

REVIEW ARTICLE

**REHABILITATION AFTER HIP FRACTURE: A LITERATURE REVIEW**

**POSTĘPOWANIE REHABILITACYJNE PO ZŁAMANIU BIODRA – PRZEGLĄD LITERATURY**

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ABSTRACT

**Introduction**

As a result of the aging population, hip fracture is emerging as a major medical, social and economical concern. A higher risk of fracture occurs in women of older age. Early surgery, preferably performed within 48 hours, is considered as the gold standard of treatment. Post-operative rehabilitation also has a significant role in patients' recovery.

**Aim**

The aim of this article is to compare the effectiveness of rehabilitation methods, such as physiotherapy and alternative interventions, provided after surgical treatment in patients with hip fracture.

**Material and methods**

Publications available on PubMed databases concerning the effectiveness of various rehabilitation methods after hip fracture were analyzed. In total, 15 works from 2018 to 2023 were included in the review.

**Results**

The review of clinical studies focused mainly on comparison of interdisciplinary home rehabilitation with conventional methods. Physiotherapy is particularly important in the recovery of patients after hip fracture. No significant difference was shown between the use of multidisciplinary therapy and classical physiotherapy in combination with in-hospital geriatric care.

**Conclusions**

The analyzed papers do not clearly indicate which form of rehabilitation should be considered most effective for elderly patients after hip fracture. Physiotherapy and Transcutaneous Electrical Nerve Stimulation play a crucial role in re-establishing mobility and improving quality of life. Chronically bed-ridden patients represent a group for whom the development of newer rehabilitation methods is particularly important. There is a need for further research into the methods and improvement of those currently in practice.

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**Keywords:** hip fracture, rehabilitation, ADL, physiotherapy, TENS

## STRESZCZENIE

### Wstęp

W związku ze starzeniem się społeczeństwa złamanie biodra staje się jednym z głównych problemów medycznych, socjalnych i ekonomicznych. Zwiększone ryzyko złamania dotyczy kobiet w starszym wieku. Wczesne leczenie operacyjne, przeprowadzone przed upływem 48 godzin, uważa się za złoty standard. Rehabilitacja pooperacyjna również odgrywa znaczącą rolę w odzyskiwaniu sprawności przez pacjentów.

### Cel

Celem niniejszego artykułu jest porównanie skuteczności metod rehabilitacyjnych, obejmujących fizjoterapię i sposoby alternatywne, stosowanych po leczeniu operacyjnym u pacjentów ze złamaniem biodra.

### Materiał i metody

Analizie poddano dostępne w bazie PubMed publikacje dotyczące skuteczności różnych metod rehabilitacji po złamaniu biodra. Łącznie w przeglądzie uwzględniono 15 prac z lat 2018–2023.

### Wyniki

Przegląd badań klinicznych koncentruje się głównie na porównaniu interdyscyplinarnej rehabilitacji domowej z metodami konwencjonalnymi. Fizjoterapia ma szczególne znaczenie w powrocie do zdrowia pacjentów po złamaniu biodra. Nie wykazano istotnej różnicy między stosowaniem terapii multidyscyplinarnej a fizjoterapii klasycznej w połączeniu ze szpitalną opieką geriatryczną.

### Wnioski

Przeanalizowane prace nie wskazują jednoznacznie, która forma rehabilitacji powinna być uznana za najskuteczniejszą u starszych pacjentów. Fizjoterapia oraz przezskórna elektryczna stymulacja nerwów odgrywają istotną rolę w odzyskiwaniu sprawności ruchowej i poprawie jakości życia. Szczególnie ważną kwestię stanowi rozwój nowszych metod rehabilitacji ukierunkowanych na pacjentów przewlekle leżących. Ze względu na niejednoznaczne wyniki, niezbędne jest kontynuowanie badań nad nowymi metodami i udoskonalanie tych, które są obecnie stosowane.

**Słowa kluczowe:** złamanie szyjki kości udowej, rehabilitacja, ADL, fizjoterapia, TENS.

### Introduction

Hip fracture is a common problem among the elderly people and thus has a major impact on length and quality of life for seniors. Worldwide, nearly 1.6 million hip fractures occur annually. However, there is a forecast that by 2050 this number may reach even 6.3 million (Liu *et al.*, 2021). According to the latest research, it is estimated that approximately 300.000

patients in the USA, 45.000 patients in Spain and 20.000 patients in Poland are treated for hip fractures annually (Tsitko *et al.*, 2023).

Hip fracture leads to serious consequences for the individual, as it can lead to disability and higher mortality. It also has a huge impact on the health service and society as a whole, mainly for economic and social reasons.

Mortality within one year after the fracture is 20–40%, predominantly in male patients (Tsitko *et al.*, 2023). About 33% of men and 22% of women suffering from a hip fracture are expected to die within 1 year (Li *et al.*, 2021).

Risk factors for hip fracture may be divided into modifiable and non-modifiable. Gender, age, low socio-economic status, family history of femoral neck fracture classify as non-modifiable risk factors. Women over the age of 85 are 10 times more likely to suffer a fracture than those aged 60–65. In contrast, modifiable risk factors for hip fracture include reduced bone mineral density, falls and chronic drug use. A bone mineral density with T-score less than -2.5 is associated with an increased risk of fractures. A lower T-score may be due to insufficient calcium and/or vitamin D supplementation as well as positive osteoporotic family history. Drugs that may increase the risk of falls include high levothyroxine doses, long-term therapy of proton pump inhibitors, benzodiazepines and selective serotonin reuptake inhibitors (Tsitko *et al.*, 2023).

Studies show that 30% of hip fractures occur in nursing homes, and this percentage is likely to increase due to the growing population over the age of 80 requiring constant care (Baek *et al.*, 2023).

There is a relationship between the risk of death after hip fracture and the general condition before the injury. The survival rate is negatively affected by: the presence of chronic diseases (e.g. renal and heart failures, diabetes, anemia, cancer), high ASA score, dementia and poor functional status before fracture (Xu *et al.*, 2019).

Due to the fact that the number of elderly patients with osteoporotic fractures is increasing, and this type of hip fracture seriously affects the quality of life and even survival rates of seniors, researchers are trying to find out which method of rehabilitation and treatment is the most effective. Early surgical treatment is recommended for hip fractures. Some guidelines advise surgery within 48 hours in order to decrease the risk of prolonged bed rest and mortality after

operation (Zhu *et al.*, 2022). The difficulty in the treatment of such fractures is associated with the coexistence of multimorbidity and polypharmacy in elderly patients (Henriksen *et al.*, 2023). The role of rehabilitation in the postoperative period is also worth emphasizing (Zhu *et al.*, 2022).

This article aims to compare the effectiveness of rehabilitation methods and other interventions after surgical treatment, as well as to find the “gold standard”.

### Materials and methods

For the literature review, the PubMed database was searched for the period from 2018 to June 2023. Key words such as: hip fracture rehabilitation OR femoral neck fracture rehabilitation OR femoral trochanteric fracture rehabilitation were used. The “free full text”, “Clinical Trial” and “Randomized Controlled Trial” filters were applied and 74 articles were identified. Only studies in English were selected. The papers that did not include methods of rehabilitation in patients with hip fracture were rejected. Finally, 15 articles matched the requirements.

### Results

The results of literature review are presented in a table (Table 1).

#### Scales

Barthel Index for Activities of Daily Living (Barthel ADL) is used to assess and monitor the activity status of rehabilitated patients with chronic disabilities. The ability to perform basic activities of daily living, such as bathing, toileting, dressing, eating, continence, walking, grooming, and stair climbing is assessed. The score varies depending on whether the patient performs the activity independently or with the help of another person. Obtaining 0 points is tantamount to dependence in all of the assessed activities, and 100 points indicates full independence (Cech *et al.*, 2012).

Katz Index of Independence in Activities of Daily Living Scale (Katz ADL) assesses basic activities of daily living of older patients

**Table 1.** Results of the literature review.

Study	Patients	Age range (years)	Mean age (years) (* median age)	% Female	Duration of intervention	Rehabilitation methods	Results	Assessment tools
Taraldsen <i>et al.</i> (2019)	143 (IG-70, CG-73)	≥70	83.4 (IG = 84.0 CG = 82.7)	69.20%	10 weeks	IG: routine treatment and rehabilitation + 20 sessions (10 weeks) structured, home exercise targeting gait and balance CG: routine treatment and rehabilitation	The intervention group improved over the control group in: Preferred GS: Mean change from T1 to T2: 0.09 m/s (p = 0.001) Mean change from T1 to T3: 0.07 m/s (p < 0.009) SL Mean change from T1 to T2: 3.85 cm (p = 0.001) Mean change from T1 to T3: 3.71 cm (p = 0.002) SPBB Mean change from T1 to T2: 1.4 points (p < 0.001) Mean change from T1 to T3: 1 points (p = 0.017) The intervention group improved over the control group in: ADL, upright time, cognitive function, health-related quality of life T1 – allocation (week 16–18) T2 – follow up (week 28–30) T3 – follow up (week 48–56)	electronic walkway, SPBB, IADL, MMSE, CDR, EQ-5D-3L
Karlsson <i>et al.</i> (2020a)	205 (IG-107, CG-98)	≥70	82.9 (IG-83.2 CG-82.6)	71.70%	max. 10 weeks	IG: GIHR CG: in-hospital geriatric care	In terms of ADL no difference between IG and CG was found	BI, Katz ADL Index, ADL Staircase
Magaziner <i>et al.</i> (2019)	210 (IG-105, CG-105)	≥60	80.8 (IG – 80.3, CG – 81.2)	76.70%	16 weeks	IG: included aerobic strength, balance, and functional training. CG: TENS + active range-of-motion exercises	Community ambulation: IG – 22.9% CG – 17.8%	an ability to walk 300 m or more in 6 minutes
Berggren <i>et al.</i> (2019)	205 (IG – 107, CG – 98)	≥70	82.9 (IG – 83.2, CG – 82.6)	71.70%	12 months	IG: GIHR CG: conventional geriatric care and rehabilitation	Complications: 53.8% (IG) vs 47.3% (CG) (p = 0.443) Falls: IG: 43.4% (IG) vs 40.9% (CG) (p = 0.828) Readmission: 35.8% (IG) vs 29.0% (CG) (p = 0.383) Mediana całkowitej liczby dni spędzonej w szpitalu: 11.5 days (IG) vs 11.0 days (CG) (p = 0.353)	Complications, readmissions, and days of hospitalization were registered from patients' digital records and interviews

**Table 1 (cont.)** Results of the literature review.

Study	Patients	Age range (years)	Mean age (years) (* median age)	% Female	Duration of intervention	Rehabilitation methods	Results	Assessment tools
Soukkio <i>et al.</i> (2022)	121 (IG-61, CG-60)	≥60	81 (IG-83, CG-80)	75.00%	12 months	IG – home-based supervised, progressive exercise program CG – conventional rehabilitation	Mean IADL score: 17.1 (IG) vs 17.4 (CG) Mean SPPB score: 3.9 (IG) vs 4.2 (CG) Mean Handgrip strength [kg]: 17.7 (IG) vs 20.8 (CG)	IADL score, SPPB score, Saehan dynamometer
Schemitsch <i>et al.</i> (2020)	332 (IG-243, CG-89)	55 to 94	79 in IG, 78 in CG*	68.70%	12 weeks	IG – romosozumab s.c. 70/140/210 mg 1st day/2/6/12 weeks after surgery CG – placebo	TUG score – no significant differences between IG and CG over weeks 6 to 20 (p = 0.198) The median time to radiographic evidence of healing – 16.6–16.9 weeks (IG), 16.4 weeks (CG) RUSH score – no significant differences between IG and CG	TUG score, time to radiographic evidence of healing, RUSH score
Howell <i>et al.</i> (2023)	32 (IG1-11, IG2-10, CG-11)	56 to 95	85 *	78.10%	IG1: 58 days, IG2: 77.5 days, CG: 80.5 days	IG1 – HIFE program IG2 – HIFE program + IMU CG – individually tailored standard rehabilitation	Balance (assessed by postural sway) – no significant improvement in any group. Improvement in all groups: functional balance (p = 0.011–0.028), activity of daily living (p = 0.012–0.027), HRQoL (p = 0.017–0.028). No significant differences between groups.	IMU, Functional Balance Test for Geriatric Patients (FBG), BI, EQ-5D
Ortiz-Piña <i>et al.</i> (2021)	71 (IG-35, CG-36)	≥65	IG-75.86, CG-80.38	74.60%	12 weeks	IG – tele-rehabilitation (instructional videos, written instructions and caregivers supervision) CG – standard post-surgery rehabilitation	IG – higher FIM score, better TUG performance, No significant differences between IG and CG in SPPB.	FIM, TUG, SPPB
Kim <i>et al.</i> (2020)	34 (IG-17, CG-17)	n/a	IG: 48.82, CG: 51.82	23.50%	4 weeks	IG: 20 min of anti-gravity treadmill training five times per week. CG: 20 min of conservative rehabilitation five times per week	Significant improvement in isokinetic muscle strength, endurance of hip flexors and extensors in both groups (p < 0.05); No significant differences between IG and CG (p > 0.05) except for muscle strength of the hip extensor. Increase in activity of VL, VM, GM, and Gm muscles before and after the intervention (p < 0.05). Significant differences in muscle activities of GM (d = 2.64, p < 0.001) and Gm (d = 2.59, p < 0.001) between IG and CG.	Isokinetic Strength Measurement (The BTE Primus RS kinetic test evaluation device), Muscle Activities (four-channel electromyography (EMG) with Clinical Direct Transmission System(DTS)

**Table 1. (cont).** Results of the literature review.

Study	Patients	Age range (years)	Mean age (years) (* median age)	% Female	Duration of intervention	Rehabilitation methods	Results	Assessment tools
Karlsson et al. (2020b)	205 (IG- 107 [57 with dementia], 50 without dementia), CG-98 [46 with dementia, 52 without dementia]	≥ 70	82.9	71.70%	max.10 weeks	IG – GIHR CG – In-hospital rehabilitation	Falls, postoperative hospitalization length, readmissions, mortality in 1st year after discharge, ambulation ability at 3 months and 1 year – no significant differences in dementia patients with GIHR and dementia patients in CG	postoperative length of stay, falls rate, readmissions rate, mortality in 1st year after discharge, walk ability in 3 and 12-months, BI, Katz ADL Index.
Elboim-Gabyzov et al. (2019)	41 (IG-23, CG-18)	> 50	79.3 (IG- 80.26, CG-78.06)	78.00%	5 days	IG – active TENS + rehabilitation CG – sham TENS + rehabilitation	IG – significantly higher reduction of pain intensity during walking ( $p < 0.001$ ), increase in ambulation distance and mobility level compared to CG. IG and CG – lesser intensity of pain at rest and night, no significant differences between groups.	intensity of pain NRS FAC; two-minute walk test)
Crotty et al. (2019)	240 (IG-121, CG-119)	≥ 70	88.6	74.20%	4 weeks	IG – postoperative rehabilitation program CG – usual care	IG – mobility improvement after 4 weeks compared to CG (NHLSD mean difference - 1.9; $p = 0.0055$ ), no differences in quality of life. Quality of life increase in patients in IG was observed after 12 months (DEMQOL sum score mean difference = - 7.4; $p = 0.0051$ )	NHLSD, DEMQOL
Jinli-Guo et al. (2019)	79 (IG-39, CG- 40)	> 65	IG – 74.1, CG-75.1	59.50%	4 weeks	IG – upper-body yoga CG – abdominal breathing training	FVC% – 78.83% (IG) vs 72.20% (CG), $p = 0.016$ PCF – 216.16 L/min (IG) vs 194.95 L/min (CG), $p = 0.008$ , BI – 70.77 (IG) vs. 65.75 (CG), $p = 0.019$	Spirometer tests, BI
Hulsbæk et al. (2019)	23 (IG-12, CG-11)	62–85	73.4	78.00%	12 weeks	IG – anabolic steroid (nandrolone decanoate), physiotherapy, protein-rich nutritional supplement CG – placebo, physiotherapy, protein-rich nutritional supplement	Non – significant difference in mean knee-extension strength in fractured leg – 0.61 Nm/kg (IG) vs 0.50 Nm/kg (CG)	Change in maximal isometric knee-extension strength (Nm/Kg) measured by a belt fixated handheld dynamometer
Sherrington et al. (2020)	336 (IG-168, CG-168)	59–99	78	76.00%	12 months	IG – individualized physiotherapist-prescribed program CG – usual care	Mean between-group difference – no statistically significant differences SPPB 0-3 scale – 0.08 points ( $p = 0.08$ , $n = 273$ ), AM-PAC 0-200 scale – 0.18 points ( $p = 0.91$ , $n = 270$ ), LLDI 0-200 scale – 1.37 points ( $p = 0.49$ , $n = 273$ )	SPPB, AM-PAC, LLDI

Abbreviations: IG – intervention group; CG – control group; F – female; M – male; GS – gait speed; SL – step length; SPPB – Short Physical Performance Battery; I-ADL, Basic and Instrumental ADL; MMSE – Mini-Mental State Examination; CDR – Clinical Dementia Rating; EQ-5D-3L – EuroQoL-5 dimension-3L; GIHR – Geriatric Interdisciplinary Home Rehabilitation; BI – Barthel Index; TENS – Transcutaneous Electrical Nerve Stimulation; TUG – Timed 'Up & Go'; RUSH – Radiographic Union Scale for Hip; IMU – Inertial Measurement Unit; HRQoL – Health-related Quality of Life; FIM – Functional Independence Measure; VL – vastus lateralis; VM – vastus medialis; GM – gluteus maximus; Gin – gluteus medius; NRS – Numeric Rating Scale; FAC – Functional Ambulation Classification; NHLSD – Nursing Home Life-Space Diameter; DEMQOL – Dementia Quality of Life; FVC% – Forced Vital Capacity; PCF – Peak Cough Flow; AM-PAC – Activity Measure Post Acute Care; LLDI – Late Life Disability Instrument.

in the community and all care settings. It assesses the need for assistance in bathing, eating, dressing, transfer, toileting and continence (Arik *et al.*, 2015).

The Lawton Instrumental Activities of Daily Living (IADL) Scale takes into account the patient's capacity to perform eight activities, which include doing laundry, using the phone or handling finances. Obtaining a low score may indicate impairment in daily functioning and a need for a deeper evaluation (Graf *et al.*, 2008).

The Short Physical Performance Battery (SPPB) test is used to assess the physical activity of patients and allows the identification of people at particular risk of disability and difficulties in performing basic life activities. It evaluates three physical activities: maintaining balance in three positions, walking speed for a short distance at a normal pace and getting up five times from a chair without the help of the upper limbs. Each task is scored from 0 to 4 points, and in total the patient can score from 0 to 12 points. Obtaining 12 points indicates the best physical capacity. A low score on the test is a risk factor for future mobility problems, disability, hospitalization and death (Zasadzka *et al.*, 2013).

The Functional Balance Test for Geriatric Patients (FBG) assesses the patient's mobility during 4 activities, such as walking, turning, sitting and standing up as well as maintaining a standing position. Each activity is scored on a scale from 0 to 6, and the test's maximum number of points is 24 (Howell *et al.*, 2023).

The EuroQol 5 Dimension (EQ5D) consists of an assessment on a 5-point scale of 5 dimensions: mobility, anxiety or depression, self-care, pain or discomfort and usual activities. In addition, patients assess their health using the Visual Analogue Scale (VAS). The score on the scale ranges from 0 (death) to 1 (full health) and reflects the patient's state of health in comparison to the health status of the population of a specific region (Howell *et al.*, 2023).

The Timed Up and Go (TUG) test consists in measuring the time in which the patient

gets up from the chair, walks a distance of 3 meters and then returns and sits back on the chair. The patient wears his comfortable shoes and may use walking aids. If the duration of these activities is greater than or equal to 13.5 seconds, this may indicate an increased fall risk (Barry *et al.*, 2014).

The Radiographic Union Score for Hip (RUSH) was designed to assess the radiographic fracture healing in femoral neck after surgeries. It is important to identify unhealed fractures to assess the need for further surgery in the patient (Frank *et al.*, 2016).

The Functional Independence Measure (FIM) assesses the need for help from others in performing specific 18 activities (such as self-care, continence, mobility, social cognition). Each activity is scored from 1 (complete dependence) to 7 (complete independence) points. The total score ranges from 18 points to 126 points (Ribeiro *et al.*, 2017).

Dementia Quality of Life Measure (DEMQOL) is a patient reported outcome measure, which is designed to enable the assessment of health-related quality of life of dementia patients. In DEMQOL 28 questions on health, well-being, daily activities, cognitive function, social contacts and self-perception are answered (Hendriks *et al.*, 2019).

#### *Training programs*

The Otago Exercise Program is usually performed at the patient's place of residence and its purpose is to prevent falls. It is based on walking as well as exercises to strengthen the muscles and improve balance (Martins *et al.*, 2018).

The High-Intensity Functional Exercise (HIFE) program is aimed at increasing the strength of lower limbs, as well as improving the balance and mobility (Sondell *et al.*, 2019).

Transcutaneous electrical nerve stimulation (TENS) is a method of pain relief involving the use of an electrical current in order to block the transmission of pain signals (Vance *et al.*, 2014).

## Discussion

The study by Taraldsen *et al.* (2019) analyzed the effect of an additional 10 weeks of home rehabilitation on a patient's preferred gait speed. Gait speed was measured in m/s using an electronic walkway. Training program focused on muscle strength and included exercises such as lunges, sit-to-stand and box step-ups. The main outcome of the trial was gait speed. The provided intervention confirmed the effectiveness of the training plan and resulted in improvement of preferred gait speed in the trial group. In addition, the study showed no increase in total health care costs in the intervention group.

Karlsson *et al.* (2020a) studied the effect of early patient discharge along with geriatric interdisciplinary home rehabilitation (GIHR) on activities of daily living (ADL). The control group consisted of patients receiving rehabilitation in the hospital. The exercise plan for the study group was individualized and tailored to the needs of each patient. It included elements of the High-Intensity Functional Exercise (HIFE). The primary outcome, which was the independence of ADL, was measured using the ADL Barthel Index and ADL Staircase. In both study groups, patients regained independence in ADL after 3 and 12 months. No significant differences were observed between groups.

A trial conducted by Magaziner *et al.* (2019) tested the effects of 16 weeks of multicomponent physical therapy on the ability to walk 300 m or more in 6 minutes. The training in the study group included elements such as endurance, strength, balance and lower limb function. General home-based exercises and transcutaneous electrical nerve stimulation (TENS) were performed in the control group. The ability to walk in the community was regained by 22.9% and 17.8% of the study group and control group, respectively. The results represent no statistically significant difference in the intervention's effectiveness in the two groups.

Berggren *et al.* (2019) aimed to verify whether interdisciplinary home rehabilitation

would reduce the number of complications, rehospitalization risk, falls risk and the total number of days of hospitalization compared to standard rehabilitation. The therapy included elements of the HIFE program. The ability to walk inside and outside the house was targeted as well. There was no significant difference in trial results between study and control groups in terms of complications, rehospitalization rates or length of hospitalization.

Soukkio *et al.* (2022) in their study focused on the effect of a 12-month supervised home-based training program on the post-hip fracture patients' performance. The exercise program introduced in the study group was based on OTAGO training. The control group consisted of patients receiving standard rehabilitation. The intervention group showed improvements in IADL score, SPPB and grip strength compared to standard rehabilitation.

Howell *et al.*'s (2023) study tested the effectiveness of HIFE. Patients were divided into 3 groups. Of these, one was the control group, and the other two included patients qualified for the HIFE program. In addition to HIFE training, one of the study groups was controlled with an inertial measurement unit (IMU) which measures movement and body position. All three groups also were assisted by a physiotherapist who modified and tailored exercises to the patient's needs during home visits. Improvements were obtained in FBG, BI and EQ5D parameters in all groups, but without significant differences between them. Also, no group showed significant improvement in balance.

Karlsson *et al.* (2020b) studied the impact of interdisciplinary home-based rehabilitation in patients with dementia after hip fracture. The control group patients received interdisciplinary in-hospital rehabilitation. Participants of the intervention group after interdisciplinary rehabilitation at hospital when no medical contraindications were present have been discharged home. After discharge, they underwent home-based personalized rehabilitation which includes elements such as ADL training, walking exercises and functional



strength and balance compliant with HIFE program. No differences in patients with dementia in study and control groups in terms of falls, postoperative hospitalization length, readmissions, ADL, mortality 1 year after hospital discharge, and the ability to walk after 3 months and after a year were found.

Crotty *et al.* (2019) aimed to study the effectiveness of 4-week post-operative rehabilitation provided at Nursing Care Facilities. Physiotherapy program followed by the intervention group's patients included mobility and muscle strength training. After 4 weeks, increased mobility was achieved in the study group compared to the control group, but no change in quality of life was observed. After 12 months of the study, patients' quality of life measured by the DEMQOL scale was higher in the study group.

Sherrington *et al.* (2020) studied the effect of exercise on improving mobility impairment and reducing the risk of falls. Training was supervised by physiotherapists, who monitored and adjusted the exercise program over a 12-month period. The training plan consisted of lower limb balance and strengthening exercises. Participants were asked to exercise three times a week for 20–30 minutes. There were no significant differences between the groups in terms of mobility improvement and fall risk.

In Schemitsch *et al.* (2020) study the effect of Romosozumab subcutaneous injections at different doses was tested. The results of the treatment used were verified by the TUG score and the RUSH score. These two parameters increased in the drug-receiving group as well as in the placebo group. However, the differences between the groups were not significant. The time to radiological evidence of bone regeneration was similar in both groups.

Hulsbæk *et al.* (2021) tested the effect of anabolic steroid use combined with training and nutritional supplement in hip-fracture patients' rehabilitation. Both, the control and research groups, received identical physiotherapy and nutritional supplementation.

In the research group, Nandrolone Decanoate was additionally used. The efficacy of the method in terms of change in maximal isometric knee-extension strength was measured in Nm/Kg using a belt-fixed handheld dynamometer. Non-significant differences between both groups in knee extension strength after the inclusion of anabolic steroid have been found.

Elboim-Gabyzon *et al.* (2019) studied the effectiveness of TENS on mobility and post-operative pain in patients after hip fracture. Both the control and study groups received standard postoperative treatment including the 30 minute physiotherapy. The exercise program consisted of balance, transfer, lower limb and ambulance training. Additionally, the active TENS and sham TENS were provided in study and control groups, respectively. The ambulation distance and mobility increased in the study group. The pain while walking was reduced as well, in comparison to the control group. No effect of active TENS on pain alleviation at rest and night was proven.

Jinli-Guo *et al.* (2019) in their study aimed to test the effectiveness of "upper-body yoga" in elderly patients after hip fracture. The therapy included elements of breath training and slow stretching movements. In short-term results, after 1 week, values of PCF and BI were higher in the study group. After 4 weeks of training the FVC%, PCF, BI increased in the intervention group. The authors noted that upper body yoga may provide a specific method for improving the function of immobilized patients after femoral neck or trochanteric fracture.

In Ortiz-Piña *et al.* (2021) trial the effectiveness of telerehabilitation and rehabilitation at home on the patients' functioning after hip fracture was compared. Both the control and research groups received usual hospital care. Tele-rehabilitation group consisted of patients' receiving three exercise sessions and two occupational therapy sessions. The online program was based on tutorial videos and written instructions. The training plan included balance, strengthening and cardiovascular exercises. The occupational

component included videos presenting advice on how to carry out everyday activities and avoid falls. The control group after discharge received usual in-person rehabilitation at home. Patients using the tele-rehabilitation program had better performance on the TUG and a higher FIM score. The SPPB score was not significantly different in the two groups.

Kim *et al.* (2020) studied the impact of 4-week training on an anti-gravity treadmill on isokinetic muscle activity and strength in post-hip fracture surgery patients. An anti-gravity treadmill by using an air pressure control system eases the impact on lower limbs during training. The control group received the conservative rehabilitation. Both groups showed significant improvement in isokinetic muscle strength and endurance of the hip extensors and flexors. However, there were no between-group differences except in hip extensor muscle strength. The activity of the tested lower limb muscles increased after the intervention. In contrast, significant differences between the groups were observed only in the activity of the gluteus maximus and gluteus medius muscles.

### Conclusions

Most studies have concentrated on the comparison of interdisciplinary home rehabilitation with standard rehabilitation. Analyzing the above studies, physiotherapy has a significant role in the recovery of patients after hip fracture. However, not much difference is observed between multidisciplinary therapy and standard physiotherapy and geriatric care provided in the hospital and after discharge. Long-term physical rehabilitation seems to be more effective compared to short-term exercises. It is worth noting that the effectiveness of exercises performed by the patient at home may be improved by instructional videos.

Romozosumab and steroid therapy have not proven effective. Functioning of patients after hip fracture may be improved by alternative methods such as TENS and “upper body yoga”. The latter is particularly useful

in chronically bed-ridden patients who are unable to perform the conventionally recommended exercises. Home rehabilitation may also be complemented by an antigravity treadmill, which in Kim *et al.* (2020) research has been shown to be effective in improving hip extensor and gluteal muscle strength.

Due to ambiguous study results and insufficient number of studies, it is not possible to determine the effectiveness of the analyzed methods. There is a need for further clinical studies to find suitable rehabilitation methods to improve the condition of post-fracture patients.

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