

Case Report

Inpatient Rehabilitation and Its Impact on Postural Control, Balance, Mobility, Motor Performance, and Physical Activity in People with Acute Stroke: A Case Series

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ABSTRACT

Purpose: Early rehabilitation in people with stroke has been demonstrated to be important for the maintenance of functional independence, but there is little data on their physical activity during inpatient rehabilitation. This study aimed to investigate the effects of inpatient rehabilitation on postural control, balance, mobility, motor performance, and physical activity parameters in people with acute ischemic stroke.

Case Reports: Six people with acute stroke received inpatient rehabilitation for the duration of their inpatient stay. The postural control, balance, mobility, and motor performance of participants were evaluated with the Postural Assessment Scale for Stroke Patients (PASS-T), Mobility Scale for Acute Stroke Patients (MSAS), Rivermead Mobility Index (RMI) and Fugl-Meyer Assessment (FMA) before and after rehabilitation, respectively. The ActiGraph GT9X link accelerometer was used to detect the physical activity behavior.

Results: Following inpatient rehabilitation, no improvements were observed in PASS-T, MSAS, RMI, and FMA scores except for Case 5. The overall physical activity levels of all participants were sedentary; however, despite daily variability, energy expenditure and vector magnitude counts increased from baseline to discharge.

Conclusion: Inpatient rehabilitation has a positive effect on the activity participation of people with acute stroke. For early mobilization and increasing activity participation of people with acute conditions, early inpatient rehabilitation is recommended.

Keywords: Rehabilitation, Stroke, Physical Activity.

ÖZET

Amaç: Akut inme tanılı bireylerde erken rehabilitasyonun, fonksiyonel bağımsızlığın sürdürülmesi açısından önemli olduğu gösterilmiştir; ancak hastane içi rehabilitasyon süresince gösterdikleri fiziksel aktivite düzeylerine ilişkin veriler sınırlıdır. Bu çalışmanın amacı, akut iskemik inme tanılı bireylerde hastane içi rehabilitasyonun postüral kontrol, denge, mobilite, motor performans ve fiziksel aktivite parametreleri üzerindeki etkilerini incelemektir.

Olgu raporları: Akut inme tanılı 6 birey, hastanede yatış süreleri boyunca hastane içi rehabilitasyon programına alındı. Katılımcıların rehabilitasyon öncesi ve sonrasında postüral kontrol, denge, mobilite ve motor performansları sırasıyla İnme Hastaları için Postüral Değerlendirme Ölçeği (İHIPDÖ), Akut İnme Hastaları için Geliştirilmiş Mobilite Ölçeği (AİHGMO), Rivermead Mobilite İndeksi (RMI) ve Fugl-Meyer Değerlendirme Ölçeği (FMDÖ) ile değerlendirildi. Fiziksel aktivite davranışlarının belirlenmesinde ActiGraph GT9X link akselerometre kullanıldı.

Bulgular: Hastane içi rehabilitasyonu takiben, Olgu 5 haricinde İHIPDÖ, AİHGMO, RMI ve FMDÖ skorlarında belirgin bir iyileşme gözlenmedi. Tüm katılımcılar genel fiziksel aktivite düzeyleri olarak sedanterdi; ancak gün içerisindeki değişkenliğe rağmen enerji harcaması ve vektör büyüklüğü sayımları başlangıç değerlendirmesinden taburculuğa kadar artış gösterdi.

Sonuç: Hastane içi rehabilitasyon, akut inme tanılı bireylerin aktivitelere katılımı üzerinde olumlu etkiye sahiptir. Akut inme tanılı bireylerin erken mobilizasyonu ve aktivitelere katılımını arttırmak için erken dönemde hastane içi rehabilitasyon önerilmektedir.

Anahtar Kelimeler: Rehabilitasyon, İnme, Fiziksel Aktivite.

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1. Introduction

Stroke is one of the most common causes of physical disability worldwide [1], affecting approximately 15 million people annually [2]. People following a stroke might suffer from typical motor impairments (one-sided muscle paralysis or weakness), postural instability, and altered gait pattern [3]. These stroke-related disabilities can affect a patient's ability to function independently and participate in activities [4].

Physical activity in the post-stroke period is regarded as a key contributor to functional recovery through mechanisms related to neuronal repair and neuroplasticity [5]. However, most individuals remain markedly inactive during the acute and subacute phases, spending the majority of their waking time sedentary, with accelerometer-based studies reporting immobility rates of approximately 94% in acute stroke units and over 70% in rehabilitation settings. Excessive sedentary behavior is associated with adverse outcomes, including an increased risk of recurrent vascular events, muscle deconditioning, and reduced cardiorespiratory capacity [6, 7]. Although appropriately dosed and timed physical activity in the acute phase may enhance gait recovery, alleviate depressive symptoms, and prevent secondary complications of bed rest, the optimal intensity and timing of early mobilization remain unclear [8].

The recovery process following a stroke may extend over many years; however, the inpatient rehabilitation phase, which typically spans several weeks to months, represents a critical period for functional improvement. Rehabilitation delivered during the early post-stroke phase enables patients and their families to regain daily living skills, enhance motor performance, and facilitate adaptation to life after discharge [9]. During this phase, intensive rehabilitation strategies such as constraint-induced movement therapy, mirror therapy, and task-specific training are commonly implemented to promote functional recovery through neuroplastic mechanisms [10]. Evidence suggests that inpatient rehabilitation focusing on balance training, postural awareness, and motor learning, when initiated early after stroke, is associated with shorter hospital length of stay and greater functional independence at discharge [11]. Consistently, in-hospital rehabilitation programs applied in the acute phase have been shown to produce meaningful gains in motor skills, balance, functional independence, and mobility [12].

However, to our knowledge, little is known about the effect of inpatient rehabilitation on physical activity behavior in people with acute stroke [13]. This study

aimed to investigate the effects of inpatient rehabilitation on postural control, balance, mobility, motor performance, and physical activity parameters in people with acute ischemic stroke. We hypothesized that conventional physiotherapy in patients with acute stroke would: (1) improve postural control, balance, mobility, and motor performance, (2) increase time spent in physical activity, and (3) reduce time spent in bed.

2. Case Report

Six patients (2 females, 4 males) with a diagnosis of ischemic stroke were referred by their neurologist at the Neurology Inpatient Unit of Dokuz Eylul University.

Inclusion criteria were people diagnosed with ischemic stroke, with a score of ≥ 24 on the Mini-Mental State Examination scale. Exclusion criteria were previous stroke history, hemodynamic instability, presence of any neurological disorders (Parkinson's disease, Multiple Sclerosis, etc), lower limb affection according to the Modified Ashworth Scale (score $> 3/5$), presence of orthopaedic/musculoskeletal conditions and cardiovascular disorders that could negatively affect participation in assessment and intervention, and absence of movement in lower limbs.

This study was conducted at the Neurology Inpatient Unit of Dokuz Eylul University. The Ethic Committee approval was obtained from Dokuz Eylul University (protocol number: 4719-GOA). Written consent was obtained from all patients before enrolment.

2.1. Inpatient Rehabilitation

The rehabilitation program was planned by a physiotherapist with 20 years of experience in neurological rehabilitation. It included the functional strengthening of trunk muscles, scapular mobilization, stretching the latissimus dorsi muscle, multidirectional functional reach of the upper extremity, weight transfer activities, and functional exercises for upper and lower extremities, gait, and balance exercises in accordance with the principles of the Bobath concept [14]. Following hemodynamic stability of patients, inpatient stroke rehabilitation was administered once daily (approximately 40-45 minutes per session), excluding weekends, under the supervision of the same physiotherapist until discharge. The intensity of each stage was modified according to the performance of the patient. The standard protocol was tailored to the patient's needs and clinical improvement.

2.2. Measures

Demographic and clinical characteristics of participants were recorded, including age, sex, weight (kg), height (cm), body mass index (kg/m²), dominant side, affected side, and time from stroke.

The Postural Assessment Scale for Stroke Patients (PASS) is a stroke-specific, easy-to-administer scale that evaluates balance by assessing the patient's ability to maintain or change a given lying, sitting, or standing posture. The scale includes 12 progressively challenging items scored on a 4-point scale (0–3), with total scores ranging from 0 to 36. The scale includes two subscales, “posture maintenance” and “posture change,” which are scored separately and then summed to obtain the total score [15]. Higher scores indicate better postural control and balance. In 2018, Zöngür et al. conducted a study on the Turkish validity and reliability of the PASS-T [16].

The Mobility Scale for Acute Stroke Patients (MSAS) is designed to assess mobility in patients during the acute phase of stroke. It evaluates six functional activities -bridging, supine-to-sitting transfer, balanced sitting, sit-to-stand, balanced standing, and gait- based on the level of assistance required. Each activity is scored on a six-point scale, yielding a total score ranging from 6 to 36. Higher scores indicate greater independence and better mobility [17].

The Rivermead Mobility Index (RMI) is used to assess functional mobility in stroke patients. It consists of 15 hierarchically ordered items that evaluate mobility-related activities, including bed mobility, transfers, balance, gait, and running. Each item is scored dichotomously (0 = unable, 1 = able), yielding a total score ranging from 0 to 15. Higher scores indicate better mobility and greater functional independence [18].

The Fugl-Meyer Assessment (FMA) is the gold standard tool for assessing sensorimotor function in individuals after stroke. The lower extremity subscale of the FMA was used in stroke patients. The lower extremity subscale assesses hip, knee, and ankle movements. Items are scored on a 3-point ordinal scale (0 = unable, 1 = partially able, 2 = able), with score ranges of 0–34 for the lower extremity subscale. Higher scores indicate better motor performance [19].

Physical activity parameters were measured with the three-axial accelerometer with a sampling rate of 30 Hz (ActiGraph GT9X link, LLC, Pensacola, FL, USA) [20, 21]. The subjects wore it on the wrist of their non-hemiparetic side throughout the inpatient rehabilitation process, including during sleep, and took

it off only for showering. The data were downloaded and analysed in 1-min epochs using ActiLife 6 (version 6.13.4) software. Energy expenditure was calculated with Freedson Combination (1998) algorithm, respectively. The activity counts (%) were categorized into sedentary (<100 counts/min; SED), light intensity physical activity (100 – 1041 counts/min; LIPA) and moderate to vigorous intensity physical activity (≥ 1041 counts/min; MVPA) [22]. The vector magnitude was derived using a default logarithm in the ActiLife software.

All participants were evaluated by the same physiotherapist at pre- and post-intervention and were allowed to continue their usual medication use.

2.3. Statistical Analysis

Statistical analysis was performed using IBM Statistic (version 24.0; Armonk, NY: IBM Corporation). Descriptive statistical methods were used to summarize the outcome measures.

3. Results

The baseline demographic and clinical characteristics of the participants are summarized in Table 1. The mean age of the participants was 64.0 ± 5.3 years. All participants completed the inpatient stroke rehabilitation safely, with no adverse events reported.

The changes that were obtained pre- and post-intervention in postural control, balance, mobility and motor performance parameters are presented in Table 2. In most cases, no improvements were observed in PASS-T (posture maintenance and change), MSAS, and FMA-lower extremity. In Case 5, a 2-point improvement was observed in the PASS-T (posture maintenance and change), RMI, and FMA-lower extremity scores, while the MSAS showed a 3-point improvement following rehabilitation. For Case 6, RMI increased from 11 to 12 points after rehabilitation.

Data related to the participants' physical activity behavior are presented in Table 3. All participants exhibited sedentary behavior throughout the rehabilitation period. SED at discharge was lower than baseline values in all cases except Case 4. LIPA showed an increase at discharge compared with baseline values in Cases 2, 5 and 6, whereas MVPA increased in Cases 5 and 6. There was an increase in energy expenditure and vector magnitude counts at discharge compared to baseline values, although daily variations were observed during the treatment period.

Table 1. *Demographic and clinical characteristics of the participants.*

		Participants					
		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Sex		Female	Female	Male	Male	Male	Male
Age (year)		57	69	61	70	67	60
Height (cm)		163	151	168	176	183	164
Weight (kg)		75	55	70	80	85	62
BMI (kg/m2)		28.23	24.12	24.80	25.82	25.38	23.04
Dominant side		Left	Right	Right	Right	Right	Right
Affected side		Left	Left	Right	Left	Right	Left
Time from stroke (day)		4	5	4	6	3	4
Abbreviations: BMI, body mass index							

Table 2. Outcome measures in postural control and balance, mobility and motor performance parameters at pre- and post-intervention

	Case 1		Case 2		Case 3		Case 4		Case 5		Case 6	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Postural control and balance												
PASS-T-Posture maintenance (0-15)	12	12	14	14	15	15	13	13	12	14	14	14
PASS-T-Posture change (0-21)	18	18	20	20	21	21	20	20	18	20	20	20
PASS-T-Total score (0-36)	30	30	34	34	36	36	33	33	30	34	34	34
Mobility												
MSAS (6-36)	33	33	35	35	36	36	35	35	32	35	35	35
RMI (0-15)	11	11	12	12	13	13	11	11	10	12	11	12
Motor performance												
FMA-lower extremity (0-34)	31	31	32	32	32	32	31	31	30	32	32	32
Abbreviations: Pre, pre-intervention; Post, post-intervention; PASS-T, Postural Assessment Scale for Stroke Patients; MSAS, Mobility Scale for Acute Stroke Patients; FMA: Fugl-Meyer Assessment.												

Table 3. Outcome measures in physical activity parameters

	Case 1	Case 2		Case3	Case 4			Case 5					Case 6		
	1*	1*	2*	1*	1*	2*	3*	1*	2*	3*	4*	5*	1*	2*	3*
Energy expenditure (kcal)	925.997	875.032	1245.116	1168.17	367.868	215.505	481.496	932.206	1474.218	1307.694	1179.834	1504.051	625.323	435.873	684.814
Physical activity intensity (%)															
SED	39.30	46.46	45.34	52.57	66.46	79.72	79.69	60.35	47.15	54.17	59.65	49.58	62.78	74.58	59.86
LIPA	41.82	24.38	27.7	19.87	29.10	17.92	16.52	22.99	25.97	21.39	19.44	24.65	20.56	13.40	21.74
MVPA	18.87	29.17	26.96	27.55	4.44	2.36	3.79	16.67	26.88	24.44	20.90	25.76	16.67	12.01	18.40
Activity counts															
Vector magnitude counts	1525486.9	1404978.4	1953065.8	1732434.5	581644.5	428412.3	791829.9	968534	1557727.3	1415750.9	1315607.3	1578173.6	1010675.6	722663.9	1129409.9

*24-hour intervals

SED: sedentary, LIPA: light intensity physical activity, MVPA: moderate to vigorous intensity physical activity.

4. Discussion

This case series presents the outcome of 6 people with acute ischemic stroke who participated in a supervised inpatient rehabilitation. We found that the overall amount of activity was low, although inpatient rehabilitation used in people with acute ischemic stroke led to improvements in activity participation; however, it did not affect postural control, balance, mobility, motor performance, except for case 5. No increase in side effects or adverse events was observed during the rehabilitation.

Inpatient stroke rehabilitation plays a crucial role in daily care for patients recovering from stroke. A systematic review and meta-analysis of 8 RCTs involving 1,910 patients with stroke demonstrated that inpatient rehabilitation programs improve functional performance and reduce the length of hospital stay for older adults with stroke [23]. Balci et al. (2011) found improvements in the motor and functional capacity among people with acute stroke following early in-hospital rehabilitation [12]. In contrast, no observable effects of inpatient stroke rehabilitation were found on postural control, balance, mobility, and motor performance in our case series. Only Case 5 indicated a more favorable response to the rehabilitation program compared with the other cases. This finding may be explained by the relatively high levels of motor performance, balance, and mobility observed in patients before intervention. Moreover, further research is required to clarify whether this improvement results from the inpatient rehabilitation program or from spontaneous recovery as part of the disease's natural course.

Physical activity encompasses all behaviors that contribute to energy expenditure [24]. A previous study revealed an association between energy expenditure and overall physical function in people hospitalised for stroke [25]. We observed an increase in energy expenditure following inpatient rehabilitation. It is important to recognize that the observed increase in patients' energy expenditure may not solely reflect greater physical activity associated with the recovery process. Increased energy demands may also arise from the challenges and inefficiencies that patients encounter while performing daily activities. Therefore, when interpreting energy consumption as an indicator of functional improvement, both the level of activity and the potential difficulties experienced during activity performance should be carefully considered.

Today, there is evidence that physical activity is essential after stroke to sustain function, health, and well-being [26-28]. Excessive sedentary time harms recurrent stroke risk factors (i.e., hypertension, dysglycemia) [29] and increased risk of physical deconditioning. In an acute setting, people with stroke spend approximately three-quarters of the day engaged in sedentary behavior or light-intensity physical activity [8]. The acute stroke patients were resting in bed >50% of the time [30] and sedentary 86.6% of their awake time despite inpatient stroke rehabilitation [6]. Using an accelerometer, Tiegues et al. reported that patients in acute settings spent 81% of their waking hours in sedentary behavior [31]. A study by Matlaga et al. reported that the daily time spent sedentary by patients with acute stroke was 94% of a three-day monitoring period [32]. However, we found that patients were sedentary for approximately 60% of the monitoring period, including sleep, until discharge. It is important to recognize the methodological differences in the aforementioned studies. For instance, Tiegues et al. defined sedentary behavior using a thigh-worn accelerometer during patients' waking hours [31], whereas Matlaga et al. defined sedentary time using an ankle-worn accelerometer that included sleep [32]. In this case series, the levels of physical activity intensity (SED, LIPA, and MVPA) were determined using a wrist-worn accelerometer, which also monitored sleep. These methodological differences lead to variations in the classification of physical activity intensity levels and contribute to variability in reported physical activity behaviors, thereby affecting the overall comparability of study findings.

Moreover, there was a reduction in SED at discharge compared to baseline values in our case series, except for Case 4. SED showed an increase in Case 4 despite his great motor function. This observed increase in SED may be associated with individual motivational/characteristic factors and physiological status.

LIPA is defined as activities (standing, cooking, eating, etc.) involving energy expenditure between 1.6 and 2.9 METs [33, 34]. The activities with an energy expenditure of ≥ 3 METs are classified as MVPA, including activities such as walking for at least 10 min, swimming, jogging, and cycling [33]. Distinguishing between SED and LIPA is essential because increasing LIPA may provide a feasible gateway to improving daily activity participation. Our findings demonstrated that patients spent less time in LIPA and MVPA, which is similar to a previous study [35]. Additionally,

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when the change from baseline to the end of treatment was evaluated, most of participants demonstrated an increase in LIPA, MVPA, and all participants showed an increase in activity count following rehabilitation. Notably, Case 2 and 5 exhibited higher physical activity intensity, which indicated a more favorable response to the rehabilitation program compared with the other cases. In the study conducted by Braakhuis et al. [13], physical activity intensity was found to increase between the 3rd and 12th weeks post-stroke; however, this increase showed no, or at best weak, associations with motor recovery. The authors also highlighted the high inter-individual variability in physical activity [13]. This lower levels of physical activity intensity could be attributed to a lack of motivation and social support, fatigue or diurnal variations in clinical stability. Therefore, acute stroke inpatient rehabilitation programs should include improving the ability to stand and walk longer bouts for taking part in activities.

This case series has a strength and limitation. An important strength of this case series is the use of objective methods to assess physical activity behavior. However, there were several limitations. The most important limitations are the lack of a control group and the inability to perform long-term follow-up. Other limitations are the wrist-worn placement of the ActiGraph accelerometer and its use during sleep, which may have affected estimates of sedentary behavior and LIPA. Movements related to changes in sleeping position may have been misclassified as LIPA, whereas prolonged recumbent postures during sleep may have been recorded as sedentary behavior, potentially influencing activity estimates. However, this does not limit the ability to detect intervention-related changes in physical activity intensity. Future studies should account for this methodological consideration in their design.

5. Conclusion

Inpatient stroke rehabilitation has positive effect on activity participation. In acute settings, inpatient rehabilitation can be applied to improve the ability to stand and walk longer bouts for taking part in activities.

Abbreviations

PASS	Postural Assessment Scale for Stroke Patients
MSAS	Mobility Scale for Acute Stroke Patients
RMI	Rivermead Mobility Index
FMA	Fugl-Meyer Assessment
SED	Sedentary
LIPA	Light intensity physical activity
MVPA	Moderate to vigorous physical intensity physical activity

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Author contributions

Conception: BAD, BB, SB; Design: BAD, BB, SB; Supervision: BB, KK; Materials: BAD, BB; Data collection and/or processing: BAD, BB; Analysis-Interpretation: BAD, BB; Literature review: BAD, BB, SB, KK; Writing: BAD, BB, SB; Critical review: BAD, BB, SB, KK

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Data availability

The data obtained in this study are available from the corresponding author upon reasonable request.

Declarations

Ethical approval

The study was carried out with the approval of Dokuz Eylül University, Non-interventional Research Ethics Committee (Protocol number: 4719-GOA).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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