

General

Impact of Physical Therapy on Neurocognitive Status Following Hip Fracture Surgery in Elderly Patients

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Background

Hip joint fractures are the most common fractures in elderly patients and a major cause of neurological disorders.

Objective

The purpose of this non-interventional, observational, prospective study is to evaluate the effects of physiotherapeutic interventions on the neuropsychophysiological profile of patients during the rehabilitation period after hip fracture surgery, starting from discharge from the hospital.

Methods

This study involved 64 mainly elderly patients who underwent surgery for various hip fractures and followed a standardized physical therapy protocol **in the rehabilitation center**. The Mini-Mental State Examination (MMSE) and Confusion Assessment Method (CAM) scores **which are part of the neurological assessment in the rehabilitation center**, were recorded on the 1st, 5th, 15th, and 30th days of hospitalization. Statistical analysis **followed and the results** aimed to evaluate the role of physical therapy in enhancing recovery and preventing cognitive complications in the postoperative period.

Results

The first 64 patients with hip fractures admitted in the rehabilitation center after the initiation of the study protocol were enrolled in the study. Always the same two observers recorded MMSE and CAM scores for each patient during the four aforementioned time points. A statistical analysis included descriptive statistics for each of the four studied time points proved that both MMSE and CAM scores showed statistically significant positive outcomes in the neuropsychophysiological profile of patients following the same physical therapy protocol.

Conclusion

Suggesting and supporting physical therapy through well standardized protocols after hip fracture surgery is crucial for improving and maintaining neurological status, particularly for patients at high risk of neurological disorders and delirium during the immediate postoperative period.

INTRODUCTION

The elderly population in Greece represents a significant portion of the general population and faces numerous medical challenges. Among these challenges, hip fractures are particularly common, especially fractures of the hip joint.¹ These fractures are the most frequent among older adults and are a leading cause of various neurological disorders, though the literature on the topic is limited. Neurological rehabilitation has seen significant advancements, with new

evaluation scales, methods, and knowledge contributing to progress in the field. After surgery, patients complete their rehabilitation at a rehabilitation center under the guidance of physiotherapists and rehabilitation physicians. Delirium is a frequently observed syndrome in these patients, leading to confusion and anxiety, which can significantly impact their neurophysiological profile, impair recovery, and prolong hospitalization.²⁻⁴ The musculoskeletal system appears to be closely linked to psychological and neurocognitive status. Physical therapy plays a crucial role in the

rehabilitation phase, both in hospitals and rehabilitation centers.^{5,6} In the weeks following surgery, patients experience significant muscle strength loss in the operated limb, often losing more than half the strength compared to the unaffected limb. Early physical therapy in the acute care phase is recommended, as studies show it accelerates recovery compared to delayed therapy, which typically starts on the third or fourth postoperative day.⁷ The speed of recovery following a hip fracture depends on early weight-bearing and muscle strengthening of the affected limb. The duration and intensity of physiotherapy in older patients with hip fractures are crucial for clinical improvement, influencing the stages of rehabilitation and determining whether recovery is rapid or gradual. High-intensity physiotherapy (three sessions per day) during the acute hospital phase has been found to help patients reach a functional level adequate for discharge 10 days earlier than those in a control group receiving only one session per day. However, not all patients are suitable for high-intensity therapy in the early postoperative stages. Several recommended exercises in the acute recovery phase include ankle pumps (dorsal and plantar flexion) and quadriceps strengthening exercises to improve knee strength in the affected leg.^{7,8}

Both very young and elderly patients are at higher risk for delirium, with those who have a history of the syndrome being more likely to experience another episode. Delirium is associated with high mortality rates, reaching up to 50% within a year following an episode.⁹ Research indicates that delirium affects between 14% and 56% of hospitalized patients.¹⁰ In the U.S., of the 12.5 million patients hospitalized annually, at least 20% experience serious complications due to delirium. The prevalence of delirium during hospitalization ranges from 14% to 24%, whereas in the general population, it is only 1% to 2%.¹¹ The incidence during hospitalization varies between 6% and 56%.¹² Postoperative delirium affects 15% to 53% of patients over 65, with ICU rates reaching as high as 70% to 87%.³ Some patients never return to their baseline cognitive and functional state after an episode, suffering from permanent deficits.¹³

The exact pathophysiology of delirium remains unclear, as it can result from various pathogenic mechanisms.^{2,13} One of the difficulties in understanding delirium lies in its transient nature and the multiple underlying causes. Brain scans of affected patients reveal widespread slowing of neural activity. However, research on stroke and brain injury patients provides insights into the neurotransmitters and brain centers most impacted by delirium.^{2,14} The cholinergic system plays a key role in the onset of delirium. The primary anatomical structure involved is the brainstem, particularly the reticular formation, which regulates attention and alertness.^{13,15} Studies suggest that factors contributing to delirium lead to decreased cholinergic neurotransmission in the brain. Delirium is characterized by a combination of acetylcholine deficiency and dopamine hypersecretion, explaining the disturbances in consciousness (acetylcholine deficit) and perceptual changes such as hallucinations and delusions (dopamine hypersecretion).^{16,17}

Every year, one hip fracture occurs for every 250,000 Americans, and this number is expected to double by 2040.² Delirium is the most common complication following hip fractures in older adults, with prevalence rates ranging from 5% to 61%, depending on the patient population. Delirium is frequently misdiagnosed or overlooked, despite its severe consequences. Mortality from postoperative delirium is significantly higher than from deep vein thrombosis or pulmonary embolism, yet it remains underreported in orthopedic literature.^{2,3}

The CAM is a tool and diagnostic algorithm designed to identify delirium.¹⁸ It was initially created through a literature review and expert consensus and subsequently validated against the reference standards set by Geriatric Psychiatrists using the Diagnostic and Statistical Manual for Mental Disorders, Third Edition Revised (DSM-III-R) criteria. The CAM was specifically developed to enable non-psychiatric clinicians to quickly and accurately diagnose delirium following a brief cognitive test.^{19,20} The instrument evaluates the presence, severity, and fluctuation of nine delirium symptoms: acute onset, inattention, disorganized thinking, altered level of consciousness, disorientation, memory impairment, perceptual disturbances, psychomotor agitation or retardation, and disruption of the sleep-wake cycle. The CAM's diagnostic algorithm centers on four key features of delirium: 1) acute onset with a fluctuating course, 2) inattention, 3) disorganized thinking, and 4) altered level of consciousness. A delirium diagnosis via CAM requires features 1, 2, and either 3 or 4 to be present. The CAM has demonstrated sensitivity between 94–100%, specificity from 90–95%, positive predictive accuracy of 91–94%, negative predictive accuracy from 90–100%, interrater reliability ranging from .81 to 1.00, and strong agreement with other mental status assessments, including the MMSE.^{21,22}

The MMSE is a tool used to assess mental status in a structured and comprehensive manner. Consisting of 11 questions, it evaluates five areas of cognitive function: orientation, registration, attention and calculation, recall, and language. The maximum possible score is 30, with a score of 23 or below indicating cognitive impairment. The MMSE can be answered in just 5–10 minutes, making it a practical tool for regular and repeated use.²³ The MMSE is effective as a screening tool for cognitive impairment in older adults, regardless of where they live in the community, in a hospital, or in an institutional setting. For accurate cognitive assessment in older adults, it is best to administer the MMSE routinely, systematically, and thoroughly.²⁴ Since its development in 1975, the MMSE has been validated and widely used in both clinical settings and research. It serves as an effective screening instrument to distinguish between patients with and without cognitive impairment. Additionally, when administered repeatedly, it can track changes in cognitive function that may warrant intervention. However, it is important to note that the MMSE does not diagnose specific causes of cognitive changes and should not replace a full clinical mental status evaluation. Moreover, the MMSE relies heavily on verbal responses, reading, and writing, meaning individuals with hearing or visual impair-

ments, those who are intubated, have low literacy, or experience other communication difficulties, may not perform well even if their cognitive function is intact.²⁵

The aim of this study is to investigate the effect of physical therapy on various neurological disorders in patients with surgical hip fractures (femoral neck fractures, subtrochanteric fractures, and intertrochanteric fractures) at a private regional rehabilitation center. Our goal is also to elucidate any potential positive and beneficial effects after the application of a specific physical therapy protocol, on patients with hip fractures who have already been diagnosed with neurological and cognitive deficits.

MATERIALS AND METHODS

After approval of the Ethics Committee of the institution, 64 elderly patients were included in the study, aged 83.97 ± 5 years (43 women and 21 men). The sample was collected from a private regional rehabilitation center where the patients were admitted and where the physical therapist, who is also the main researcher of the study, works. The recruitment of the patients started in January 2018 and came to an end in September of the same year. All participants were Greek residents of Greece.

The primary criterion for inclusion in the study was the main injury (hip fracture) and the patients' age, as those over 65 years old were selected, as the study focuses on the elderly. An additional inclusion criterion was that the patients had undergone surgery for intertrochanteric, subtrochanteric, or femoral neck fractures. Upon their initial admission to the rehabilitation center, it was checked whether they met the criteria for inclusion in the study. The first 64 patients who admitted to the rehabilitation center with hip fracture and both satisfied the inclusion criteria and gave a written consent to be observed for the study purposes were the study sample. If they were eligible, their age, reason for admission, type of fracture, and admission date were recorded. Additionally, the dates of discharge were noted, allowing for the tracking of each patient's treatment duration. The study excluded patients with neurological conditions such as strokes, Parkinson's disease (PD), and multiple sclerosis (MS). Information about the inclusion and exclusion criteria for each patient was collected from the patient's personal medical file, held by the rehabilitation center and the physician of physical rehabilitation.

A scientifically validated fixed physical therapy protocol was developed for the purpose of the study. During the rehabilitation period, this protocol was applied to the patients and it is described below. The physiotherapist is responsible for designing the rehabilitation program, including the intensity and duration of each session. The protocol was implemented from Monday to Saturday, with each session lasting between 30 and 45 minutes. The rehabilitation program is structured into three distinct phases

- Immobilization Phase
- Mobilization Phase
- Strengthening Phase

PHASE I: IMMOBILIZATION (DAYS ONE–TWO)

Primary Physiotherapeutic Objective:

Achievement of seated and standing positions

Interventions:

- Upper limb strengthening exercises
- Core strengthening exercises
- Strengthening exercises for the unaffected lower limb
- Gentle strengthening exercises for the affected lower limb
- Postural training: From a seated to a standing position with the aid of a walker (5 repetitions with a one-minute rest between repetitions)

PHASE II: MOBILIZATION (DAYS TWO–SEVEN)

Primary Physiotherapeutic Objective:

Gait training using a walker.

Interventions:

- Cryotherapy application using the Zimmer device for 3 minutes
- Gait training
- Stair training
- Balance and proprioceptive exercises performed from a seated position on the bed

PHASE III: STRENGTHENING (DAYS SEVEN–30)

Primary Physiotherapeutic Objective:

Complete functional recovery of the patient.

Interventions:

- Gait retraining using a quad cane
- Therapeutic exercises using a stall bar while the patient holds on for support
- Progressive difficulty is introduced by having the patient perform the exercises using only one hand for support

Alongside the protocol, the patients' mental state and the presence or absence of delirium were evaluated using the MMSE and the CAM score, always by the same two observers. These tests have been translated and validated for the Greek geriatric population with excellent reliability and validity results.^{26,27} It should be stated that these two evaluation tests are part of the neurological evaluation protocol in many rehabilitation centers included the aforementioned one. Evaluations were recorded on the first, fifth, fifteenth, and thirtieth days of hospitalization. These four timepoints were chosen based on the three phases of the standardized physiotherapeutic protocol and they were considered as the main assessment timepoints. The physical therapist, who is also the researcher, visited each patient four times during their treatment to assess their mental state.

Each of tests was collected four times for every patient: T1 is the first day of admission, T2 is the fifth day of admission, T3 is the 15th day of admission and T4 is the 30th day of admission. The MMSE was administered in a paper-based format, with the physical therapist conducting it in

Table 1. Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Age	64	26	67	93	83,97	5,086
Time of hospitalization (days)	48	48	14	62	36,46	10,695
MMSE T1	64	24	3	27	18,53	6,394
MMSE T2	64	22	6	28	20,53	5,651
MMSE T3	64	21	9	30	22,78	5,217
MMSE T4	64	19	11	30	24,13	4,943

an interview style. Similarly, the CAM score was assessed by the patients' relatives through an interview. Finding relatives was not difficult, as visiting hours at the rehabilitation center were extensive and allowed twice a day—once in the morning and once in the afternoon. The results of both tests were recorded in each patient's individual file, then transferred to an account sheet, and used for statistical analysis to determine whether physical therapy had a positive or negative effect on the neurophysiological state of patients with hip fractures, and more broadly, on the restoration of neurological deficits.

ETHICAL CONSIDERATIONS

The study was approved by the board of Alexander Technological Institute of Thessaloniki within the frames of Master of science program “Neuromusculoskeletal Physiotherapy” under the statement with protocol number 90/07-11-2017.

All patients and their relatives were informed and consented about the procedure of the study and the data of the patients were being collected anonymously and were being protected and remained confidential.

STATISTICAL ANALYSIS

The statistical analysis was conducted using IBM SPSS Statistics 21.0. Descriptive statistical methods such as frequency tables, pie charts, and bar charts were used. Equality values of mean values in dependent samples (parametric and non-parametric) were also applied.

RESULTS

Tables and charts were created with the help of descriptive statistics. Dependent sample control was used to check the mean equality of values. The analysis was done with the statistical package IBM SPSS Statistics 21.0.

64 patients participated in the study. Their ages ranged from 67 to 93 years. [Table 1](#) provides total information for each of the variables giving the Range, the Minimum and Maximum value, the Mean value and the Standard Deviation.

Out of a total of 64 patients, 26 patients had a femoral neck fracture, 24 patients had an intertrochanteric fracture and 14 patients had a subtrochanteric fracture. The relative

frequency of patients with a femoral neck fracture is 40.6%, the relative frequency of patients with an intertrochanteric fracture is 37.5%, and the relative frequency of patients with a subtrochanteric fracture is 21.9%. 78.1% of all patients are patients with femoral neck and intertrochanteric fractures.

MINI-MENTAL STATE TEST

In MMSE T1 (first day of admission) 6.3% of patients had a score of 3, 9.4% of patients had a score of less than 8, 12.5% of patients had a score of less than 9, 15.6% of patients had a score of less than 13, 21.9% of patients had a score of less than 14, 25% of patients had a score of less than 15, 34.4% of patients had a score of less than 16, 37.5% of patients had a score of less than 17, 46.9% of patients had a score of less than 18, 53.1% of patients had a score of less than 19, 62.5% of patients had a score of less than 20, 65.6% of patients had a score of less than 22, 71.9% of patients were and less than 23, 78.1% of patients had a score of less than 24, 84.4% of patients had a score of less than 25 and 96.9% of patients had a score of less than 27. No patient had a score greater than 27.

In MMSE T2 (fifth day of admission) 3.1% of patients had a score of 6, 6.3% of patients had a score of less than 11, 15.6% of patients had a score of less than 12, 18.8% of patients had a score of less than 14, and 21.9% of patients had a score of less than 15, 28.1% of patients had a score of less than 17, 31.3% of patients had a score of less than 18, 34.4% of patients had a score of less than 19, 50% of patients had a score of less than 21, 53.1% of patients was less than 22, 68.8% of patients were less than 23, 75% of patients were less than 24, 81.3% of patients were with a score of less than 25, 84.4% of patients had a score of less than 26 and 90.6% of patients had a score of less than 27. No patient received a score greater than 28.

In MMSE T3 (15th day of admission) 3.1% of patients had a score of 9, 6.3% of patients had a score of less than 12, 9.4% of patients had a score of less than 14, 12.5% of patients had a score of less than 15, and 18.8% of patients had a score of less than 17, 21.9% of patients had a score of less than 19, 25% of patients had a score of less than 20, 34.4% of patients had a score of less than 21, 37.5% of patients had a score of less than 22, 43.8% of patients had a score of less than 23, 59.4% of patients had a score of less than 24, 68.8% of patients had a score of less than 25, 75%

Table 2. MMSE Groups

	MMSE T1	MMSE T2	MMSE T3	MMSE T4
Severe cognitive impairment	8 (12.5%)	2 (3.1%)	2 (3.1%)	12 (18.8%)
Moderate cognitive impairment	32 (50%)	20 (31.3%)	14 (21.9%)	12 (18.8%)
Mild cognitive impairment	10 (15.6%)	26 (40.6%)	22 (34.4%)	24 (37.5%)
Cognitive impairment	14 (21.9%)	10 (15.6%)	14 (21.9%)	16 (25.0%)

of patients had a score of less than 26, and 81.3% of patients had less than 27, 87.5% of patients had a score of less than 28 and 93.8% of patients had a score of less than 29.

In MMSE T4 (30th day of admission) 3.1% of patients had a score of 11, 6.3% of patients had a score of less than 12, 9.4% of patients had a score of less than 14, 12.5% of patients had a score of less than 18, 18.8% of patients had a score of less than 20, 25% of patients had a score of less than 21, 31.3% of patients had a score of less than 22, 34.4% of patients had a score of less than 23, 37.5% of patients had a score of less than 24, and 50% of patients had a score of less than 25, 62.5% of patients had a score of less than 26, 75% of patients had a score of less than 27, 84.4% of patients had a score of less than 28 and 90.6% of patients had a score of less than 29.

[Table 2](#) shows the MMSE groups. Grouping was done according to the following:

- 0-10: Severe cognitive impairment
- 10-20: Moderate cognitive impairment
- 20-24: Mild cognitive impairment
- 24-27: Cognitive impairment
- 27-30: No cognitive impairment

In MMSE T1, 8 patients had severe cognitive impairment that corresponded to 12.5%, 32 patients had moderate cognitive impairment that corresponded to 50%, 10 patients had mild cognitive impairment that corresponded at a rate of 15.6% and 14 had cognitive impairment which corresponded to a rate of 21.9%.

In MMSE T2, 2 patients had severe cognitive impairment corresponding to 3.1%, 20 had moderate cognitive impairment corresponding to 31.3%, 26 had mild cognitive impairment corresponding to a percentage 40.6%, 10 had cognitive impairment corresponding to 15.6% and 6 had no cognitive impairment corresponding to 9.4%.

75% of patients had severe, moderate, and mild cognitive impairment.

In MMSE T3, 2 patients had severe cognitive impairment corresponding to 3.1%, 14 patients had moderate cognitive impairment that corresponded to 21.9%, 22 patients had mild cognitive impairment corresponding to 34.4%, 14 patients had cognitive impairment corresponding to 21.9% and 12 patients had no cognitive impairment corresponding to 18.8%. 59.4% of patients had severe, moderate, and mild cognitive impairment.

In MMSE T4, no patient had severe cognitive impairment. 12 patients had moderate cognitive impairment corresponding to 18.8%, 12 patients had mild cognitive impairment corresponding to 18.8%, 24 patients had cognitive impairment corresponding to 37.5% and 16 patients had no

cognitive impairment which corresponds to 25%. 37.5% of patients had moderate and mild cognitive impairment.

CAM SCORE

The CAM score was evaluated by the relatives of all 64 patients.

The CAM T1 was negative in 34 patients and positive in 30 patients. The relative frequency of patients with negative CAM is 53.1% and the relative frequency of patients with positive CAM is 46.9%.

The CAM T2 was negative in 46 patients and positive in 18 patients. The relative frequency of patients with negative CAM is 71.9% and the relative frequency of patients with positive CAM is 28.1%.

The CAM T3 was negative in 54 patients and positive in 10 patients. The relative frequency of patients with negative CAM is 84.4% and the relative frequency of patients with positive CAM is 15.6%.

The CAM T4 was negative in 60 patients and positive in 4 patients. The relative frequency of patients with negative CAM is 93.8% and the relative frequency of patients with positive CAM is 6.3%.

PAIRED SAMPLES ([TABLE 3-5](#))

We set a significance level of 5%. Since these are measurements made on the same experimental units, we find that they are a test of equality of average value in dependent samples. For this reason, we used Paired Samples Test, which shows that there is a statistically significant difference between the measurements of the MMSE T1 and subsequent times (p-values <0.05). The null hypothesis of equality of mean values between the samples is rejected, which means that there is a statistically significant difference between the samples ($t = -12.755$, $df = 63$, $p \text{ value} = 0.000$). In other words, patients appear to improve over time by scoring higher on the mini-mental scale.

DISCUSSION

According to Gustafson et al., 111 patients with femoral neck fractures were studied, all of whom underwent surgery. The researchers assessed patients' pre-existing dementia using the DSM III (Diagnostic and Statistical Manual of Mental Disorders) and also evaluated preoperative and postoperative development of delirium. 61% of patients exhibited severe confusion: 33% had acute confusion preoperatively and 28% had severe confusion postopera-

Table 3. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	MMSE T1	18.53	64	6.394	.799
	MMSE T2	20.53	64	5.651	.706
Pair 2	MMSE T1	18.53	64	6.394	.799
	MMSE T3	22.78	64	5.217	.652
Pair 3	MMSE T1	18.53	64	6.394	.799
	MMSE T4	24.13	64	4.943	.618

Table 4. Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	MMSE T1 & MMSE T2	64	.937	.000
Pair 2	MMSE T1 & MMSE T3	64	.895	.000
Pair 3	MMSE T1 & MMSE T4	64	.839	.000

Table 5. Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Mini-mental T1- Mini- mental T2	-2.000	2.254	.282	-2.563	-1.437	-7.099	63	0.000
Pair 2	Mini-mental T1- Mini- mental T3	-4.250	2.895	.362	-4.973	-3.527	-11.744	63	0.000
Pair 3	Mini-mental T1- Mini- mental T4	-5.594	3.508	.439	-6.470	-4.717	-12.755	63	0.000

tively. The researchers followed these patients for 6 months post-surgery and observed a significant difference in their length of hospital stay, as well as postoperative complications such as urinary incontinence, feeding problems, and pressure ulcers. Additionally, patients with delirium were more likely to have died or required transfer to a rehabilitation facility, making it harder for them to return to their functional level before the fracture. Through our study it is clear that based on delirium-assessment tools, such as MMSE and CAM, we can assess the progress of the neurological status of patients with hip fractures under physiotherapeutic protocols. Physical therapy protocols standardized for rehabilitation of hip fractures help the improvement of MMSE scores and prevent or enhance delirium. According to the research by Gustafson et al., patients with hip fractures and pre-existing cognitive deficits can benefit significantly from physical rehabilitation and should not be excluded from physical therapy programs.⁹ The study by Robertson et al. showed that the contribution of a scientific team, consisting of the orthopedic surgeon, nurse, and therapist, can be crucial in the effective manage-

ment of delirium, and systematic monitoring for potential recurrence of the syndrome should be carried out.² The present clinical study reaches the same conclusion, supporting the role of physical therapists as a crucial part of this scientific team. Furthermore, this clinical study concludes that an organized approach to managing delirium in patients with hip fractures requires early mobilization immediately after surgery and physical rehabilitation. The research by Robertson et al. also supports the same conclusion.²

In a similar study by Marcantonio et al., 126 patients over the age of 65 with hip fractures were examined. The patients were evaluated preoperatively and postoperatively each day, as well as on the first and sixth month. Delirium developed in 41% of the patients, or 52 out of 126, with 15 patients still experiencing delirium after one month and 3 patients after six months. These patients had reduced ability to perform daily activities, poor walking ability, and significantly higher mortality or need for transfer to another healthcare facility compared to those without delirium. Furthermore, patients who continued to experience delirium had worse outcomes compared to those who over-

came the syndrome.¹¹ Our study follows a similar pattern postoperatively after hip fractures.

Edelstein et al. studied 921 hip fracture patients. Although they reported a lower prevalence (5.1%) than the researchers in the studies above including ours, these patients were examined for delirium only at a specific time post-surgery, and the healthiest patients were selected based on inclusion and exclusion criteria. They found that patients with this disorder had longer hospital stays and higher mortality rates within the first year. They also showed that the chances of returning to their functional level (walking and performing daily activities) before surgery were low.¹

In our study all patients with intertrochanteric, subtrochanteric, and femoral neck fractures followed the same physical therapy protocol six times a week, performing the same exercises each time. The mental condition of these patients improved, and they became capable of following the physical therapist's instructions while being continuously monitored by the rehabilitation physician. Specifically, the first signs of improvement in their mental state were observed on the 5th day of hospitalization. Some patients started to return to their cognitive level by the 15th day of hospitalization. These conclusions became evident as the patients scored higher on MMSE at the end of their rehabilitation.

Some further clinical implications of the study results include potential improvements in functional rehabilitation, a reduction in subsequent fractures, and decreased costs associated with hip fracture care, thereby lowering both the economic and social burden. It is also important to highlight that this study provides new perspectives for clinical physical therapy protocols, emphasizing the significant role physiotherapists can play as clinicians. Multidisciplinary therapy has been shown to improve physical function and mobility more effectively than traditional care. Ultimately, the goal of all interventions should be to prolong survival and enhance patient well-being.

LIMITATIONS

Regarding the understanding and completion of the process, some difficulties were also noted. The Mini-Mental Test was completed in the form of an interview with the patients, making it difficult sometimes to complete the test form, especially when the patients were lethargic, in pain or tired. For some patients it was mandatory to repeat the test after some hour to have an accepted result. Notably, patients experienced particular difficulty with calculation ability, such as subtraction, and with recall, as they were unable to remember the three objects they were asked to recall. The CAM score was assessed by the patients' relatives in the form of an interview, where no significant difficulties were observed in the communication process, in contrast to Mini-Mental Test. For the completion process of the two tests process, we managed always to maintain the same two observers to avoid both any personal bias and different recruitment management. Moreover, the results of the study are based on a specific physiotherapeutic protocol which of course is one of most famous and accepted proto-

cols regarding the rehabilitation in hip fractures, but they could possibly differ if this protocol changed or the adherence with it was minimal. Furthermore, limitations encompass the recruitment of patients who originated from only one rehabilitation center in Greece. One more thing to be considered as limitation is that the patients came to the rehabilitation center after hip surgery in various hospitals, considering the different circumstances regarding the patients' care in and after the perioperative period.

This study is the first of its kind conducted in Greece. Future clinical research using the same rehabilitation protocol would be of interest. A subsequent study involving a larger and more diverse sample from various regions of Greece would be desirable. Additionally, modifying the protocol to incorporate alternative physiotherapeutic approaches could provide valuable insights, potentially enabling a future meta-analysis comparing different rehabilitation strategies. Moreover, broader interdisciplinary collaboration—particularly the inclusion of a neurologist—would enhance the implementation of personalized neurological assessments. Finally, conducting a multicenter study involving both public and private rehabilitation facilities across Greece would be a valuable next step.

CONCLUSION

Throughout the clinical study, we drew several conclusions. Upon admission to the rehabilitation center and evaluating their mental state, it was observed that all patients had some cognitive disorder, with the majority experiencing severe, moderate, or mild dementia. On the 5th day of hospitalization, a small percentage of patients showed no cognitive disorder, but the percentage of patients with mild, moderate, or severe dementia increased. At the end of the rehabilitation period, one out of four patients had no cognitive disorder. These results were confirmed by the patients' relatives through the evaluation of the CAM score, without the relatives knowing the specific questions asked or the scores recorded each time.

The clinical study provided significant conclusions, which were essentially what we expected and hoped to prove. Over time, patients improved both mentally and cognitively, as evidenced by comparing their scores at admission and discharge from the rehabilitation center.

For more reliable results regarding the significance of physical therapy rehabilitation and its impact on reducing neurological deficits caused by hip fractures, it is recommended that similar future studies be conducted with even larger sample of elderly patients who have undergone surgery, and that data be collected from more regions of Greece, as well as from a wider variety of fracture types. It would be interesting to study the effects of physical therapy in patients with a history of pathology, such as cerebrovascular incidents.

CONFLICTS OF INTEREST

There are no conflicts of interest for all the authors.

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