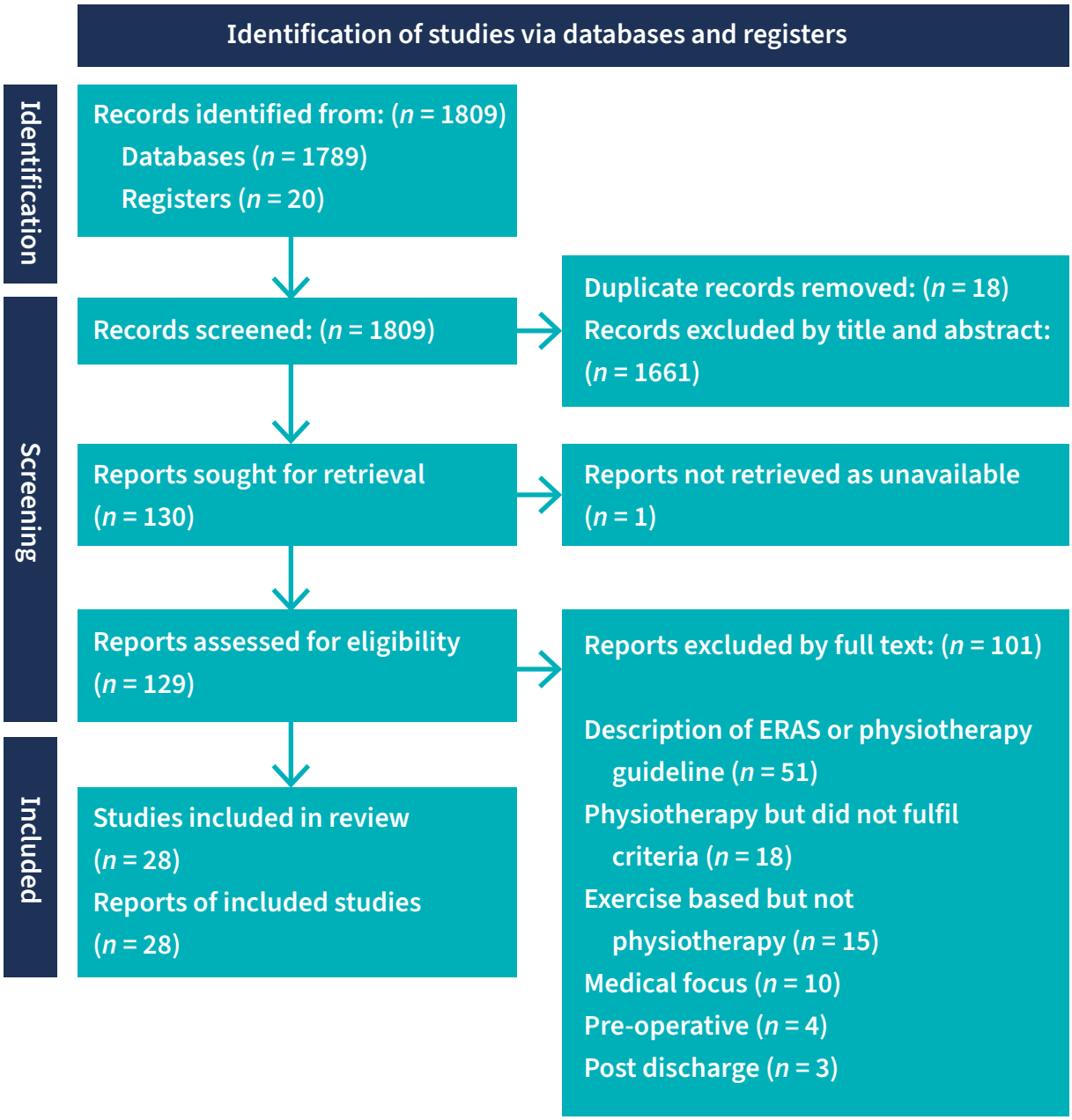

Figure 1: PRISMA-ScR flow chart.

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.

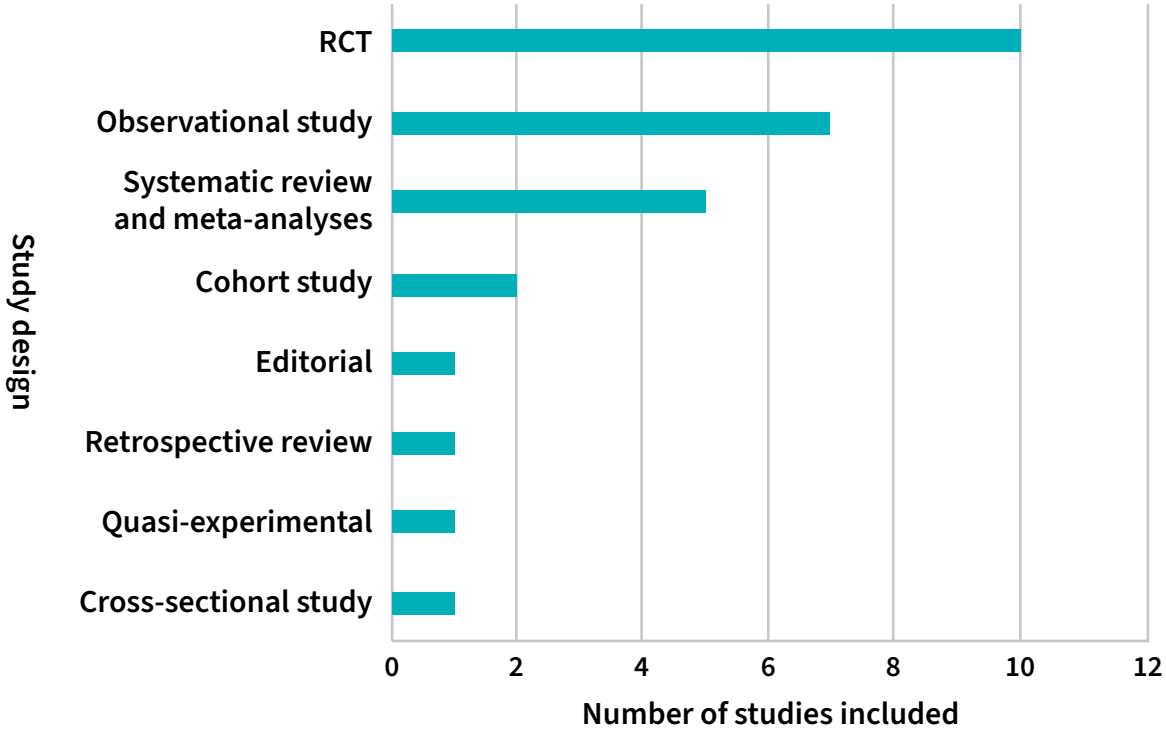

Figure 2: Methodology types and number of studies included.

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.

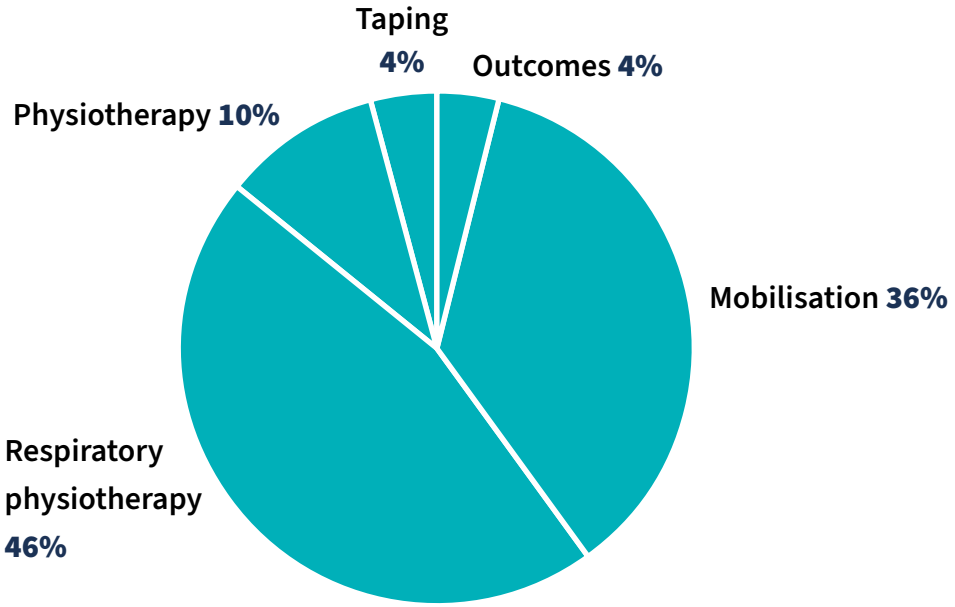

Figure 3: Types of physiotherapy intervention in studies.

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.

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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.

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).

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).

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.

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[1] DiBlasi RM. Clinical Controversies in Aerosol Therapy for Infants and Children. Respiratory Care 2015;60(6):894-914; discussion 914-896. – Data available upon request.
[*] AERogen is a trademark of Aerogen, Inc. Vapotherm does not make the Aerogen Solo.

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The future is bright and exciting, and it must involve research

Ema Swingwood[1,2] and Harriet Shannon[3]

The ongoing COVID-19 pandemic has thrown clinical research into the spotlight like never before. The processes for research project development, initiation, analysis and dissemination have been streamlined and rationalised. The timeframe from research conception to clinical implementation has been rapid, without compromising ethics or quality. It has been a privilege to observe, learn and see patients benefit from such work.

Key studies during the pandemic have included the RECOVERY trial, a randomised evaluation of COVID-19 therapy that, to date, has recruited over 40,000 participants worldwide (www.recoverytrial.net). Of particular note are the highly anticipated results from Recovery-RS Respiratory Support (Perkins et al., 2021), which compared three ventilation strategies including CPAP and HFNO. There has also been a plethora of vaccine trials (both into the U.K. and internationally), which people have benefited from globally.

Gaps in the research have also been highlighted, illustrating the vulnerability of respiratory physiotherapy. One of the most frequently asked questions of 2020 was, 'is it an aerosol generating procedure (AGP)?'. There was uncertainty about whether physiotherapy respiratory techniques were classed as AGP, with significant associated implications regarding viral spread and staff and patient safety. There was a scarcity of data relating to physiotherapy-specific techniques. The use of broad terms such as 'chest physiotherapy', encompassing multiple techniques or with no supporting definition, further hindered interpretation of findings (Jackson et al., 2020).

This year (2021), substantial progress has been made through publications linked to the U.K. based AERATOR study (Hamilton et al., 2021). Authors examined aerosol

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Keywords
Respiratory physiotherapy, research.

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generation during medical procedures, with additional focus on whether generated aerosols were infective. The study provided data that dispels earlier thoughts about respiratory oxygen delivery systems. Results demonstrated CPAP to produce less aerosol emission in comparison to breathing, speaking and coughing. There was no evidence of increased aerosol emission from the respiratory tract with HFNO. Going forwards, clinicians and researchers should continue to collaborate to ensure relevant AGP research related specifically to physiotherapy interventions is completed. Results could have huge implications regarding the logistics of patient management, cost of PPE equipment and clinic capacity.

It is hoped that the COVID-19 pandemic will continue to provide the impetus for more research into the wider respiratory physiotherapy field. There are exciting studies at early stages, with physiotherapists playing an integral role in the TEAM ICU trial (NCT03133377), CFHealthHub (Wildman et al., 2021) and the MARCH study (NIHR130454). The longer-term consequences of COVID-19 are still unknown, and research into long COVID-19 is vital if we are to continue to support our patients appropriately over the next months and years. We still have so much to learn, and we are faced with new challenges as the virus continues to mutate and present with different clinical features. This is a stark reminder that the services we put in place need to be adaptable to change to ensure we are providing the right care required at the right time. We must also work hard to identify and explore health inequalities across many areas of our work. Only then will we understand what interventions may work and how best to implement them to provide most benefit for all our patient populations. Collaborations continue to be key across the multi-professional team, the clinical setting, academia and research teams. The future is certainly bright and exciting with so many opportunities for physiotherapy, and it must involve research.

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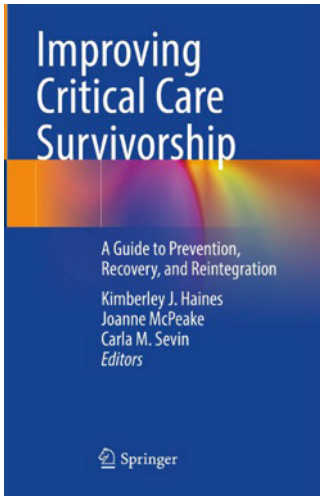
Improving critical care survivorship: A guide to prevention, recovery and reintegration



Editors

Kimberley J. Haines, Joanne McPeake and Carla M. Sevin.

Publisher

Springer.

ISBN-13

978-3-030-68679-6.

As awareness of the numerous physical and cognitive problems intensive care survivors and their families face become more globally recognised, this book gives a great depth of insight into how the quality of survivorship can be improved through focusing on current best practise and gaps for future research.

The book is broken down into four main overarching themes with each examining a different aspect of survivorship, from intensive care unit (ICU) environments to primary care integration. Much of the book focuses on prevention of post-intensive care syndrome (PICS) while in the ICU alongside recovery enhancement immediately post ICU. The book has a logical, easy to follow approach with use of images and tables where required to allow for easy examination of the main points discussed.

The opening chapters look at optimising quality of survivorship while the patient is within the ICU setting. The focus is on breaking down the ABCDEF bundle made up of **A**ssessing, preventing and managing pain, **B**oth spontaneous awakening and breathing trials, **C**hoice of analgesia and sedation, **D**elirium assessment, prevention and management, **E**arly mobilisation and **F**amily engagement. Evidence-based strategies are reported for each of the individual ABCDEF bundle elements.

From a physiotherapy perspective there is an in-depth examination of the importance of early mobilisation with key components such as timing and type discussed. The authors provide strategies for the reader to consider and discuss what the future directions of early mobilisation may be. Advice is offered regarding simple measures such as sleep optimisation and the use of ICU diaries to aid preventing adverse patient outcomes. The importance of ICU humanisation is also discussed in line with the far-reaching impacts PICS can have.

The 2nd section of the book investigates multiple aspects of patient recovery after discharge from ICU with a focus on holistic care. Chapters include topics such as neurocognitive and physical rehab, peer support, follow-up clinics and home-based care.

For physiotherapists there is great discussion around the issues with post-ICU rehabilitation studies and thoughts are given by the authors around why these programmes have not yet been demonstrated to impact outcomes. Theories and mechanisms are clearly explained throughout using easy to interpret figures where necessary. ICU follow up clinics are reviewed in detail regarding their rationale, the challenges that MDT members can be faced with and suggestions on how to assess the impact these clinics can have. There is also a nice focus on future research recommendations detailing methodologies and intervention descriptors.

Overall, this part of the book provides a concise summary of the current evidence base around post-ICU care delivery and introduces the reader to emerging concepts that may be new to them. It provides expert discussion around some of the challenges to post-ICU care provision and provides some suggestions to the readers of how this may be delivered.

The 3rd chapter delves into ways to integrate care and ensure continuity from ICU discharge to primary care facilities. Recommendations are clear for clinicians to review based on evidenced frameworks tailored to numerous complications that may impact ICU survivors. These complications range from physical and cognitive impairments to socio-economic reintegration. The reader is prompted to consider the impact an ICU stay can have on not only the patient that is affected, but also their relatives and caregivers. Detailed investigation into the realities of social isolation and financial disruption really make the reader reflect on how they can potentially play a pivotal role in impacting the quality of survivorship.

The final chapter reports on the problems facing ICU survivors in both high- and lower-income countries discussing mortality rate differences and resource utilisation. The complexity of admitting a patient to ICU is examined with ideas on how to triage patients effectively to allow for better resource utilisation. The authors stress how surviving does not mean a high quality of life on discharge home and the importance of a tailored approach to try to limit the risk of PICS.

In summary this book gives valuable insight into the current evidence-based strategies and methods used to try to prevent and manage PICS throughout the patient's critical illness.

It provokes thoughts on the simple measures that can have lasting meaningful impacts and would be a valuable resource for all clinicians involved in critically ill patient journeys.

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Inspiring *excellence* in cardio-respiratory care

Publication design and typesetting by
User Design, Illustration and Typesetting
www.userdesignillustrationandtypesetting.com

www.acprc.org.uk

ISSN 2059-0199 (Online)