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Effects of Structured Exercise Interventions for Older Adults Hospitalized with Acute Medical Illness: A Systematic Review

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Abstract

This review examined effects of structured exercise (aerobic walking, with or without complementary modes of exercise) on cardiorespiratory measures, mobility, functional status, healthcare utilization, and Quality of Life in older adults (≥ 60 years) hospitalized for acute medical illness. Inclusion required exercise protocol, at least one patient-level or utilization outcome, and at least one physical assessment point during hospitalization or within 1 month of intervention. MEDLINE, Embase, and CINAHL databases were searched for studies published from 2000 to March 2015. Qualitative synthesis of 12 articles, reporting on 11 randomized controlled (RCT) and quasi-experimental studies described a heterogeneous set of exercise programs and reported mixed results across outcome categories. Methodological quality was independently assessed by 2 reviewers using the Cochrane Collaboration Risk of Bias tool. Larger, well-designed RCTs are needed, incorporating measurement of pre-morbid function, randomization with intention-to-treat analysis, examination of a targeted intervention with pre-defined intensity, and reported adherence and attrition.

Keywords

Exercise; Hospitalization; Outcome Assessment; Quality of Life; Older Adults

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Introduction

All stakeholders - health care providers, delivery systems, policy communities, patients and families - share concern for older adults who require hospitalization and seek interventions that support restorative processes. Hospitalized older adults are at high risk for rapid deconditioning and functional decline (Anpalahan & Gibson, 2008; Cynthia M. Boyd et al., 2008; Kenneth E. Covinsky, Pierluissi, & Johnston, 2011; Creditor, 1993; Kortebein, 2009; Mahoney, Sager, & Jalaluddin, 1998; Sager et al., 1996). Within 24 to 48 hours of bed rest inactivity, multiple changes in organ system physiology begin to occur and contribute to overall weakness and functional decline (Creditor, 1993; Kleinpell RM, 2008). Even in healthy older adults prolonged bed rest results in substantial loss of lean body mass in the lower extremities, primarily as a result of skeletal muscle wasting (Kortebein et al., 2008; Puthuchear et al., 2013). Without a preventive intervention, hospital-associated deconditioning and disability has the potential to precipitate short and long-term consequences including loss of mobility, independence and quality of life. Additional negative outcomes may include falls, the need for higher levels of care, and readmission, all resulting in higher healthcare costs (Kalisch, Dabney, & Lee, 2013). Older adults who are already functionally compromised prior to admission may be at particularly high risk of these outcomes.

Based on its well-recognized, positive effects in healthy, community-dwelling adults, structured exercise is one intervention of interest. It has been shown to thwart the process of deconditioning, build resilience (Luthar SS, 2000), abbreviate the periods of exacerbation of acute illness, and reduce the impact of subsequent health crises (Hawkey LC, 2005). In contrast, for older adults hospitalized with acute illness the specific effects of structured exercise remain ill-defined.

Our systematic review refines and extends previous work by de Morton, Keating, & Jeffs, specifically the 2007 Cochrane review of 9 trials, 7 of which were published between 1986 and 2000. Of the 9 trials, 6 represented multicomponent intervention versus 3 exercise-only intervention trials. Reviews of multicomponent programs for hospitalized older adults, which included exercise as one of its components, have been associated with improved patient outcomes (Bachmann et al., 2010; Baztan, Suarez-Garcia, Lopez-Arrieta, Rodriguez-Manas, & Rodriguez-Artalejo, 2009; Counsell et al., 2000; Fleck et al., 2012; Inouye, Bogardus, Baker, Leo-Summers, & Cooney, 2000; Landefeld, Palmer, Kresevic, Fortinsky, & Kowal, 1995). In multicomponent models, however, it is not possible to disentangle effects of structured exercise from other intervention components, such as a specially designed environment or input from a multidisciplinary team (Landefeld et al., 1995). Multicomponent programs have not been widely adopted, and this may be due in part to uncertainty about the relative impact of individual program features.

Our literature review, starting in 2000 and extending through March 2015 overlaps and advances the 2007 Cochrane review by focusing exclusively on structured exercise interventions, thus allowing a more precise estimate of its isolated effects among hospitalized older adults in the inpatient setting and extending to home/community-based interventions.

This review examined effects of structured exercise (defined as aerobic walking, with or without complementary modes of exercise) on performance measures, mobility, functional status, healthcare utilization and Quality of Life, in older adults hospitalized for acute medical illness. Specific objectives of this review were to answer the following key questions: 1) How effective are structured exercise interventions for older adults hospitalized with medical illness in improving the above mentioned outcomes?, and 2) How do variables such as exercise parameters, target population, and health care setting modify the effectiveness of exercise interventions?

Methods

Data Sources and Searches

Using pre-defined PICOT guidelines (summarization of population, intervention, comparison, outcome and time) as shown in Table 1 and in consultation with a medical librarian, we searched MEDLINE, Embase, and CINAHL with a combination of subject headings and text words for inpatients, elderly, and exercise. We narrowed results to randomized controlled (RCT) and quasi-experimental trials using a modified version of the Cochrane Highly Sensitive Search Strategy for identifying randomized trials in MEDLINE (*Cochrane Handbook for Systematic Reviews of Interventions*). Results were further limited to those published in the English language from 2000 to March 2015 to achieve overlap with timeframe of the 2007 Cochrane Review as described above. The full search strategy is available in Appendix 1. Duplicate citations were eliminated using EndNote software, resulting in 2506 citations. The Prospero registration number for this study is CRD42015019161.

Study Selection

Inclusion and exclusion criteria were pre-specified to focus on older adults who were hospitalized for an acute medical episode (PICOT Table 1). Studies in which all patients were 60 years, median age of 60, and with at least 50% of participants 60 years were included. The intervention setting included at least an inpatient hospital stay with the possibility of extending the intervention to a home/community-based setting. The comparator was usual care or attention control. In brief, included articles had to report: exercise protocol and parameters, at least one patient-level or utilization outcome, and at least one physical assessment point during hospitalization or within 1 month of intervention.

Specifically excluded were studies of multicomponent interventions, that is programs that included medical or geriatric consultation, studies that only reported safety outcomes, and specific settings of intensive care, psychiatric units, skilled nursing facilities, rehabilitation centers and exclusively outpatient settings.

Data Abstraction and Quality Assessment

A publicly available abstracting tool, Abstrackr, was used for citation management (Wallace BC, 2012). Two investigators independently assessed titles and abstracts. Full-text articles identified by either investigator as relevant were retrieved for further review; disagreements on inclusion/exclusion were resolved by discussion or by a third investigator. The PRISMA

flow diagram in Figure 1 outlines the process steps and outcomes of the literature search. Total records identified in the search were 2506; 39 articles received full-text review. Twelve articles, reporting on 11 trials described effects of exercise intervention on patient-level or utilization outcomes.

Risk of bias (ROB) (Appendix 2) and outcome data were then abstracted independently by two investigators. Disagreements were resolved by consensus or a third investigator. Risk of bias assessment was performed, at the study level, using key quality criteria described in the Cochrane Collaboration ROB Tool (CCRB) (*Cochrane Handbook for Systematic Reviews of Interventions*). This ROB tool evaluates 6 different domains with guidelines to score each item; each domain was evaluated as low, unclear/medium, or high ROB.

Data Synthesis and Analysis

We identified five outcome categories of interest. Cardiorespiratory capacity and/or performance represent measurable capacity (e.g., maximum oxygen consumption and airflow obstruction) and performance (e.g., walk distances, walk time). Mobility refers to assessments of basic motor skills required for functional ambulation (e.g., Timed Up and Go [TUG] Functional Ambulatory Classification Score). Functional status includes self-reported measures of Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL). Healthcare utilization comprises all measures of planned and unplanned use of health care services and discharge destination. QoL/patient experience incorporates responses to validated, survey instruments, perception of health status, and self-reported patient experience.

The studies were stratified by setting (Inpatient Hospital versus Inpatient Hospital to Home/Community Settings) and within setting by exercise intervention mode to: 1) identify and compare patterns of outcome measures, both primary and secondary, and 2) to evaluate the relationship of characteristics of individual studies and their findings.

Results

Summary study characteristics

Total records identified in the search were 2506; 39 articles received full-text review. Twelve articles, representing 11 studies were included in the qualitative synthesis. (Figure 1) Table 2 provides an overview of characteristics and outcomes of exercise interventions for included studies distinguished by exercise mode. Overall the review included data from 11 published studies, including 7 RCTs, (Behnke M, 2003; Courtney et al., 2012; Eaton T, 2009; Greening NJ, 2014; Jones CT, 2006; Ozdirenc M, 2004; Siebens, Aronow, Edwards, & Ghasemi, 2000) 3 cluster randomized trials, (de Morton, Keating, Berlowitz, Jackson, & Lim, 2007; Mudge AM, 2008; Mundy, Leet, Darst, Schnitzler, & Dunagan, 2003) and 1 non-randomized, concurrent control study (Hastings, Sloane, Morey, Pavon, & Hoenig, 2014). Assessment of ROB found 2 studies as low risk (i.e. high quality) (Jones CT, 2006; Siebens et al., 2000), 5 studies as unclear/medium risk (de Morton, Keating, Berlowitz, et al., 2007; Eaton T, 2009; Greening NJ, 2014; Hastings et al., 2014; Mudge AM, 2008), and 4 studies as high risk (Behnke M, 2003; Courtney et al., 2012; Mundy et al., 2003; Ozdirenc M,

2004). Studies were conducted at hospitals in Australia (5), USA (3), UK (1), Germany (1), and Turkey (1). Six studies included patients with general medical conditions (Courtney et al., 2012; de Morton, Keating, Berlowitz, et al., 2007; Hastings et al., 2014; Jones CT, 2006; Mudge AM, 2008; Siebens et al., 2000), 4 with respiratory illness (Behnke M, 2003; Eaton T, 2009; Greening NJ, 2014; Mundy et al., 2003), and 1 with type II diabetes (Ozdirenc M, 2004). Exercise intervention mode included aerobic walking alone in 4 studies (Behnke M, 2003; Hastings et al., 2014; Mudge AM, 2008; Mundy et al., 2003), aerobic and resistance exercise in 3 studies (de Morton, Keating, Berlowitz, et al., 2007; Eaton T, 2009; Greening NJ, 2014), and aerobic, resistance, balance and/or flexibility exercise in 4 studies (Courtney M, 2009; Courtney et al., 2012; Jones CT, 2006; Ozdirenc M, 2004; Siebens et al., 2000). Six studies performed the intervention in the inpatient setting only (de Morton, Keating, Berlowitz, et al., 2007; Hastings et al., 2014; Jones CT, 2006; Mudge AM, 2008; Mundy et al., 2003; Ozdirenc M, 2004), 4 studies extended it to home-based setting (Behnke M, 2003; Courtney M, 2009; Courtney et al., 2012; Greening NJ, 2014; Siebens et al., 2000), and 1 study extended to both home-based and outpatient settings (Eaton T, 2009). Outcome assessment was executed at variable time points, ranging from the end of hospital stay to 18 months post-hospitalization.

In total, the review considers studies of 2089 participants. Study sizes included 3 studies with <100 participants (Behnke M, 2003; Eaton T, 2009; Ozdirenc M, 2004), 4 studies between 101 and 200 participants (Courtney et al., 2012; Hastings et al., 2014; Jones CT, 2006; Mudge AM, 2008), and 4 studies between 201 and 500 participants (de Morton, Keating, Berlowitz, et al., 2007; Greening NJ, 2014; Mundy et al., 2003; Siebens et al., 2000). The age range of study participants was 17 to 103 years; 2 studies enrolled participants below the age of 60 years (Greening NJ, 2014; Mundy et al., 2003). Average age, among 9 studies reporting mean age, was 75 years (range 60 to 96 years). Males represented between 38% and 97% of study populations.

Key Question 1: Effect of exercise on cardiorespiratory capacity and/or performance, mobility, functional status, healthcare utilization, and quality of life (QoL)/patient experience

Study results are summarized in Table 2. In general, findings were mixed both within and across the 5 outcome categories.

Cardiorespiratory capacity and/or performance.—Five studies reported cardiorespiratory measures, though none was considered a primary outcome (Behnke M, 2003; Eaton T, 2009; Greening NJ, 2014; Mundy et al., 2003; Ozdirenc M, 2004). More consistent impact was observed for performance than for capacity measures. Three studies showed significant findings toward beneficial effects in performance (Behnke M, 2003; Greening NJ, 2014; Ozdirenc M, 2004); 6 minute walk distance (6MWD) was improved in the Behnke (Behnke M, 2003) and Ozdirenc (Ozdirenc M, 2004) studies which used aerobic and aerobic, resistance and flexibility exercises respectively as the intervention; and the endurance shuttle walk time improved in the Greening study (Greening NJ, 2014), which used aerobic and resistance exercise as the intervention. The Ozdirenc (Ozdirenc M, 2004)

study demonstrated a significant difference in capacity, as measured by estimated maximal oxygen consumption ($\text{Vo}_2 \text{ max}$), between intervention and control groups.

Mobility.—Four studies (Courtney et al., 2012; de Morton, Keating, Berlowitz, et al., 2007; Jones CT, 2006; Mudge AM, 2008) specified a mobility outcome including Timed Up and Go, Functional Ambulatory Classification Score, and Modified Walking Impairment Questionnaire. Positive mobility effects were evident in two studies that combined walking plus resistance, balance and/or flexibility exercises. The Courtney study, including exercise in inpatient and home settings, found significant between-group differences ($P < .001$) in the primary outcome measure of modified walking impairment (mWIQ) for distance, speed and stairs with the largest improvement in the first 4 weeks post-hospitalization (Courtney et al., 2012). Jones, an inpatient-setting only trial, showed a significant difference ($P = 0.01$) in Timed Up and Go (Jones CT, 2006).

Functional Status.—Three studies specified one or more functional status measures as a primary outcome (Courtney et al., 2012; Jones CT, 2006; Mudge AM, 2008). Of 3 studies examining inpatient exercise alone (de Morton, Keating, Berlowitz, et al., 2007; Jones CT, 2006; Mudge AM, 2008), Mudge (Mudge AM, 2008) reported significant improvement in ADLs using the Barthel Index, while deMorton (de Morton, Keating, Berlowitz, et al., 2007) did not. Jones (Jones CT, 2006) reported a greater improvement in Modified Barthel Index (mBI) scores in the intervention group when admission mBI scores were low.

Among studies that examined multiple settings, Siebens (Siebens et al., 2000) and Courtney (Courtney et al., 2012) reported significant improvement in IADLs. Courtney collected outcome data at 4, 12, and 24 weeks following discharge and reported the greatest improvement in both ADLs and IADLs was observed in the first 4 weeks post hospitalization.

Utilization.—A total of 35 utilization measures (9 specified as primary) were reported among 10 of 11 studies; yet only 20% of measures were significant. Primary outcome measures that significantly favored the intervention group in any study included: length of stay (LOS) (Mundy et al., 2003); number of hospital admissions (Behnke M, 2003); and percent of emergency hospital admissions, emergency general practitioner visits and emergency allied health services (Courtney M, 2009). Seven studies measured LOS (de Morton, Keating, Berlowitz, et al., 2007; Eaton T, 2009; Greening NJ, 2014; Hastings et al., 2014; Mudge AM, 2008; Mundy et al., 2003; Siebens et al., 2000). Only one study in this review, Mundy et al, reported a statistically significant reduction in hospital length of stay (Mundy et al., 2003); notably this study ($n = 458$) was explicitly powered to detect a one-day difference in LOS for patients with community acquired pneumonia (Mundy et al., 2003). It is unclear how many of the other included studies were adequately powered to assess this outcome. Seven studies included readmission measures (Behnke M, 2003; Courtney M, 2009; de Morton, Keating, Berlowitz, et al., 2007; Eaton T, 2009; Greening NJ, 2014; Hastings et al., 2014; Mudge AM, 2008); 2 studies showed significant findings (Behnke M, 2003; Courtney et al., 2012). The Courtney study, (Courtney et al., 2012) which implemented both inpatient and home-based exercise, evidenced multiple positive utilization findings with significantly fewer emergency readmissions at both 4 and 24 weeks in the

intervention group (Courtney M, 2009). Significant findings of secondary outcomes of utilization included between group differences in discharge disposition in Hastings (Hastings et al., 2014) walking study.

Quality of life/patient experience.—Five of 11 studies measured QoL/patient experience (Behnke M, 2003; Courtney M, 2009; Eaton T, 2009; Greening NJ, 2014; Siebens et al., 2000). The QoL/patient experience findings tended to be the most consistently positive category of outcomes across studies; 7 of a total of 9 (78%) measures (i.e., chronic respiratory disease questionnaire, transitional dyspnea index, SF-12 physical component score, hospital anxiety and depression index, St. George's respiratory score, SF-12 mental component score, and Rand general health scale) demonstrated significant findings. The Courtney study which was the only one to specify QoL/patient experience as a primary outcome measure, found highly significant differences at 24 weeks in both Short Form (SF)-12 Physical Health Component Score (PCS) and Mental Health Component Score (MCS) with greater improvement for the intervention group (Courtney M, 2009).

Key Question 2: Factors modifying effectiveness of interventions

Intervention characteristics.—Exercise interventions varied considerably across studies and are summarized in Table 3. Four studies encompassing 395 patients included aerobic walking as the sole exercise mode (Behnke M, 2003; Hastings et al., 2014; Mudge AM, 2008; Mundy et al., 2003); all except Behnke were inpatient-only programs. Three studies accounting for 393 participants applied aerobic and resistance exercise interventions; 1 was inpatient only (de Morton, Keating, Berlowitz, et al., 2007), 1 combined inpatient and home-based, (Greening NJ, 2014), and 1 used inpatient, outpatient and home-based settings (Eaton T, 2009). Four studies with 316 total participants used aerobic, resistance and balance and/or flexibility exercises; of these, 2 studies were conducted in inpatient settings (Jones CT, 2006; Ozdirenc M, 2004) and 2 studies extended to home (Courtney et al., 2012; Siebens et al., 2000). Six studies specified the timeframe to initiate the exercise intervention, ranging from 24 to 72 hours of admission. Inpatient exercise was prescribed at least once each day in all but one study (Courtney et al., 2012), and 4 studies specified twice daily inpatient exercise (de Morton, Keating, Berlowitz, et al., 2007; Jones CT, 2006; Mudge AM, 2008; Siebens et al., 2000). In contrast to a daily routine, the Courtney study (Courtney M, 2009) provided exercise 2–3 times per week while inpatient and markedly increased frequency for home based exercise to 3 to 4 days per week and 1 to 3 times per day (Courtney et al., 2012). Where specified, session duration ranged from 5 to 45 minutes and averaged 20–30 minutes per day. Intervention duration varied from the length of hospital stay (5 to 12 days) to 18 months, with varying specifications for intensity and progression. Individualized training was noted in 5 studies (Behnke M, 2003; Courtney et al., 2012; de Morton, Keating, Berlowitz, et al., 2007; Greening NJ, 2014; Jones CT, 2006); of these, 3 tailored exercise according to the patient's functional status (de Morton, Keating, Berlowitz, et al., 2007; Jones CT, 2006; Mudge AM, 2008).

Setting.—Studies examining interventions that extended beyond hospitalization evidenced a greater absolute number of significant findings. Five studies extended the intervention to home and/or outpatient settings. Of four studies that included home-based exercise (Behnke

M, 2003; Courtney et al., 2012; Greening NJ, 2014; Siebens et al., 2000), all but 1 reported between 2 and 5 significant between-group differences (Siebens et al., 2000). All five studies that included home-based exercise included some level of patient support follow-up including home visit (Courtney et al., 2012), telephone calls (Siebens et al., 2000; Courtney et al., 2012; Greening NJ, 2014; Behnke M, 2003), and an encouragement postcard (Siebens et al., 2000). The Eaton study offered free outpatient oxygen to participants, free door-to-door transport to an outpatient exercise program, and a free prescription to a local gym to maintain an exercise regimen. One trial, Eaton et al (Eaton T, 2009), used all three settings and reported 3 significant findings in QoL category only (CRQ-Self Administered fatigue score, SF-36 PCS, and Hospital Anxiety and Depression Scale anxiety score) (Eaton T, 2009). In contrast, the 6 inpatient-only studies evidenced a more limited number of significant findings. One study did not report any significant finding (de Morton, Keating, Berlowitz, et al., 2007) and 5 reported one significant finding each (Hastings et al., 2014; Jones CT, 2006; Mudge AM, 2008; Mundy et al., 2003; Ozdirenc M, 2004) across outcome categories (discharge to home, mBI, LOS, TUG, and 6MWD). Mudge (Mudge AM, 2008) instituted ward-based nursing and interdisciplinary training, as well as patient group sessions.

Population.—Five studies enrolled patients with defined diagnoses (e.g., respiratory illness, COPD, diabetes, pneumonia) (Behnke M, 2003; Eaton T, 2009; Greening NJ, 2014; Mundy et al., 2003; Ozdirenc M, 2004). These studies were more likely to measure and report cardiorespiratory capacity and/or performance outcomes with 3 out of 4 studies demonstrating significant positive impact in measures in this category.

Few studies incorporated sub-group analyses to explore potentially important moderators of intervention effectiveness (Jones CT, 2006; Mudge AM, 2008; Mundy et al., 2003). Mundy's study of those with community-acquired pneumonia distinguished effect of exercise by participants' pneumonia severity index (PSI) group (Mundy et al., 2003). Jones reported that greater improvement in mBI scores were observed in the intervention group for those whose admission mBI was low and the effect diminished as the admission mBI score increased (Jones CT, 2006).

Exercise Type.—There was no clear pattern of benefit among studies examining walking plus additional exercise modes (N=7) versus walking alone (N=4). However it is notable that the Courtney study, which used the most comprehensive mode, showed beneficial effects on multiple outcome categories, namely mobility, functional status, utilization, and QoL/patient experience (Courtney M, 2009; Courtney et al., 2012). This study employed a multimodal approach, combining aerobic, resistance, flexibility and balance exercises that extended to home-based intervention for a total of 24 weeks. Post-hospital follow up support and encouragement occurred via nurse telephone calls, weekly in the first month post discharge.

Discussion

While there is broad clinical consensus that immobility among hospitalized older adults contributes to functional decline and other adverse outcomes, evidence of exercise intervention effects is inconsistent. The previously cited Cochrane review (deMorton,

Keating, Jeffs, 2007) that included evaluation of 3 exercise-only interventions concluded that “for older patients who are admitted to hospital, exercise sessions may not lead to any difference in function, harms, length of stay in hospital, or whether they go home or to a nursing home or other care facility.” Cumulative evidence from more recent studies on hospital exercise adds little more to this conclusion.

This systematic review summarizes the current state of literature on exercise-only interventions for hospitalized older adults and factors that modify effectiveness, and offers several key observations and recommendations for future work in this area. We found 11 studies examining exercise-only interventions for hospitalized older adults published in the past 15 years. Only 3 of the reviewed studies were conducted in the U.S. despite the fact that more than 1 in 5 Medicare beneficiaries are hospitalized at least once annually and thus are at risk of hospital-associated functional decline. With downward pressure on hospital LOS, especially in the US healthcare system, the ability of short-term exercise interventions to generate rapidly the measurable, positive patient outcomes we seek may be severely challenged. Increasingly older adult patients who are admitted to the inpatient setting are of more advanced age, of higher complexity, in less stable condition (C. M. Boyd et al., 2008; Buurman et al., 2011). Furthermore implications for the inpatient care process are influenced by the use of hospitalists with a focus on readiness for discharge (Yoo et al., 2014).

Overall the data regarding the effectiveness of structured exercise interventions for older adults hospitalized with medical illness were mixed across the five outcome categories that we examined: cardiorespiratory capacity and/or performance, mobility, functional status, healthcare utilization, and quality of life (QoL)/patient experience. Across the 11 studies, significant findings accounted for between 20% (healthcare utilization) to 78% (QOL/patient experience) of total measures within the categories. Functional measure impacts were variable depending on modes of exercise and potentially limited by ceiling or floor effects as described further below. Future studies aiming to understand the true potential value of exercise programs for hospitalized older adults should include patient-centered measures from physical and cognitive health domains including QoL (Courtney M, 2009; Eaton T, 2009). Patient-reported outcomes that evaluate QoL for the older adult are increasingly as meaningful as physiologic measures since they may more effectively reflect patient’s life goals including independence (Tinetti, Fried, & Boyd, 2012). In general, we found that programs that continued in the home-based setting appeared to be more consistently associated with positive results.

The results of this review highlight several challenges and opportunities for the design of future research. Our limited ability to draw firm conclusions based on this review reflects the challenges faced by practitioners and researchers in designing and implementing exercise interventions in acutely hospitalized older adults who may simultaneously be negatively affected by inadequate nutrition, polypharmacy, pain, and sleep deprivation. Patients’ complexity and variability throughout hospitalization likely contributed to the dual challenge of attrition and adherence consistently found among the studies, with drop-out rates of 7% to 32% and adherence rates between 40% and 94%, when reported. Since those who choose not to participate or adhere to an intervention are likely substantially different from those who do, randomized designs with intention to treat analysis are critical to estimate unbiased

effect sizes. The low adherence rates also suggest the need for better targeting, tailoring and implementing interventions. Evidence from the Jones study suggests that targeting exercise to those with moderate or severe baseline impairments likely will have the largest effect (Jones CT, 2006); a secondary analysis of pooled data by deMorton supports the targeting strategy for patients who required assistance or supervision to ambulate at the time of hospital admission (De Morton, Jones, et al., 2007). An environment that actively promotes physical activity and patient adherence to exercise participation, established through staff training and telephone home follow-up (Courtney et al., 2012; Greening NJ, 2014; Mudge AM, 2008) may provide more effective, positive interactions than didactic strategies alone. Interdisciplinary, collaborative teams can more effectively influence the culture of patient care. (Yoo et al., 2014).

Selecting appropriate measures for a highly heterogeneous population experiencing a variety of acute stressors is a particular challenge. The Barthel Index, for example, may not be appropriate for patients who are highly robust or very frail prior to admission. Mobility measures (e.g., TUG) can be challenging to carry out among inpatients who have intravenous lines, telemetry monitors, urinary catheters, and are experiencing acute physical symptoms. Utilization measures such as readmission are highly influenced by factors such as social support and co-morbidities, and health system factors and thus may not be sufficiently sensitive to exercise intervention. Evidence suggests that a trade-off relationship exists between LOS and readmission rates that may be particularly relevant for older adults (News, 2015). That said, LOS is an important performance measure for hospital systems; outliers, especially in a heterogeneous patient population, can skew these data (Haines et al., 2015). Studies reporting LOS as an outcome should report whether the study was adequately powered to detect an effect. New measures that take account of premorbid function and the physiologic reserve capacity to meet the demands of exercise during periods of acute illness may be useful (Goldspink, 2005; Hill, Dranka, Zou, Chatham, & Darley-USmar, 2009; Whitson et al., 2016). Patient or provider-reported measures such as the Activity Measure for Post Acute Care (AMPAC) have been shown to be clinically meaningful, comparable within and across settings, and sensitive to 1, 6, and 12 month follow up (Jette et al., 2014).

A relevant study by Brown and colleagues (Brown et al., 2016) that was published after our search activities were completed provides substantive additional information complementary to our original summation of the literature. This study reinforces the importance of patients' self-reported measures reported by the current review, especially those that may more effectively reflect older adults' QoL goals, including maintaining one's social role in the community.

In the Brown study, implications for recovery of pre-admission mobility level attributable to an in-hospital mobility program are highlighted using self-reported ADL and a community mobility measure, Aging Life-Space Assessment (LSA) (Brown et al., 2016). The LSA is a composite measure based on the level, degree of independence in achieving each level, and frequency of attaining each level of distance traversed during the preceding 4 weeks. At 1-month post hospitalization, patients who had received the intervention (walking up to twice daily) versus those who had received usual care (twice-daily visits by a research assistant; request to document frequency of visitors, both family and health care professionals in a

diary) demonstrated a significantly higher LSA, similar to the LSA score at admission. A decline of approximately 10 points was observed in the 1-month LSA score for the usual care group compared to their admission score. Notwithstanding this important QoL outcome, no effect on ADL function was observed.

Our review has several limitations. Risk of bias assessment found 5 studies as unclear/medium risk (de Morton, Keating, Berlowitz, et al., 2007; Eaton T, 2009; Greening NJ, 2014; Hastings et al., 2014; Mudge AM, 2008), and 4 studies as high risk (Behnke M, 2003; Courtney et al., 2012; Mundy et al., 2003; Ozdirenc M, 2004) raising concerns about validity. Studies of low or unclear ROB showed limitations in design and absence of important information. Small study sizes limited the generalizability of findings. Studies were often not adequately powered to detect changes in outcomes. The international nature of these studies is noteworthy. Inherent health system differences among the five countries represented, including local admission, medical treatment, personnel resources, and health systems policies, can affect generalizability of findings.

Conclusion

While there is broad clinical consensus that immobility among hospitalized older adults contributes to functional decline and other adverse outcomes, evidence of 11 exercise-only intervention studies across 5 outcome categories is inconsistent. Larger, well-designed RCTs are needed to further delineate the potential impact and value of hospital-based exercise programs for older adults. Specifically, an ideal study design would incorporate the following elements: a targeted moderate and/or severe risk group (e.g., defined by Modified Barthel Scale), ("Modified Barthel Index (Shah Version): Self-Care Assessment,") measurement of pre-morbid function, randomization to exercise intervention with a pre-defined intensity, intention to treat, adherence and attrition measures, validated outcome measures without ceiling/floor effects, QoL/patient experience and function after discharge, and subgroups of interest should be identified a priori. Furthermore, it is recommended that future studies measure and report intervention fidelity and enroll adequate numbers of participants to ensure appropriate statistical power to determine intervention effectiveness in light of the considerable risk of attrition in this population and setting.

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Appendix 1:: Search Strategy

Database: PubMed

Date: 3/9/2015

Search	Query	Items found
#1	"Inpatients"[Mesh] OR Inpatient[tiab] OR inpatients[tiab] OR "Hospitalization"[Mesh] OR "Hospitalization"[tiab] OR "Hospitalized"[tiab] OR "Hospitalised"[tiab] OR "Hospitalisation"[tiab] OR "Immobilized"[tiab] OR "Immobilised"[tiab]	371939
#2	"Aged"[Mesh] OR "Aged"[tiab] OR "Geriatrics"[Mesh] OR "Geriatrics"[tiab] OR "Geriatric"[tiab] OR "older adult"[tiab] OR "older adults"[tiab] OR "elderly"[tiab]	2700247
#3	"Exercise Movement Techniques"[Mesh] OR "Physical Therapy Modalities"[Mesh:NoExp] OR "Exercise Therapy"[Mesh] OR "Exercise Movement Techniques"[Mesh:NoExp] OR "Early Ambulation"[Mesh] OR "Exercise"[Mesh:NoExp] OR "exercise"[tiab] OR "Walking"[Mesh] OR "walk"[tiab] OR "walks"[tiab] OR "walking"[tiab] OR "Muscle Stretching Exercises"[Mesh] OR "Resistance Training"[Mesh] OR "Physical Conditioning, Human"[Mesh] OR mobility[tiab] OR physiotherapy[tiab] OR physical therapy[tiab] OR physical therapist[tiab] OR physical rehabilitation[tiab] OR mobilization[tiab]	456353
#4	#1 AND #2 AND #3	5129
#5	("Comparative Study"[pt] OR "Controlled Clinical Trial"[pt] OR Nonrandom[tiab] OR non-random[tiab] OR nonrandomized[tiab] OR non-randomized[tiab] OR nonrandomized[tiab] OR non-randomised[tiab] OR quasi-experiment*[tiab] OR quasiexperiment*[tiab] OR quasirandom*[tiab] OR quasi-random*[tiab] OR quasi-control*[tiab] OR quasicontrol*[tiab] OR (controlled[tiab] AND (trial[tiab] OR study[tiab])) OR randomized controlled trial[pt] OR randomized[tiab] OR randomised[tiab] OR randomization[tiab] OR randomisation[tiab] OR randomly[tiab] OR trial[tiab] OR groups[tiab]) NOT (animals[mh] NOT humaNot Specified[mh]) NOT (Editorial[ptyp] OR Letter[ptyp] OR Case Reports[ptyp] OR Comment[ptyp])	2744728
#6	#4 AND #5	2324
#7	#6, limited to English and 2000-	1645

Database: Embase

Date: 3/9/2015

Search	Query	Items found
#1	'hospital patient'/exp OR 'hospitalization'/exp OR Inpatient:ab,ti OR inpatients:ab,ti OR Hospitalization:ab,ti OR Hospitalized:ab,ti OR Hospitalised:ab,ti OR Hospitalisation:ab,ti OR Immobilized:ab,ti OR Immobilised:ab,ti	519614
#2	'aged'/exp OR 'geriatrics'/exp OR Aged:ab,ti OR Geriatrics:ab,ti OR Geriatric:ab,ti OR 'older adult':ab,ti OR 'older adults':ab,ti OR elderly:ab,ti	2651541
#3	'kinesiotherapy'/exp OR 'physiotherapy'/de OR 'exercise'/exp OR 'mobilization'/exp OR 'walking'/exp OR walk:ab,ti OR walks:ab,ti OR walking:ab,ti OR mobility:ab,ti OR physiotherapy:ab,ti OR 'physical therapy':ab,ti OR 'physical therapist':ab,ti OR 'physical rehabilitation:ab,ti' OR mobilization:ab,ti	590549

Search	Query	Items found
#4	#1 AND #2 AND #3	5840
#5	('comparative study'/exp OR 'controlled clinical trial'/exp OR 'randomized controlled trial'/exp OR 'crossover procedure'/exp OR 'double blind procedure'/exp OR 'single blind procedure'/exp OR random* OR factorial* OR crossover* OR cross NEAR/1 over* OR placebo* OR doubl* NEAR/1 blind* OR singl* NEAR/1 blind* OR assign* OR allocat* OR volunteer* OR Nonrandom OR non-random OR nonrandomized OR non-randomized OR nonrandomised OR non-randomised OR quasi NEAR/1 experiment* OR quasiexperiment* OR quasirandom* OR quasi NEAR/1 random* OR quasi NEAR/1 control* OR quasicontrol* OR (controlled AND (trial OR study))) NOT ('case report'/exp OR 'case study'/exp OR 'editorial'/exp OR 'letter'/exp OR 'note'/exp)	6197281
#6	#4 AND #5	2601
#7	#6 AND [humaNot Specified]/lim AND [english]/lim AND [embase]/lim NOT [medline]/lim	395

Database: CINAHL

Date: 3/9/2015

Search	Query	Items found
S1	(MH "Inpatients") OR (MH "Hospitalization+") OR TI (Inpatient OR inpatients OR Hospitalization OR Hospitalized OR Hospitalised OR Hospitalisation OR Immobilized OR Immobilised) OR AB (Inpatient OR inpatients OR Hospitalization OR Hospitalized OR Hospitalised OR Hospitalisation OR Immobilized OR Immobilised)	150702
#2	(MH "Aged+") OR (MH "Geriatrics") OR TI (Aged OR Geriatrics OR Geriatric OR "older adults" OR elderly) OR AB (Aged OR Geriatrics OR Geriatric OR "older adults" OR elderly)	580202
#3	(MH "Therapeutic Exercise+") OR (MH "Physical Therapy") OR (MH "Early Ambulation") OR (MH "Exercise+") OR TI (exercise OR walk OR walks OR walking OR mobility OR physiotherapy OR "physical therapy" OR "physical therapist" OR "physical rehabilitation" OR mobilization) OR AB (exercise OR walk OR walks OR walking OR mobility OR physiotherapy OR "physical therapy" OR "physical therapist" OR "physical rehabilitation" OR mobilization)	157220
#4	#1 AND #2 AND #3	2849
#5	(PT randomized controlled trial) OR (MH "Randomized Controlled Trials") OR (MH "Comparative Studies") OR (MH "Nonrandomized Trials") OR (MH "Clinical Trials") OR TI (Nonrandom OR non-random OR nonrandomized OR non-randomized OR nonrandomised OR non-randomised OR quasi-experiment* OR quasiexperiment* OR quasirandom*OR quasi-random* OR quasi-control* OR quasicontrol* OR randomized OR (controlled AND (trial OR study)) OR randomised OR randomization OR randomisation OR randomly OR trial) OR AB (Nonrandom OR non-random OR nonrandomized OR non-randomized OR nonrandomised OR non-randomised OR quasi-experiment* OR quasiexperiment* OR quasirandom*OR quasi-random* OR quasi-control* OR quasicontrol* OR randomized OR (controlled AND (trial OR study)) OR randomised OR randomization OR randomisation OR randomly OR trial)	337446
#6	#4 AND #5	859
#7	#6, limited to English and 2000-	770

Appendix 2:: Risk of Bias Assessment by Setting

	Inpatient Hospital Setting						Inpatient Hospital to Home/Community Setting					
	Jones, 2006	deMorton, 2007	Mudge, 2008	Hastings, 2014	Mundy, 2003	Ozdiorenc, 2003	Siebens, 2000	Courtney,2009 Courtney,2012	Greening,2014	Eaton, 2008	Behnke, 2003	
Was the allocation sequence adequately generated?	+	+	-	-	-	+	+	+	?	+	?	Was the allocation sequence adequately generated?
Was allocation adequately concealed?	+	?	+	-	-	?	+	?	?	+	?	Was allocation adequately concealed?
Was knowledge of the allocation intervention adequately prevented during the study?	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Was knowledge of the allocation intervention adequately prevented during the study?
Was knowledge of the allocation intervention adequately prevented from the outcome assessors?	+	?	+	+	+	?	+	+	+	?	?	Was knowledge of the allocation intervention adequately prevented from the outcome assessors?
Were incomplete outcome data adequately addressed?	+	+	+	+	+	+	+	-	+	-	?	Were incomplete outcome data adequately addressed?
Are reports of the study free of suggestion of selective outcome reporting?	+	+	+	+	+	+	+	+	+	+	+	Are reports of the study free of suggestion of selective outcome reporting?
Are reports of the study free from	+	+	+	+	?	?	+	?	+	+	?	Are reports of the study free from

Inpatient Hospital Setting							Inpatient Hospital to Home/Community Setting					
+	?	?	?	-	-	-	+	?	?	-	?	-
other bias due to problems not covered above?												
Overall												

For overall score, low ROB required random sequencing, allocation concealment, and blinding in order to be scored low risk with no other important concerns; unclear ROB was assigned if 1 or 2 domains were scored not clear or not done; high ROB was assigned if >2 domains were scored not clear or not done.

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Figure 1:
PRISMA flow diagram.

Table 1:

PICOT guidelines

Study characteristic	Inclusion criteria	Exclusion criteria
Population	Older adults hospitalized with acute medical episode; studies for which older adults' participation is recorded for: <ul style="list-style-type: none"> All patients aged 60 years, or At least 50% of participants are 60, or Median age 60 Studies in which older adults are included but number or proportion not specified will be included in full and separate analyses.	Studies without significant population of older adults (as defined above); studies that exclusively enrolled patients expected to have a new mobility impairment (i.e., stroke, hip fracture); post-surgical patients; patients in the intensive care unit (ICU).
Intervention	<i>"Structured exercise intervention" includes inpatient execution of:</i> <ul style="list-style-type: none"> Walking alone Walking with other exercise (i.e., strength, stretch, resistance) 	Multicomponent intervention, i.e., programs that include elements not focused on exercise or mobility, e.g., medical or geriatric consultation
Comparator	Usual care; attention control	None; study must have an external control condition
Outcome	At least one patient level or utilization outcome	Only reports safety outcomes
Timing	At least one assessment point during hospitalization or within 1 month of intervention	No assessment
Setting	Inpatient acute care unit	<ul style="list-style-type: none"> Intensive care Psychiatric in-patient units Skilled nursing facilities Exclusively outpatient Rehabilitation center
Study design	<ul style="list-style-type: none"> Patient or cluster RCTs Prospective randomized or pseudo-randomized controlled trials Nonrandomized controlled trials Controlled before-and-after studies Interrupted time series designs 	Cross-sectional studies and other observational study designs not specifically listed as "included" study designs
Publications	<ul style="list-style-type: none"> English-language only Published from 2000 to present Peer-reviewed article 	<ul style="list-style-type: none"> Non-English language publication Published before 2000

Table 2: Study characteristics and outcomes of exercise interventions for hospitalized older adults by setting

First author, year Design Dx Focus Setting	Participants: Total N Intervention/Control N Age % Male % Attrition % Adherence ROB Power calculation Intention to treat principle	Primary outcome	Outcome Measures by Categories					QoL/patient experience
			Cardio-respiratory capacity and/or performance	Mobility	Functional status	Utilization		
INPATIENT HOSPITAL SETTING								
Aerobic Exercise								
Hastings, 2014 Non-randomized concurrent control [29] Dx: Medical	Participants: 127 I=92/C=35 Age: 74±7/75±8 % Male: 96.7/3.3 % Attrition: 7 % Adherence: 76 ROB: Unclear risk Power calculation: Not reported Intention to treat principle: No	None specified				Discharge to home I=92%; C=74% p=0.007 Median Length of Stay; 30-day ED visits and readmission rate		
Mudge, 2008 Cluster randomized trial [30] Dx: Medical	Participants: 124 I=62/C=62 Age: 81.7±7.8/82.4±7.4 % Male: 43.5/40.3 % Attrition: No % Adherence: Not reported ROB: Unclear risk Power calculation: Not reported Intention to treat principle: Yes	Modified Barthel Index p=0.03	Timed Up and Go		modified Barthel Index I=8.5 points (IQR 3–19); C=3.5 points (IQR 0–15) p=0.03	Change in mobility Length of Stay Discharge destination 30-day readmission		
Mundy, 2003	Participants: 458 I=227/C=231 Age: 17–103	Length of stay Significant reduction; No p value reported				Length of stay	Mundy, 2003 Cluster randomized trial [33]	

Outcome Measures by Categories									
First author, year Design Dx Focus Setting	Participants: Total N Intervention/Control N Age % Male % Attrition % Adherence ROB Power calculation Intention to treat principle	Primary outcome	Cardio-respiratory capacity and/or performance		Mobility	Functional status	Utilization	QoL/patient experience	
Cluster randomized trial [33] Dx: Community Acquired Pneumonia	% Male: 44/56 % Attrition: No attrition % Adherence: 73 ROB: High risk Power calculation: Yes Intention to treat principle: Yes						I=5.8 (0.43) 95% CI 0.0 – 2.2; C=6.9 (0.36) 95% CI 0.2 – 5.0 Significant reduction; No p value reported Emergency Department visits (30 and 90 days)	Dx: Community Acquired Pneumonia Setting: Inpatient	
Aerobic and Resistance Exercise									
deMorton, 2007 Cluster randomized trial [26] Dx: Medical	Participants: 236 I=110/C=126 Age: 80±8 % Male: 44.5/46 % Attrition: 29 % Adherence: Not reported ROB: Unclear risk Power calculation: Yes Intention to treat principle: Yes	Discharge destination – no significant effect on any outcome		Functional Ambulatory Classification Score Timed Up and Go		Barthel Index	Discharge destination Length of Stay Intensive Care Unit admission 28-day readmission		
Aerobic, Resistance, Balance and/or Flexibility Exercise									
Jones, 2006 RCT [24] Dx: Medical	Participants: 160 I=80/C=80 Age: 81.9±8/82.9±7.6 % Male: 42.6/38.7 % Attrition: 24 % Adherence: 94 ROB: Low risk Power calculation: Yes Intention to treat principle: Yes	Modified Barthel Index – in multivariate analysis when admission mBI scores were low, there was a greater improvement in mBI scores in intervention group compared with control group		Timed Up and Go (decrease in seconds) I=5.4 (1.0, 12.4); C= 1.2 (–0.9, 4.3) p=0.012		Modified Barthel Index – in multivariate analysis when admission mBI scores were low, there was a greater improvement in mBI scores in intervention group compared with control group	Discharge destination Length of stay in acute care; Length of stay in sub-acute care; Total Length of stay (acute plus sub-acute); HR 1.46 (95%CI 1.04 – 2.05); p = 0.026 Admission to Intensive Care Unit	Jones, 2006 RCT [24] Dx: Medical Setting: Inpatient	

First author, year Design Dx Focus Setting	Participants: Total N Intervention/Control N Age % Male % Attrition % Adherence ROB Power calculation Intention to treat principle	Primary outcome	Outcome Measures by Categories				
			Cardio-respiratory capacity and/or performance	Mobility	Functional status	Utilization	QoL/patient experience
Ozdiirenc, 2003 RCT [34] Dx: Type II Diabetes Mellitus	Participants: 44 I=23;C=21 Age:60.9±19.9 % Male:78.3/88.9 % Attrition: Not reported % Adherence: Not reported ROB: High risk Power calculation: Not reported Intention to treat principle: Not reported	6MWD p<0.05	6MWD I=537.6 m; C=511.5 m p<0.05 Estimated VO ₂ max I=18.2;C= 14.9 p<0.05				
INPATIENT HOSPITAL TO HOME/COMMUNITY SETTINGS							
Aerobic Exercise							
Behnke, 2003 RCT [31] Dx: COPD	Participants: 26 I=14/C=12 Age: 64±7.5/69.0±6.9 % Male: 78.6/75 % Attrition: 13 % Adherence: Not reported ROB: High risk Power calculation: Not reported Intention to treat principle: NR	# hospital admissions I=3; C=14 p=0.026	6MWD I=518 (438; 597); C=208 (148; 270) p<0.001			# hospital admissions p=0.026	Chronic Respiratory Disease Questionnaire I=117 (108;126); C=77 (62; 92) p<0.001 Transitional Dyspnea Index I=4.4 (4.4; 2.9); C= -3.1 (-5.4; -0.7) p<0.05
Aerobic and Resistance Exercise							
Eaton, 2008 RCT [27] Dx: COPD	Participants: 97 I=47/C=50 Age: 78 (65–96) % Male: 38/62 % Attrition: 13 % Adherence: 40 ROB: Unclear risk	# COPD-related readmission days – no significant difference	BODE Index Modified Medical Research Council Dyspnea score Exercise capacity index			# COPD-related readmission days Time to 1 st COPD-related readmission Length of stay	Chronic Respiratory Questionnaire–Self Administered (fatigue) T0–T1 (3 months) significant differences between intervention and

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First author, year Design Dx Focus Setting	Participants: Total N Intervention/Control N Age % Male % Attrition % Adherence ROB Power calculation Intention to treat principle	Primary outcome	Outcome Measures by Categories				QoL/patient experience
			Cardio-respiratory capacity and/or performance	Mobility	Functional status	Utilization	
	in which power calculation was reported Intention to treat principle: Yes	IADL I (4 weeks) p<0.001 I (24 weeks) p<0.001 Emergency hospital admissions T0-T1 (4 weeks) p<.05 T0-T3 (24 weeks) p=.007 Emergency GP visits T0-T1 (4 weeks) p<.005 T0-T3 (24 weeks) p=.001 Emergency Allied health visits T0-T1 (4 weeks) p<.05 T0-T3 (24 weeks) p=.04 SF-12 Physical Component Score I (24 weeks) p<0.001 SF-12 Mental Component Score I (24 weeks) p<0.001	I (4 weeks) =41.30 (21.90); C=22.09 (22.52); p<0.001 W/Q stairs I (4 weeks)= 46.73 (29.35); C=26.06 (25.65); p<0.001	IADLs I (4 weeks) 1.47 (1.50); C=3.29 (2.03) p<0.001 I (24 weeks) 1.13 (1.71); C=4.33 (2.15) F(3, 282)= 30.645, p<0.001	T0-T3 (24 weeks) I= 25.0%; 67.3% p=.001 Emergency Allied health visits T0-T1 (4 weeks) p<.05 T0-T3 (24 weeks) I=2; C=13 p=.04		
Siebens, 2000 RCT [25] Dx: Medical & Surgical	Participants: 300 I=149/C=151 Age: 78.5/78.2 %Male: 40.9/37.8 % Attrition: 10 % Adherence: 42 ROB: Low risk Power calculation: Yes Intention to treat principle: Yes	Length of stay – no significant difference			IADLs I= mean 5.1 (SD 2.0); C= 4.6 (2.2) (Beta=.443; 95% CI .044,.842 p<.05 Functional Independence Measure Locomotion scale	Length of stay	RAND general health scale

First author, year Design Dx Focus Setting	Participants: Total N Intervention/Control N Age % Male % Attrition % Adherence ROB Power calculation Intention to treat principle	Primary outcome	Outcome Measures by Categories				
			Cardio-respiratory capacity and/or performance	Mobility	Functional status	Utilization	QoL/patient experience
					Frequency of leaving neighborhood National Health Interview Survey physical activity scale		
# of positive outcomes per category (#, % of total)		12/19; 63%	3/9; 33%	4/7; 57%	5/11; 45%	7/35; 20%	7/9; 78%

Notes: DX – diagnosis; Gen Med-General Medical; CAP-community acquired pneumonia; DM-diabetes mellitus; I-intervention; C-control; A-aerobic; R-resistance; B/F-balance and/or flexibility; NR-not reported; min.-minutes; mBI-modified Barthel index; TUG-timed up and go; LOS-length of stay; 6MWD-6 minute walking distance; PT-physical therapy; SF-12 PCS - short form physical component score; SF12 MCS-short form mental component score; Surg-surgical; COPD- chronic obstructive pulmonary disease; ADL-activities of daily living; IADL-instrumental activities of daily living; WIQ-walking impairment questionnaire; GP-general practitioner; TDI-transitional dyspnea index; CRD-chronic respiratory disease questionnaire; w/i-within; ROB-risk of bias; ED-emergency department; T0-time point 0; T1-time point 1; '+', '-'-positive increase in intervention group; '-','-'-effective reduction in measure for intervention group; NS-not specified

Table 3:

Exercise interventions, prescriptions, and settings

First author	Mode of Training	Setting	Program duration	Session duration	Frequency	Intensity	Progression	Supervision
INPATIENT HOSPITAL SETTING								
Aerobic Exercise								
Hastings [29]	Walking	Inpatient	Hospital length of stay	As tolerated up to 20 min	Daily	Not Specified	Increase as tolerated up to 20 min	Physical Therapist, Walking Aide
Mudge [30]	Exercise determined by functional status: bed, sitting, standing, or walking-based exercise	Inpatient	Within 48 hours and through hospital length of stay	Not Specified	2x/day	Not Specified	Increase exercise level per functional status	Physiotherapist
Mundy [33]	Mobility (movement out of bed with change from horizontal to upright position, including walking)	Inpatient	Within first 24hr of admission and through hospital length of stay	20 min	Daily	Not Specified	Progressive mobilization each subsequent day of hospitalization	Not Specified
Aerobic and Resistance Exercise								
deMorton [26]	Exercise Levels determined by functional status: Level 1 – bed exercise; Level 2 – sitting exercise; Level 3 – standing exercise; Levels 4 – stair exercise. All levels performed Upper Extremity, Lower Extremity, and trunk strengthening (gravity, body weight, and/or light weights)	Inpatient	Within 48 hours of admission and through hospital length of stay	20–30 min	Inpatient: 2x/day, 5 days/week	Not Specified	Walking: Once at level to do so, increase distance as tolerated Strengthening: Increase resistance upon completion of 10 reps	Physiotherapist, Allied Health Assistant
Aerobic, Resistance, Balance and/or Flexibility Exercise								
Jones [24]	Exercise level determined by functional status: Level 1 – bed and sitting exercise; Level 2 – sitting to standing exercise; Level 3 – standing to walking exercise; Level 4 – walking to stair climbing exercise. All levels performed strengthening (gravity, body weight), and balance	Inpatient	Hospital length of stay	30 min	2x/day	Not Specified	Increase exercise level per functional status	Allied Health Assistant
Ozdirenc [34]	Walking; strengthening (resistance bands); flexibility	Inpatient	Hospital Length of stay	10–45 min	5x/week	Not Specified-submaximal	Walking: Increase to 30 min Strengthening: increase reps and/or resistance as tolerated	Physiotherapist
INPATIENT HOSPITAL TO HOME/COMMUNITY SETTINGS								
Aerobic Exercise								
Behnke [31]	Walking (corridor, treadmill)	Combined (Inpatient, Home-based)	Inpatient: 10 days Home-based: 18 months	Inpatient: Not Specified Home-based: 15 min	Inpatient: 1x/day Home-based: 3x/day	Walking: achieving in each 15 min session 125% of the best hospital self-paced, horizontal 6MWD	Not Specified	IN: Not Specified HB: Medical Doctor

First author	Mode of Training	Setting	Program duration	Session duration	Frequency	Intensity	Progression	Supervision
Aerobic and Resistance Exercise								
Eaton [27]	Walking: strengthening body weight, weights; Neuro-muscular electrical stimulation to quadriceps	Combined: Inpatient, Outpatient, Home-based	Inpatient: Within 48 hours of admission and through hospital length of stay Outpatient: 8 weeks Home-based: 8 weeks	Inpatient: 30 min Outpatient: 60 min Home-based: 30 min	Inpatient: Daily Outpatient: 2x/week Home-based: Daily	Not Specified	Increase as tolerated 30 min	Inpatient: Nursing Outpatient: Not Specified Home-based: Not Specified
Greening [28]	Walking: strengthening (gravity, body weight, weights); Neuro-muscular electrical stimulation to quadriceps	Combined: Inpatient, Home-based	Inpatient: Hospital LOS Home-based: 6 weeks	Inpatient: Not specified for walking or strengthening; 30 min Neuro-muscular electrical stimulation Home-based: Not specified	Inpatient: Daily Home-based: Walking (daily); strengthening (3x/week); Neuro-muscular electrical stimulation (daily)	Walking: 85% predicted VO ₂ max, 3–5 Borg breathless-ness score (DOE), 13 Borg Rating Perceived Exertion Strengthening: 3 sets 8 reps or 70% 1RM	Walking: Increase time at set walking speed Strengthening: Increase load by 0.5 kg once 3 sets 8 reps performed at RPE < 13	Inpatient: Pulmonary rehabilitation team (Physical Therapy, Nursing)
Aerobic, Resistance, Balance and/or Flexibility Exercise								
Courtney [32,35]	Walking: UE and LE strengthening (resistance band); balance; flexibility	Combined (Inpatient, Home-based)	Inpatient: Within 72 hours of admission and through hospital length of stay Home-based: 24 weeks	Inpatient: Not Specified Home-based: Not Specified	Walking: strengthening, flexibility; Inpatient: 2–3x/week Home-based: 3–4x/week Balance: daily	Walking: slow pace for 3–5 min, moderate pace for 5–10 min, slow pace for 3–5 min Strengthening: lowest level resistance band, contraction held 3–5 sec, 1 set x 5 reps	Walking: 2–3x/week to 3–4x/week Strengthening: 2–3x/week to 3–4x/week, build to 2–3 sets of 10 reps, progress level of resistance band	Inpatient: Physiotherapist, Nursing Home-based: Nursing
Siebens [25]	Walking: strengthening; flexibility	Combined: Inpatient, Home-based	Inpatient: Within 48 to 72 hours of admission through hospital Length of stay Home-based: 4 weeks	Inpatient: 5–30 min Home-based: 5–30 min	Inpatient: 2x/day (1x/day with aide, 1x/day independently) Home-based: 3x/week (24 sessions)	Walking: 60–80% predicted Heart Rate max, talk test Strengthening: 5 reps of 8 exercises	Walking: Increase from 5 min to 30 min Strengthening: Increase to 10 reps	Inpatient: Physical Therapy, Physical Therapy aide Home-based: None

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