CRITICAL CARE

REVIEW

Exercise rehabilitation following hospital discharge in survivors of critical illness: an integrative review

Bronwen Connolly[1,2], Linda Denehy[3], Stephen Brett[4], Doug Elliott[5] and Nicholas Hart[1,2,6]*

Abstract

Although clinical trials have shown benefit from early rehabilitation within the ICU, rehabilitation of patients following critical illness is increasingly acknowledged as an area of clinical importance. However, despite recommendations from published guidelines for rehabilitation to continue following hospital discharge, there is limited evidence to underpin practice during this intermediate stage of recovery. Those patients with ICU-acquired weakness on discharge from the ICU are most likely to benefit from ongoing rehabilitation. Despite this, screening based on strength alone may fail to account for the associated level of physical functioning, which may not correlate with muscle strength, nor address non-physical complications of critical illness. The aim of this review was to consider which patients are likely to require rehabilitation following critical illness and to perform an integrative review of the available evidence of content and nature of exercise rehabilitation programmes for survivors of critical illness following hospital discharge. Literature databases and clinical trials registries were searched using appropriate terms and groups of terms. Inclusion criteria specified the reporting of rehabilitation programmes for patients following critical illness post-hospital discharge. Ten items, including data from published studies and protocols from trial registries, were included. Because of the variability in study methodology and inadequate level of detail of reported exercise prescription, at present there can be no clear recommendations for clinical practice from this review. As this area of clinical practice remains in its relative infancy, further evidence is required both to identify which patients are most likely to benefit and to determine the optimum content and format of exercise rehabilitation programmes for patients following critical illness post-hospital discharge.

Introduction

Despite a greater prevalence of pre-existing co-morbidities in survivors, survival rates for critically ill patients admitted to the intensive care unit (ICU) have improved in recent years. Consequently, there is an increasing frequency of patients reporting both physical and psychological impairment with reduced health-related quality of life (HRQL) persisting long after the initial insult of the critical illness has resolved [1-11]. In many cases functional disability and psychological sequelae result in significant care-giver burden [12-14]. More recently, the rehabilitation requirements of patients surviving critical illness have been considered with the development of specific guidelines [15,16]. A seamless rehabilitation pathway from ICU admission to post-hospital discharge has been advocated [16]. Although these guidelines have increased the profile of this important area of clinical practice, they lack evidence detailing the patients most likely to benefit and details of the exercise component of rehabilitation programmes. Clearly, the level or 'dosage' of an exercise prescription is essential in the same way a clinician advocates the use of a drug to treat a specific disease only after understanding the target population as well as the timing, dose and duration of the drug.

A significant body of evidence has emerged demonstrating that early mobilisation of patients, adopting clinical management algorithms, within the ICU is safe [17-19], effective and beneficial [20-31]. This is often characterised by a 'hierarchical progression' of techniques from passive movement to sitting, sit-to-stand, bed-to-chair transfers, marching on the spot and ultimately walking [32-34]. In addition, the reliability and feasibility of mobility-based functional outcome measures has been demonstrated [30]. Comprehensive early rehabilitation, commencing from ICU admission and continuing throughout the hospital stay, has been shown to reduce

*Correspondence: nicholas.hart@gstt.nhs.uk
[6]Lane Fox Respiratory Unit, St Thomas' Hospital, Westminster Bridge Road, London SE1 7EH, UK
Full list of author information is available at the end of the article

ICU length of stay, improve functional performance status at hospital discharge and is more likely to result in discharge home [29].

The feasibility of specific ward-based rehabilitation intervention has been determined in two recent studies [35,36] with further investigation planned of enhanced rehabilitation including physiotherapy and nutrition [36]. At this stage of recovery, the restoration of physical function aims to promote safe and effective hospital discharge. Beyond this stage, rehabilitation for ICU survivors has been inconsistent in delivery. Utilisation of post-hospital discharge ICU follow-up clinics has demonstrated mixed results [37], with the most recent study showing a lack of benefit [38]. Furthermore, only a small number of studies exist, both completed and ongoing, investigating the effect of rehabilitation programmes following discharge from hospital [35,37-45].

Patients likely to benefit from exercise rehabilitation on hospital discharge

Skeletal muscle wasting and weakness are common features in survivors of critical illness [46-49]. Commonly reported as ICU-acquired weakness (ICU-AW) [48], this is defined as weakness secondary to critical illness in the absence of any neurological or metabolic aetiology [50-52]. Risk factors for development of ICU-AW include severity of acute critical illness, level of systemic inflammatory response, length of ICU stay, duration of mechanical ventilation, prolonged immobility and duration of sedation [47,48,50,53-55]. Interestingly, the adverse effects of corticosteroids and neuromuscular blocking agents have recently been questioned following results of a randomised controlled trial investigating neuromuscular blocking agents in patients with acute lung injury [56-58]. There are no data reporting the effect of chronic cardiorespiratory disease, such as chronic obstructive pulmonary disease and chronic heart failure, as a risk factor for ICU-AW. Because these conditions demonstrate changes in both the size and type of skeletal muscle fibres [59,60], it would be reasonable to assume critical illness could result in an acute-on-chronic muscle wasting condition in patients with such co-morbidities.

Long-term follow-up of patients following critical illness reveals deficits in both HRQL and exercise capacity evident for up to five years following the index admission [2,6,11,61]. Furthermore, this longstanding adverse effect on exercise capacity and HRQL in the presence of a restoration in lung function [11] implies that the long-term deficit is a consequence of ongoing skeletal muscle weakness, although this hypothesis has not yet been tested. These observations support physical rehabilitation therapy as a strategy to enhance exercise performance by improving muscular strength and endurance [62]. Exercise rehabilitation would therefore

seem a rational approach in the post-critical illness population who continue to demonstrate ICU-AW at the time of discharge from critical care, although the most appropriate tool for diagnosing ICU-AW has yet to be determined. In a prospective uncontrolled study, exercise-based rehabilitation following hospital discharge was found to significantly improve exercise capacity and anxiety and depression in a cohort of 38 ICU survivors [44]. However, recent findings from a randomised controlled trial of a home-based physical rehabilitation programme showed no effect on HRQL and physical recovery [41]. One explanation for the lack of difference between intervention and control groups in this trial is that 'all comers' were included with no stratification of patients according to strength at point of study entry. These findings lend support to the rationale of directing future exercise-based rehabilitation trials following hospital discharge to patients with ICU-AW, rather than using mechanical ventilation hours or ICU length of stay as inclusion criteria.

Screening patients by assessing muscle performance

Assuming those patients with ongoing presentations of ICU-AW on discharge from the ICU would benefit from further rehabilitation, a screening tool is required during this stage of recovery. Manual muscle testing (MMT) offers a simple clinical test to determine muscle strength [52] and both the Medical Research Council (MRC) sum score [63] and handgrip dynamometry [46], as forms of MMT, have been used for this purpose. However, despite widespread use in clinical studies and practice, MMT in critically ill patients has limitations. Patients must be sufficiently awake and cognitively alert to perform the manoeuvres for each muscle assessment [46,47,49]. The clinician must also be confident that the patient is performing maximum volitional efforts. The ICU environment *per se* may not be conducive to such testing and extraneous conditions, such as pain, level of analgesia, level of sedation, the presence of arterial monitoring and venous access lines, can all affect patient compliance with the assessment resulting in poor reliability and reproducibility. In addition, the MRC sum score is dependent on the skill and experience of the clinician to deliver and assess the response of the patient both accurately and reliably. This results in differential sensitivity, or bias, across the levels of muscle strength, in particular for those not objectively quantified. Finally, standardisation of muscle testing position is essential for accurate and reliable results.

Despite the number of potential caveats associated with MMT to quantify muscle strength in critically ill patients, an MRC sum score of less than 48 (that is, <4 per muscle group tested) [46,47,49,55,64-66] and a handgrip strength of <11 kg for males and <7 kg for females

[46] is reported diagnostic of ICU-AW. More importantly, high levels of inter-rater reliability of the MRC sum score have been reported in stable patients in the recovery phase [67-69] and for handgrip dynamometry in awake and cooperative critically ill patients within the ICU [69]. Thus, although MMT has limitations in the early phase of critical illness, MMT could be used to facilitate screening patients for ICU-AW on discharge from critical care for enrolment to a post-critical care rehabilitation programme.

Relationship between MRC sum score and functional performance

The absence of a clear relationship between MRC sum score and functional performance remains a challenging factor. MRC sum score and handgrip dynamometry are static measures of strength and currently there are no data defining the relationship between ICU-AW and functional status. Future studies need to clearly define clinically significant weakness in this patient population. A linear relationship between ICU-AW and physical performance is unlikely as functional tests are complex motor tasks, whereas MMT measures assess individual muscle actions that do not represent muscle endurance, a property that represents the resistance of the muscle to fatigue. It remains a requirement to investigate the natural history of recovery of those patients with an MRC sum score ≥48, which can be compared to that of weak patients (MRC sum score <48). If reduced physical performance is evident in clinically strong patients with an MRC sum score ≥48, the entry criteria into a rehabilitation programme may need to be refined further to include a functional criterion. Currently only one post-hospital discharge exercise rehabilitation study specifies MRC sum score <48 as a screening inclusion criterion [39] with 'normal physical function' a reported exclusion criterion for one other rehabilitation programme [43].

Maximising activity within safety limits

Several studies have established reasonable safety parameters for rehabilitating critically ill patients in the ICU environment [15,18,19,24,27-30,70]. Ward-based rehabilitation is similarly feasible with no reported adverse effects [35,36]. Patients commencing exercise rehabilitation following hospital discharge are at the next stage of physical recovery and, by inference, demonstrate greater clinical stability. Our own data have previously shown that early rehabilitation within one week of hospital discharge is both safe and beneficial following acute exacerbation of chronic obstructive pulmonary disease [62,71], and the same is the case for post-critical illness patients [41,43]. All exercise rehabilitation programmes should include assessment of cardiac and respiratory risk factors before implementing an exercise programme to ensure patient safety, but this should not, however, detract from the goal of exercise rehabilitation, which requires a patient to achieve a sufficient work rate to produce a physiological training effect.

Design of the review

The aim of this integrative review was to report (1) the content of exercise rehabilitation programmes for survivors of critical illness on discharge from hospital with regard to timing of programmes and exercise prescription, and (2) considerations for relevant non-exercise components required in rehabilitation programmes. An integrative review method was adopted [72] to incorporate evidence obtained from studies with published data and protocols of ongoing trials listed on recognised trial databases. This approach enabled inclusion of a variety of study designs to inform knowledge on the topic, and is not restricted to randomised controlled trials. This approach was used as the body of evidence in this clinical area is limited, but evidence is growing as trials are ongoing.

Search methods

Published literature was identified through searches of relevant databases, including Pubmed, CINAHL, ScienceDirect, and the trial registration databases Clinical Trials.gov [73], Current Controlled Trials [74,75], INVOLVE [76] (part of the National Institute of Health Research [77]) and the Australian New Zealand Clinical Trials Registry [78]. The search terms used were 'rehabilitation following critical illness', 'exercise following critical illness', 'survivors of critical illness', 'follow-up after critical illness', 'physical recovery and critical illness', 'exercise and intensive care' and 'hospital discharge'. Further items were obtained through searching the reference lists of identified sources. Identified sources of evidence were only included if they (i) were reported from January 2000 to November 2011 and (ii) reported rehabilitation programmes for survivors of critical illness on discharge from hospital. Evidence was excluded if it solely pertained to rehabilitation of post-ICU patients whilst still in hospital. A total of only ten sources of evidence were identified that were eligible for inclusion, which are described in Table 1 [35,37-45].

Prescription of exercise post-critical illness
Timing of exercise programmes

Early rehabilitation within one week of an acute exacerbation of chronic obstructive pulmonary disease is safe and effective, resulting in fewer hospital attendances [62] and improved exercise capacity [71]. In principle, this model can reasonably be applied in the post-critical care population. In the limited number of studies investigating post-hospital discharge exercise rehabilitation for patients following critical illness, programmes

Table 1. Rehabilitation post-critical illness: overview of programmes post-hospital discharge

Study and status	Design (sample)	Location/ commenced/ duration	Intervention		Assessments	Outcome
			Exercise component description	Participant contact		
Jones et al. 2003 [37]; study complete	Multi-centre RCT (n = 126)	Home-based/in hospital post-ICU discharge/6 weeks	Unsupervised, patient-directed home-based. Printed rehabilitation manual, focus on exercise and psychosocial function	Three phone calls during intervention period	Baseline, 8/52 and 6/12 post-hospital discharge. Assessor and patients blind to randomisation. Exercise capacity measured by SF-36 PF domain	Significant improvements in SF-36 PF in intervention group compared to control at 8/52 and 6/12 ($P = 0.006$), with a trend towards lower rates of depression at 8/52 (12% versus 25%)
Denehy et al. 2008 [35][a]; protocol	Single-centre RCT (n = 150)	Hospital out-patient and home-based/within 2 weeks post-hospital discharge/8 weeks	Individualised exercise programme[b] with functional, resistance and aerobic components; unsupervised home walking programme. Instruction sheet focusing on HRQL and physical function	Minimum two (of three) supervised sessions/week in-class format	Baseline, 3, 6 and 12/12 post-hospital discharge. Assessor blind to randomisation. Exercise capacity measured by 6MWT, TUG, SF-36 PF	Recruitment complete. Results not available
Danjoux et al. [40]; protocol	Multi-centre, parallel group RCT (n = 64)	Location unspecified/8 to 16 weeks post-hospital discharge	Supervised exercise sessions/8 weeks duration	Two supervised 40-minute exercise sessions and one unsupervised (40 minute brisk walk) session per week	Baseline, week 9, week 26. Exercise capacity measured by anaerobic threshold	Recruitment complete. Results not available
Connolly et al. 2009 [39]; protocol	Dual-centre RCT (n = 148)	Hospital out-patient and home-based/within two weeks post-hospital discharge/16 session duration (each session comprises education and exercise)	Focus on exercise capacity and HRQL. Individualised exercise programme of cardiovascular and upper and lower limb strength training. Home exercise diary to accompany exercise advice	Two supervised 40-minute exercise sessions in class format. Up to three unsupervised sessions per week	Baseline and three months. Assessor non-blind to randomisation. Exercise capacity measured by ISWT, 6MWT, SF-36 PF	Recruitment ongoing. Results not available
McWilliams et al. 2009 [44]; study complete	Non-randomised, uncontrolled (n = 38)	Out-patient and home-based/up to three weeks post-hospital discharge/6 weeks duration	Each session comprised exercise and education, with interval approach[d]. Home exercise diary accompanied exercise advice, focus on exercise capacity and anxiety/depression	One supervised 20-minute session per week. Two unsupervised 20-minute sessions per week[e]	1/52 prior and 1/52 post-programme. Assessor non-blinded to randomisation. Exercise capacity measured by ISWT and 6MWT	Significant improvements in exercise capacity (ISWT median improvement 160 m, $P < 0.001$, 6MWT median improvement 160 m, $P < 0.001$) and anxiety and depression ($P = 0.001$)
Cuthbertson et al. 2009 [38]; study complete	Multi-centre RCT (n = 286)	In hospital/continuing at home post-hospital discharge/3 months	Manual-based physical rehabilitation programme, focus on HRQL	Self-directed physical rehabilitation programme	Baseline, 6 and 12/12. Assessor blinded to randomisation	No significant differences in SF-36 (physical ($P = 0.46$) or mental function domain ($P = 0.83$)) at 12/12. Intervention significantly more costly

Table 1. Continued

Study and status	Design (sample)	Intervention				Outcome
		Location/ commenced/ duration	Exercise component description	Participant contact	Assessments	
Griffiths et al. 2010 [42]†; protocol	Dual-centre RCT (n = 180)	Outpatient and home-based/in hospital/3 months	Enhanced physiotherapy programme	One 1 hour supervised session, and two home exercise sessions per week	Baseline, 3/12 post-intensive care discharge; Outcomes assessor blinded to randomisation; Exercise capacity measured using 6MWT	Recruitment ongoing; Results not available
Elliott et al. 2011 [41]; study complete	Multi-centre RCT (n = 183)	Home-based/1 week post-hospital discharge/8 weeks	Graded, individualised programme of walking, upper and lower limb strengthening, core stabilisation, flexibility and stretches; up to 5 sessions per week un-supervised, of 20 to 30 minutes duration; Exercise manual accompanied exercise advice, focus on endurance and strength training	Three home visits with supervised sessions of 60 to 90 minutes[9], and five phone call follow-ups monitoring progress and to revise exercise prescription	Baseline, 8/52 and 26/52; Assessor blind to randomisation; Exercise capacity measured by 6MWT and SF-36 PF	Non-significant improvements in 6MWT and SF-36 PF domain at 8/52 and 26/52
O'Neill et al. 2011 [45]; protocol	Multi-centre RCT (n = 68)	Outpatient and home-based/post-hospital discharge, exact time-frame not specified/6 weeks	Warm-up, exercise circuit, aerobic exercise, cool down; Accompanying written exercise manual	Two supervised and one unsupervised exercise session per week	Baseline, 6/52; secondary measures also at 6/12; Physical function measured using SF-36 PF subscale	Recruitment not yet commenced; Results not available
Jackson et al. 2012 [43]; study complete	Single-centre RCT (n = 21)	Home-based/post-hospital discharge, exact time-frame not specified/12 weeks	Primarily targeted to lower extremity function and endurance; Exercise prescription tailored to individual functional status	Six televideo visits and six motivational telephone calls; Unsupervised exercise in interim	Baseline, 3/12; Physical function measured using TUG	Significant improvement in cognitive executive functioning ($P < 0.01$) and functional status ($P = 0.04$); Non-significant improvement in TUG ($P = 0.51$)

[a]Study also includes rehabilitation within ICU and on ward; detail of post-hospital discharge stage only reported. [b]Exercise prescription determined on results of submaximal cycling or walking tests. [c]Exercise intensity set using Borg score and ISWT distance. [d]Interval approach – alternating cardiovascular exercise involving all major muscle groups and active recovery. [e]Exercise intensity set according to four defined levels of varying ratios between cardiovascular exercise and active recovery. Exercise prescription based on target heart rate and Borg score. [f]Study also includes rehabilitation in hospital; detail of post-hospital discharge stage only reported. [g]Exercise intensity set using 6MWT distance and Borg score. Exercise prescription based on results of 6MWT and 8RM. 6MWT, six minute walk test; HRQL, health-related quality of life; ISWT, incremental shuttle walk test; PF, physical function; RCT, randomised, controlled trial; RM, repetition maximum; SF-36, Short-Form 36; TUG, Timed Up And Go.

often commence within two weeks of discharge [35, 39,41] whilst the exact time-frame is not specified in two studies [43,45]. In many cases the rehabilitation programme commences during the in-patient stay [35,37, 38,42], implying a seamless continuation of the programme at hospital discharge. However, detail on the time-frame for commencing the post-hospital discharge stage of these rehabilitation programmes is only reported by one study [35]. One uncontrolled observational study had a delay of up to 3 weeks post-hospital discharge [44] and the baseline time point prior to intervention commencing in one study protocol is stated as 8 to 16 weeks following hospital discharge [40]. A significant delay in baseline assessment and initiation of exercise-based rehabilitation could reduce the effect size of any response to the rehabilitation, as any potential benefits may be masked by the extent of ongoing natural recovery.

For such studies, a control group is essential [35,37-43,45], which provides data on independent physical recovery following critical illness and also determines the true effect of exercise rehabilitation. To illustrate this point, significant improvements in exercise capacity following rehabilitation were demonstrated by McWilliams and colleagues [44]; however, a maximum time frame of three weeks between hospital discharge and initiation of the exercise rehabilitation programme and lack of a control group limited interpretation of the results. All the patients recruited were subject to physical recovery pre-rehabilitation, which would vary between individuals, and it is therefore impossible to separate the impact of the intervention from natural history of physical recovery. Further data are required to determine the optimum time for commencing rehabilitation programmes post-hospital discharge, although within two weeks appears common at present. Furthermore, there may be added value in commencing exercise rehabilitation on hospital discharge as an extension of an in-hospital programme spanning ICU and the ward [35] to maximise the benefits gained to patients from familiarity and continuity with exercising.

Type and dose of exercise prescription
Lack of reported detail from some studies [37,38,40, 42,43], combined with variation in exercise prescription and study design, limits investigation of this area. Where greater detail is provided [35,39,41,44,45], a common feature is aerobic cardiovascular endurance activity, such as treadmill walking, ground walking or cycling. Initial prescriptions of exercise intensity utilise results of preliminary walking tests and cycle ergometry, and exercise intensity is monitored through the use of modified Borg scores and percentage of heart rate reserve. In many studies patients are instructed to exercise to between moderate and severe levels of breathlessness (Borg score 3 to 5) [35,39,41,44], although it is not yet confirmed that this level of exertion confers any benefit on functional or HRQL outcomes. Physiological measures such as Borg score and heart rate can be taught to patients to facilitate independent unsupervised exercise by providing clear limits for safely continuing exercise in the home environment at appropriate levels. Progression of exercise is determined using similar physiological measures and repeated exercise tests, although reference to performance of functional tests may also be of value. Strength exercises are also included in programmes [35,39,41], most commonly employing the repetition maximum (RM) principle to guide initial resistance prescription. An assessment is made of the maximum weight a patient can lift over a set number of repetitions. Either a specific RM set is prescribed (for example, 8RM) [41] or a percentage of a specific RM set is used (for example, 80% 10RM) [39]. Progression is based on reassessment of RM.

Two studies investigating detailed exercise rehabilitation programmes in patients post-critical illness on discharge from hospital have shown differences in their findings. Significant improvements were shown in exercise capacity in an uncontrolled study that adopted an interval style programme of cardiovascular activity and active recovery for 20-minute periods (Table 1). Different exercise intensities were achieved through altering the ratio of these components within the set time period. Heart rate reserve and Borg scores were used to determine exercise intensity and monitor status during exercise [44]. More recently, a randomised controlled trial found no significant differences between control and intervention groups that followed an 8-week, home-based, semi-supervised exercise programme of graded endurance and strength training of up to 60 to 90 minutes per session [41] (Table 1).

Furthermore, one recent study investigating a three-armed, home-based, semi-supervised rehabilitation protocol incorporating cognitive, physical and functional rehabilitation demonstrated non-significant improvements in physical function measured using the validated 'Timed Up And Go' measurement [43]. However, lack of reported detail of the exercise component limits further comment of these findings with regard to exercise prescription. Supervised exercise sessions allow clinicians to ensure patients are performing exercises correctly and safely, but may not be feasible in all situations, such as patients who live a long distance from the hospital. Some patients may also not wish to exercise in a group setting, but equally the psychological support from other patients may further encourage participation [79,80]. Data from pulmonary rehabilitation support supervised sessions as these provide enhanced clinical outcomes and patient-centred outcomes, such as increased exercise capacity

and HRQL [81]. Unsupervised home exercise programmes are influenced not only by the motivation of the patient to engage and complete the exercise programme, but also the ability of the patients to correctly learn and perform the specific activities. An in-depth and detailed education package is required for this purpose. As adherence with documentation in home exercise diaries may be variable depending on the individual patient, pedometers [82] and accelerometers [83] could be used to encourage activity and provide objective monitoring and feedback on performance. These provide patients with more structured and objective home exercise programmes to supplement diary records.

Non-exercise rehabilitation components

Neurobehavioural outcomes, such as impaired cognitive function, are also recognised as consequences of critical illness [7]. Symptoms of anxiety and depression can be evident for up to two years following ICU discharge [8,10] and other psychological issues are often present [84]. A recent stakeholder conference recommended the term 'post-intensive care syndrome' (PICS) to describe new or worsening problems in physical, cognitive, or mental health status persisting post-hospital discharge following a critical illness [85].

The impact of these impairments on HRQL for patients can be significant, resulting in disengagement from rehabilitation and a delay in physical recovery [10]. Furthermore, this disengagement could impact on motivation and the ability to perform volitional MMT, resulting, for example, in overestimation of ICU-AW on MRC sum score. Whilst the main goal of exercise rehabilitation programmes on discharge from hospital must be targeted at improving exercise capacity and physical activity, strategies to address psychological sequelae should also be included.

Jones and colleagues [37] demonstrated improvements, albeit non-significant, in symptoms of depression six months post-hospital discharge with the use of a self-help manual containing advice on psychological and psycho-social issues. Jackson and colleagues [43] acknowledged the potential benefit of cognitive rehabilitation to enhance functional outcome in post-critical illness patients using goal-management training to demonstrate significant improvements in cognitive executive functioning and activities of daily living. A logical approach, based on the prevalence and ranges in severity of psychological symptoms, would be to include a clinical psychologist in the post-critical illness rehabilitation team, although this needs to be tested. The established rehabilitation guidelines for cardiac and pulmonary rehabilitation programmes advocate a multidisciplinary approach to the delivery of rehabilitation [86-89]. In addition, cardiac and pulmonary rehabilitation guidelines recommend the

inclusion of education sessions, albeit these are targeted at these specific disease groups. Only three of the recent clinical studies report education sessions with topics including benefits of exercise, stress management and nutritional advice [37,39,44]. However, the heterogeneity of the post-critical illness population, which may include patients with no significant pre-existing chronic disease, suggests caution should be used in applying standard education topics. Further investigation and determination of the most appropriate education and 'non-exercise' input required in rehabilitation programmes is urgently needed.

Limitations of the review

The aim of this integrative review was to focus on exercise rehabilitation programmes for patients following critical illness on discharge from hospital. It is important to highlight that only a very small number of sources were identified for inclusion, in itself a challenging factor for drawing clear conclusions from the evidence. Furthermore, only five studies reported published data [37,38,41, 43,44], whilst the remainder were available in protocol format only [35,39,40,42,45]. Of the published data, four were randomised controlled studies [37,38,41,43], and one an observational study [44]. According to the GRADE system of classification of evidence sources [90], randomised controlled trial methodology automatically assumes the highest evidence grade, with observational studies low quality and other forms of evidence very low. Furthermore, evidence grading can be reduced if limitations are identified in the study [90]. In the context of this review, lack of reported detail on the exercise component of the rehabilitation programme [37,38] could be considered a limitation influencing the strength of these studies. All five protocols reported ongoing randomised controlled trials. As none of these have published data at present, however, the advantages of the strong methodology employed are outweighed by lack of results on which to determine the success of these protocols.

Conclusion and future directions

Data are emerging that report the outcome of post-critical illness patients receiving exercise rehabilitation at the post-hospital discharge stage. Patients at risk of developing ICU-AW can be identified during the early stages of critical illness, and if clinically significant weakness persists on discharge from the ICU, are likely to be those who may benefit from ongoing rehabilitation in terms of exercise capacity, physical activity and HRQL. There are no data defining the relationship between peripheral muscle strength, functional capacity and physical activity in this recovery stage post-critical illness. Furthermore, at present the limited volume and

variable quality of evidence available fails to provide substantive direction regarding optimum type and dose of exercise prescription or timing of rehabilitation required for this patient group. Future research, of robust methodology, needs to accurately address these issues and develop assessment tools that monitor the recovery of patients on which to substantiate rehabilitation needs. Ideally, a short battery of performance tests would encourage standardisation in practice between clinicians and facilitate comparison across future studies. Finally, the management of psychological consequences of critical illness also needs careful consideration and should be embedded in exercise-based rehabilitation programmes.

Abbreviations

6MWT, six minute walk test; HRQL, health-related quality of life; ICU-AW, ICU-acquired weakness; ISWT, incremental shuttle walk test; MMT, manual muscle testing; MRC, Medical Research Council; PF, Physical function; RCT, Randomised, controlled trial; RM, repetition maximum; SF-36, Short-Form 36; TUAG, Timed Up And Go.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Department of Asthma, Allergy and Respiratory Science, Division of Asthma, Allergy and Lung Biology, King's College London, London SE1 9RT, UK. [2]Guy's and St Thomas' NHS Foundation Trust and King's College London, National Institute of Health Research Comprehensive Biomedical Research Centre, London SE1 9RT, UK. [3]Department of Physiotherapy, Melbourne School of Health Sciences, The University of Melbourne, Melbourne, 3010 Australia. [4]Centre for Perioperative Medicine and Critical Care Research, Imperial College Healthcare NHS Trust, London W12 0HS, UK. [5]Faculty of Nursing, Midwifery and Health, University of Technology, Sydney, Sydney, 2007 Australia. [6]Lane Fox Respiratory Unit, St Thomas' Hospital, Westminster Bridge Road, London SE1 7EH, UK.

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