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Post-surgery interventions for hip fracture: a systematic review of randomized controlled trials

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Abstract

Background Interventions provided after hip fracture surgery have been shown to reduce mortality and improve functional outcomes. While some systematic studies have evaluated the efficacy of post-surgery interventions, there lacks a systematically rigorous examination of all the post-surgery interventions which allows healthcare providers to easily identify post-operative interventions most pertinent to patient's recovery.

Objectives We aim to provide an overview of the available evidence on post-surgery interventions provided in the acute, subacute and community settings to improve outcomes for patients with hip fractures.

Methods We performed a systematic literature review guided by the Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA). We included articles that were (1) randomized controlled trials (RCTs), (2) involved post-surgery interventions that were conducted in the acute, subacute or community settings and (3) conducted among older patients above 65 years old with any type of non-pathological hip fracture that was surgically treated, and who were able to walk without assistance prior to the fracture. We excluded (1) non–English language articles, (2) abstract-only publications, (3) articles with only surgical interventions, (4) articles with interventions that commenced pre-surgery or immediately upon completion of surgery or blood transfusion, (5) animal studies. Due to the large number of RCTs identified, we only included "good quality" RCTs with Jadad score ≥ 3 for data extraction and synthesis.

Results Our literature search has identified 109 good quality RCTs on post-surgery interventions for patients with fragility hip fractures. Among the 109 RCTs, 63% of the identified RCTs (n = 69) were related to rehabilitation or medication/nutrition supplementation, with the remaining RCTs focusing on osteoporosis management, optimization of clinical management, prevention of venous thromboembolism, fall prevention, multidisciplinary approaches, discharge support, management of post-operative anemia as well as group learning and motivational interviewing. For the interventions conducted in inpatient and outpatient settings investigating medication/nutrition supplementation, all reported improvement in outcomes (ranging from reduced postoperative complications, reduced length of hospital stay, improved functional recovery, reduced mortality rate, improved bone mineral density and reduced falls), except for a study investigating anabolic steroids. RCTs involving post-discharge osteoporosis care

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management generally reported improved osteoporosis management except for a RCT investigating multidisciplinary post-fracture clinic led by geriatrician with physiotherapist and occupational therapist. The trials investigating group learning and motivational interviewing also reported positive outcome respectively. The other interventions yielded mixed results. The interventions in this review had minor or no side effects reported.

Conclusions The identified RCTs regarding post-surgery interventions were heterogeneous in terms of type of interventions, settings and outcome measures. Combining interventions across inpatient and outpatient settings may be able to achieve better outcomes such as improved physical function recovery and improved nutritional status recovery. For example, nutritional supplementation could be made available for patients who have undergone hip fracture surgery in the inpatient settings, followed by post-discharge outpatient osteoporosis care management. The findings from this review can aid in clinical practice by allowing formulation of thematic program with combination of interventions as part of bundled care to improve outcome for patients who have undergone hip fracture surgery.

Keywords Hip fracture, Systematic review, Rehabilitation, Post-surgery, Post-operative

Introduction

Hip fracture is an important medical condition associated with adverse outcomes, including mortality [1]. The incidence of hip fractures is expected to increase due to ageing populations worldwide - the number of hip fractures occurring in the world each year will rise from 1.66 million in 1990 to 6.26 million by 2050 [2]. Only a minority of individuals fully regained their pre-fracture functional level [3]. Elder patients suffering from proximal femoral fractures were more likely to develop depressive symptoms, that further impeded on functional recovery and increased mortality [4]. With higher incidence and associated poor outcomes, the impact of hip fractures on the healthcare system is expected to become increasingly costly.

Interventions provided at different stages after a hip fracture has shown to reduce mortality and improve functional outcomes for the patient. For example, having less than 48 h to surgery after admission could decrease 30-day mortality by 41% and of one-year mortality by 32% [5], and time to surgery is a predictor of achieving independent mobility one week postoperatively [6]. Prophylactic treatment for blood clotting and infection and better operative treatment with fewer technical failures have been shown to result in shorter hospitalisation [4], hence patients were more likely to regain their basic activities of daily life [7]. Post-operative interventions that have been shown to improve function after a hip fracture include home-based rehabilitation [8], comprehensive geriatric care [9], and individualised occupational training [10].

Although surgical and peri-surgical interventions are important to reduce mortality after fracture, a significant number of patients demonstrate permanent disability and dependency even after a successful repair [4]. This points to the importance of post-operative interventions when it comes to improving patients' outcomes [10]. However, there is a myriad of interventions offered post-surgery across various settings from acute to subacute to community, that aims to improve on different outcomes for patients [4]. There are existing systematic reviews evaluating efficacy of specific post-hip fracture interventions such as occupational therapy [11], electrical stimulation [12], rehabilitation practices [13], lower-limb progressive resistance exercise [14].

In this study, we aim to provide an overview of the available literature on interventions provided post-surgery in the acute, subacute and community settings to improve outcomes for patients with hip fractures using a systematic review. With the consolidation of evidence-based information on wider range of post-hip fracture interventions as compared to previous studies, this study will enable easier comparison by the healthcare providers on the effects of the interventions. The systematic rigorous examination of all the post-hip fracture interventions will allow healthcare providers to easily identify post-operative interventions most pertinent to a patient's recovery.

Methods

We performed a systematic literature review guided by the Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) 2009 [15]. The PRISMA 2009 checklist can be found in Supplemental Table 1. This study has been registered in Open Science Framework (registration DOI: https://doi.org/10.17605/OSF.IO/2JWEF).

Search strategy

We identified potentially relevant articles using PubMed®, Embase®, Cochrane Library® and ClinicalTrials.gov searches. Literature review start date was unrestricted and was current as of June 2020. A search strategy (Supplemental Table 2) of two components was used: (1) disease terms and (2) randomized controlled trials (RCTs). The disease terms were adapted from a previously published paper regarding hip fractures [16]. We also

reviewed reference lists and searched previous reviews on similar topics.

Inclusion/exclusion criteria

Two authors (ZYL and WQY) independently screened the titles of selected articles and excluded duplicates and those obviously irrelevant. Two authors reviewed abstracts and full-text articles against prespecified eligibility criteria. We included RCTs of post-surgery interventions conducted in the acute, subacute or community settings, among older patients above 65 years old with any type of non-pathological hip fracture that was surgically treated, and who were able to walk without assistance prior to the fracture. We did not exclude trials that included younger participants if the mean age minus one standard deviation or median age was greater than 65 years.

We also included trials that involved community-dwelling older people who underwent hip fracture surgery. We excluded non–English language articles and abstract-only publications, surgical related RCTs, RCTs with interventions that commenced pre-surgery or immediately upon completion of surgery, blood transfusion, if participants did not undergo surgery, non-randomized trials and animal trials. The references of all selected relevant articles were manually searched to obtain additional relevant publications. Any disagreement was resolved by discussion to reach consensus.

Data extraction and quality assessment

Two investigators (ZYL and WQY) extracted study data, and another investigator (JKP) verified the accuracy of the data extracted. The data items extracted were: sample size, age, experimental design, characteristics of the intervention in all trial arms including type, dose of therapy and settings, primary and secondary outcome measures and findings.

Two investigators (ZYL and WQY) independently assessed the quality of each study using the Jadad scoring system [17]. The Jadad scale is a scoring system that has three items adding up to a maximum score of 5. Zero, one, or two points can be given for randomization and double-blinding; zero or one point for the description of drop-outs and withdrawals. It should be noted that for Jadad scoring system, double blinding was considered appropriate if it was stated or implied that neither the evaluator nor the subject could identify the intervention being assessed [17].

The Jadad scoring system is relatively straightforward to apply and was chosen because it has been shown to present the best validity and reliability evidence for assessment of methodological quality of RCTs [18]. Given the large number of RCTs of post-surgery interventions among patients with fragility hip fractures, only RCTs with a Jadad score of at least 3 were included in the review. Risk of bias was assessed using Jadad scoring.

Data presentation

We presented the interventions by types and their settings, as well as the primary and secondary outcome measures, findings and comments for each trial, to allow readers to understand the benefit and anticipated outcome for each type of intervention. We also present the control used in each study. For this review, placebos are defined as inactive substances used to compare results with active substances while sham treatments refer to false treatments for procedures.

Results

As shown in Fig. 1, we identified 35,266 records from our searches in Embase®, PubMed®, Cochrane Library® and ClinicalTrials.gov. After removing 5684 duplicates, 29,582 articles remained. Of these, 714 articles were deemed relevant after title and abstract screening. Of the 715 articles included in full-text screening, 560 articles were excluded. A total of 154 articles met the inclusion criteria. We identified 1 additional article from handsearching of other sources.

Our search has identified 109 good quality RCTs on post-surgery interventions for patients with fragility hip fractures: 39 RCTs on rehabilitation, 30 that used medication/nutrition/supplementation, 6 RCTs for osteoporosis management, 9 RCTs on optimizing clinical management, 8 RCTs to prevent venous thromboembolism, 4 RCTs to prevent falls, 7 RCTs that used multidisciplinary approaches, 1 RCT on supported discharge, 3 RCTs on managing post-operative anaemia and 2 RCTs on other interventions like group learning and motivational interviewing. These have been categorized according to intervention type and their settings in Table 1, with more details of outcome measures and findings in Supplementary Table 3. The reasons for exclusion at the full-text screening stage can be found in Supplementary Table 4.

Rehabilitation (n = 39)

There are 56 articles reporting 39 unique rehabilitation interventions, consisting of exercises, nerve stimulation, specialized rehabilitation (occupational therapy or geriatric rehabilitation), early rehabilitation, multi-component rehabilitation, self-efficacy and telerehabilitation. Around 46% (n = 18) of rehabilitation interventions were carried out in the outpatient setting, 33% (n = 13) in the inpatient setting and the remaining conducted in transition of care from inpatient to outpatient setting (n = 8).

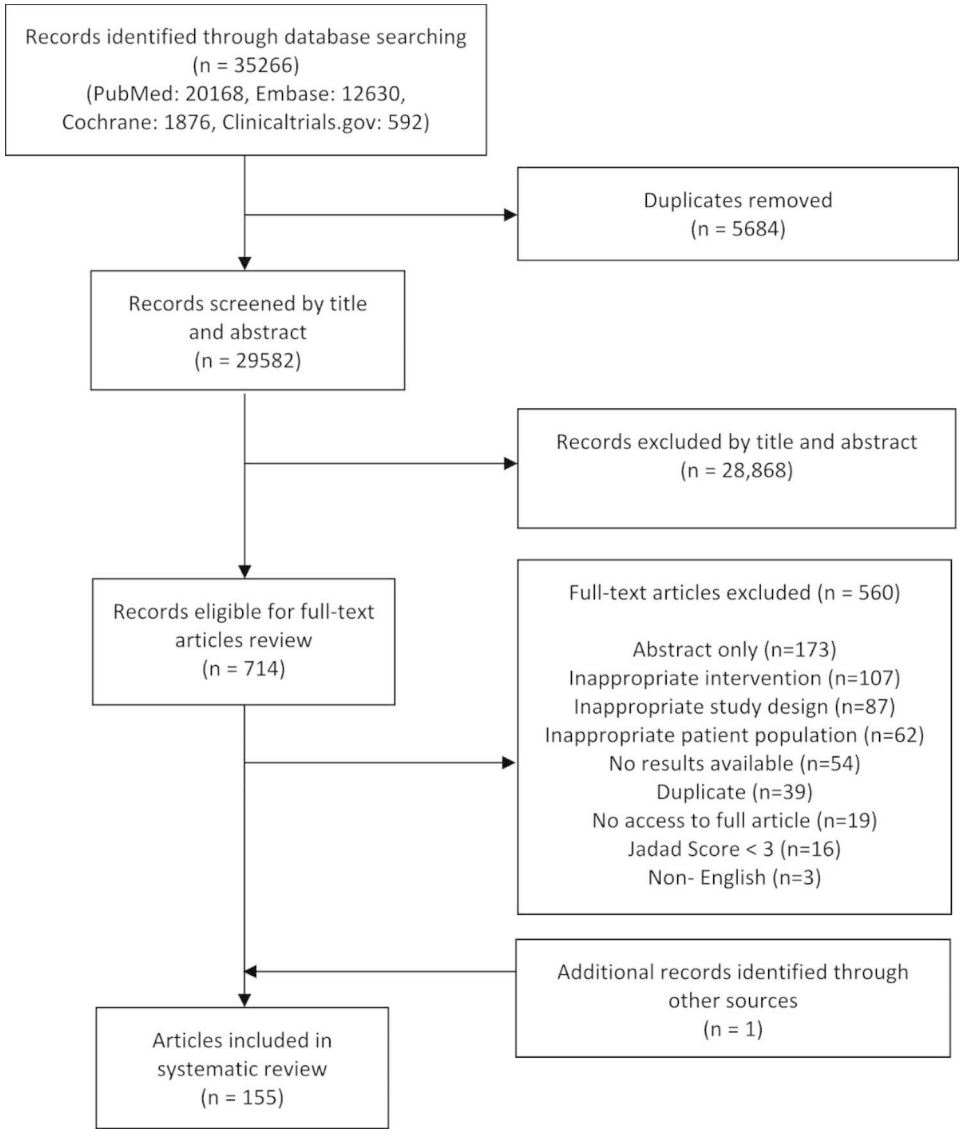

Fig. 1 Flow chart on selection of articles for review

Inpatient

For the 2 studies investigating nerve stimulation interventions in inpatient settings [19, 20], both showed improvements in pain level and functional recovery. In addition, early ambulation as soon as possible on post operative day 1 or 2 showed better functional recovery and reduced length of stay as compared to delayed ambulation commencing on postoperative day 3 or 4 [21].

For exercise interventions (intensive physiotherapy [22], progressive strength training [23, 24], aerobic training [25], balance exercise [26], weight bearing exercise [27], treadmill training [28, 29]) conducted in inpatient settings, the number of interventional therapy sessions ranged from 5 to 15 during the inpatient stay.

A twice weekly progressive quadriceps training conducted over 12 sessions conversely reported a large increase in leg extensor power and reduced disability [24]. Upper body aerobic training and balance exercises showed improvements in functional performance [25], and balance task-specific training also improved pain and quality of life [26]. An intensive physiotherapy that includes 2 additional daily sessions on top of usual care did not improve functional performance but showed better scores in the level of assistance required and reduced hospital length of stay [22].

A study investigating the effects of weight-bearing and non-weight-bearing exercise on strength, balance, gait and functional performance among older inpatients found that there was little difference between groups in the extent of improvement [27]. Another study showed that adaptability treadmill training, conventional treadmill training and usual physical therapy

Table 1 Intervention types and settings of selected RCTs to improve outcomes post hip fracture surgery

RCT intervention type (n)	RCT intervention focus area, intervention group setting		
	Inpatient	**Outpatient**	**Inpatient – Outpatient**
Rehabilitation (n = 39) 56 articles	• *Rehabilitation department / ward* ○ Aerobic training [25] ○ Specialised physical rehabilitation [32] ○ Weight bearing exercise [27]* ○ Treadmill training [28, 29] * • *Orthopaedics ward* ○ Progressive strength training [23] * ○ Transcutaneous electrical nerve stimulation [19] • *Geriatric ward* ○ Specialised geriatric rehabilitation [32] ○ Progressive high intensity training [24] • *Trauma unit* ○ Intensive physiotherapy [22] • *Non-specified ward* ○ Neurostimulation [20] ○ Individualized occupational therapy [31] ○ Balance task-specific training [26] ○ Early ambulation [21] ○ Accelerated rehabilitation [30] *	• *Indoor exercise facilities* ○ Progressive resistance training [33, 34] / resistance training [35, 36, 143, 144] • *Outpatient clinic* ○ Strength training [37, 38] / resistance training [39] ○ Physical training and self-efficacy [40] ○ Intensive training [41] * • *Home* ○ Home physiotherapy [8, 42] / strength training [49–51] / high intensity exercises [52] / weight bearing [145, 146] ○ Self-efficacy based exercise [147] ○ Multicomponent home physiotherapy [54] * ○ Telerehabilitation [148] • *Home / institutional care* ○ Weight bearing exercise [53]	• *Inpatient to home* ○ Extended physical therapy plus supplementation [149, 150] ○ Electrical stimulation [55–57] * ○ Individualized occupational therapy [58, 59] ○ Higher dose, weight bearing [151–153] ○ Cognitive behavioural therapy with / without sensor monitoring [61, 62] • *Inpatient to nursing home / home / day hospital* ○ Accelerated rehabilitation [60]
Medication, nutrition and supplementation (n = 30) 38 articles	• *Non-specified ward* ○ Nutritional support [63–65] ○ Dietetic assistants [70] ○ Growth hormone [71] • *Rehabilitation / Orthopedic ward* ○ Nutritional support [66–69] ○ Essential amino acid supplementation [73] ○ Anabolic steroids [72] * ○ Vitamin D [74]	• *Home* ○ Essential amino acid supplementation [76] ○ Vitamin D supplementation [77]	• *Inpatient to home / nursing home / care facility* ○ Growth hormone secretagogue mimetic [88] * ○ Essential amino acid supplementation [75] * ○ Nutritional support [91–93, 154–156] * ○ Nutritional support with dietetic counselling [83, 84] ○ Bisphosphonates [89, 90] * ○ Bone anabolic drug [85–87] ○ Vitamin D loading dose [94–96] * ○ Vitamin D and calcium [157] ○ Anabolic steroids [78–81] ○ Intranasal calcitonin [82]

Table 1 (continued)

RCT intervention type (n)	RCT intervention focus area, intervention group setting		
	Inpatient	**Outpatient**	**Inpatient – Outpatient**
Optimizing clinical management (n = 9) 11 articles	• *Non-specified ward* ○ Physiotherapy education [97] ○ Management of pressure ulcers [105] * ○ Management of pain [158, 159] ○ Management of postoperative delirium [102] ○ Management of incontinence [103] * ○ Dislocation precautionary measures [104] * • *Post-acute care unit* ○ Enhanced medical rehabilitation [98] • *Geriatric unit* ○ Management of postoperative delirium [101] • *Orthopedic unit* ○ Cognitive functioning / depression management [99, 100] *	Nil	Nil
Prevention of venous thromboembolism (VTE) (n = 8) 9 articles	• *Non-specified ward* ○ Factor inhibitors / antithrombotic [106, 160, 161] * ○ Antithrombotic, factor inhibitor [107, 162] * ○ Ancrod [108]	Nil	• *Inpatient to home / outpatient* ○ Fondaparinux Sodium [109, 110] ○ Antithrombotic [111]
Multidisciplinary, multifactorial programme (n = 7) 13 articles	• *Geriatric Unit* ○ Geriatric vs. orthopedic care [112] * • *Orthopedic rehabilitation* ○ Orthopedic + Geriatric care [113, 114] • *Interdisciplinary care ward* ○ Interdisciplinary care [115] *	• *Home* ○ Multidisciplinary [118, 119] • *Multidisciplinary clinic* ○ Geriatrician, Physiotherapist, Occupational therapist [116, 117] *	• *Inpatient to home* ○ Intensive geriatric rehabilitation [120, 121] ○ Early discharge supported by Geriatric interdisciplinary team [122–124]
Osteoporosis management / Fracture prevention post-discharge (n = 6) 15 articles	Nil	• *Outpatient* ○ Yearly bisphosphonates [163–170] ○ Vitamin D and / or calcium [129] * ○ Osteoporosis case manager [125, 126]	• *Inpatient to home* ○ Primary care and patient empowerment [127] ○ Vitamin D and / or calcium [171, 172] • *Inpatient to outpatient (clinic / primary care)* ○ Osteoporosis management [128]
Falls prevention (inpatient, post-discharge) (n = 4) 7 articles	• *Post-acute Geriatric Rehabilitation Unit* ○ Multicomponent cognitive behavioural intervention [173] ○ Multidisciplinary care [130–133]	• *Home* ○ Follow up call [174]	• *Inpatient and home* ○ Home assessment visit pre-discharge [134]
Post-operative Anaemia (n = 3) 3 articles	• *Non-specified ward* ○ Oral iron therapy [135] *	Nil	• *Inpatient to home* ○ Oral iron therapy [136, 137] *
Supported discharge (n = 1) 1 article	Nil	Nil	• *Inpatient to home* ○ Gerontologic advanced practice nurse care [138]

Table 1 (continued)

RCT intervention type (n)	RCT intervention focus area, intervention group setting		
	Inpatient	**Outpatient**	**Inpatient – Outpatient**
Others (group learning, motivational interviewing) (n = 2) 2 articles	Nil	• *Unspecified outpatient setting* ○ Group learning and exercise [139] • *Home* ○ Motivational interviewing [140]	Nil
Total:		109 studies (155 articles)	

*At least one trial with no positive outcome

resulted in similar effects on walking ability, fear of falling and fall incidence in older adults rehabilitating from a fall- related hip fracture [28, 29]. Physiotherapy with 5 sessions of strength training using ankle weight cuffs did not demonstrate additional improvements compared to physiotherapy without strength training in reducing the knee-extension strength deficit [23].

The study that involved accelerated rehabilitation by interdisciplinary team did not show any differences in activities of daily living (ADL) or gait outcomes, possibly due to the study's premature termination [30]. The 2 studies involving occupational therapy or geriatric rehabilitation showed no significant improvement in activities of daily living, walking ability and independence, but showed lower levels of emotional distress from the start of treatment, decreased fatigue [31], lower mortality and more patients who were at home post-treatment [32].

Outpatient

There were 18 RCTs investigating rehabilitation performed at outpatient settings, with most demonstrating positive effect in at least one outcome.

For resistance therapy in indoor exercise facility, the studies improvements in strength, physical function and disability [33–36]. For physical training in outpatient clinic, most studies reported positive outcomes in terms of improvement in physical activity [37–40]. One study investigated telerehabilitation in outpatient settings, which reported significant improvements in mobility functions and had good compliance rates [148].

One study reported that 5 home visits by a physiotherapist after patients' discharge from acute hospital showed greater ambulation ability than 1 month of conventional institution-based rehabilitation [42]. A 6-month home exercise program with 3 home visits by physiotherapist reported a modest improvement in physical function at 6 months for patients who had completed standard rehabilitation, but increased self-efficacy after 6 months [43, 44]. A 12-month individually tailored home rehabilitation program with 5 to 6 home visits by a physiotherapist reported significant improvements in mobility recovery, more apparently in balance and physical function in the long-term rather than short-term [8, 45–48].

The evidence on the effect of strength training interventions on gait and physical function were not consistent, with one study involving a 10-week intervention (twice a week, 30–40 min each session) reporting an improvement along with force production [49], but another intervention lasting 12 months involving strength training (≥3 days per week) and aerobics (≥2 days per week) reported increase in activity level but no significant improvement in gait and physical function [50, 51].

One study consisting of 20 home visits by physiotherapist reported improved isometric force of the fractured

limb in both moderate and high-intensity exercise groups [52]. A study consisting of weight-bearing exercises (at least once a day) for 1 month in the home or institutional care setting reported significant increase in lower limb strength and walking velocity [53].

Multicomponent rehabilitation consisting of home visits by physical therapist supplemented with nutritional counselling; and daily vitamin D (2000 IU), calcium (600 mg), and multivitamins reported no significant improvement in community ambulation, possibly due to insufficient dose of exercise received by some participants as well as low adherence [54]. An 8-week intensive rehabilitation consisting of circuit training concomitant with an individualised balance and gait training programme reported no significant improvement in outcome due to low compliance in the control and study groups [41].

Transition of care from inpatient to outpatient

There were 3 studies exploring electrical stimulation interventions in the transition of inpatient to outpatient setting [55–57]. Two studies reported improvements in outcomes, including significant improvements in fracture healing and reduced pain (for pulsed electro-magnetic fields given for at least 8 h/day within 7 days from surgery for 90 days) [57], as well as improvement in recovery of walking speed and better postural stability (for neuromuscular stimulators worn daily for 3 h for 6 weeks commencing 1 week after surgery) [55]. However, electrical stimulation given for 6 weeks (5 days/week as inpatient and twice weekly once discharged, 18 min/session) reported no significant improvement in leg extensor power and disability [56].

There were 2 studies investigating specialized rehabilitation involving occupational therapy which started from inpatient and carried on to the outpatient setting [58, 59], which reported significant improvement in daily functioning, which is not observed in inpatient settings [31, 32]. There was 1 study exploring early rehabilitation in the transition of inpatient to outpatient setting [60], which reported reduction in length of hospital stay, and improvement in functional recovery. This is in line with one study exploring early rehabilitation in inpatient setting [21]. A cognitive behavioral therapy-based occupational therapy coupled with sensor monitoring reported significant improvement in patient reported daily functioning [61, 62].

Medication, nutrition and supplementation (n = 30)

There are 38 articles reporting 30 medication, nutrition and supplementation interventions which were conducted in inpatient, outpatient and inpatient-outpatient settings. 60% (n = 18) of medication or nutrition supplementation interventions were carried out from inpatient to outpatient setting, 33% (n = 10) in the inpatient setting and the remaining 7% (n = 2) in the outpatient setting.

Inpatient

The 10 interventions conducted in inpatient settings investigated nutritional support [63–69], dietetic assistants [70], growth hormone supplementation [71], anabolic steroid [72], essential amino acid supplementation [73] and vitamin D supplementation [74], all of which reported improvement in outcomes (ranging from reduced postoperative complications [63, 64, 65], reduced length of hospital stay [63], improved functional recovery [75], reduced mortality rate [64, 65, 70], improved BMD [74] and reduced falls [74]), except for a study investigating anabolic steroids (nandrolone 2 mg/kg by weekly injection for 4 weeks) which reported minimal benefit on biochemical parameters, grip strength, rehabilitation outcomes, length of stay or functional endpoints [72].

Outpatient

There were 2 RCTs conducted in the outpatient settings exploring oral supplementation in addition to home rehabilitative program reported beneficial outcomes. Essential amino acid supplementation was effective in improving function and decreasing disability, in particular sarcopenic patients [76], while vitamin D supplementation reported increased survival rate and reduced medical complications [77].

Transition of care from inpatient to outpatient

There were 18 RCTs conducted in the inpatient to outpatient setting. These RCTs yielded mixed results. While RCTs exploring anabolic steroid [78–81], intranasal calcitonin [82], nutritional support with dietetic counselling [83, 84] and bone anabolic drug supplementation [85–87] reported beneficial outcomes, the other interventions yielded negative or mixed results.

One RCT using daily growth hormone secretagogue mimetic [88] for 24 weeks with supplemental vitamin D and multidisciplinary rehabilitation was terminated early due to adverse experiences, making the risk benefit of the drug unacceptable. Two RCTs evaluating bisphosphonate supplementation (35 mg/week), with daily calcium and vitamin D, reported no significant differences in fracture healing, incidence of complications or short-term functional recovery [89, 90].

Studies investigating protein supplementation reported mixed results, with only 2 out of the 5 RCTs reporting conclusive positive outcomes in terms of significant improvement in serum levels of insulin-like growth factor-I and muscle strength, with reduced proximal femur bone loss and length of stay in rehabilitation hospital (intervention: oral protein supplement of 65 g/day, 5

days/week for 6 months) [91], as well as beneficial effects on total body BMD, total hip BMD, hand grip strength, and health-related quality of life (intervention: liquid supplementation with 40 g of protein and 600 kcal daily for six months, in addition to bisphosphonates once weekly for 12 months) [92, 93].

For the 2 RCTs investigating vitamin D loading dose, one RCT with loading dose (250,000 IU) of vitamin D3 within 96 h or up to 7 days post-surgery, with oral maintenance vitamin D3 and calcium, reported higher percentage of replete 25-OHD, reduced rates of falls and reduced pain levels [94, 95]. However, another RCT exploring loading dose (100,000 IU) in addition to daily vitamin D (1,000 IU) had no significant improvement in serum 25-hydroxy vitamin D levels [96].

Optimizing clinical management (n = 9)

There are 11 articles reporting 9 RCTs on optimization of clinical management interventions in inpatient settings, of which 5 reported positive results.

Inpatient

Inpatient physiotherapy education and engagement enhanced with the use of technology and by integrating behavioural skills for therapists into their OT/PT practice has shown to increase patient satisfaction and ability to recall physiotherapy information [97].

Continuous-flow cryocompression therapy (CFCT) applied in the acute recovery phase has demonstrated its effectiveness in reducing pain levels [132, 133]. Integration of a set of behavioural skills for therapists into their OT/PT practice was effective in increasing therapy intensity, therapy engagement, and functional outcomes [98]. In contrary to depression management which did not show any beneficial effect [99, 100], the 2 delirium management interventions reported positive outcomes in terms of significant reduction postoperative delirium [101, 102].

The other interventions with no positive outcomes included multifactorial best practice case management model for incontinence management [103], standard postoperative hip precautions (which reported no significant differences in the risk of dislocation, patient reported outcome and complications) [104], and high-protein nutritional supplement enriched with arginine, zinc and antioxidants dose of 400 ml/day for pressure ulcer management [105].

Prevention of venous thromboembolism (n = 8)

There are 9 articles reporting 8 RCTs investigating prevention of venous thromboembolism interventions.

Inpatient & transition of care from inpatient to outpatient

All interventions for the prevention of venous thromboembolism (VTE) started during inpatient stay during the early acute recovery phases, with 62.5% of the interventions (semuloparin [106], phenindione [107], ancrod [108], fondaparinux sodium [109, 110], enoxaparin [111]) reporting effectiveness in reducing incidence of VTE.

Multidisciplinary, multifactorial programme (n = 7)

There are 13 articles reporting 7 multidisciplinary, multifactorial programme interventions, with 3 in inpatient settings, and 2 in the outpatient setting and 2 conducted in the inpatient to outpatient setting.

Inpatient

There were 3 RCTs conducted in the inpatient setting involving geriatricians for post-surgery care, with the involvement of orthopaedic surgeon / generalist / allied health (physiotherapist, occupation therapist, social worker) / nurse specialist [112–115]. Only the RCT involving geriatrician-generalist-orthopaedic specialist reported a significant reduction in length of hospital stay, and improvement in functional independence and independent living [113, 114].

Outpatient

There were 2 RCTs conducted in the outpatient settings. A multidisciplinary post-fracture clinic led by geriatrician with physiotherapist and occupational therapist [116, 117] reported no significant improvement in sedentary time or physical activity. Home visit by a home rehabilitation interdisciplinary team (team coordinator, physiotherapist, occupational therapist, speech pathologist, social worker and therapy aid) and weekly case conferences with a specialist in rehabilitation medicine or a geriatrician, reported significant increase in physical independence and confidence, and reduced caregiver burden [118, 119].

Transition of care from inpatient to outpatient

There were 2 RCTs conducted transitioning from inpatient to outpatient settings. Intensive rehabilitation in a geriatric ward combined with occupational therapist evaluation for daily living aids and home visits by physiotherapist, reported several significant improvements including reduced length of hospital stay, increased independence in instrumental activities of daily living (IADL) and more patients with mild or moderate dementia being able to return to community and independent living [120, 121].

Geriatric interdisciplinary home rehabilitation team (geriatrician, nurse, occupational therapist, physiotherapists, social worker and dietician) aiming for early discharge with comprehensive geriatric assessment and

frequent home visits during the first days after discharge, reported a significant reduction in length of hospital stay, but not significant improvements in walking ability or reduced complications and readmissions [122–124].

Osteoporosis management / fracture prevention post-discharge (n = 6)

There are 15 articles reporting 6 osteoporosis management/ fracture prevention interventions. 50% (n = 3) of osteoporosis management/ fracture prevention interventions were carried out in the outpatient setting and the others were conducted in the inpatient to outpatient setting (n = 3).

All RCTs involving post-discharge osteoporosis care management, either through case manager [125, 126], primary care physician [127] or osteoporosis care clinic [128], reported improved osteoporosis management post-discharge. The findings from one study in outpatient settings did not support routine oral supplementation with calcium (1000 mg per day) and vitamin D3 (800 IU per day), either alone or in combination, for the prevention of further fractures in previously mobile elderly people [129].

Falls prevention (n = 4)

There are 7 articles reporting 4 falls prevention interventions, with 2 in inpatient settings, and 1 each for outpatient and inpatient to outpatient setting. Two RCTs reported positive results in falls prevention – (1) An inpatient geriatric rehabilitation [130–133] and (2) a home visit by an occupational therapist prior to discharge [134]. Interventions in both inpatient and outpatient settings could be valuable in preventing falls and injuries post hip fracture surgery.

Post-operative anaemia (n = 3)

There are 3 RCTs investigating oral iron therapy for patients post-hip fracture, in which one RCT was conducted in inpatient setting (325 mg/day of oral ferrous sulphate for the duration of the hospitalization [135]), while the other two RCTs were conducted in inpatient to home setting (200 mg oral ferrous sulphate 2 times/day for 28 days [136] and 200 mg oral ferrous sulphate 3 times/day for 28 days [137]). Among the three RCTs, only 1 study (200 mg oral ferrous sulphate 3 times/day for 28 days) reported positive outcome in terms of significant improvement in haemoglobin levels [137].

Supported discharge (n = 1)

Nursing intervention model consisting of a gerontologic advanced practice nurse (GAPN) post-acute care coordinator for 6 months of care activities reported significant improvements in most ADLs and IADLs (mobility, household chores and personal care) [138]. Care activities included interactions with patients once/week in the first month post-discharge and twice/week until 6 months after surgery, and communication with primary physician, surgeon and staff in various facilities and documenting patients' progress [138].

Others (group learning, motivational interviewing) (n = 2)

A 10-week group learning RCT for participants in groups of 5–8, led by a geriatric team (dietician, occupational therapist, physician, physiotherapist and social worker) conducting education on osteoporosis and falls prevention, as well as physical training, reported a significant improvement in the ability to resume meaningful social life and reduced difficulties in ADL [139]. Motivational interviewing by physiotherapist for 8 sessions (30 min/session) reported significant improvements in physical activity, self-efficacy and health-related quality of life, and reduced anxiety and depression [140].

Discussion

Principal findings

This review is the first to summarise all the post-hip fracture surgery interventions in the acute, subacute and community settings. The studies presented in this systemic review were heterogenous in terms of settings, interventions, disease, measures used to assess outcomes, and efficacy of the post-hip fracture interventions.

For all the 10 categories of interventions, the evidence base either contains too few trials or contains trials with contradictory findings which preclude any definitive summary. However, for medical practitioners in the acute, subacute and community setting interested in improving certain post-hip fracture outcomes, this review provides comprehensive summary on the possible interventions that may be useful. The interventions in this review had minor or no side effects reported. Notable adverse reactions were observed in patients treated with growth hormone secretagogue mimetic MK-0677 [88], which led to early termination of the trial.

For some studies, the lack of positive outcomes may be attributed to the low compliance to the intervention. For example, the authors suggested that the lack of significant improvement in community ambulation after home visits by physiotherapist may be due to insufficient dose of exercise received by some participants as well as lower adherence rate in this group [54].

It was also postulated that an 8-week intensive rehabilitation consisting of circuit training concomitant with an individualised balance and gait training programme reported no significant improvement in rehabilitation due to low compliance in the control and study groups [41]. This highlights the need to consider feasibility, and monitor the fidelity and compliance to the intervention in future studies for more conclusive evidence

on the efficacy or effectiveness of the post- hip fracture interventions.

Comparison to prior work

In this review, we found that RCTs involving post-discharge osteoporosis care management, either through case manager [126125], primary care physician 127] or osteoporosis care clinic [128], reported improved osteoporosis management. Except for a RCT investigating multidisciplinary post-fracture clinic led by geriatrician with physiotherapist and occupational therapist [116, 117] which reported no significant improvement in sedentary time or physical activity, the other RCTs reported the positive effects of occupational therapy on daily functions and emotions, which is in agreement with findings from another systematic review [11].

For the 2 RCTs involving nerve stimulation in inpatient settings, both showed improvements in pain level and functional recovery, suggesting that nerve stimulation could play a valuable role in reducing the length of inpatient stay [20], and the effect of nerve stimulation on long-term functional outcomes should be explored further [19].

A recent study has shown that patients who underwent a blood transfusion had lower preoperative haemoglobin levels and longer durations of surgical treatment [141]. Our review included three RCTs investigating post-operative anaemia, and only 1 study (200 mg oral ferrous sulphate 3 times/day for 28 days) reported positive outcome in terms of significant improvement in haemoglobin levels [137].

A recent review on physical therapy for patients with femoral neck fracture has found that the most effective intervention appears to be exercise of progressive resistance [142]. This aligns with the findings from studies by Binder et al. [33] and Host et al. [34], both included in this review, which demonstrated that extended outpatient rehabilitation that includes progressive resistance training improves physical function.

Strengths and Limitations

The findings from this review can aid in clinical practice by allowing formulation of thematic program with combination of interventions as part of bundled care to improve outcome for patients who have undergone hip fracture surgery. For example, nerve stimulation could be made available for patients who have undergone hip fracture surgery in the inpatient settings, followed by post-discharge outpatient osteoporosis care management.

However, future research on optimal duration and dosage/ frequency of each type of intervention may be warranted as our review has demonstrated that the beneficial effect of the exercise intervention did not seem to be correlated to duration of exercise. For example, one study involving a 10-week intervention (twice a week, 30–40 min each session) reporting an improvement along with force production [49], but another intervention lasting 12 months involving strength training (≥3 days per week) and aerobics (≥2 days per week) reported increase in activity level but no significant improvement in gait and physical function [50, 51].

There are limitations in this study. Firstly, publication bias may result in overestimation of the efficacy or effectiveness of the post-hip fracture surgery interventions. In addition, study design e.g., dosage, frequency and duration of treatment was heterogenous among the studies included in this review, making it difficult to compare results across studies. The heterogeneities of the follow-up period, enrolment time after fracture, and variable outcomes also preclude the possibility of performing a meta-analysis in this study.

Moreover, as the search in the scholarly literature was restricted to articles published before June 2020, our review may have excluded studies published after the cut-off date. Nevertheless, the findings from this review can serve as foundation for future research on post-surgery interventions for hip fracture.

Lastly, the Jadad scale may have shortcomings such as incompleteness and the use of an additive (not multiplicative) scoring system that allows compensation for weaknesses [175]. However, previous studies have demonstrated the reliability and validity of the Jadad scale [176, 177].

Conclusion

The identified RCTs regarding post-hip fracture surgery interventions were heterogeneous in terms of type of interventions, settings and outcome measures. Post-hip fracture surgery interventions should span from acute inpatient to post-discharge outpatient care as part of bundled treatment for patients to achieve better improvement in outcomes such as improved physical function recovery, lower rate of complications, and shortening of length of stay. For example, nutritional supplementation could be made available for patients who have undergone hip fracture surgery in the inpatient settings, followed by post-discharge outpatient osteoporosis care management. The findings from this review can aid clinicians and researchers by allowing formulation of thematic program with combination of interventions as part of bundled care to improve outcome for patients who have undergone hip fracture surgery.

Supplementary Information

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Supplementary Material 1

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Authors' contributions
JK Phang and ZY Lim wrote the main manuscript text and prepared the tables. ZY Lim prepared the figure. LL Low and YH Kwan conceptualised the study and are involved in the acquisition of funding. LL Low, YH Kwan and CYF Tan contributed to the analysis of the results. All authors reviewed the manuscript.

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Data Availability
All data generated or analyzed during this study are included in this published article and its supplementary information files.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no conflict of interest.

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