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Review Article

The effect of an exercise-based rehabilitation programme in functional recovery and prevention of secondary falls after a hip fracture in older adults: A systematic review

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Abstract

We performed a systematic review to evaluate whether an exercise-based intervention programme, for older people with a hip fracture, is effective in functional recovery and in preventing secondary fall-related injuries. This systematic review was conducted according to Cochrane review guidelines and based on the PRISMA statement. Six electronic databases (Medline, PubMed, Cochrane Library, CIHNAL, Embase, Google Scholar) from 2010 to 31 December 2021 were searched for randomised controlled trials (RCTs) of functional recovery or fall prevention exercises after a hip fracture surgery in older people (≥65 years). Thirty-four references were identified initially, however, only 8 studies (1617 patients) met the eligibility criteria. Despite the heterogeneity of the onset, duration and of the characteristics of exercise-based intervention, as well as the type of setting it was delivered in, there was evidence that an exercise-based rehabilitation programme improved physical function and gait ability. There was no evidence about preventing a secondary fall after a hip fracture. In conclusion, an exercise-based intervention programme can generally improve functional recovery after a hip fracture. It remains uncertain if it affects the prevention of a secondary fall over a 1-year follow-up period.

Keywords: Exercise, Functional outcome, Fall prevention, Hip fracture, Review

Introduction

Fall-related injuries in older adults are quite common and are the most prevalent cause of presentation in the emergency department, resulting in hospitalisation, long length of hospital stay and impaired rehabilitation, with further social consequences and high economic costs[1]. Falls occur in hospitals and residential homes and are a major cause of long-term pain and functional lack of movement among older patients[2]. Various interactions, frailty syndrome and multiple risk factors, patient related or not, cause fall injuries in older people with a serious impact to their health status, daily living and independence in their daily activities[3]. Therefore, fall prevention programmes are important for the older population. A large number of RCTs have investigated the effects of simple home-based exercise programmes, such as the Otago Exercise Programme, to prevent falls, to reduce fear of falling, to regain functional mobility and to improve quality of life in primary care settings, or in residential homes and private houses[4,5].

It is reported that about 30% of falls result in physical injury, while 3-5% of them are hip fractures. According to CDC data, 300,000 older people (≥65 years) are hospitalised each year for hip fractures in the U.S. due to

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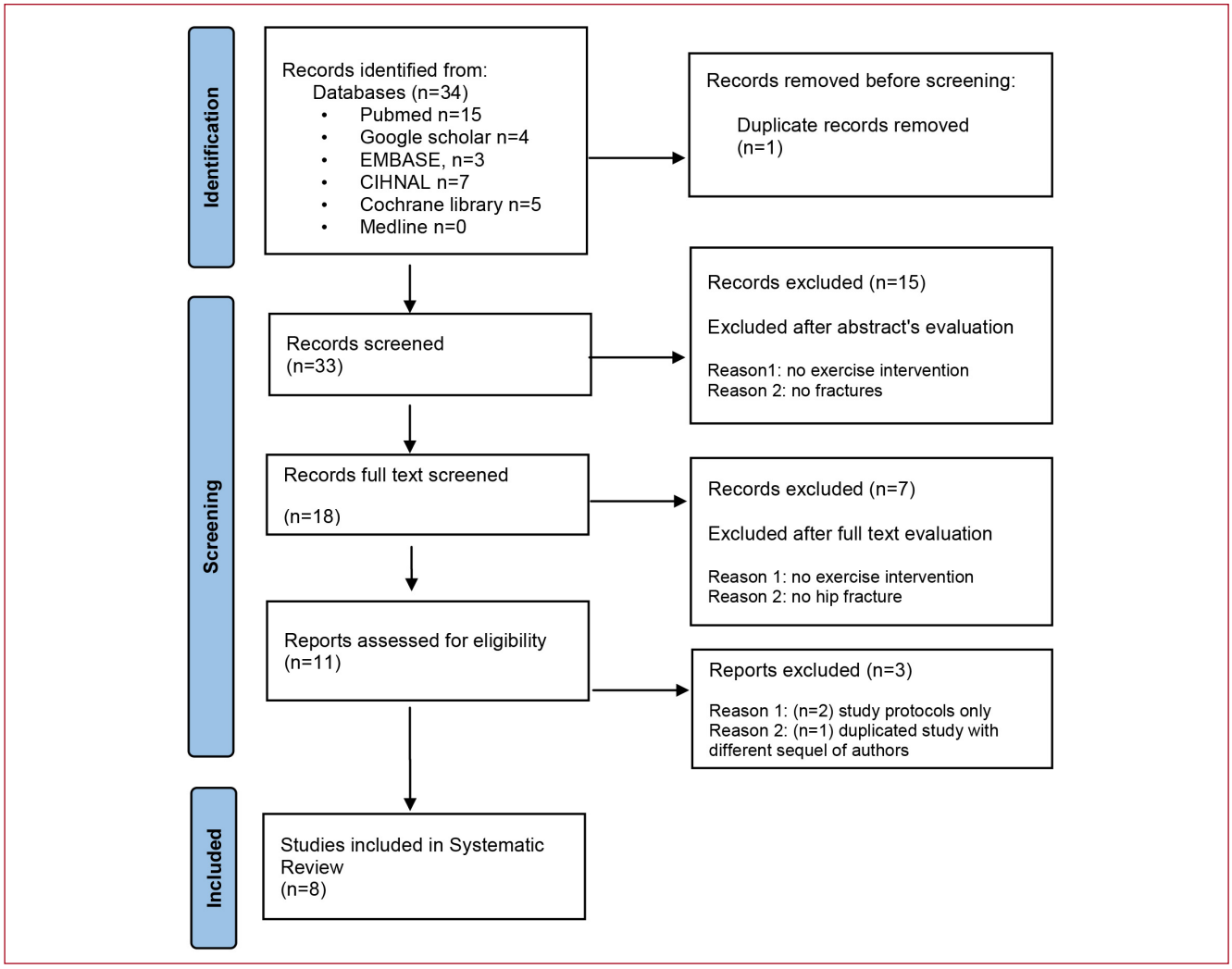

Figure 1. Prisma flowchart.

falls. Furthermore, the patients could experience secondary falls, functional restrictions or re-hospitalisation within a year following the first fall[3]. Therefore, it is important to determine the results of multifactorial interventions and suggest an ideal rehabilitation model, in order to prevent future falls, injuries and associated managements, along with all socio-economic consequences[6].

Various studies have been conducted revealing the complications and risk of death after a hip fracture, the length of hospital stay, the type, the onset time and the duration of the rehabilitation programme performed and the discharge to nursing homes. There is also an interest in studying the effects of inpatients' exercise programmes or multiple rehabilitation programmes in home settings and in functional recovery after hip fractures[7,8]. Unfortunately the conclusions are rather conflicting and it must be noted that there is significant variability in the way and the type of settings where the interventions are implemented in clinical practice. There are studies supporting the superiority of an exercise programme in mobility and quality of life, while others conclude there is limited support for the exercise regimen's effectiveness in performing daily activities[9,10]. Handoll et al., conducting a Cochrane systematic review, stated there is minimal evidence to establish a rehabilitation model in order to improve functional outcome after a hip surgery[11]. In their systematic review and meta-analysis Kuijlaars et al. concluded there was a low therapeutic validity in the randomised control trials involved, which explains the limited evidence of supervised home-based exercise intervention against any other[12]. Chen et al. in a recent meta-analysis supported that home exercise programmes were not significantly associated with physical health and

improved ADL and that there was no significant relevance for a community-based rehabilitation programme assessing outdoor mobility with improved ambulatory mobility or falls-related self-efficacy[13]. The evidence for functional recovery and the prevention of secondary falls after an acute hip fracture in older people (≥65 years old) was evaluated in literature in order to identify the effectiveness of current interventions used in clinical practice[14,15]. The risk of hip fractures following falls increases with the age of a population, while the incidence of re-fracture has been monitored by researchers as a real risk with serious social and economic costs[16,17]. To our knowledge, no review or meta-analysis has examined the effect of any rehabilitation programme in preventing secondary falls within a year of a hip fracture.

Even if secondary falls cause minor injury, they should be considered and evaluated thoroughly, because they cause decreased self-confidence, social isolation and functional impairment, which might increase the possibility of placements in nursing homes. The aim of this review is to evaluate all suggested multifactorial interventions in clinical practice regarding rehabilitation programmes after hip surgery and the potential impact on functional outcome, plus preventing secondary falls. Thus, the following research strategy is based on the PICO formulated question, "Does a rehabilitation programme after a hip fracture in older adults have an impact on functional recovery and in preventing secondary falls?"

Materials and Methods

A systematic review was performed according to the criterion of both the Cochrane review guidelines and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)[18].

Search strategy

A preliminary search was done in PubMed and Google Scholar with the search terms "hip fracture", "exercise intervention" and "fall prevention", in order to identify relevant articles and to ensure the validity of the proposed idea. During this step, systematic reviews were found referring to exercise rehabilitation after hip fractures or to fall prevention programmes after a fall. Six electronic databases (Medline, PubMed, Cochrane Library, Embase, CINAHL, Google Scholar) were searched from 2010 to 31 December 2021. The search strategy developed using relevant medical terms and keywords customised to each database as needed such as "hip fracture", "rehabilitation", "exercise", "fall prevention", "functional outcome" (Figure 1).

Eligibility criteria

Two reviewers independently screened the databases, first searching the terminology within titles or abstracts based on the following inclusion criteria:

1) The studies assessed were (RCTs) with the full text published, from January 2010 till 31 December 2021.
2) The publication language was English, with no restriction regarding country.
3) The study participants were patients, both male and female, who had sustained a hip fracture requiring surgery and were aged 65-90 years old.
4) The intervention was an exercise-based rehabilitation programme (e.g. Otago Exercise Programme or walking activity) after a hip fracture, offered in community housing or participants' homes or hospital outpatient clinics.
5) The intervention outcomes included functional activities and falls rate or risk.

The exclusion criteria were participants with dementia or cancer, any severe health problem provoking a lack of mobility or a high possibility of mortality. Duplicate articles and articles with incomplete data were also excluded.

Study selection and data extraction.

Two reviewers independently extracted data from the included studies, while a third reviewer was available to resolve possible disagreements. Demographic data referring to characteristics of the included studies such as country of origin, sample size, number of participants, randomisation method, duration of study and type of intervention were reported in a standard extraction sheet. All data extracted were tabulated (Tables 1, 2).

Results

This systematic review summarised the results of 8 randomised control trials. Demonstrating there is limited evidence in favour of a home or supervised exercise-based rehabilitation programme versus usual geriatric care after a hip fracture in functional recovery and in prevention of secondary falls.

In accordance with Cochrane review guidelines about conducting a systematic review, a PRISMA flow diagram was formed, adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses[18,19]. Six electronic databases were searched and the extracted results were based on the eligibility criteria (Figure 1).

Search results

The first process was conducting a manual search of the general references in the included studies and reviews. This process identified 4 studies in Google Scholar related to our topic. The initial search of databases using the keywords, identified 34 records answering our PICO question. One study was excluded due to duplication. After abstract evaluation 25 studies were rejected as not meeting the inclusion criteria, while after full text screening 7 more studies were eliminated due to the absence of both exercise intervention and hip fracture. Finally, 2 studies were research protocols and 1 was the same as another although with a different co-author (Figure 1). The remaining 8 articles were included in the final systematic review.

Table 1. Characteristics of the included studies.

Study	No of participants (IG) N=1617)	Age, Mean (SD)	Country of study	Female Male (IG)	Study duration	Randomization method	Type of fracture	Time assessment points	Assessment tools
Sherrington et al 2020[20]	336(168)	77,6 (8,9)	Australia	F=125 M=43	2 yrs	Blinded, Concealed	Lower leg, pelvic fracture	1,3,8,11 m	-SPPB -AM-PAC -LLDI -Rate of falls
Karlsson et al 2016[21]	205(107)	82.9±6.7	Sweden	F=147 M=58	1 yr	Blinded, concealed	Cervical, Trochanteric fracture	3,12m	-Gait of speed -Rate of falls -LOS
Ooijen et al 2016[22]	70(24,23,23)	83,3±6.7	The Netherlands	F=51 M=19	1 yr	Single blinded, controlled parallel group	Cervical, Trochanteric Sub-trochanteric fracture	Baseline,1,12m	-Elderly mobility scale -Nottingham activity daily living -FES-1 -TUG -10MWT
Tseng et al 2016[23]	281(188)	76.36(7.28)	Taiwan	F=188	1 yr	Controlled parallel group	Femoral neck Trochanteric fracture	1,3,6,12m	-HR-QOL -SF-36 -Barthel index
Chang et al 2015[24]	232(120)	79±9.4	Taiwan	F=83 M=37	1 yr	Single Blinded		Baseline,6,9m	-AM-PAC -SPPB -Self efficacy for exercise scale
Salpakoski et al 2014[25]	81(40)	80.9±7.7	Finland	F=40	1 yr	Controlled parallel group	Hip fracture	3,6,12m	-BBS -LEP -SPPB
Latham et al 2014[26]	232(120)	77.2(10.2)	U.S.	F=83 M=29	6m	Single blinded	Hip fracture	1,6,9m	-SPPB -AM-PAC
Orwig et al 2011[27]	180 (91)	82.5 (7.1)	U.S.	F=91	1 yr	Single blinded	Inter-trochanteric/ Sub-trochanteric fracture	2,6,12m	-Yale Physical activity scale -short SF-36 -Grip strength -Lower extremity gain scale -Geriatric depression scale

Abbreviations: IG: Intervention group, SPPB: Short Physical Performance Battery, AM-PAC: Activity Measure for Post-Acute Care, LLDI: Late Life Disability Instrument, LOS: Length of stay, FES-1: Falls Efficacy Scale, TUG: Time up and go test, 10MWT: 10 minute walking test, HR-QOL: Health Related Quality Of Life, SF-36: 36 item Short Form instrument, BBS: Berg-Balance scale, LEP: Leg Extension Power deficit.

Table2. Intervention characteristics of the included studies.

Study	Intervention (beginning)	No of sessions/ Intervention duration	Providers	Type of ex's program	Parameters of ex's program	Additional intervention	Control group	Results Primary outcomes
Sherrington et al 2020[20]	Within 2 years post-fracture	-10 Home visits -12m	Physiotherapists	Home based ex's RESTORE Balance/ strengthening ex's Seven 2h group sessions	20-30min program 3 times/ week 12m RESTORE	Education booklet/fall prevention	Usual geriatric care	-Mobility related disability -Rate of falls: no significant difference
Karlsson et al 2016[21]	After discharge	-Nearly daily home visits -10w	Geriatric team	Home based ex's program, walking activity	Individualized HIFE	Fall prevention advice	Usual geriatric care	-Walking ability: no significant difference
Ooijen et al 2016[22]	After discharge	-30 sessions/ 6 weeks -6w	Physiotherapists	I.Adaptational treadmill II.Conventional treadmill III.Physical therapy (strengthening ex's, balance ex's, walking activity)	40min program 5 times/week	Fall prevention advice	-	-Improved walking ability and functional status in all groups
Tseng et al 2016[23]	1m	-Home visits I.4m II.12m III.7 days -16w/12m	Physiotherapists	I.Interdisciplinary care II. Comprehensive care III. Hospital rehabilitation	I. balance training program/ aerobic capacity II. muscle-strength training program III.Usual inpatient physiotherapy	Geriatric consultation	-	Improved walking ability and functional status in all intervention groups
Chang et al 2015[24]	Within 20m	-3 Home visits -6m	Physiotherapists	Standing ex's (steps, varying height, weighted vests)	3 times/week	Monthly phonecalls Digital videodisc Exercise calendar	Nutrition education	Improved functional status related with self-efficacy
Salpakoski et al 2014[25]	42±23days After discharge	-5-6 home visits -12m	Physiotherapists	Strengthening , balance training, functional exercises (modified Otago program)	2-3 times/week Updated 4-5 times	Evaluation, modification of environmental hazards	Usual geriatric care	Improved functional mobility /stairs
Latham et al 2014[26]	Within 20m	-3 home visits -6m	Physiotherapists	Strengthening , balance training, functional exercises	3 times/week-1h		Usual post-fracture care	Improved functional mobility
Orwig et al 2011[27]	15 days of fracture	-56 sessions -12m	Exercise trainers	Aerobic, resistive ex's	30 min, 3 times/week Adopted intensity		Usual post-fracture care	Improved functional mobility

Abbreviations: RESTORE: Recovery Exercises and STepping On afteR fracturE, HIFE: High Intensity Functional Exercise Programme.

Risk of bias in studies

Most of the RCTs included in this review, used random sequence generation[20-25,27], blinding of participants[20-24], blinding of participants and personnel[20-21] and blinding of outcome assessment[20-22,24]. The risk of bias at the outcome level of the included studies was not assessed in the present review.

Characteristics of included studies

Half of the assessed studies were performed within the last 5 years. Studies were performed in 6 different countries (Australia, Sweden, The Netherlands, Taiwan, Finland and United States). The total number of participants was 1617, mostly community-dwelling, with a an age range of 65 to 85 years old. Five of the studies were performed in both genders and in the other 3, only female participants were recruited, totalling 796 women (57.8%). The sample size of the studies varied from 81 to 323 participants while the mean age of the population was 80.63 years. Six of the studies were only conducted on participants with hip fractures, whereas 2 studies referred also to cervical fractures due to falls[20,21]. All studies reported that the hip fractures were acute or accidental without giving adequate information about the cause or where the hip fracture occured. In 2 studies there were no specific descriptions of the hip fractures. In 4 studies the hip fracture was described as inter-trochanteric, in 2 as trochanteric or sub-trochanteric, in 1 as femoral neck and in another as lower leg fracture[22-24]. Participants were recruited from different settings-hospitals, nursing homes and health care communities, which could bias the functional outcome and the risk factors of secondary falls. The main characteristics of the studies are summarised in Table 1.

Characteristics of study intervention

All 8 studies included in this review presented very dissimilar treatment approaches. There was no similarity in the rehabilitation model for functional recovery after hip surgery, while different parameters were assessed or measured in the final follow-up session, according to the scope of the researchers. In 5 studies the intervention began immediately or a few days to 10 weeks after discharge from the hospital and in 2 studies the recruitment of the participants occurred within 2 years of their surgery[21-25]. The intervention phase varied from 6 to 10 weeks in 2 studies respectively, 12 weeks in 2 studies, 6 months in 1 study and 12 months in 3 studies. In all studies a home-based exercise programme was performed and the assessment based on 3 major categories: functional training, muscle strength exercises, flexibility and balance exercises to regain gait ability. In 1 study and in 1 intervention group the home exercise programme was supported with 6 group sessions[21]. Another study mentioned that the exercise plan was a modified Otago Exercise Programme[25], while in 4 studies the intervention was supported by fall prevention education[20-23]. The control group received no intervention in 5 trials, only instructions and post-fracture geriatric care[21,22,24,25,27]. The number of sessions varied from 5 or 6 home visits to 56 sessions of intervention and the frequency varied from daily to weekly. The duration of intervention sessions was adjusted to the type of intervention, so a session lasted from 20 to 45 minutes. In 6 studies the exercise programme was held by physiotherapists, in 1 by exercise trainers and in another by a member of a geriatric team. In 1 study there was also identification and modification of environmental hazards (Table 2). The types of setting interventions were given in varied. In 6 studies the intervention programme took place only in participants' homes[20,21,24-27] and in the other 2 studies at community or residential care units, hospitals and participants' homes[22,23].

Outcomes and effectiveness of interventions

Over all trials, data was pooled from various research tools. The most popular were the Short Physical Performance Battery (SPPB), the SF-36 and the Activity Measure for Post-Acute Care (AM-PAC). For lower mobility strength assessment, the Berg-Balance test (BBT), and the Timed Up and Go Test (TUG) were used, while in many cases the modified Falls Efficacy Scale International (FES-I) was used to assess fear of falling. Secondary tools were also employed, like handgrip strength and Barthel Index (BI) for evaluating functional ability.

Assessing the impact of an exercise-based rehabilitation programme after a hip fracture, supervised or unsupervised, versus usual post-fracture geriatric care, 2 studies reported no significant differences in functional mobility or walking ability[20,21]. In 2 studies with 3 different parallel exercise-based intervention groups, an improvement in functional status and walking ability was reported[22,23]. Comparing a home exercise programme after a hip fracture, with the usual geriatric care (as described in 4 studies) functional recovery was reported to be slightly improved, assessing physical activity and mobility[24-27].

The prevention of secondary falls was reported only in 2 studies[20,21], which through the evaluation of a daily calendar, demonstrated no significant differences between intervention and control groups in the number of falls. In 1 study the risk factors of falling were assessed with no significant differences reported[23].

Discussion

The literature search identified randomised control trials and systematic reviews have been conducted to assess the role of an exercise-based, multifactorial intervention with specific characteristics and parameters, in promoting physical activity, preventing falls and reducing recurrent falls in older adults from community and residential care settings[28]. Although the incidence of hip fracture increases with age and the possibility of a secondary fall or even a contralateral hip fracture with relative risk factors are present, only a few studies had considered a rehabilitation

programme after a hip surgery with the aim to secure the best functional recovery and to eliminate risk factors for recurrent falls and fractures.

This systematic review goes beyond the randomised control trials conducted to assess the effects of an exercise-based rehabilitation programme in functional recovery and secondary fall prevention after a hip surgery in older participants. Eight studies were identified from searching 6 research databases, conducted in 6 different countries with different cultures, health status and health care systems. The principal findings of the present study showed that there is limited efficacy of the rehabilitation programme given in functional outcome and in prevention of secondary falls. In 6 trials the results of the intervention group were compared with those of a control group which received the usual geriatric care or the inpatients' post-fracture care provided by the health care system of the country where the study was conducted. It is quite significant to note that the description of what standard care constituted was often lacking. Therefore, it is quite possible that "usual" geriatric care differs significantly across health care systems, which might be considered as a bias factor in a rehabilitation outcome or in the statistical results of studies. In 2 trials it was attempted to compare 2 different intervention group outcomes, presenting no significant differences between them and the control group.

The initiation of the intervention programme also varied significantly, from the day after discharge from the hospital, to a period within 2 years after hip surgery, which creates inequality between patients' 'functional ability'. The impact of timing onset of different exercise interventions in the different stages of rehabilitation of hip fracture (early or late stage) is unknown. The duration of study trials had quite a large range (10 weeks to 2 years) and the number of intervention sessions was very different in each trial with no similar pattern, which could bias the assessed functional outcomes up to a follow up of 12 months.

The main element of the rehabilitation programme after a hip surgery was an exercise-based plan, which is widely considered to be essential after a hip fracture[29]. All exercise programmes performed in trials included strengthening, balance exercises and standing exercises to improve functional ability, walking activity and to secure the independence of patients[30,31]. Patients were trained to perform their exercise programme initially by physiotherapists in 6 trials and by other health or fitness professionals in 2 trials. Patients were performing their exercise programme mostly without supervision in their home environment in all trials. In 1 trial patients had the opportunity to perform a rehabilitation programme which included the supervised use of a treadmill. The comparison between performing a home-based exercise programme and a community-based programme is important, yet it is unknown which setting is more beneficial for functional outcomes. After interpreting the extracted data of this review, the conclusion is that the components of intervention programmes evaluated were dissimilar and varied in their time of onset, duration and intensity of treatment.

A number of functional outcomes were captured across the 8 studies but different outcome measures were used. Looking across all the interventions, the most frequently reported outcomes referred to evaluating walking ability.

The research tools employed to assess the functional outcome at baseline (the time 1st assessment was done), 3, 6 and 9 months, were diverse. The most frequently used tools were for functional measures, the Short Physical Performance Battery (SPPB) and the Activity Measure for Post-Acute Care (AM-PAC) and for lower mobility strength assessment the Berg-Balance test (BBT) was used. While in a few studies the Falls Efficacy Scale International (FES-I) was also assessed.

Considering the suggested type of intervention programme, with its specific parameters, the only common element mentioned was that strengthening and balance exercise, such as used in the Otago Exercise Programme, was performed to improve functional recovery after a hip surgery[29]. Apart from the reported usual geriatric and post-fracture care given after a hip fracture, which is not actually described, there is no strong evidence for the exact time the rehabilitation programme must begin after discharge from the hospital, the duration of the intervention therapy performed, the 'ingredients' of the rehabilitation programme, or the necessity of supervision while exercising[32,33].

Despite the differences between exercise-based interventions, researchers agree that an exercise regimen had a positive impact on the functional recovery and walking ability of patients after a hip fracture surgery. The findings of this review are consistent with the results of a previous review from Cadore et al. which reported that a multicomponent programme consisting of muscle strength training, plus endurance and balance ability is the best therapeutic strategy to improve functional recovery[34].

Fall prevention advice and home modifications seem to be highlighted as additional intervention elements which enhance rehabilitation of the hip surgery. Although the term fall prevention is mentioned in various studies, the rate of secondary falls or recurrent injurious falls was not measured. There is no suggestion in rehabilitation training for the prevention of secondary falls and how the risk factors can be assessed or eliminated after a hip surgery.

Another two important elements absent in the studies involved are the description of the socioeconomic needs of the population included and the effect of psychological factors in the performance of the rehabilitation programme. Patients' compliance to a home-based rehabilitation programme or to rehabilitation centres and nursing homes is considered crucial for functional outcomes after a hip surgery but it is not assessed in the studies involved in this review. Various previous studies showed that following hip fractures, patients had poor functional outcomes after

discharge to the community. It was also likely that patients entered a cycle of a fear of falling, muscle weakness, relative immobility and recurrent fractures which affected prognosis and quality of life. The results show that there is limited evidence about the effect of exercises in all settings and on overall mobility in older people after hip fracture.

Further comprehensive research and randomized clinical trials must be done to interpret the above findings and considerations and to suggest the ideal multifactorial rehabilitation interventions after a hip fracture. It is important that the promoted rehabilitation programme should enhance the pre-fracture functional level to reduce the number of secondary injurious falls and the fear of falling.

Study strengths and weaknesses

The strengths of this study are that it was based on the Cochrane guidelines of conducting a systematic review, that a research question was formulated using the PICO approach and a search strategy applied according to the requirements of the PRISMA statement. The eligibility criteria were specific and pre-defined prior to searching databases throughout the last decade. The selection of studies -which were all randomised control trials- and data extraction were completed by two reviewers independently. A third researcher supervised any discussion or disagreement involved.

Limitations are considered to be the exclusive use of the English language which might exclude some statistically robust studies in other languages and also the inclusion of only an objective measurable analysis of outcomes. The majority of studies excluded patients with cognitive impairment, dementia or delirium which might restrict the review's findings and prohibit the results from being generalised. There was a notable heterogeneity in the included clinical studies that may lead to limited findings concerning the type of setting as well as the definition of primary and secondary outcomes detected after the performance of the multifactorial intervention programme. All studies had a maximum 12 month follow-up period, so it is possible that a different outcome could be interpreted in a longer follow-up period. Finally, the risk of bias regarding the outcomes was not thoroughly assessed to identify the methodological quality of the studies included in this review. Therefore, data extracted from such studies must be carefully assessed in order to conclude which is the best rehabilitation plan for functional recovery and prevention of a secondary fall after hip surgery.

Conclusion

The positive effects of an exercise-based intervention for preventing falls and enhancing physical activity in older adults with a hip fracture incidence who might present a functional impairment and a high possibility of a secondary fall is not well investigated.

The present study indicates there is a lack of evidence to support the effectiveness of an exercise-based intervention after an injurious fall which includes a hip fracture. As measurements and methods characterising settings and parameters of rehabilitation interventions are not well standardised and are very dissimilar, any conclusion regarding the best rehabilitation procedure after a hip fracture in older adults is controversial.

Rehabilitation of injurious falls following hip surgery aims to help patients return to pre-fracture functional status and mobility, to prevent recurrent falls, to eliminate patients' dependency and to reduce socioeconomic costs. This review reveals that functional outcomes, as well as secondary fall prevention, are not well reported in literature. Further research needs implementing to suggest an evidenced-based rehabilitation programme after a hip fracture concerning all risk factors that provoke secondary falls.

Authors' contributions

All authors contributed considerably to the development of this manuscript. AP designed and prepared the manuscript. AP and GK searched, screened articles and completed the data extraction. EP and KA assisted in the revision of the manuscript. MZS provided supervision and support throughout the preparation and completion of the review process. All authors agree with the current version of the manuscript.

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