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Impact of rigorous muscle strength and power training on mobility among individuals with hip fractures: A randomized controlled trial

Velmurugan Varadharajan [1,*] and Pavithran Venkatesan [2]

[1] *Department of Orthopaedics, School of Physiotherapy, Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry, India.*
[2] *Department of Neurology, School of Physiotherapy, Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry, India.*

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Abstract

Patient's mobility is not restored to pre-fracture levels until two years following a fractured hip. A persistent weakness in the muscles on the fractured leg may contribute to mobility limitations. A randomized controlled trial was conducted on individuals with hip fractures aged 60-85 to examine the effect of strength and power training twice a week on mobility. A random assignment was made between a 46-person intervention group and a 40 person control group. Over a period of twelve weeks, strength training was conducted twice per week under supervision. All measurements were conducted by a blinded measurer. We assessed mobility by timing the time it takes to climb stairs, get up from a chair, and walk. To analyze the data, we used intention-to-treat analysis. A study of efficacy was conducted for subjects who adhered to training more than 50% of the time (n = 40). 4 of the controls did not show a statistically significant improvement in mobility ($p < 0.001$). Training had no significant effect on walking time or TUG. During the efficacy analysis, the average chair rise time for the exercise group improved by 5.4% ($p < 0.005$). The results of intense muscle strength and power training were observed in self-reported improvements in mobility. Participants with higher training compliance had an improved chair rise rate.

Keywords: Exercise training; Hip fractures; Mobility; Muscle strength; Power training

1. Introduction

Over the past four decades, global peoples have experienced an increase in hip fractures, burdening the healthcare system. There are several factors that increase the risk of hip fractures, including inactivity, women, osteoporosis, prior hip fractures, obesity, and weakness [1]. First-year hip fracture treatments can cost as much as 14,000 euros, while second-year hip fracture treatments can cost as much as 35,000 euros. People who have already suffered fragility fractures are at greater risk of further fractures [2]. Hip fracture limitations affect patients, their families, and the healthcare system in terms of mobility, disability, mortality risk, pain, and other disadvantageous effects. The rehabilitation of hip fractures requires consideration of different factors and rehabilitation methods.

As people age, their muscles should become stronger and more powerful (less), their balance should improve, and their interactions were significant contributors to mobility disabilities. A hip fracture leads to decreased mobility, physical capacity, and quality of life for at least 2 years after the fracture has healed up [3-5], and these decrements persist for at least 2 years [6]. About half of all hip fracture patients can't function independently outside four months after their fracture [7-10] and need a walking aid or somebody's support. When the fractured leg suffers from a persistent muscle weakness, range of motion may be limited.

* Corresponding author: Velmurugan Varadharajan

An analysis conducted by researchers, indicates that physical therapy, walking exercises, and intensive physical therapy are all effective methods of rehabilitation when it comes to mobility recovery after hip fractures. Muscle power can predict physical performance in older individuals and can improve mobility in older people [11, 12]. Research has shown that strength training was beneficial for older people with muscle weakness and mobility issues. Intense progressive resistance training has not been extensively studied with hip fracture patients. Over a period of 12 weeks, intensive strength and power training was conducted in order to evaluate the effect of this kind of training on mobility in older people with hip fracture histories. Through the training program, the fractured as well as unfractured sides gained strength and power.

2. Materials and methods

An analysis of the effects of resistance training compared with non-resistance training is presented in this study. Earlier reports [13, 14] described in detail how the subjects were recruited. Those enrolled in the study had a femoral neck or trochanteric fracture within 6 months to 7 years before baseline, to avoid potential confounding effects of acute recovery. Based on the Hospital patient records in 2022 and 2023, all 452 survivors of hip fracture were identified. Initially, all patients with dementia and those without persistent severe illnesses in Health Care center were informed of the study. Telephone interviews were conducted to ensure that they did not suffer from neurological disorders or lower limb amputations. As part of the baseline medical exam, the nurse and physician examined the participants for inclusion criteria. The study was declined by 14 out of 158 individuals. 52 subjects were also excluded from the study due to recent trauma or acute illness. A control group consisted of 12 men and 32 women, while an experimental group consisted of 46 men and women based on average age, gender, and gender average. As a result of personal reasons, one participant left the control group and another was dissatisfied with their randomization outcome. Personal reasons led to the withdrawal of one participant from the training group. The same protocol, infrastructure, and staff were used to obtain a larger sample size. As far as recruitment is concerned, only the area was expanded.

2.1. Measurements

An assessment of health needs. Base-line clinical examinations were conducted by a physician and a research nurse. Medical records, current prescriptions, and a questionnaire were used to determine chronic conditions, medication use, and surgery for hip fractures. Using the American College of Sports Medicine's exercise participation criteria, measurements were taken and strength training was implemented. Patients were blinded to their group assignment before and after the 12-week intervention. A measure of an individual's physical activity level and their anthropometry. A standard protocol was used in the laboratory to measure body height and weight. As part of the evaluation, a questionnaire on physical activity, was administered. Among the five weighted sub-indices of the physical activity dimension sum index, vigorous physical activity is scored especially well (weight 5), leisure walking is rated highly (weight 4), moving around is rated highly (weight 3), standing is rated highly (weight 2), and sitting is rated highly (weight 1). In each activity, the weights and frequency scores were multiplied.

For both legs, the maximal voluntary isometric knee extension strength was measured using a dynamometer chair. An ankle strain gauge was connected to a knee angle of 608 at full extension. In order to achieve the best results, it was encouraged for the leg to be extended as hard as possible. After two to three practice trials, measurement was repeated three times to determine if improvements were observed. There was a 30-second rest period between the trials. It was determined which leg had the best measured force. This leg was analyzed because it was the most forceful leg. According to our laboratory, the test-retest precision is 696% after 2 weeks.

2.2. Assessment of mobility

An online questionnaire was used to gather self-reported mobility changes. The exact question was:

'Is your mobility different now than it was in autumn? : As response alternatives, you had the option of saying something like: "my mobility has improved," "my mobility hasn't changed," or "my mobility has deteriorated [12].

Using timed-up-and-go (TUG), the system was measured for how fast it responds. TUG tests will require an individual to stand from a chair, walk approximately 2.44 meters, circle a cone, and return to the chair within a given amount of time. From a seated position (back against backrest to seated position) [13], a stopwatch was started by a "ready / go" command. This task could be performed by participants using a walking aid if they normally do so. The healthy lower extremity must be closest to the cone when turning in order to perform the test. Through the TUG test, mobility can be assessed in a reliable and valid manner. By comparing clinical changes, it is possible to assess clinical change.

Stability and safety were ensured by placing the chair near a wall. The seat height from the ground was 0.44m and it had no arms. The participants were required to hang their arms freely by their side and place their backs against the backrest. A completed chair rise consisted of standing up from a seated position, returning to a seated position, and then completing again. Next, five repetitions were to be performed as quickly as possible by the participant. Stopwatches were used to time the performance.

A standard flight of 10 stairs was used for this test, with handrails on both sides [14]. It was advised that participants should climb as quickly as possible, not run, in order to ascend the stairs safely. Walking aids and handrails could both be used if necessary. As soon as the participant began climbing the stairs, the stopwatch began and was stopped as soon as their first foot hit the tenth step. A walking aid or the left or right handrail was used. There has been a report of a 0.96 ICC of stair climbing time.

2.3. Walking time

During the lab corridor, a walking time of ten meters was measured. Photocells were used to measure participants' walking speed without compromising their safety. Participants were instructed to walk as quickly as possible while remaining safe. There was a three-meter acceleration allowance. ICC for maximum walking speed was reported to be 0.94–0.96 [15, 16].

2.4. Training program

For 12 weeks, physiotherapy supervision was provided twice a week at the senior gym. A 60-90 minute training session included a warm up (10 minutes) and cool down (5 minutes). Strengthening and increasing the power of the lower limbs was the focus of the training program. Strength and power exercises were included in every training session [17-19]. Among the exercises performed, leg press, knee extension, hip abduction, and adduction included pneumatic resistance equipment. Legs could be individually limited in their range of motion with the training equipment. Wearing a weighted vest helped increase ankle plantar flexion.

The first two training sessions introduced participants to the facility, equipment, and staff. An estimation of the maximum number of repetitions (RMs) was provided below. Throughout the course of training, training intensity was gradually increased as tolerated by each participant. Training resistance was adjusted accordingly based on the assessment conducted in weeks 6-8. An intensive training program was conducted on the weaker leg. Baseline tests were done to determine the weaker leg's strength, force production rate, power and maximal leg extension. At least three of the measures had lower values in the weaker leg (usually the fractured leg).

A total of 24 repetitions of leg press and ankle plantar flexion power exercises were performed at the beginning of the training session. A rapid and low-resistance concentration was performed. The leg press exercise was performed three to four times with a resistance of forty to fifty percent of one repetition maximum for each leg. A weighted vest with 0% of body weight added to the ankle joint was used to perform ankle plantar flexion exercises on both legs in two to three sets.

Weak legs should be trained in pairs or three sets of 16 repetitions. Strong legs can be trained with 20 repetitions. Strength exercises were performed at a slower pace and with fewer repetitions. Exercises that target weaker legs were constructed using 60 - 80% of their 1RM for leg presses, knee extensions, and hip abductions and adductions. After week 8, only 2 leg press strength exercise per week was required. An ankle plantarflexion exercise was performed with a weighted vest of 10 percent.

2.5. Statistical analysis

Analyzing the results was carried out using SPSS 13.0. When comparing baseline characteristics between groups, t-tests were used. We studied the training effect using analysis of covariance (ANCOVA) using intention-to-treat (ITT) principles. Furthermore, three participants were excluded from the efficacy analysis due to inability to extend their knees and low exercise compliance. Consequently, each exercise group and control group consisted of 20 subjects. The relative changes in mobility between pre- and post-trial were calculated by dividing the pre- and post-trial measurements by 100. The chi-square test was used to analyze self-reported mobility changes.

3. Results

According to **Table 1**, the study groups had the following characteristics at baseline. The groups were not significantly different except for fractures fixed surgically (p <0.001). 32 of the exercise group participants received prostheses while 14 received screws or nails. A control group of 32 and 8 had the corresponding numbers.

Table 1 Patients with hip fractures aged 60-85 years (mean, SD)

	Exercise group	**Control group**	
	n =46	**n =40**	**p-value**
Age	64 (12)	64 (14)	0.89
Weight	61 (22)	63 (26)	0.58
Height	153 (18)	155 (18)	0.37
Body mass index	27 (8)	27 (8)	0.87
Physical activity	30 (40)	43 (38)	0.68
Number of diseases	6 (2)	4 (2)	0.09
Number of medications	8 (6)	6 (6)	0.18
Fracture (in yrs)	6.4 (4.2)	6.4 (2.4)	0.99

Participants were complying with exercise at an average rate of 87%. The maximal knee extension strength increased from 289 N in the exercise group to 318 N in the control group, whereas it decreased in the exercise group from 269 N to 262 N (SD=89 N). In **Table 2**, we describe how self-reported mobility has changed. The number of people reporting improved mobility during the intervention period was 28 out of 40 (p<0.002).

Table 2 Observations of changes in mobility after 12 weeks of exercise and control

	Exercise group ***n*=46**	**Control group** ***n*=40**
Improved (*n*=32)	28	4
Remained same (*n*=42)	12	30
Decreased (*n*=6)	6	6

Time to rise from chair, stair climbing, and walking effects are shown **Table 3.** According to the ITT analysis (including all participants), training did not have statistically significant effects on measurements. A chair rise time of 2.2 seconds was only observed in those with over 50% compliance (efficacy analysis).

Table 3 Patients with hip fractures aged 60-85 years were studied for their mobility test performance after strength and power training: Means and standard deviations

	Baseline	**End**	**Baseline**	**End**	**Difference in change**	**95% CI**	**p-value**
ITT analysis	**(n =46)**		**(n =40)**				
TUG (s)	8.9 (4.4)	8.9 (4.6)	10.3 (4.5)	9.9 (3.6)	0.28	(—0.6 to 0.1)	0.63
Chair rise time (s)	14.7 (5.8)	13.6 (4.6)	17.9 (9.1)	16.7 (5.6)	1.57	(—2.2 to 0.3)	0.06
Stair climbing time (s)	6.9 (1.6)	4.9 (2.7)	8.2 (1.8)	7.4 (2.7)	0.66	(—0.2 to 0.8)	0.16
Walking time (s)	8.3 (3.4)	8.0 (1.3)	8.7 (1.7)	8.0 (1.8)	0.56	(—0.2 to 0.7)	0.25
Efficacy analysis	(n =40)		(n =40)				

TUG (s)	8.8 (1.2)	8.6 (1.7)	9.3 (2.3)	8.9 (1.4)	0.15	(—0.9 to 0.8)	0.82
Chair rise time (s)	14.5 (30.7)	12.9 (3.8)	16.9 (2.0)	15.7 (3.3)	2.42	(—2.6 to —0.6)	0.004
Stair climbing time (s)	6.8 (0.7)	7.1 (0.1)	7.3 (3.8)	6.5 (1.7)	0.14	(—0.5 to 0.8)	0.32
Walking time (s)	8.1 (1.7)	6.9 (2.5)	6.6 (1.7)	6.0 (1.8)	0.08	(—0.6 to 0.8)	0.65

4. Discussion

A three-month exercise program that focused on Patients with hip fractures who enhanced their muscle strength and power reported greater mobility [20]. After participating in the training, over 60% of the subjects reported an improvement in their mobility. As well as this, participants with higher training compliance were able to rise from a chair more easily. Research indicates that exercise rehabilitation doesn't work well for patients who have hip fractures and have a limited range of motion. Muscle strength, power, and endurance training and exercises have shown to improve hip fracture patients' function and mobility [21]. Despite training improving functional motor performance, which failed to detect any improvement in gait following training after hip fractures and although walking improved mobility, no improvement in gait was detected after exercising after hip fractures. While self-reported mobility and chair rise time improved after training, walking and stair climbing did not. Interventions were typically conducted before 4 months after fracture for most study participants. To avoid confounding the acute effects of the fracture, we began training 3.5 years after it was sustained. Older people with limited mobility and reduced mobility had their lower limb muscles strengthened and powered to improve their mobility.

Patients undergoing physical therapy for hip fractures may benefit from muscle strength and power training. To rise from a chair or climb stairs effectively, you must have sufficient lower leg extension power that can generate force rapidly. Furthermore, muscle strength and power training increases the confidence of hip fracture patients in walking following surgery, in addition to improving muscle power and strength. Gains in mobility may boost exercise motivation and reduce the fear of falling.

The lower extremities must be strong and enduring, and balance and walking ability must be adequate for mobility tests. Walking ability and dynamic balance are especially assessed in the TUG test, whereas muscle strength and power are measured in the chair rise test. As fast as possible, five repetitions of the chair rise test were the only mobility test in which strength and power training was beneficial. Using chair rise tests was more accurate than using other mobility tests for measuring muscular strength and power [22]. There was a closed kinetic chain that occurs when a chair rises. Chair rises were similar to leg presses in that participants keep their legs on the ground. As opposed to a closed kinetic chain, an open kinetic chain activates muscles more evenly and instantly. Unlike the other mobility tests, the chair rise requires more static balance control. It was clinically relevant to improve chair rises, since they were important for daily living. A person who cannot rise from a chair unaided without assistance was at risk for future hip fractures [23]. Therefore, strength and power training regimens order to assist rehabilitated patients in maintaining their daily living abilities. Our study demonstrated the importance of both strength and power training.

It was likely that there was too little training in our study since participants trained twice a week. We also found that regular training had a greater effect on training effects than subjects who trained infrequently. The twice-weekly training schedule we offered our relatively healthy and mobile participants might have been too low for them, despite their hip fractures. Strength and power training significantly increased muscle strength of those who had not previously done it [24]. It is also possible to increase muscle strength by training only once a week.

As part of our training program, we did not include mobility exercises, and most strength and power exercises were performed sitting down. Although acquired muscle strength can be transferred to other movements besides those specifically trained, which conclude that there was only a limited transfer. The best muscle strength training would target each of the three factors according to the tests for strength, speed, and power [25]. The present study found no significant impact of muscle strength or power training on movement tests. With upright training and functional exercise, mobility can be further improved. In planning rehabilitation programs for patients with hip fractures, this should be considered. It was evident from this study that it has a number of strengths. The exercise intervention trial was randomized, controlled, and had few dropouts. The baseline and post-trial measurements were conducted by a physiotherapist blinded to group assignment. In addition, we would like to comment on how well the general training complemented the technical training. There was some strength to the study despite its limitations. All targets who met the inclusion criteria were enrolled in the study, despite only 86 participants meeting the inclusion criteria. Despite being clinically healthy, all participants in this study had good physical functioning, so the results cannot be generalized to all older hip fracture patients. Due to this, they had to undergo quite intensive strength and power training.

5. Conclusion

A study found that people with hip fractures aged 60-85 can increase muscle strength and improve mobility by exercising twice a week. In addition to exercise, muscle strength and power training can be beneficial to older patients after a hip fracture.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

All experiments were performed as per the recommendations of GCP/GLP guideline. The experimental protocol was approved by the Institutional ethics committee of Sri Lakshmi Narayana Institute of Medical Sciences (NO.IEC/C-P/7/2022).

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Kannus P, Niemi S, Parkkari J, Palvanen M, Vuori I, Ja¨rvinen M. Hip fractures in Finland between 1970 and 1997 and predictions for the future. Lancet. 1970, 353:6:802–5.

[2] Cummings SR, Nevitt MC, Browner WS, Stone K, FoX KM, Ensrud KE, et al. Risk factors for hip fracture in white women. Study of Osteoporotic Fractures Research Group. N Engl J Med. 1995, 332:767–73.

[3] Stevens JA, Olson S. Reducing falls and resulting hip fractures among older women. MMWR Recomm Rep. 2000, 31:3–12.

[4] Nguyen ND, Pongchaiyakul C, Center JR, Eisman JA, Nguyen TV. Identification of high-risk individuals for hip fracture: A 14-year prospective study. J Bone Miner Res. 2005, 20:1921–8.

[5] Nurmi I, Narinen A, Lu¨ thje P, Tanninen S. Cost analysis of hip fracture treatment among the elderly for the public health services: A 1-year prospective study in 106 consecutive patients. Arch Orthop Trauma Surg. 2003, 23:10:551–4.

[6] Cooper C, Melton LJ. Vertebral fractures. J Bone Miner Res. 1992, 20:1634–5.

[7] Kannus P, Sieva¨nen H, Palvanen M, Ja¨rvinen T, Parkkari J. Prevention of falls and consequent injuries in elderly people. Lancet. 2005, 26:1885–93.

[8] Visser M, Goodpaster BH, Kritchevsky SB, Newman AB, Nevitt M, Rubin SM, et al. Muscle mass, muscle strength, and muscle fat infiltration as predictors of incident mobility limitations in well-functioning older persons. J Gerontol A Biol Sci Med Sci. 2005, 60:324–33.

[9] Era P, Avlund K, Jokela J, Gause-Nilsson I, Heikkinen E, Steen B, et al. Postural balance and self-reported functional ability in 75-year-old men and women: A cross-national comparative study. J Am Geriatr Soc. 1997, 45:21–9.

[10] Rantanen T, Guralnik JM, Ferrucci L, Penninx BW, Leveille S, Sipila¨ S, et al. Coimpairments as predictors of severe walking disability in older women. J Am Geriatr Soc. 2001, 49:21–7.

[11] Magaziner J, Hawkes W, Hebel JR, Zimmerman SI, FoX KM, Dolan M, et al. Recovery from hip fracture in eight areas of function. J Gerontol A Biol Sci Med Sci. 2000, 55:498–507.

[12] Boonen S, Autier P, Barette M, Vanderschueren D, Lips P, Haentjens P. Functional outcome and quality of life following hip fracture in elderly women: A prospective controlled study. Osteoporos Int. 2004, 15:87–94.

[13] Magaziner J, Fredman L, Hawkes W, Hebel JR, Zimmerman S, Orwig DL, et al. Changes in functional status attributable to hip fracture: A comparison of hip fracture patients to community-dwelling aged. Am J Epidemiol. 2003, 157:1023– 31.

[14] Fredman L, Magaziner J, Hawkes W, Hebel JR, Fried LP, Kasper J, et al. Female hip fracture patients had poorer performance-based functioning than community-dwelling peers over 2-year follow-up period. J Clin Epidemiol. 2005, 58:1289–98.

[15] Rosell PA, Parker MJ. Functional outcome after hip fracture. A 1-year prospective outcome study of 275 patients. Injury. 2003, 34:7:529–32.

[16] Nevalainen TH, Hiltunen LA, Jalovaara P. Functional ability after hip fracture among home-dwelling at the time a fracture. Cent Eur Public Health. 2004, 12:211–6.

[17] Osnes EK, Lofthus CM, Meyer HE, Falch JA, Nordsletten L, Cappelen I, et al. Consequences of hip fracture on activities of daily life and residential needs. Osteoporos Int. 2004, 15:567– 74.

[18] Van Balen R, Essink-Bot ML, Steyberg E, Cools H, Habbema DF. Quality of life after hip fracture: A comparison of four health status measures in 208 patients. Disabil Rehabil. 2003, 25:507–19.

[19] Madsen OR, Lauridsen UB, Sørensen OH. Quadriceps strength in women with a previous hip fracture: Relationships to physical ability and bone mass. Scand J Rehab Med. 2000, 32:37–40.

[20] Handoll HH, Sherrington C. Mobilisation strategies after hip fracture surgery in adults. The Cochrane Database Syst Rev. 2007, 1.

[21] Fielding RA, LeBrasseur NK, Cuoco A, Bean J, Mizer K, Fiatarone MA. High-velocity resistance training increases skeletal muscle peak power in older women. J Am Geriatr Soc. 2002, 50:655–62.

[22] Miszko TA, Cress ME, Slade JM, Covey CJ, Agrawal SK, Doerr CE. Effect of strength and power training on physical function in community-dwelling older adults. J Gerontol A Biol Sci Med Sci. 2003, 58:171–5.

[23] Suzuki T, Bean JF, Fielding RA. Muscle power of the ankle flexors predicts functional performance in community-dwell- ing older women. J Am Geriatr Soc. 2001, 49:1161–7.

[24] Bean JF, Kiely DK, Herman S, Leveille SG, Mizer K, Frontera WR, et al. The relationship between leg power and physical performance in mobility-limited older people. J Am Geriatr Soc. 2002, 50:461–7.

[25] Mikkola T, Sipila¨ S, Portegijs E, Kallinen M, Ale´n M, Kiviranta I, et al. Impaired geometric properties of tibia in older women with hip fracture history. Osteoporos Int. 2007, 18:1083–90.