Title: Improving rehabilitation in older people after emergency hospital admission

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Abstract:

Purpose:

Older adults are at risk of functional decline during emergency hospital admissions. This review aims to understand which exercise-based interventions are effective in improving function for older adults who experience unplanned admissions.

Methods:

Database searches identified randomised control trials (RCTs) comparing exercise-based interventions with usual hospital care. The primary outcome was functional status measured by activities of daily living (ADL) scores. Secondary outcomes were length of hospital stay (LOS), mortality and readmissions. Sub-group meta-analyses were conducted on interventions delivered in-hospital only compared to interventions provided in-hospital and post-discharge.

Results:

After reviewing 8365 studies, nine studies were eligible for inclusion. Seven were included in the meta-analysis. Participants from five countries had a mean age of 79 years (1602 participants). Usual care varied considerably and the interventions showed heterogeneity with different combinations of strengthening, resistance, high intensity or mobility exercises. There were limited descriptions of exercise intervention delivery and participant adherence. There is low quality evidence supporting exercise interventions including both in-hospital and post-discharge components (3 trials, SMD 0.56 (-0.02, 1.13)). Trials involving only in-hospital interventions were inconclusive for functional gains (5 trials, SMD -0.04 (-0.31, 0.22)).

Conclusions:

Exercise based rehabilitation for older patients after emergency hospitalisation improves functional ability if the intervention starts in-hospital and continues post-discharge. No conclusions can be made on the effective exercise dose or content.

Implications:

Understanding the components of exercise interventions will improve service planning and delivery. Further studies are needed to understand the effective dose and content of exercise for hospitalised older adults.

1. Introduction

Emergency hospital admissions for older patients are increasing [1, 2]. Hospitalisation is a risk factor for functional decline and disability [4], and can be a 'deconditioning' process leading to loss of independence [3]. Functional decline during an acute hospital admission is multifactorial in nature; contributing factors include lack of activity and immobility, the effects of acute illness in the context of chronic diseases, and the vulnerability of older patients to polypharmacy and nutritional deficiencies [5]. The consequences include reduced muscle strength, reduced physiological reserve and increased risk of falls [3]. Rehabilitation can restore personal autonomy, reduce disability, and reduce the rates of institutionalisation in this older age group; however, the content of optimal rehabilitative interventions is not clear [5].

Current rehabilitative interventions in hospital aim to restore functional ability to a level where patients can be safely discharged from hospital, but setting this target for rehabilitation may not be effective at restoring personal autonomy. The current model for medical care for older patients is centred on the comprehensive geriatric assessment (CGA) [5], which restores function through collaborative work by multi-disciplinary teams using a variety of interventions. CGA reduces rates of institutionalisation for older adults [6] as well as mortality [7]. These programmes often have a significant physical component using exercise to maintain muscle strength [8]. Exercise during inpatient hospital admission is not associated with increased adverse events and allows more patients to be discharged home with improved physical function [8] [9].

This review aims to evaluate which rehabilitation interventions are effective at restoring function in older patients requiring a hospital admission for an acute medical illness. Previous reviews have suggested that targeted CGA based rehabilitation early in a hospital admission can improve function, reduce mortality and the risk of institutionalisation compared with usual care [6, 8, 9]. However, there was great variation in the duration, content, measures used to assess functional ability and the type of patient (medical, surgical and orthopaedic) involved in the exercise interventions evaluated. Consequently, the optimal exercise intervention for older patients remains unknown [3, 5] and an update of the evidence, concentrating on an in-depth description and synthesis of the intervention components, is warranted. This review will concentrate on the effective 'dose', content and timing of rehabilitation.

Aim: To understand which exercise-based rehabilitation interventions are effective in improving function for older adults who are hospitalised during an unplanned emergency admission for an acute medical condition.

2. Methods

2.1 Objectives

To determine the effectiveness of exercise-based rehabilitation programmes that improved the functional status of older adults after an emergency hospital admission as measured by their activities of daily living (ADL). Secondary outcomes included length of hospital stay (LOS), mortality and readmission.

2.2 Eligibility criteria (Appendix 1)

Studies were included in this review if they met the following inclusion criteria:

- Participants were 65 years or older and had been admitted to hospital via the emergency department or in an unplanned way.
- Participants' admission to hospital lasted at least 4 hours.
- Randomised controlled trials comparing an exercise-based rehabilitation intervention with usual hospital care.
- Exercise was the main component of the intervention and was delivered by a healthcare professional, starting after an emergency hospital admission and took place in hospital or at home.
- The comparison group was usual hospital care which was defined as an assessment conducted by a health professional resulting in the provision of an intervention to ensure that the patient was safe to be discharged home.
- Assessed at least one measure of function using either: Barthel index (BI), Katz ADL, Instrumental ADL (IADL) and Nottingham Extended ADL, Short Form Health Surveys SF36 or SF12, Elderly Mobility Score (EMS)

Exclusion criteria:

- Greater than 20% of the included patient sample were under the age of 65 years.

- Participants recruited from the community without an acute medical illness requiring an emergency department visit.
- Participants with surgical or orthopaedic treatment or who had disease processes requiring specialised rehabilitation such as stroke.
- The intervention was designed to reduce the incidence of falls. These studies were excluded as they have been described in detail elsewhere [10].

2.3 Information sources and search strategy (Appendix 2)

The following databases were searched from inception to the 10th February 2017; CINAHL, Cochrane Library, Embase, Ovid Medline, OTSeeker, PEDRO, and Web of Science. The search strategy is detailed in Appendix 2.

2.4 Study Selection

Two authors (SM and AH) screened the studies based on title and abstract and independently selected papers for inclusion after full text retrieval. Any differences in the results were resolved through discussion.

2.5 Data collection process

Standardised data extraction tables were adapted from the Template for Intervention Description and Replication (TIDieR) guide to ensure systematic data retrieval [11]. Two authors (HR and SF) extracted data on the study participants (mean age), usual care, study intervention (components, frequency and timing), intervention provider (single healthcare professional, multi-disciplinary team), location (hospital, community setting, home), and study outcomes. The results were reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Figure 1) [12]. The Cochrane Collaborations Tool for assessing bias was used to judge the risk of bias and methodological quality of the included studies [13].

2.6 Study quality

Methodological quality was assessed using the 12-item risk of bias tool. The studies were assessed according to the following categories: sequence generation, allocation concealment, participant and

staff blinding, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, and other sources of bias. Each criteria of risk of bias was judged to be 'high', 'low' or 'unclear' (Figure 2)

2.7 Data analysis

We investigated the following contrasts:

- Rehabilitation interventions delivered in hospital versus usual hospital care
- Rehabilitation interventions delivered in hospital and post discharge versus usual hospital care

Studies were assessed for heterogeneity from clinical, methodological and statistical perspectives. Statistical heterogeneity was judged using forest plots, Chi-squared testing and I^2 statistical tests.

A random effects meta-analysis was performed using Review Manager (RevMan) version 5.3, with pooled results from individual studies. The random effect model was used due to expected heterogeneity amongst the interventions and study outcomes, plus variation in the content of 'usual care' can also limit the size of the treatment effect [14]. In cases where data was measured using different instruments, the standardised mean difference (SMD) and 95% confidence intervals (CIs) were the primary summary effect measure. A positive SMD indicated an effect in favour of the exercise-based rehabilitation intervention. Effect sizes were interpreted as follows: 0.2 representing a small effect, 0.5 a moderate effect and 0.8 a large effect [15].

<u>Pre-planned subgroup analyses</u>

We planned to explore the effect of the setting as previous studies have shown that rehabilitation interventions occur both inside and outside of the hospital [6, 16-18].

<u>Outcome measure priority</u>

Studies were included if they used at least one functional measure assessing activities of daily living such as the Barthel ADL Index. Other functional measures which could be included were the Katz ADL measure, Functional Independence Measure (FIM), Lawton's Instrumental ADL (IADL), Nottingham extended ADL (EADL), Physical functioning components of the Health Related Quality of Life Short Form 36 (HRQOL SF-36 or SF-12), Timed Up and Go (TUG) [9].

2.8 Data synthesis

The GRADE approach was used to describe the quality of evidence for each outcome in each contrast [19]. Quality was downgraded by one level based on four factors; (i) methodological quality, (ii) inconsistency in the results; (iii) indirectness of evidence and (iv) imprecision of evidence. The quality of evidence was described as high, moderate, low, very low or no evidence.

3. Results

3.1 Search Strategy

The search strategy identified 8365 studies after duplicates were removed. Nine studies met the inclusion criteria and were included in the descriptive analysis. Eight studies were involved in the meta-analysis.

3.2 Description of included trials (Table 1)

Participants

Study participants were older adults with a mean age 79 years (range 73-85 years). In total, 1602 patients contributed to this analysis; 795 in the intervention groups and 807 in the control groups. The trials took place in Australia (3), Denmark, France, Norway (2) and the USA (2).

Usual Care

There were considerable differences in 'usual care' across studies, possibly due to differences in clinical practice and healthcare provision. Six studies described the exercise provision in the usual care groups [20-25]. Exercise was prescribed as two 45 minute sessions weekly [24] three times a week [20, 25] or five times weekly [22]. In three trials patients were also followed up at home [20, 24, 25]. One study included a month of rehabilitative exercises at home as part of the usual care group [20], in others, physiotherapists visited patients at home [24] or conducted telephone follow up appointments [25]. In one study, research assistants visited the patient the same number of times (3x 15 minutes twice daily) as the intervention group without providing rehabilitative content, but 35% of this usual care group also received additional physiotherapy [21]. Three studies reported that the intervention group received routine care, however, the content and duration was not defined [26-28].

3.4 Intervention description using the TIDieR Guidelines

Summary of reporting

All studies reported on the type and frequency of the exercise intervention. Exercise interventions were provided either as the sole intervention or as part of a geriatric assessment. Functional status was measured at baseline and post-intervention; however, studies varied in the post intervention assessment time point. Four studies reported on participant adherence with the programme. No studies described the fidelity of intervention provision to the exercise intervention protocol.

3.5 Description of the interventions (Table 1)

All exercise interventions involved a physiotherapist or physiotherapy assistant; two studies provided additional training for the therapist. One study stated the experience level of the therapist as measured by the number of years worked [27]. No training manual was provided for the physiotherapists and four studies provided written material for the participants [24, 26-28].

All the studies incorporated strengthening exercises. In addition, three programmes included balance exercises [24-26], four studies included general physical activity [24-26, 28] and one included nutritional support [20]. In four studies the patient had specific instructions to follow in the exercise component [20, 24-26].

Exercise interventions varied greatly in the frequency of sessions. The most intense programmes had patients exercising twice a day [20, 27, 28], with the remainder between two and five times per week. These sessions ranged between 20 and 60 minutes. Only two studies reported on the total number of sessions [24, 25] completed by participants and these programmes lasted 12 weeks' post discharge. One study lasted four weeks post discharge [28]. The remaining four did not report the duration of the programme.

All studies described the location of the intervention. Five trials were conducted solely in hospital [20-23, 27], three trials had both in-hospital and post discharge components [24, 26, 28], and one trial occurred in the patients' home [25]. Of the six in-hospital studies, four reported starting the rehabilitative intervention within 72 hours of admission [20, 23, 26, 27].

3.5 Adherence to treatment and intervention fidelity

Four studies reported participant adherence to the exercise intervention. One reported that 70% of participants self-reported an adherence level of 80% with the home exercise programme [24]. In a second study adherence varied over 6 months, with 53% of the intervention group undertaking their programme daily or nearly every day, another 19% doing their exercises 3 to 4 days per week, and 28% doing their exercises on two or fewer days per week or none of the time [26]. The third study reported that 58% of the intervention subjects had undertaken no home exercise as prescribed and only 19.5% in the intervention group performed 67-100% of their home exercises [28]. A further study measured the mean session attendance rate as 10 sessions per participant [23]. None of the studies reported intervention fidelity.

3.6 Methodological Quality (Figure 2)

Based on the five key risk of bias items, seven out of nine studies were rated as low risk of bias (three or more items judged at low risk). For most trials (7/9), patients and intervention providers were un-blinded to the exercise allocation. One trial allocated participants blindly to groups so they were unaware which group received the intervention [27]. All studies employed patient-reported measures of function, and this outcome was thus un-blinded in all studies. Other common reasons for high or unclear risk of bias were greater than 20% data loss at short-term follow-up (71%) and lack of intention to treat analysis (43%). The risk of bias ratings for each study is presented in Figure 2.

3.7 In hospital rehabilitation vs Usual Care

Five studies [20-23, 27] compared an exercise based rehabilitation programme delivered in hospital to usual care. All studies measured daily function with questionnaires (Barthel Index, Katz, EMS). Three studies [22, 23, 27] objectively measured function with the TUG. Outcomes were assessed on hospital discharge with two studies also repeating the functional measures at 1-month post discharge [20, 21].

Effect on primary and secondary outcomes (Table 2)

In four trials, both control and intervention groups showed improvement in their functional scores (Katz, ADL and Barthel scores) between admission and discharge [20, 22, 23, 27]. One trial showed little difference in the mean ADL score (8.2 at discharge, both groups) between intervention groups (p=0.62) and also with change over time (p=0.77) [21] but this may be related to a relatively short length of stay (4.06 days for both groups). In the three trials measuring TUG there was no significant difference between the control and intervention groups [22, 23, 27].

Four studies were included in a random effects meta-analysis. Pooled results found no significant difference between the intervention and control groups on functional ability (SMD -0.04 (-0.31, 0.22) [20, 21, 23, 27]. Raymond et al (2016) was not included due to the non-parametric nature of the data [22] (Figure 3).

Two studies reported mean LOS. In one trial the patients in the intervention group stayed 4.6 days compared to 3.6 days in the control arm [21]. The second reported 28 days (intervention) and 24 days (control) [23]. Studies reporting median LOS showed little difference between the groups [22, 27]. One study reported on the time to clinical stability which was 12.6 days for both groups [20].

Readmissions data was available for one trial with a 28-day readmission rate of 20% in the intervention group and 19% in the control group with relative risk of readmission 1.10 (95% CI 0.65-

1.86)) [27]. Patient deaths were reported by two trials; in one study two patients in the intervention group died and one in the control group [21]. In the second trial, two from each arm died (relative risk 1.15% (0.16-8))[27].

3.8 In hospital and post discharge rehabilitation vs Usual Care

Three trials (530 participants) [24, 26, 28] compared a rehabilitation programme delivered both in-hospital and post-discharge to usual care. All studies measured general physical function with questionnaires (SF12, SF36 or IADL) assessing activities of daily living or similar. Two measured physical performance using the TUG [24, 26]. Outcomes were reported at 1-month [28], 3-months [24] or 6-months after discharge [26].

Effect on the primary and secondary outcomes (Table 2)

For activities of daily living, one study found a statistically significant improvement in the SF12 scores in the intervention group compared to the control group at 4, 12 and 24 weeks after discharge [26]. Brovold et al (2012) reported improved mean SF36 scores in both groups after 3-months but was considered as a result of time effect (p=0.0001) rather than treatment effect (p=0.5) [24]. The third study reported a reduced average number of independent ADLs at 1-month post discharge. All three studies were included in the random effects meta-analysis which showed a moderate effect size of SMD 0.56 (-0.02, 1.13) for in-hospital and post discharge rehabilitation as compared to usual care (Figure 3)

One trial reported on length of hospital stay with the mean LOS 10.5 days in the control group and 12 in the intervention group [28]. Another trial reported a seven-fold increase in readmissions in the control group using a multi-variant logarithmic regression [26]. A final trial found similar readmissions in both groups [24].

Deaths were reported in three trials. One study had 3 deaths in both arms [24], another had 2 deaths in the control arm and 3 in the intervention group [26]. The final trial reported 2 deaths in the intervention group only during the intervention but by one month there were ten deaths in both groups (6%) [28].

3.9 Usual care and post discharge rehabilitation vs Usual Care

One trial investigated the effect of high intensity group based exercise on function. [25]. Participants exercised twice weekly for 3-months after discharge from hospital. They attended a hospital twice weekly for 60 minutes of high intensity exercise, as compared to a home exercise programme (6 exercises 3x weekly) with telephone follow up from a physiotherapist once a month. The study was

judged to have a low risk of bias but there was no reporting on the fidelity or adherence to the exercise programme. There was little difference in the SF36 (mean change 0.5) or TUG (mean change -0.3) between the intervention and control groups. There was one death in the intervention group. Adverse events were reported in 24% of the intervention group and 29% of the control group, these included reporting feeling ill, falls, musculoskeletal pain or dizziness experienced during the exercise.

4. Discussion

4.1 Statement of Principle Findings

This systematic review of exercise-based rehabilitation interventions to improve function in older patients after a hospital admission with an acute medical illness, found low quality evidence to support exercise interventions which include both in-hospital and post-discharge components (3 trials, SMD 0.56 (95% CI -0.02, 1.13). There is inconclusive evidence for trials involving only in-hospital interventions (SMD -0.04 (-0.31, 0.22). The review is unable to make any recommendations on the content or dose of an exercise programme to improve function after hospitalisation due to the variation and heterogeneity of the rehabilitative interventions.

4.2 Outcome significance in relation to other research

Previous reviews of exercise interventions for older patients demonstrated the safety of physical interventions for this vulnerable group but were inconclusive about any functional gain when compared to usual care [8, 9]. Exercise appeared to be most beneficial when part of a multi-disciplinary intervention, however, which components confer the benefit are not well understood [8, 29]. This is in keeping with previous research into falls prevention, where physical interventions as part of a complex intervention were most effective at reducing falls [10].

Most rehabilitative interventions have been examined in hospital setting [7], however, out of hospital interventions have been shown to have similar outcomes whilst reducing length of stay, reducing hospital associated costs [16] and may be a more cost effective option [30]. This review suggests that for functional gain exercise needs to start in-hospital but continue into the community. This is in keeping with falls prevention interventions where the duration of effective exercise programmes is between 3 and 6 months [31].

4.3 Strengths

This study has examined the dose, content and timing of exercise-based rehabilitative interventions designed to improve the function of older patients after hospital admission for an acute medical

problem. These patients are at particularly high risk of mortality or institutionalisation after a hospital admission [3] and it is important to understand which exercise-based interventions are most effective at maintaining functional ability for patient autonomy. The findings of this review adds to the body of evidence promoting exercise for older adults to prevent functional decline [7-9] and in addition recommends that exercise is most effective if introduced in-hospital but continued after discharge, in the community.

4.4 Limitations

The interventions showed considerable heterogeneity in the exercise provided (resistance, strength, high intensity group or mobility programmes). Descriptive reporting of the exercise intervention delivery was limited and few studies reported on the number of exercise sessions, programme duration, and participant adherence to the programme. Due to the different functional outcome measures used by the trials, it was difficult to directly compare results and the meta-analysis relies on differences in standardised mean difference.

Usual care varied considerably; some groups receiving physiotherapy up to 5x weekly and one trial providing one month of physiotherapy at home in the routine care group. The two in-hospital trials showing a negative SMD, may be explained by extensive physiotherapy in the usual care groups. Previous authors have acknowledged the difficulties of 'usual care' as control groups, in particular highlighting the difficulties of "active" controls who are receiving an exercise intervention as usual care [16, 32].

4.5 Clinical implications

This review has highlighted the resource intensity required for effective rehabilitative interventions. In most of the trials healthcare professionals were involved over long periods of time to provide intensive exercise interventions. Further research is needed to decide how effective rehabilitation interventions can be provided within healthcare budget restraints.

The in-hospital group had shorter duration of intervention, with patients staying between 4-28 days, as compared to a 4-8 week intervention time for the in-hospital and post discharge groups. This increased contact time with the physiotherapist may explain the differences between the groups [33]. In addition in-hospital rehabilitation has been shown to have less noticeable effects on long term patient outcomes [7].

4.5 Recommendations for improving future research

Further research is recommended to understand the most effective approach to restoring function to older patients after an acute hospital admission for a medical illness. None of the trials recruited more than 500 patients and larger studies are needed to understand the size of any intervention effect. Standardisation in reported outcome measures are needed to aid comparison between trials. Finally, improved reporting describing the intervention and usual care would allow conclusions to be made on the optimal dose and content of any rehabilitative measure.

5. Conclusions

There is low quality evidence to suggest that exercise based rehabilitation for older patients after emergency hospitalisation improves functional ability, if the exercise component includes both in-hospital and post-discharge components. No conclusions can be made on the effective dose or content of exercise.

With limited healthcare resources, understanding what entails an effective exercise intervention will improve service planning and delivery for these vulnerable older patients at risk of functional decline and an inability to return to independent living. Further studies are urgently needed to understand the effectiveness of exercise for older adults hospitalised after an acute medical illness.

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Figures

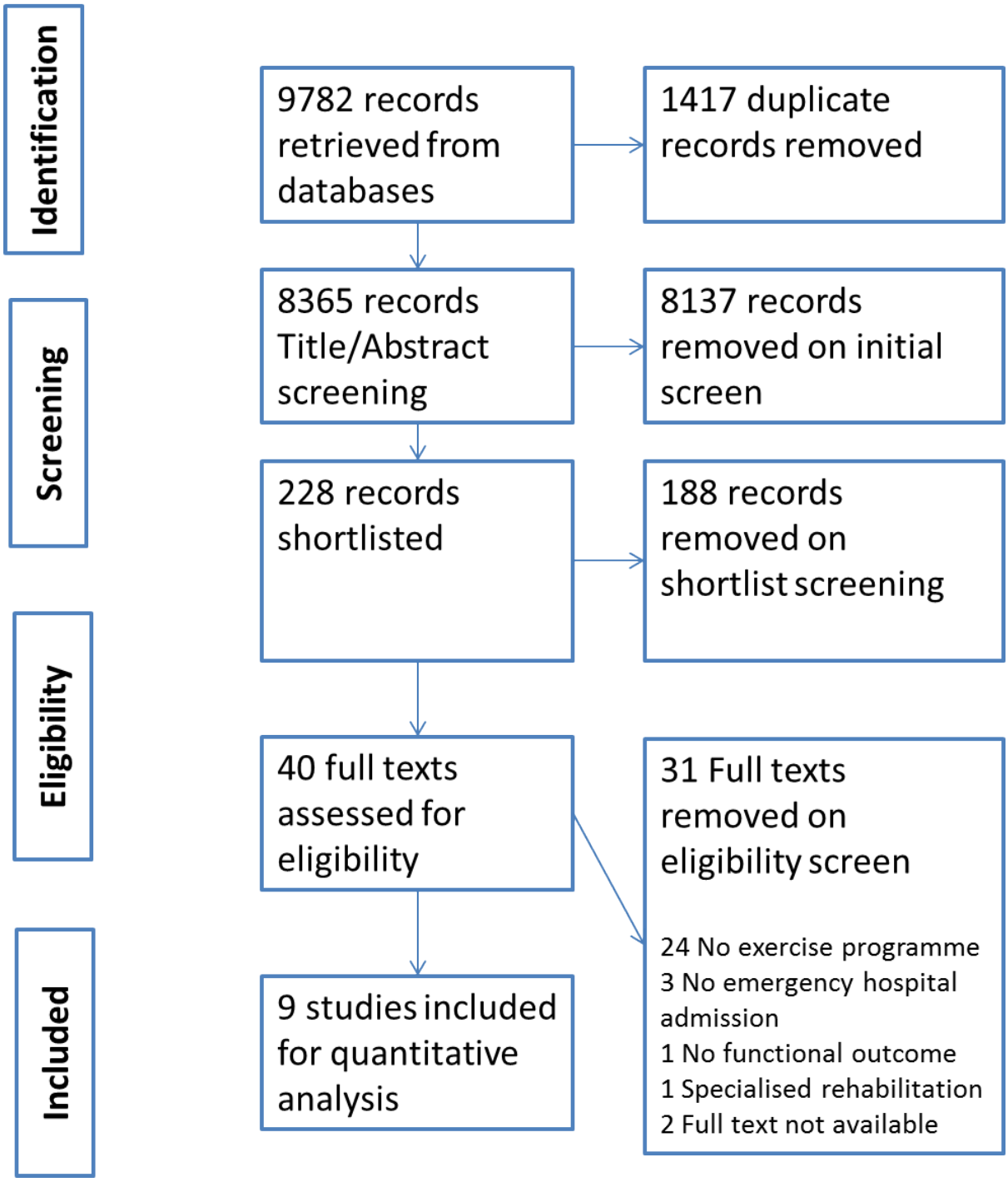

Figure 1: PRISMA Flow Chart

Figure 2: GRADE Risk of Bias

Study or Subgroup	Intervention Mean	Intervention SD	Intervention Total	Usual care Mean	Usual care SD	Usual care Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.1.1 Hospital plus post discharge rehab								
Brovold 2012	56	20	53	50	23	55	32.3%	0.28 [-0.10, 0.66]
Courtney 2009	39.4	8	58	29	9.2	64	32.1%	1.19 [0.81, 1.58]
Siebens 2000	5.1	2	149	4.6	2.2	151	35.5%	0.24 [0.01, 0.46]
Subtotal (95% CI)			**260**			**270**	**100.0%**	**0.56 [-0.02, 1.13]**
Heterogeneity: Tau² = 0.23; Chi² = 18.42, df = 2 (P = 0.0001); I² = 89%								
Test for overall effect: Z = 1.91 (P = 0.06)								
1.1.2 In hospital only								
Blanc-Bisson 2008	6.7	3.7	26	7.3	3.9	29	18.7%	-0.16 [-0.69, 0.37]
Brown 2016	12.9	0.29	44	13	0.25	48	26.4%	-0.37 [-0.78, 0.05]
DeMorton 2007	79	23	80	75	26	87	37.0%	0.16 [-0.14, 0.47]
Tibaek 2014	14	2.7	28	13.6	3.6	24	17.9%	0.13 [-0.42, 0.67]
Subtotal (95% CI)			**178**			**188**	**100.0%**	**-0.04 [-0.31, 0.22]**
Heterogeneity: Tau² = 0.03; Chi² = 4.62, df = 3 (P = 0.20); I² = 35%								
Test for overall effect: Z = 0.32 (P = 0.75)								

Test for subgroup differences: Chi² = 3.47, df = 1 (P = 0.06), I² = 71.2%

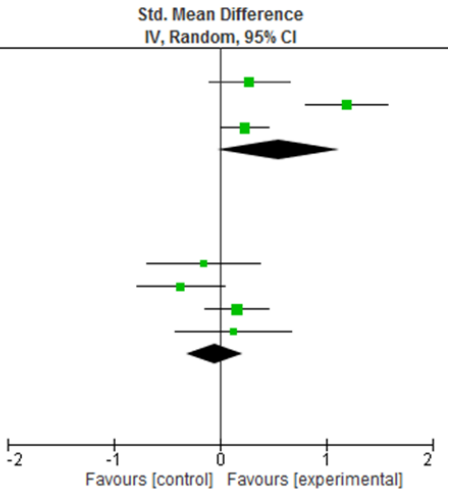

Figure 3: Random Effects Meta-analysis Forest Plot

Appendices

Appendix 1: Rehabilitation after Emergency Admission of Older Adults: Inclusion-Exclusion Criteria	
Inclusion criteria	
Age	80% Participants aged over 60 years
Population	Admitted to a hospital ward as an emergency/unplanned way for urgent care
Intervention	Exercise Based Rehabilitation intervention to improve function
Timing of intervention	Patients are admitted to hospital as an emergency/or in an unplanned way Hospital admission lasts greater than 4 hours Intervention takes place during or after the hospital admission
Study Design	Randomised control trials
Outcome measured	Measures of functional ability (Activities of Daily Living): Barthel's ADL Index (BI), Functional Independence Measure (FIM), Katz ADL, Lawton's Instrumental ADL (IADL), Nottingham extended ADL (EADL), Physical functioning aspect of the Health Related Quality of Life Short Form 36 (HRQOL SF-36)
Language	English
Exclusion Criteria	
Age	<60 years
Population	Patients living in residential or nursing homes Patients recruited from the Community without an emergency hospital admission
Intervention	Interventions designed solely to reduce the incidence of falls Complementary or Alternative Therapies Exercise is not the main component of the intervention

Timing of intervention	During an elective planned admission e.g. for a planned surgical procedure Hospital admission lasts less than 4 hours
Diagnosis	Disease processes which require specialized rehabilitation: Pulmonary rehab for COPD Cardiac rehabilitation after Myocardial Infarction, Acute Coronary Syndrome or Heart Failure Rehabilitation after Stroke Rehabilitation after Orthopaedic Injury such as hip fractures Rehabilitation for Spinal Injuries or Traumatic Brain Injury (TBI) Rehabilitation after Intensive care treatment, Psychological disorders, Cancer
Study Design	Cohort, Case Control, Pilot, Feasibility, Cost Analysis and Review articles
Outcome measured	No specific measures of function

Appendix 2: Search Strategy for Embase
exp Aged/
(older adj2 (adult? or person? or people? or patient?)).ti,ab.
(elder? or elderly or old age or seniors).ti,ab.
Geriatrics/
elderly care/ or geriatric care/
geriatric*.ti,ab.
1 or 2 or 3 or 4 or 5 or 6
hospital admission/ or hospitalization/
(hospitali?ation? or hospitali?ed or (hospital adj2 (admit* or admission?))).ti,ab.
((emergenc* or acute* or unplanned) adj2 (admission? or admitted*)).ti,ab.
hospital patient/
inpatient?.ti.
transitional care.ti,ab.
8 or 9 or 10 or 11 or 12 or 13
rehabilitation/ or geriatric rehabilitation/
rh.fs.
physiotherapy/
Physical Activity/
Occupational Therapy/
rehabilitat*.ti,ab.
(physical therap* or physiotherap*).ti,ab.
occupational therap*.ti,ab.
exp Exercise/ or kinesiotherapy/
exercise?.ti,ab.
(physical adj2 (activity or train*)).ti,ab.
(aerobic adj2 (train* or activit*)).ti,ab.
(strengthening or (strength adj2 train*)).ti,ab.
(fall? adj2 (prevent* or program* or intervention?)).ti,ab.
15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28

daily life activity/ or independent living/
((activit* adj2 daily living) or adl or iadl*).ti,ab.
(bathing or dressing).ti,ab.
(barthel or whodas or functional reach).ti,ab.
Fitness/
convalescence/
immobility/ or limited mobility/ or walking difficulty/
unsteadiness/
(function* adj2 (capacity or outcome? or status or performance or decline or recovery)).ti,ab.
(physical* adj2 (function* or capacity or outcome? or status or performance or decline or recovery)).ti,ab.
(aerobic adj2 (function* or capacity or outcome? or status or performance or decline or recovery)).ti,ab.
(mobility or debility or disability).ti,ab.
body equilibrium/ or walking speed/ or gait/ or muscle strength/
((muscle or hand or grip) adj2 (strength or weakness)).ti,ab.
(gait or (walk* adj3 (test* or speed* or distance))).ti,ab.
walking.ti,ab.
(standing or balance or stand test*).ti,ab.
"get up and go".ti,ab.
falling/
(falls or falling).ti,ab.
hospital discharge/ or hospital readmission/ or hospital utilization/
((patient? or hospital) adj2 (discharge or readmission or transfer)).ti,ab.
(discharg* adj5 (home? or nursing home? or residential home? or nursing care or residential care)).ti,ab.
30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52
7 and 14 and 29 and 53

limit 54 to "reviews (maximizes specificity)"
54 not 55
(review or comment or letter or editorial).pt.
56 not 57
conference*.pt.
58 not 59
58 nd 59

Table 1. Study Characteristics: Rehabilitation after Emergency Admission for Older Adults

Study	Brief Description of Intervention	Usual Care	Intervention	Control	Mean Age	Function Measures	Secondary Measures	Assessment time points
	Type of exercise and programme description	***Type and frequency of exercise***	**n**	**n**	**years**	**ADL, Barthel Index, Katz ADL, IADL, FIM, TUG, SF36, SF12, EMS**	**Length of stay, Readmissions, Mortality**	**Wks/months**
In Hospital Exercise Interventions								
Blanc-Bisson 2008	Early intensive physiotherapy focused on dynamic leg extension exercise with nutritional support	Walking and physiotherapy 3x/week, continues at home for 1 month after discharge	38	38	85.4 (6.6)	Katz ADL	Not assessed	Baseline, Clinical stability (normal vital signs, mental status and independent with feeding) and 1 month after stabilisation
Brown 2016	Mobility programme (MP) - began with assisted sitting, then standing, progressing to weight shifting, stepping in place, and then ambulation as tolerated with the assistance of the research assistant.	Research assistant visits for 15-20 minutes twice daily 7x/week 34% have extra physio	50	50	73.9 (6.96)	ADLs	Length of stay	Baseline, hospital discharge and by telephone at 1 month after discharge
DeMorton 2007	Individually prescribed exercise programme in addition to UC, ranging from Level 1 Bed based exercise programme, Level 2 Sitting, Level 3 Standing and Level 4 Stairs. Including resistance training where possible	Usual care	110	126	UC 78(7) Int 80(8)	Barthel Index, TUG	Length of stay, readmission	Baseline (within 48 hrs of admission) and at discharge (within 48 hrs of discharge)
Tibaek 2014b	Progressive resistance strength training in addition	Regular physiotherapy	36	35	UC 79 Int 80	Barthel Index, TUG	Length of stay	Baseline and after intervention but

	to usual physiotherapy							before discharge
Raymond 2017	High-intensity functional exercise (HIFE). Exercise group 3x/week and physiotherapy 2x/week. Exercises were lower limb progressive resistance strength exercises in supported and unsupported positions and balance exercises.	Individual physiotherapy balance, strength or aerobic exercise 5x/week	236	232	Control 84.05 (6.88) HIFE 84.51 (7.30)	Elderly Mobility Scale, TUG	Length of stay	Prior to randomisation and within 48 hours of discharge
In hospital and Post Discharge Exercise Interventions								
Brovold 2012	Combined counselling and exercise programme including balance and progressive resistance training.	45 minutes balance exercise 2x/week.	53	55	80 (6.1)	SF36, TUG	Not assessed	Baseline, after discharge from hospital, and after 3 months
Courtney 2009	Discharge planning and in-home follow-up care including an individually tailored exercise programme, including muscle stretching, walking, balance and resistance training	Usual care	64	64	78.8 (6.9)	SF12, TUG	Hospital readmissions	Baseline and 4,12, and 24 weeks after discharge
Siebens 2000	Hospital based general exercise programme and encouragement to continue to exercise at home. Combination of strength, flexibility exercises and walking.	Usual care	149	151	UC 78.2 (5.6) Int 78.5 (5.6)	IADL	Length of stay	Baseline and at 1 month after discharge
Post discharge Exercise Interventions								
Brovold 2013	High intensity group-based aerobic interval training programme.	Low intensity home exercise 3x/week	59	56	78 (5.2)	SF36, TUG	Not assessed	Baseline (2-4 weeks post discharge) and at 3 months after discharge

Table 2. Primary and Secondary Outcomes: Function, Length of Stay, Readmissions and Mortality

Study	Brief Description of Intervention	Assessment time point	Functional Measures used	Functional Outcome	Length of stay	Readmissions	Mortality
In Hospital Exercise Interventions							
Blanc-Bisson 2008	Early intensive physiotherapy focused on dynamic leg extension exercise with nutritional support	Baseline (T0), at clinical stability (T1), and 1 month later (T2)	Katz ADL Score 0 independent 12 dependent	Change in mean ADL score T0 to T2 Intervention 2.2 Control 3	Time to clinical stability 12.6 days both groups	Not assessed	Not assessed
Brown 2016	Mobility programme (MP) - began with assisted sitting, then standing, progressing to weight shifting, stepping in place, and then ambulation as tolerated with the assistance of the research assistant.	Baseline (T0), hospital discharge (T1) and by telephone at 1 month after discharge (T2)	ADL Score 7 independent 21 dependent	Both groups similar ADLs (p=0.62) No change over time (p=0.77)	INT 4.6 days UC 3.6 days P=0.13	Not assessed	INT 2 deaths UC 1 death
DeMorton 2007	Individually prescribed exercise programme in addition to UC, ranging from Level 1 Bed based exercise programme, Level 2 Sitting, Level 3 Standing and Level 4 Stairs. Including resistance training where possible	Baseline (within 48 hrs of admission, T0) and at discharge (within 48 hrs of discharge, T1)	Barthel Index 0 dependent 20independent	Change in mean ADL score T0 to T2 INT 12 UC 10	Median LOS INT 5 days UC 6 days P=0.45	28 days readmission rate INT 20% UC 19%	INT 2% UC 2% RR 1.15 (0.16-8)
			TUG Time in seconds	Reduction in time T0 to T1 INT -10 seconds UC -5 seconds			
Tibaek 2014b	Progressive resistance strength training in addition to usual physiotherapy	Baseline (T0) and after intervention but before	Barthel Index 0 dependent – 20 independent	Change in Mean ADL score Transfers	Mean LOS INT 28 days UC 24 days P=0.23	Not assessed	Not assessed

		discharge (T1)	Divided into transfer, walking and stairs	INT 1.8 UC 0.3 Walking INT 2 UC 1.2 Stairs INT 3.8 UC 3.9			
			TUG Time in seconds	Reduction in time T0 to T1 INT -7 seconds UC -6 seconds P=0.29			
Raymond 2017	High-intensity functional exercise (HIFE). Exercise group 3x/week and physiotherapy 2x/week. Exercises were lower limb progressive resistance strength exercises in supported and unsupported positions and balance exercises.	Prior to randomisation (T0) and within 48 hours of discharge (T1)	Elderly Mobility Scale 0 independent 20 dependent	Change in mean ADL score T0 to T1 INT 5 UC 5 P=0.446	Median LOS INT 12.3 days UC 12.2 days	Not assessed	Not assessed
			TUG Time in seconds	No significant difference p=0.819			
In Hospital and Post Discharge Exercise Interventions							
Brovold 2012	Combined counselling and exercise programme including balance and progressive resistance training.	Baseline (T0), after discharge from hospital (T1), and after 3 months (T2)	SF36 0 dependent 100 independent	Change in mean ADL T0 to T2 INT 6.0 UC 6.5 Time effect p=0.0001 Treatment effect p= 0.5	Not assessed	INT 5 UC 7	INT 3 deaths UC 3 deaths

			TUG Time in seconds	Reduction in time T0 to T2 INT -1.9 seconds US -1.3 seconds			
Courtney 2009	Discharge planning and in-home follow-up care including an individually tailored exercise programme, including muscle stretching, walking, balance and resistance training	Baseline (T0) and 4 (T1) ,12 (T2), and 24 weeks after discharge (T4)	SF12 Physical component score 0 dependent 100 independent	Change in mean score T0 to T4 INT 11.2 UC -8.5 P=<0.001	Not assessed	INT 21 UC 49 UC 7.2x more likely to be readmitted (multi-variant log regression)	INT 3 deaths UC 2 deaths
			TUG Time in seconds	Not reported			
Siebens 2000	Hospital based general exercise programme and encouragement to continue to exercise at home. Combination of strength, flexibility exercises and walking.	Baseline (T0) and at 1 month after discharge (T1)	IADL Average number of independent ADLs T0 to T1 0 dependent 7 independent	Change in mean score T0 to T1 INT -0.2 UC -0.7	Mean LOS INT 12 days UC 10.5 days P=0.23	Not assessed	At T0 INT 2 deaths UC 0 deaths At T1 10 deaths both groups
Post discharge exercise interventions							
Brovold 2013	High intensity group-based aerobic interval training programme.	Baseline (2-4 weeks post discharge) and 3 months after discharge	SF36 0 dependent 100 independent	Change mean score 0.5 INT & UC	N/A	Not assessed	Not assessed (Adverse events INT 23% UC 29%)
			TUG Time in seconds	Reduction in time -0.3 seconds INT & UC			

Conflicts of Interest Declaration:

There are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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