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Can the exercise-based and occupational therapy improve the posture, strength, and mobility in elderly Greek subjects with hip fracture? A non-randomized control trial

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Abstract

Objectives: The effects of a rehabilitation program on static balance, mobility, and strength of lower limbs in elderly fallers operated after a hip fracture and non-operated were studied. **Methods**: Ninety-one elderly (>65 years) were divided in two groups, the Operated Group (OG, 43 fallers) and the Non-Operated Group (NOG, 48 fallers). Posture during bipedal stance (30s), mobility (Up-and-Go, Falls Efficacy Scale, Berg Balance Scale) and isokinetic strength of several muscular groups in both limbs were evaluated before and after a rehabilitation intervention, consisting in 20 sessions (3 sessions/week) including kinesiotherapy and occupational therapy. **Results**: After intervention, the average velocity of Center of Pressure displacement decreased significantly for OG and NOG ($p<0.005$). Similarly, all other variables describing static balance, mobility ($p<0.05$) and isokinetic strength ($p<0.005$) were improved significantly for both groups. **Conclusions**: The applied intervention led to improvement in static balance, mobility, and strength of lower limbs after hip fracture. Physical and Rehabilitation Medicine physicians should prescribe evidence-based rehabilitation protocols in elderly fallers because they could show just as remarkable improvements as non-operated patients when the program is carefully designed.

Keywords: Aging, Hip fracture, Mobility, Posture, Rehabilitation

Introduction

Over one-third of the elderly experience at least one or more falls per year. Accidental falls result in possible injuries and long-term hospitalizations, while they are the leading cause of death in old age[1]. A number of studies have estimated 30% of those over 65 years of age and 50% of those over 85 years of age shall experience at least one fall during one year[2]. There are multiple factors that increase the risk of falling such as age[3], gender[4], obesity[5,6], and bone density loss[7]. Many falls result in fractures and also soft tissue injuries, longstanding pain, functional impairment, reduced quality of life, increased mortality, and excess in healthcare costs[2]. Nearly all patients with hip fractures are admitted to the hospital for care, and most hip fractures are treated surgically[8].

Rehabilitation interventions after total hip arthroplasty should contain well-chosen exercises, well described, adhere to basic exercise physiology to enhance recovery[9]. The aim is the control of pain, restoration of normal range of motion, strength, endurance, and neuromuscular control to achieve

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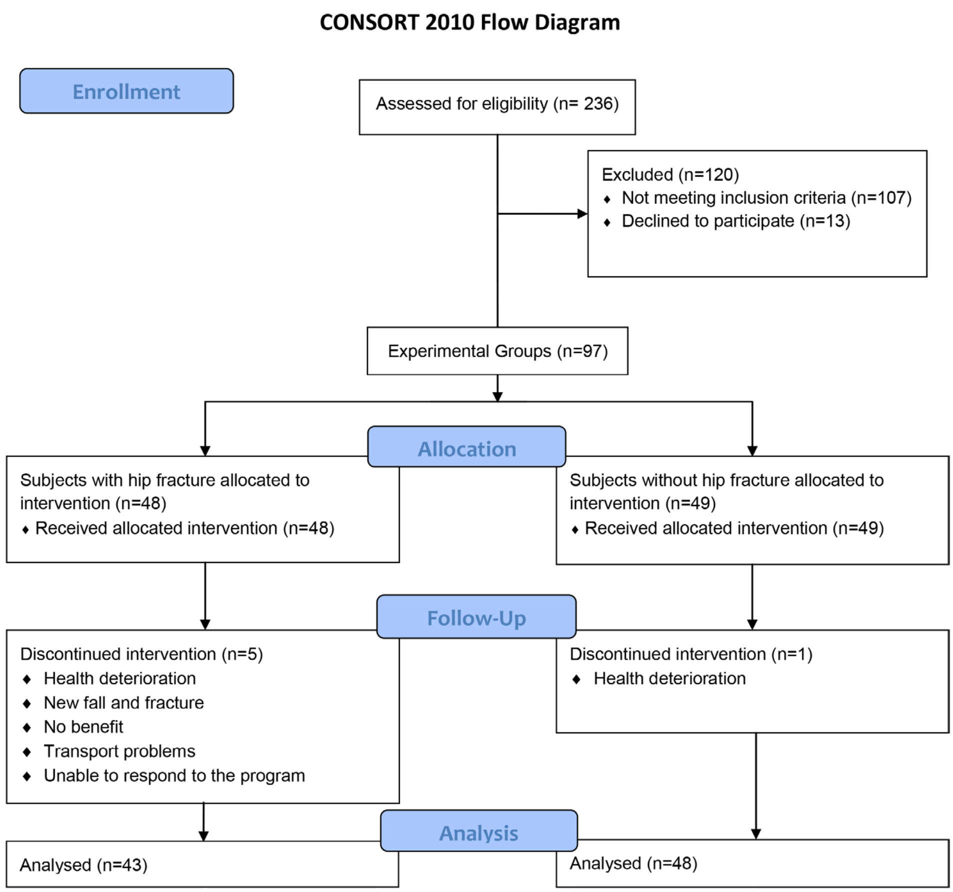

Figure 1. Flow Diagram of the study.

the optimum functional level and return to activities[10]. It was reported that extended supervised outpatient rehabilitation in elderly hip fracture patients with physical frailty results in improved physical performance and mobility, reduced disability, and improved quality of life[11]. Resistance training offers an effective way of increasing maximal muscle strength in elderly postoperative patients[12]. Physical modalities also can be used to relieve pain in musculoskeletal diseases or to stimulate tissue healing improving elderly patients' mobility, function, and quality of life[13]. There is high-quality evidence that postoperative rehabilitation programs, provided to elderly patients undergoing major joint replacement surgery, are well tolerated, safe and effective[14]. The recovery after a fracture is lengthy, and a relatively high number of patients do not manage to achieve preinjury levels of independence[15]. The length and intensity of rehabilitation after hip fracture is a topic of great importance. Studies have shown that long periods of rehabilitation improve function[8]. That is why, late postoperative rehabilitation programs can be very useful, and patients should be advised to comply with their exercise programs for at least one year after surgery[16]. There is a myriad of studies on the assessment of the risk of falls and balance disorders in the elderly, however, there is no clear information about the effects of a late rehabilitation program after hip fracture on postural control, mobility, and strength of the lower limbs.

Materials and Methods

Participants

Ninety-one old adults (>65 years) participated in a retrospective non-randomized control trial between April 2017 and May 2019. Six of them interrupted and resigned, for personal reasons. Ninety-one (91 males) fallers, with a history of at least one fall during the last year, divided into two groups, the Operated (after an intertrochanteric or femoral head or neck fracture) Group (OG, n=43) and the Non-Operated (they hadn't suffered any fracture) Group (NOG, n=48). As can be seen from the flow diagram (figure 1 near here), during the intervention process some participants discontinued for various reasons. Participants of the OG had a hip fracture and surgery at least 6 months

(8.7±2.2 months) ago (the intervention started within the second six months after surgery)[17].

Patients with a 'Mini-mental state' score <25, neurological conditions such as a stroke, multiple sclerosis, Parkinson's disease, polyneuropathy or vestibular and visual acuity deficits, psychotropic medication, total knee replacement, or artificial lower extremity, rheumatoid arthritis or severe cardiac or respiratory disease, and metastatic Ca, were excluded from the study. All participants signed an informed consent form prior to their inclusion in the study. They were asked to refrain from taking alcohol or any medication 24 h prior to testing. Approval for the experiment was obtained from the local Ethics Committee on Human Research in accordance with the Declaration of Helsinki (Scientific Council of Asklepieion General Hospital, Athens).

Intervention

Participants were familiarized with the laboratory and apparatus over a period of 1 week (2 visits to the hospital). During the first visit, the standardized Mini-Mental Health Examination was administered to confirm an adequate cognition, with the requirement that all participants score at least 25/30. Then, the patients of both experimental groups followed a rehabilitation program for 61/2 weeks (20 sessions, 3 sessions/week, 45 to 60 min), including a conventional kinesiotherapy program (10 sessions), based on Otago Exercise Program (1 to 3 sets and 4 levels of difficulty) and Occupational therapy (10 sessions) using the Nintendo Wii Exercise program with 5 different tasks and 2 levels of difficulty: i. strength exercises (knee extensors and flexors, hip abductors and adductors, and ankle plantar flexors and dorsiflexors) and ii. balance exercises (knee bends, backward walking, walking and turning, sideways walking, tandem stance, tandem walk, one leg stance, heel walking, toe walk, heel-toe walking backwards, sit to stand, stair walking)[18]. All sessions were supervised by specialized personnel at the Physio- and Occupational Therapy Departments of the Asklepieion General Hospital, Athens. After the intervention, all parameters were re-evaluated, and all measurements were made. Finally, all participants were asked about the discomfort associated with the protocol, with 0 denoting no discomfort and 10 corresponding to extreme discomfort. They reported discomfort values ≤3.

Experimental setup

Posture

To evaluate static balance, participants performed the bipedal stance test on a pressure platform (Comex, 50Hz, Loran Engineering Ltd, Bologna, IT), taking a natural balancing position and maintaining their stance for 30 s. The stance width was set to an approximate intermalleolar distance of 10-15 cm. The arms were freely hanging along the two sides of the body. Ample time was provided for familiarization with the required posture. Participants were instructed to look straight ahead fixating their gaze at a marker (3 cm diameter) positioned at eye level at a distance of approximately 1.5 m. They performed three trials (2 min rest between trials) and the best was further analyzed. Posturographic analysis was performed using a computer program (Footchecker 4.0, Loran Engineering Ltd) based on the analysis of the Centre of Pressure (CoP) displacement in Anterior/Posterior (A/P) and Medio/Lateral (M/L) axis. Subsequently, the following variables were calculated: i. the average velocity (mm/s) of CoP in which reflects the amplitude and frequency of CoP movements and is calculated as the total length of the path of CoP divided by the test trial time[19], ii. the standard deviation (CoPsd, mm) of CoP oscillations, and iii. the total path of CoP displacement (mm), the ellipse surface (mm^2), estimated using an algorithm that constructs a smooth closed curve that encloses all recorded CoP points, considered as a measure of how well an individual can stand quietly[20]. In order to avoid the dynamic phase of the task reflecting the postural adjustments caused by the weight transfer[21] as well as any fatigue effect during the task, 2s from the beginning and 2s from the end were disregarded from the analysis. The static phase of 26s requiring postural equilibrium to maintain the position was analyzed.

Isokinetic strength

The isokinetic strength of the knee extensors and flexors and the hip abductors and adductors was measured for both legs using an isokinetic dynamometer (Con-Trex, Physiomed Elektromedizin, DE). Participants were positioned and secured according to the isokinetic multi-joint module for testing and training. All tests for hip muscles performed from the side-lying position, with the hip and knee, of the tested leg, extended and neutrally rotated. After a standardized warm-up, they performed 3 maximal repetitions at the concentric velocity of $60^{o}\cdot s^{-1}$. A 2-min rest was allowed between trials to eliminate the effects of fatigue. The better of the three trials based on maximum moment output was selected for further analysis. The tests were realized at the same time of the day in order to avoid any chronobiological effect.

Mobility

Time Up and Go (TUG) Test: Participants performed the TUG (get up from the chair, walk 3 m and return to sit back) moving as quickly as they feel safe and comfortable until the end of the marked course with both feet. They completed one practice run and two that are counted. The time required in seconds is crucial for identifying those prone to falling, and also for separating those who report a fall in the past, from those who do not. For the age group of 65-69, values up to 8.1 s are considered as normal, for the age group of 70-79 years, values up to 9.2 s are considered as normal, and for the age group of 80-99 years, values up to 11.3 s are considered as normal[22].

Falls Efficacy Scale-International (FES-I): FES-I consists of the best-ever certified measurement for the Falling Fear Measurement (ProFaNe-Prevention of Falls Network Europe).

Its score ranges from 16 (no care) to 64 (serious care is required)[23,24].

Berg Balance Scale (BBS): To objectively determine the participant's ability to perform balanced tasks the BBS was used. The mobility registration form includes 14 questions, each question corresponds to a movement which is dictated by the examiner and is scored from 0 to 4, with 0 corresponding to the complete inability to execute the movement and 4 corresponding to the perfectly normal execution (maximum score 56, not including the assessment of gait)[25,26].

Statistical analysis

A priori analysis (GPower 3.1) showed that at least 42 subjects in total were required to detect moderate effect size (partial $\eta^2>0.06$) among means with the statistical design performed (ANOVA with between and repeated factors) with alpha and power levels set at 0.05 and 0.80, respectively. Differences in changes of posture variables, mobility (TUG, FES-I, BBS scores) and strength variables, during the follow-up period between the three study groups (OG and NOG) were evaluated using repeated measurements analysis of variance (ANOVA). Significant interactions were analyzed employing a post hoc Tukey test. All p-values reported are two-tailed. Statistical significance was set at 0.05 and analyses were conducted using SPSS statistical software (version 25.0).

Results

The demographic profiles of the two groups are presented in Table 1. The groups were similar with regards to gender, anthropometric characteristics, and BMI.

	Operated	Non-operated
Men	12	7
Women	31	41
Age (yrs), mean (SD)	76.1 (6.8)	72.6 (6.0)
Height (cm)	164.3 (10.6)	161.0 (8.1)
Mass (kg)	68.3 (11.1)	69.3 (12.0)
BMI, mean (SD)	25.5 (4.2)	26.5 (3.8)
Normal	18	15
Overweight	20	29
Obese	5	4

Table 1. Demographic profile of the two groups, Operated Group (N=43) and Non-operated Group (N=48).

		OG (43)	NOG (48)
CoP_{vel} (mm/s)	Pre	3.11±0.96	2.98±0.53
	Post	2.17±0.63^b	2.00±0.78^b
CoP_{sd} A/P (mm)	Pre	1.61±0.58	1.39±0.33
	Post	0.80±0.28^b	0.60±0.25^b
CoP_{sd} M/L (mm)	Pre	1.38±0.61	1.29±0.57
	Post	0.56±0.23^b	0.56±0.39^b
Total path (mm)	Pre	93.37±28.64	94.18±11.75
	Post	65.07±18.84^b	66.48±25.03^b
Sway ellipse (mm²)	Pre	0.72±0.30	0.64±0.27
	Post	0.54±0.19^b	0.53±0.16^b
^{a}=significant at p<0.05 level, ^{b}=significant at p<0.005 level.			

Table 2. Postural variables.

Posture

Velocity of the Center of Pressure displacement (CoP_{vel})

Table 2 presents all postural variables. A two-way repeated measures ANOVA (group x time) was selected for all the postural variables. The analysis revealed that there was no main effect of group on CoP_{vel} ($F(1,42)=1.336$, $p=0.254$, $\eta p^2=.031$), a significant main effect of time ($F(1,42)=112.835$, $p<0.0005$, $\eta p^2=.729$) and non-significant group x time interaction ($F(1,42)=0.032$, $p=0.859$, $\eta p^2=.001$) on CoP_{vel}. For both experimental groups, the CoP_{vel} after rehabilitation was significantly ($p<0.0005$) lower than before. Moreover, post hoc analysis revealed that the CoP_{vel} for the OG (2.17+0.63 mm/s) was similar ($p>0.05$) to the NOG (2.00+0.78 mm/s) (Table 2).

Standard deviation of Center of Pressure displacement (CoPsd)

In A/P direction, the analysis for CoPsd revealed a main effect of group on CoP_{vel} ($F(1,42)=11.137$, $p=0.002$, $\eta p^2=.210$), a significant main effect of time ($F(1,42)=266.329$, $p<0.0005$, $\eta p^2=.864$), but not significant group x time interaction ($F(1,42)=0.027$, $p=0.870$, $\eta p^2=.001$) on CoPsd. The CoPsd in A/P direction after rehabilitation was significantly ($p<0.0005$) lower than before for both experimental groups (OG: from 1.61±0.58 mm to 0.80±0.28 mm; NOG: from to 1.39±0.33 mm to 0.60±0.25 mm).

In M/L direction, the analysis for CoPsd revealed a non-significant main effect of group on CoP_{vel} ($F(1,42)=0.276$, $p=0.602$, $\eta p^2=.007$), a significant main effect of time ($F(1,42)=178.549$, $p<0.0005$, $\eta p^2=.810$), but not significant group x time interaction ($F(1,42)=0.542$, $p=0.466$, $\eta p^2=.013$) on CoPsd. The CoPsd in M/L direction after rehabilitation was significantly ($p<0.0005$) lower than before for both experimental groups (OG: from 1.38±0.61 mm to 0.56±0.23 mm; NOG: from to 1.29±0.57 mm to 0.56±0.39 mm).

Total path of Center of Pressure displacement

The analysis for total path revealed a non-significant main effect of group ($F(1,42)=0.099$, $p=0.755$, $\eta p^2=.002$), a significant main effect of time ($F(1,42)=99.709$, $p<0.0005$, $\eta p^2=.704$), but not significant group x time interaction ($F(1,42)=0.012$, $p=0.913$, $\eta p^2=.000$) on total path. The total path after rehabilitation was significantly ($p<0.0005$) lower than before for both experimental groups (OG: from 93.37±28.64 mm to 65.07±18.84 mm; NOG: from to 94.18±11.75 mm to 66.48±25.03 mm).

Ellipse of Center of Pressure displacement

Similarly, the analysis revealed a non-significant main effect of group on ellipse ($F(1,42)=0.828$, $p=0.368$, $\eta p^2=.019$), a significant main effect of time ($F(1,42)=32.424$, $p<0.0005$, $\eta p^2=.436$), but not significant group x time interaction ($F(1,42)=1.891$, $p=0.176$, $\eta p^2=.043$) on ellipse. The ellipse after rehabilitation was significantly ($p<0.0005$) lower than before for both experimental groups (OG: from 0.72±0.30 mm^2 to 0.54±0.19 mm^2; NOG: from to 0.64±0.27 mm^2 to 0.53±0.16 mm^2).

Strength

Hip abduction-adduction

Right Limb

Table 3 presents the changes in abduction, adduction, extension, and flexion isokinetic strength after the rehabilitation period for both limbs. The results of the two-way repeated-measures ANOVA revealed a significant main effect of group on right abduction isokinetic strength ($F(1,42)=33.537$, $p<0.0005$, $\eta p^2=.444$) suggesting that the strength of right abductors was different between groups. Similarly, a significant main effect of time was revealed on right abduction strength ($F(1,42)=53.791$, $p<0.0005$, $\eta p^2=.562$). Finally, a significant group x time interaction ($F(1,42)=7.839$, $p<0.05$, $\eta p^2=.157$) suggests that the right abduction torque evolved differently for the two groups. Post hoc Tuckey test revealed that for the OG, the right abduction strength after rehabilitation (52.46±16.82 N·m) was significantly ($p<0.0005$) higher than before (43.87±10.51 N·m). Similarly, for the NOG, the right abduction strength after rehabilitation (69.35±14.76 N·m) was significantly ($p<0.0005$) higher than before (52.41±8.32 N·m). After rehabilitation the abduction strength of the NOG was significantly ($p<0.0005$) higher than the OG.

The analysis for the right adduction isokinetic strength revealed a significant main effect of group ($F(1,42)=32.990$, $p<0.0005$, $\eta p^2=.444$), a significant main effect of time ($F(1,42)=322.250$, $p<0.0005$, $\eta p^2=.885$), but not a significant group x time interaction ($F(1,42)=0.124$, $p=0.727$, $\eta p^2=.003$). The isokinetic strength of the right adductors of the OG (42.32±9.84 N·m) and the NOG (49.93±7.75 N·m) were significantly increased compared to before rehabilitation. Post hoc analysis showed that the right adduction strength for the NOG ($p < 0.005$) was higher than the OG (Table 3).

		OG (43)	NOG (48)
Right hip abduction	Pre	43.87±10.51	52.41±8.32
	Post	52.46±16.82^{b}	69.35±14.76^{b,c}
Right hip adduction	Pre	27.48±9.83	35.65±6.48
	Post	42.32±9.84^{b}	49.93±7.75^{b,c}
Left hip abduction	Pre	59.20±16.11	56.11±13.00
	Post	74.19±16.80^{b}	72.82±14.45^{b}
Left hip adduction	Pre	43.78±12.41	48.49±14.01
	Post	54.06±13.57^{b}	64.65±15.11^{b,c}
Right knee extension	Pre	58.59±16.32	64.62±14.17
	Post	85.14±30.33^{b,c}	73.86±14.54^{b}
Right knee flexion	Pre	46.08±14.03	52.49±17.35
	Post	54.88±14.91^{b}	57.67±17.12
Left knee extension	Pre	79.85±30.68	70.17±17.56
	Post	102.91±50.08^{b,c}	83.31±14.44^{b}
Left knee flexion	Pre	48.26±12.86	47.62±14.37
	Post	60.29±11.77^{b}	57.93±12.46^{b}

^{b}=significant at p<0.005 level; Pre vs. Post for each group.
^{c}=significant at p<0.005 level; OG vs. NOG in post measurements.

Table 3. Isokinetic strength (N·m) before and after the rehabilitation period for the two study groups.

Left limb

The ANOVA revealed no significant main effect of group on left abduction isokinetic strength ($F(1,42)=0.758$, $p=0.389$, $\eta p^2=.018$), a significant main effect of time ($F(1,42)=139.647$, $p<0.0005$, $\eta p^2=.769$) and a non-significant group x time interaction ($F(1,42)=0.575$, $p=0.453$, $\eta p^2=.014$). For the OG, the left abduction strength after rehabilitation (74.19±16.80 N·m) was significantly ($p<0.0005$) higher than before (59.20±16.11 N·m). Similarly, for the NOG, the left abduction strength after rehabilitation (72.82±14.45 N·m) was significantly ($p<0.0005$) higher than before (56.11±13.00 N·m). No significant differences were observed between the experimental groups after rehabilitation (Table 3).

The ANOVA for the left adduction revealed a main effect of group ($F(1,42)=8.681$, $p=0.005$, $\eta p^2=.171$), a main effect of time ($F(1,42)=184.380$, $p<0.0005$, $\eta p^2=.814$) and a significant interaction ($F(1,42)=12.612$, $p=0.001$, $\eta p^2=.231$). For the OG, the left adduction strength after rehabilitation (54.06±13.57 N·m) was significantly ($p<0.005$) higher than before (43.78±12.41 N·m). Similarly, for the NOG, the left adduction strength after rehabilitation (64.65±15.11 N·m) was significantly ($p<0.005$) higher than before (48.49±14.01 N·m). It was also greater ($p<0.0005$) than the OG after rehabilitation (Table 3).

Knee extension – flexion

For right knee extensors strength, ANOVA revealed a non-significant main effect of group ($F(1,42)=0.466$, $p=0.498$, $\eta p^2=.011$), a significant main effect of time ($F(1,42)=130.470$, $p<0.0005$, $\eta p^2=.756$) and a significant group x time interaction ($F(1,42)=23.632$, $p<0.0005$, $\eta p^2=.360$). For both experimental groups, the right knee extensors strength after rehabilitation was significantly ($p<0.0005$) higher than before. Moreover, post hoc analysis revealed that knee extensors strength for the OG (85.14±30.33 N.m) was significantly ($p<0.05$) higher than the NOG (73.86±14.54 N.m).

For right knee flexors strength, no main effect of group, a main effect of time and a significant interaction ($F(1,42)=5.337$, $p=0.026$, $\eta p^2=.113$) was observed. For the OG, the right flexion strength after rehabilitation (54.88±14.91 N·m) was significantly ($p<0.005$) higher than before (46.08±14.03 N·m), but no for the NOG (Table 3).

For left knee extensors strength, ANOVA revealed no significant main effect of group, main effect of time and a significant group x time interaction ($F(1,42)=4.593$, $p=0.038$, $\eta p^2=.099$). For both experimental groups, the left knee extensors strength after rehabilitation was significantly ($p<0.0005$) higher than before (Table 3). Moreover, post hoc analysis revealed that knee extensors strength for the OG (102.91±50.08 N.m) was significantly ($p<0.05$) higher than the NOG (83.31±14.44 N.m).

For left knee flexors strength, no main effect of group, a main effect of time ($F(1,42)=127.648$, $p<0.0005$, $\eta p^2=.752$) and non-significant interaction ($F(1,42)=0.555$, $p=0.460$, $\eta p^2=.013$) were observed. For both groups, the left knee flexion strength after rehabilitation was significantly ($p<0.005$) higher than before (Table 3).

Mobility

Table 4 presents all mobility variables. The analysis revealed a main effect of group on TUG task ($F(1,42)=13.679$, $p=0.001$, $\eta p^2=.246$), a main effect of time ($F(1,42)=107.008$, $p<0.0005$, $\eta p^2=.718$) and a significant group x time interaction ($F(1,42)=5.491$, $p=0.024$, $\eta p^2=.116$) on TUG task. The time to accomplish the TUG task after rehabilitation was significantly ($p<0.05$) lower than before for both experimental groups (OG: from 16.14±5.27 s to 12.73±3.71 s; NOG: from 13.09±3.91 s to 10.75±3.66 s) (Table 4).

The analysis for the FES-I score revealed no main effect of group ($F(1,42)=0.309$, $p=0.581$, $\eta p^2=.007$), main effect of time ($F(1,42)=36.817$, $p<0.0005$, $\eta p^2=.467$) and a significant group x time interaction ($F(1,42)=4.551$, $p=0.039$, $\eta p^2=.098$) on FES-I score. The FES-I score after rehabilitation was significantly ($p<0.05$) lower than before for both experimental groups (OG: from 38.05±11.48 to 31.21±10.34; NOG: from 34.88±14.18 to 31.58±12.33) (Table 4).

Similarly, the analysis for the BBS score revealed a main effect of group ($F(1,42)=13.126$, $p=0.001$, $\eta p^2=.238$), a main effect of time ($F(1,42)=32.783$, $p<0.0005$, $\eta p^2=.438$) and a significant group x time interaction ($F(1,42)=6.775$, $p=0.013$, $\eta p^2=.139$) on BBS score. The BBS score after rehabilitation was significantly ($p<0.05$) higher than before of both experimental groups (OG: from 47.35±6.37 to 50.63±4.42; NOG: from 51.23±4.80 to 53.09±3.33) (Table 4).

		OG (43)	NOG (48)
TUG (s)	Pre	16.14±5.27	13.09±3.91
	Post	12.73±3.71[a]	10.75±3.66[a]
FES-I (score) index)	Pre	38.05±11.48	34.88±14.18
	Post	31.21±10.34[a]	31.58±12.33[a]
BBS (score) index)	Pre	47.35±6.37	51.23±4.80
	Post	50.63±4.42[a]	53.09±3.33[a]

[a]=*significant at p<0.05 level.*

Table 4. Mobility variables (TUG, FES-I, and BBS) for the two study groups.

Discussion

After intervention, all postural variables (CoP_{vel}, CoPsd A/P, CoPsd M/L, total path, sway ellipse) were significantly improved as well as the strength of hip abductors/adductors and knee extensors/flexors for both limbs. Moreover, the mobility variables (TUG, FES-I and BBS scores) have substantially improved for both experimental groups.

Our findings suggest that significant functional improvement can be gained later in the recovery process than is usually believed. This improvement possibly means there is no "plateau" in rehabilitation and any observed plateau may be a consequence of less intensive therapy. If further studies corroborate our findings, it might lead to a change in existing practices and recommendations[27].

Physical and Rehabilitation Medicine physicians should prescribe evidence-based rehabilitation protocols in elderly subjects after hip fracture[17,28,29]. "Standard treatment" is considered to be 12 to 18 sessions within a 4- to 6-week period, although theoretically this can be extended pursuant to a written plan provided by a physician[11]. Our findings suggest that Physicians may be necessary to implement this type of protocol for a treatment period of up to 9 months. Unfortunately, only a small number of controlled studies have been conducted of rehabilitation interventions after hip fracture. Most were performed in the acute hospital or immediate post discharge setting and focused on short-term outcomes, with mixed results[11].

Posture

The main finding of the study was the important improvements in static balance control of both operated and non-operated group after rehabilitation, accompanied by an amelioration in mobility and isokinetic strength of several lower limb muscles. Our results demonstrate that there were significant improvements after the rehabilitation program in all postural parameters (CoP_{vel}, CoPsd A/P, CoPsd M/L, total path, sway ellipse). This finding is in line with a study investigating the influence of a rehabilitation training program over the standing balance in elderly hip osteoarthritis (OA) patients where significant differences were observed, before and after the intervention, between all postural variability measures (range, standard deviation, mean velocity, and area sway in both sagittal and frontal plane)[30].

Strength

For both groups, after the rehabilitation program, the knee extensors and flexors strength improvements were significant and varied from 7.27 to 31.50% for the right knee, and from 16.23 to 27.15% for the left knee. These findings are in line with others reporting that a 6-month supervised exercise program can induce gains in strength such that the fractured limb is essentially equivalent to the nonfractured limb. The authors reported a strong relationship between exercise training intensity and functional performance adaptations[31]. Other authors demonstrated that 12 weeks of intensive strength training could also improve muscle strength and power, concluding that more intensive training especially for the weaker leg may be needed to obtain more marked effects on the asymmetric deficit, mobility, and balance[32]. In the same line, Gmitter et al., (2009) in a case study, proposed a progressive high-intensity resistance training program over a 2-month period to augment lower-extremity strength (hip extension and abduction and knee extension) and function[33]. Finally, the progressive strength-training program commenced shortly after hip fracture seems feasible and efficient by improving mobility, balance, and increasing isometric knee extension strength[34] and may reduce strength asymmetry between limbs without hip pain interfering[35]. It should be noted that the key point for all these studies is progression. Older adults were encouraged to participate in progressive strength programs, starting at an individual level appropriate with their abilities, and progress toward the recommended daily amounts of activity.

It is worth noting that after this rehabilitation program, the strength of hip abductors and adductors was improved in both groups by 19.45 to 31.93% for the right hip, and by 14.70 to 25.64% for the left hip. In our knowledge, this is the first study evaluating the hip muscles isokinetic strength. Pils et al.[36] measured the range of motion during hip adduction and abduction of the healthy hip and found out that the increased range of motion was significantly associated with an increased risk of falling. Further research is however required to enhance our understanding of what is important for the patients during the period after a hip fracture. Often, the absence of results in the functional and strength outcomes may indicate exercise prescription not carefully adapted to provide a sufficient stimulus to improve the functional capacity of frail elderly.

Mobility

The score in up and go test significantly reduced after the rehabilitation program, suggesting an improvement for both groups. This is in line with previous studies reported immediate[37] and/or postponed (a month) improvements[38] after rehabilitation programs including balance exercises. Similar studies reported combining improvements in time to perform the up and go test and the Berg balance scale, suggesting greater body balance and reduction of the fall risk[39,40] and overall improvement quality of life[41]. Moreover, Sylliaas et al. stated that the home-dwelling hip fracture patients can benefit from an extended supervised strength-training program in a rehabilitation setting, which should optimize gains in physical function, strength, and balance[42]. In our study, the time for TUG tasks was decreased by almost 20% and the FES-I and BBS scores have improved to about the same degree, which is really very encouraging. Despite the fact that numerous studies have been published about the validity of six-minute walk test (6MWT) as a tool for measurement of functional capacity and mobility after total knee replacement[43], TUG was preferred due to its popularity and shorter duration.

The scores on the FES-I scale significantly decreased after the rehabilitation program, suggesting a reduction in the fear of falling, both in patients with a fracture or not. Our results confirmed previous studies reporting significant improvement in physical function and self-efficacy was observed after the fall, following an intensive rehabilitation program. It was also stated after a home-based rehabilitation program, patients had a greater improvement and were rated higher in the FES Scale after four months[44]. However, other studies reported no significant difference in balance confidence (FES) between discharge and 1 month[45]. The authors attribute these results to the very big variety of rehabilitation services after discharge, while they recognize that continued rehabilitation is beneficial for persons following hip fracture.

Conclusion / Summary

We showed that after attending a holistic, well-designed late rehabilitation program, including physiotherapy, occupational and strengthening sessions, patients who have suffered a hip fracture significantly improved their postural balance, mobility, and muscular strength, resulting in a noticeable reducing in their fear of falling and their self-perceived health level, a supportive factor for the prevention of falls.

Further research is needed to determine whether the effects obtained in this study can be replicated, how much does it cost, and which are the long-term effects of late rehabilitation intervention. Although these questions regarding the optimal training protocol remain unanswered,

the present findings have important implications for late rehabilitation programs for patients after a hip fracture. If further studies verify our findings, it might lead to a change in existing guidelines.

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