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Rehabilitation for balance impairment in patients after stroke: a single-blind randomized controlled study

Rehabilitacija bolesnika sa poremećajem ravnoteže posle moždanog udara: jednostruko slepa randomizovana kontrolisana studija

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Abstract

Background/Aim. Balance problems in post-stroke patients should be recognized and treated with the most effective rehabilitation approaches. The aim of this study was to assess a group exercise program with chairs for improving balance and walking ability in post-stroke patients. **Methods.** This single-blind, randomized, controlled study included 86 post-stroke patients recruited from the only inpatient rehabilitation facility in the country. Patients were randomly assigned to one of the two groups: a group that had conventional rehabilitation only (control group) or a group that had a group exercise program with chairs, along with the conventional rehabilitation (treatment group). The methodology encompassed examination of demographics, history, clinical (balance was assessed using a Berg Balance Scale – BBS), and functional characteristics (walking ability and ability to use stairs). The assessments were made at baseline and after three weeks of rehabilitation. **Results.** All participants completed the exercise program. According to BBS, the balance improved in both examined groups: by 3.16 ± 2.16 (t = -4.989; p = 0.001) in the control group and by 8.33 ± 5.85 (t = -9.326; p = 0.001) in the treatment group. Significant improvement in balance and walking ability was registered in the treatment group compared to the control group. **Conclusion**. Group exercises with chairs appear to be effective in improving balance and stroke rehabilitation in post-stroke patients.

Key words:
core stability; physical and rehabilitation medicine; stroke; walking.

Apstrakt

Uvod/Cilj. Problemi povezani sa ravnotežom kod bolesnika nakon moždanog udara trebalo bi da se prepoznaju i leče najefikasnijim pristupima rehabilitacije. Cilj rada bio je da se proceni program grupnih vežbi sa stolicama za poboljšanje ravnoteže i sposobnosti hodanja bolesnika nakon moždanog udara. **Metode**. Ovom jednostrukom slepom randomizovanom kontrolisanom studijom obuhvaćeno je 86 bolesnika posle moždanog udara koji su regrutovani iz jedine ustanove za bolničku rehabilitaciju u zemlji. Bolesnici su nasumično raspoređeni u jednu od dve grupe: grupu koja je imala samo konvencionalnu rehabilitaciju (kontrolna grupa) ili grupu koja je uz konvencionalnu rehabilitaciju imala i program grupnih vežbi sa stolicama (testirana grupa). Metodologija je podrazumevala ispitivanje demografskih, anamnestičkih, kliničkih (procena ravnoteže primenom skale *Berg Balance Scale* – BBS) i funkcionalnih osobina (sposobnost hodanja i korišćenja stepenica). Procena je vršena na početku i nakon tronedeljne rehabilitacije. **Rezultati.** Svi učesnici su završili program vežbi. Prema BBS, ravnoteža je poboljšana u obe ispitivane grupe: za 3,16 ± 2,16 (t = -4,989; p = 0,001) u kontrolnoj grupi, i za 8,33 ± 5,85 (t = -9,326; p = 0,001) u testiranoj grupi. U testiranoj grupi je utvrđeno značajno poboljšanje ravnoteže i sposobnosti hodanja u odnosu na kontrolnu grupu. **Zaključak.** Grupne vežbe sa stolicama su korisne u poboljšanju ravnoteže i rehabilitacije bolesnika posle moždanog udara.

Ključne reči:
ravnoteža; medicina, fizikalna i rehabilitacija; moždani udar; hod.

Introduction

Stroke is a neurological disorder that affects roughly 13.7 million people annually [1]. Globally, stroke is the second leading cause of death, with significant increases in stroke incidence and stroke mortality [2]. The stroke incidence among younger adults, in contrast to the older population, is increasing globally [3].

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Hemiparesis is the most common consequence of a stroke, which affects about 65% of patients [4, 5]. In addition to the motor, there are numerous other disorders resulting from a stroke: loss of sensitivity, reduced attention, impaired vision, and spatial orientation, which contribute to balance problems and possible falls [6]. Balance is a complex system that includes motor, sensory, and cognitive components, as well as the interactions among these components and with the external environment. A deficit in any of these three systems after a stroke can lead to instability [7]. Good balance is a prerequisite for achieving independence in walking and performing activities of daily living (ADL) [8, 9]. For stroke patients and their families, establishing independent walking and achieving independence in ADL stand out as essential for functional recovery and quality of life (QoL) [10]. Therefore, it is important to give adequate importance to the problem of balance and its successful rehabilitation. Numerous rehabilitation programs have been implemented to improve balance in stroke patients, including maintaining different standing positions with external and internal perturbations [11], agility and stepping exercises [12], physioball exercises [13], virtual reality exercises [14], postural control exercises [15], robot-assisted therapy [16], balance platform exercises [17], etc. Although the effectiveness of different programs in the rehabilitation of balance after stroke has been proven, there are no general guidelines on the most effective therapeutic approach [9]. On the other hand, a large number of rehabilitation programs for improving balance use specific and sophisticated equipment (computerized balance platforms, virtual programs, robotics), which is quite expensive and not always available [18, 19]. It is important to adopt a unique rehabilitation approach with the primary goal of improving balance, gait, and functional independence after a stroke [20].

Starting from these grounds, we posed the question of proving the efficacy of a simple and achievable program of group exercises on improving balance in stroke patients. The recommendations based on the results of this and similar research could help physiotherapists make a better choice for improving balance, walking ability, and QoL after stroke.

In the present study, we aimed to determine whether group exercises with chairs, as an addition to conventional rehabilitation, can improve balance in post-stroke patients. The additional aim of the research was to establish the impact of the interventions on the patient's ability to walk and use stairs.

Methods

This single-blind, randomized, controlled study was conducted between November 2020 and July 2021 at the Institute for Physical Medicine, Rehabilitation, and Rheumatology "Dr. Simo Milošević", Igalo, Montenegro.

The study protocol was approved by the Ethics Committee of the University of Sarajevo, Faculty of Health Studies, Bosnia and Herzegovina (No. 04-7-99/20, from July 27, 2020). The study was conducted following the principles of the Declaration of Helsinki. Written informed consent was obtained from each patient.

A total of 86 stroke survivors who agreed to participate in the study and who met the inclusion criteria were recruited for research during rehabilitation. The patients were divided into two groups: the control group (n = 43), which consisted of patients who received standard rehabilitation, and the treatment group (n = 43), which consisted of patients who, in addition to standard rehabilitation, received a program of group exercises with chairs. All patients were examined by a physiatrist in the inpatient setting. Randomization occurred after the medical assessment, without the research physiotherapist having any prior knowledge of the patients' conditions. The patients were randomly and equally allocated into the control and treatment groups. Randomization (allocation ratio 1 : 1) was conducted with protocol numbers for each patient included in the study. Independent research assistants allocated patients to a control or treatment group. The assistants used numbered envelopes to conceal the patient allocation from the researcher. However, the research physiotherapist and patients were aware of the group allocation after the first evaluation, owing to the nature of the research process. Patients could not be blinded to their group allocation because there was no placebo intervention in this research.

Patients were excluded from the study if they could not walk independently for at least 10 m, could not stand independently or with support for at least 10 min, could not perform exercises in a standing position with or without holding onto the back of a chair, or if they were diagnosed with an unstable medical or psychiatric condition. The study flow chart is shown in Figure 1. All participants in each group completed the study.

Assessment and data collection

The medical history (diagnosis, type of stroke, number of strokes, date of the last stroke) and demographic information (age, gender, working status, family status) of all patients were collected from facility medical records and by self-report (with permission from the department and informed consent of the participants).

Balance ability was measured using the Berg Balance Scale (BBS), a measuring instrument designed in 1993 by Katherine Berg. The scale objectively assesses the patient's ability to safely maintain balance while performing a series of specific tasks. BBS measures several different aspects of balance, both static and dynamic, with relatively little equipment and space. This 14-item objective scale, with high inter- and intra-examiner reliability (98%) and specificity (96%), is the most frequently used instrument for balance assessment in neurological practice [8, 21].

To conduct the assessment, we needed the following equipment: a 25 cm long ruler, two standard chairs (one with armrests and one without), a footstool or step, and a stopwatch. The examination lasts for a total of about 20 min. The test consists of 14 different items—tasks evaluated on a five-point scale from 0 to 4, based on clearly established criteria. Grade 0 is for the lowest level of function, and grade 4 is for the highest level of function. The maximum possible score is 56, where a higher score means better stability.

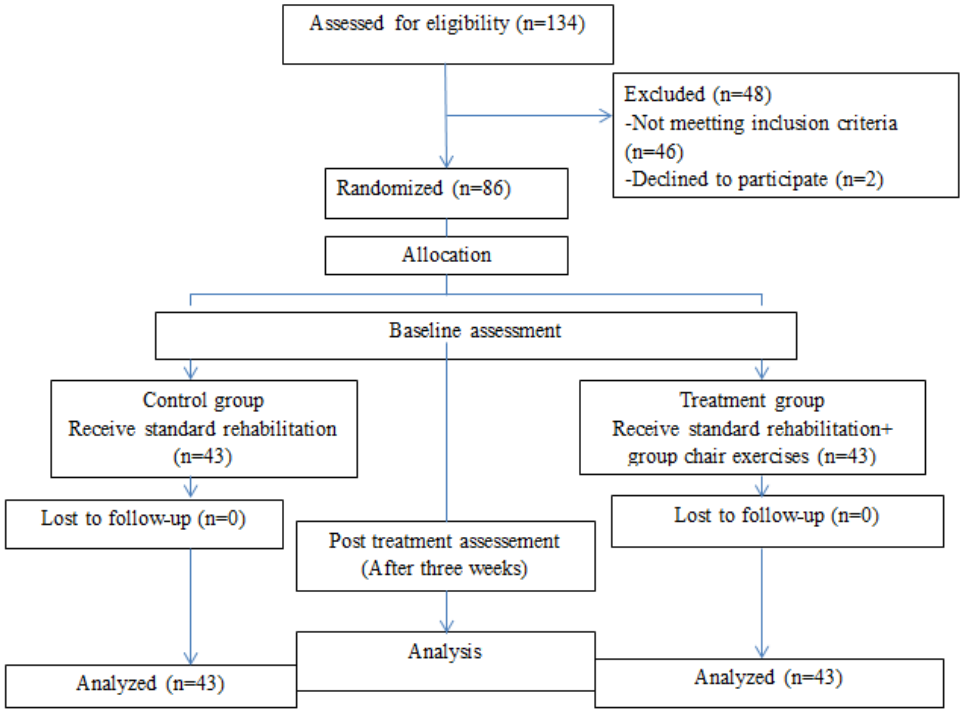

Fig. 1 – Study flow chart.

Walking ability and ability to use stairs were assessed based on careful observation of performance. After assessing the walking ability, all patients were classified into one of the three categories: walking indoors, walking outdoors, and walking as before the stroke. Regarding the ability to use stairs, all patients were classified into one of the five categories: independent, independent but holding handrail, supervision needed, help needed, and cannot use stairs. The testing was conducted on the baseline and after three weeks of rehabilitation. All tests, physiotherapy examinations, and chair exercises were carried out by a research physiotherapist with extensive experience in neurological rehabilitation.

Exercise program

A conventional inpatient stroke rehabilitation program, including a maximum of four therapeutic interventions (individual exercises, manual massage, occupational therapy, and physical modalities), was applied to both groups for three weeks, five days a week. The individual exercise program, lasting 45 min, consisted of strengthening and flexibility exercises for the affected half of the body, as well as walking exercises. Occupational therapy lasted a total of 30 min. The treatment group, in addition to conventional rehabilitation, received group exercises with chairs for three weeks, five days a week. There were at most six patients in the group. If there were more than six participants in a certain period, the exercises were organized in two sessions. The chair exercise program lasted a total of 30 min. During the first 20 min, the participants performed exercises in a sitting position, and the last 10 min in a standing position. During the last 10 min of the program, the patients stood between the chairs and the wall for additional safety during exercise. A combination of flexibility, body weight resistance strengthening, coordination, and static and dynamic balance exercises was applied. Each exercise was repeated up to 10 times. The same set of exercises was repeated daily, with progressive adjustments introduced based on individual tolerance. Progression in the exercises was achieved through increases in the number of repetitions, the time spent standing in tandem or single stance support, the distance reached forward, and the stride length, among other factors. The chairs in the exercise room were arranged in a semicircle to facilitate demonstration, monitoring, and correction of exercise performance.

These chair balance exercises introduced a group approach to exercise, unusual for stroke rehabilitation. The exercise program also promoted activities in upright, sitting, and standing positions, which are necessary for daily functioning. These exercises were designed according to available relevant programs, recommendations, and guidelines based on current best practices, research, and opinions of experts in the field [22–25].

Statistical analysis

Statistical analysis was performed using SPSS Statistics v.20.0. Descriptive statistics were used to express the data as the arithmetic mean ± standard deviation (SD) for both groups. Analysis of categorical variables was performed using Pearson's χ^2-test or Fisher's exact probability test. If the distribution of continuous variables was symmetrical, we used the arithmetic mean and SD to display the mean value and measures of dispersion; to compare these variables, we

used the analysis of variance (ANOVA) test. A student's *t*-test was used to compare the means of the two groups. The influence of non-changeable variables on changeable variables was analyzed by linear regression. We used Pearson's and Spearman's rank correlation coefficients to examine the linear relationship between ratio and ordinal characteristics. The threshold of statistical significance was set at the conventional level of $\alpha = 0.05$. The level of significance was established at $p < 0.05$.

Results

The general characteristics of the study subjects are summarized in Table 1. No statistically significant differences between the two groups were found in terms of patient demographics or clinical characteristics. The average age was 64.79 ± 9.21 years in the control and 66.97 ± 8.06 years in the treatment group. A chi-square test was used to analyze the gender distribution between the control and treatment groups, revealing no statistically significant difference ($\chi^2 = 0.047$; $p = 0.500$). Regarding employment status, most patients in this study were retired, with no statistically significant difference between groups ($\chi^2 = 0.544$; $p = 0.461$). In the control group, an average of 4.30 ± 2.13 months had passed since the stroke, compared to 4.67 ± 2.50 months in the treatment group. The chi-square test also showed no statistically significant difference in stroke frequency based on etiology ($\chi^2 = 0.806$; $p = 0.274$).

The average BBS value at admission for the control group was 46.51 ± 8.36, and for the study group, 44.77 ± 7.78. Using the ANOVA test, no statistically significant difference was found (F = 1.003; $p = 0.319$). In both study groups, there was an improvement after rehabilitation. The average BBS value at discharge for the control group was 49.67 ± 7.76, and for the treatment group, 53.09 ± 3.37. Using the ANOVA test, a statistically significant difference was found between the study groups (F = 7.028; $p = 0.010$) (Table 2).

In the control group, after rehabilitation, there was an improvement of 3.16 ± 2.16 compared to the BBS value at admission, which is a statistically significant difference ($t = -4.989$; $p = 0.001$). In the treatment group, after rehabilitation, there was an improvement of 8.33 ± 5.85 compared to the BBS values at admission, which is a statistically significant difference ($t = -9.326$; $p = 0.001$). By comparing BBS values before and after rehabilitation in relation to the examined

Table 1

The general characteristics of patients after stroke according to study groups

Parameters	Control group (n = 43)	Treatment group (n = 43)	Total
Gender			
female	20 (46.5)	21 (48.8)	41 (47.7)
male	23 (53.5)	22 (51.2)	45 (52.3)
Work status			
employed	7 (16.3)	5 (11.6)	12 (14)
retired	27 (62.8)	30 (69.8)	57 (66.3)
unemployed	9 (20.9)	8 (18.6)	17 (19.8)
Living status			
living alone	11 (25.6)	7 (16.3)	18 (20.9)
not living alone	32 (74.4)	36 (83.7)	68 (79.1)
Side of hemiparesis			
left	16 (37.2)	23 (53.5)	39 (45.3)
right	23 (53.5)	15 (34.9)	38 (44.2)
non-specific	4 (9.3)	5 (11.6)	9 (10.5)
Cause of stroke			
ischemia	38 (88.4)	35 (81.4)	73 (84.9)
hemorrhage	5 (11.6)	8 (18.6)	13 (15.1)

Values are given as numbers (percentages).

Table 2

Comparison of values of the BBS score before and after rehabilitation between groups (each consisting of 43 participants)

Parameters	Mean ± SD	SEM	95% CI		Min–Max	F	*p*
			lower	upper			
Before rehabilitation							
control group	46.51 ± 8.36	1.27	43.94	49.09	23.00–56.00	1.003	0.319
treatment group	44.77 ± 7.78	1.19	42.37	47.16	26.00–56.00		
After rehabilitation							
control group	49.67 ± 7.76	1.18	47.29	52.06	21.00–56.00	7.028	0.010
treatment group	53.09 ± 3.37	0.51	52.06	54.13	40.00–56.00		

BBS – Berg Balance Scale; SD – standard deviation; SEM – standard error of the mean; F – analysis of variance (ANOVA) test; CI – confidence interval; min – minimum; max – maximum; $p < 0.05$.

groups, a statistically greater improvement was found in the treatment group ($p = 0.006$) (Table 3).

The average value and comparison of individual BBS 14 items between the examined groups were determined at the time of discharge from rehabilitation (Table 4). The ANOVA test showed a statistically significant improvement in the treatment group for 6 of the 14 items, namely Standing unsupported ($p = 0.041$), Standing to sitting ($p = 0.049$), Transfers ($p = 0.007$), Standing unsupported with feet together ($p = 0.042$), Reaching forward with outstretched arms ($p = 0.002$), and Pick up (retrieving) object from the floor ($p = 0.004$).

The influence of the independent variables (gender, age, working status, living status, diagnosis, and cause of stroke)

Table 3

Comparison of values of the BBS score before and after rehabilitation within each particular group (each consisting of 43 participants)

Groups	Mean ± SD	SEM	95% CI		*t*	df	*p*	*P*
			lower	upper				
Control	3.16 ± 2.16	0.63	-4.44	-1.88	-4.989	42	0.001	0.006
Treatment	8.33 ± 5.85	0.89	-10.13	-6.52	-9.326	42	0.001	

***t* – paired *t*-test; For other abbreviations, see Table 2.**

Table 4

The average value of individual BBS items of the examined groups at discharge

Parameters	Mean ± SD	SEM	Min–Max
Sitting to standing			
control group	3.84 ± 0.37	0.06	3.00–4.00
treatment group	3.95 ± 0.21	0.03	3.00–4.00
Standing unsupported			
control group	3.91 ± 0.29	0.04	3.00–4.00
treatment group	4.00 ± 0.00	0.00	4.00–4.00
Sitting unsupported			
control group	4.00 ± 0.00	0.00	4.00–4.00
treatment group	4.00 ± 0.00	0.00	4.00–4.00
Standing to sitting			
control group	3.86 ± 0.35	0.05	3.00–4.00
treatment group	3.98 ± 0.15	0.02	3.00–4.00
Transfers			
control group	3.72 ± 0.59	0.09	2.00–4.00
treatment group	3.98 ± 0.15	0.02	3.00–4.00
Standing with eyes closed			
control group	3.63 ± 0.82	0.12	0.00–4.00
treatment group	3.88 ± 0.32	0.05	3.00–4.00
Standing unsupported with feet together			
control group	3.56 ± 0.96	0.15	0.00–4.00
treatment group	3.88 ± 0.39	0.06	2.00–4.00
Reaching forward with an outstretched arm			
control group	3.42 ± 0.73	0.11	2.00–4.00
treatment group	3.81 ± 0.39	0.06	3.00–4.00
Retrieving an object from the floor			
control group	3.67 ± 0.71	0.11	0.00–4.00
treatment group	4.00 ± 0.00	0.00	4.00–4.00
Turning to look behind			
control group	3.74 ± 0.66	0.10	1.00–4.00
treatment group	3.93 ± 0.34	0.05	2.00–4.00
Turning 360°			
control group	3.28 ± 1.03	0.16	0.00–4.00
treatment group	3.53 ± 0.93	0.14	0.00–4.00
Placing the alternate foot on a stool			
control group	3.47 ± 1.03	0.16	0.00–4.00
treatment group	3.79 ± 0.56	0.09	2.00–4.00
Tandem standing			
control group	2.95 ± 1.11	0.17	0.00–4.00
treatment group	3.33 ± 0.78	0.12	2.00–4.00
Standing on one foot			
control group	2.63 ± 1.33	0.20	0.00–4.00
treatment group	3.02 ± 1.03	0.16	0.00–4.00

For abbreviations, see Table 2.

on the dependent variable, the BBS score, at discharge, is shown in Table 5. It is obvious that the BBS score in the respondents of the control group was influenced by the cause of the disease, and in the treatment group by the number of strokes.

Walking ability and the ability to use stairs among the examined groups before and after rehabilitation are presented in Table 6. In the control group, no clinically significant improvement in walking ability was observed following rehabilitation. In contrast, the treatment group

Table 5

The influence of the independent research variables on the dependent variable BBS in the examined groups at discharge

Parameters	Unstandardized coeff.		Standardized coeff.	*t*	Sig.	95% CI for B	
	B	SE	ß				
Constant	51.622	10.685		4.831	0.000	29.952	73.291
Control group							
gender	-2.439	2.362	-0.159	-1.033	0.309	-7.230	2.351
age	0.176	0.128	0.209	1.372	0.179	-0.084	0.436
stroke	-0.705	4.694	-0.023	-0.150	0.882	-10.225	8.816
time	-0.518	0.551	-0.143	-0.940	0.354	-1.635	0.600
diagnosis	0.900	1.768	0.077	0.509	0.614	-2.686	4.486
cause	**-7.338**	**3.581**	**-0.307**	**-2.049**	**0.048**	**-14.601**	**-0.075**
Constant	59.279	6.651		8.912	0.000	45.790	72.769
Treatment group							
gender	0.702	1.013	0.105	0.693	0.493	-1.353	2.757
age	-0.50	0.071	-0.119	-0.697	0.490	-0.194	0.095
stroke	**-4.261**	**1.623**	**-0.411**	**-2.625**	**0.013**	**-7.553**	**-0.969**
time	0.030	0.215	0.022	0.140	0.889	-0.405	0.466
diagnosis	-0.081	0.823	-0.016	-0.098	0.922	-1.750	1.589
cause	0.722	1.482	0.084	0.487	0.629	-2.285	3.728

coeff. – coefficient; B (or b) – used for denoting the realization (value of) regression coefficient in the sample; SE – standard error; β – generally used for denoting population regression coefficient; n – number. For other abbreviations, see Tables 2 and 3.

***Note*: Influenced factors and their values are bolded (cause in the control group and the number of strokes in the treatment group).**

Table 6

Walking ability and the ability to use stairs among the examined groups before and after rehabilitation

Parameters	Control group (n = 43)	Treatment group (n = 43)
Walking ability		
indoors		
before	11	13
after	11	5
outdoors		
before	25	29
after	25	36
walking as before the stroke		
before	7	1
after	7	2
Ability to use stairs		
independent		
before	11	8
after	12	15
independent, but holding a handrail		
before	16	22
after	20	25
supervision needed		
before	4	1
after	5	1
help needed		
before	9	11
after	4	2
cannot use the stairs		
before	3	1
after	2	0

showed a statistically significant improvement (Z = -2.887; $p = 0.004$). The majority of patients in both groups were able to walk independently before and after rehabilitation, which is consistent with the study's inclusion criteria.

Regarding the ability to use stairs, a statistically significant improvement was established in the treatment group compared to the control group. In the treatment group, 8 patients were able to use the stairs independently, without holding the handrail. After rehabilitation, the number increased to 15, which is a statistically significant improvement compared to the control group ($\chi^2 = 4.764$; $p = 0.029$).

Discussion

The results showed that a statistically significant balance improvement was achieved in both examined groups. By comparing the BBS values before and after rehabilitation, it was found that a statistically significantly greater improvement was achieved in the treatment group. Analysis of the influence of independent variables on the BBS score at discharge showed that, in the control group, the BBS score was associated with the cause of the disease, while in the treatment group, it was influenced by the number of strokes. A higher BBS score indicates better postural stability. A significant negative correlation between the BBS score and the number of registered strokes in the treatment group is logical and expected, as individuals with fewer strokes tend to exhibit greater stability. In various studies, authors have analyzed the correlation between independent variables and the BBS score; however, the variables are different from ours, which makes comparing the correlation results difficult [26–28].

The improvement in balance most likely occurred as a result of rehabilitation programs. The results indicate that conventional rehabilitation improves balance; however, the combination of conventional rehabilitation and group chair exercises is significantly more efficient. The positive change in balance in the treatment group was probably due to the content of the chair exercise program. The chair exercises included a combination of flexibility, body weight resistance strengthening, coordination, and static and dynamic balance exercises. A statistically significantly greater improvement in 6 out of the 14 BBS items in the treatment group speaks in favor of the program's effectiveness.

Currently, post-stroke rehabilitation is most often carried out in institutions with the aim of establishing functional independence after discharge [29], following the realization of our research. Our program targeted stroke survivors who were admitted for inpatient rehabilitation. We were guided by the presumption that improving balance function would enable stroke survivors to effectively participate in routine daily activities. We assumed that, along with the improvement of balance, there would also be a recovery of the ability to walk, which is crucial for the functional independence of stroke patients. Many studies and review studies show that rehabilitation and various rehabilitation approaches are effective in improving walking ability after stroke [12, 30–32].

In our research, walking ability was significantly improved in the treatment group after rehabilitation. Our results on walking ability improvement are in agreement with those of a study by Mohd Nordin et al. [33]. They reported walking improvement with group-supervised exercises, which were organized in stations once a week for 90 min *per* session over 12 weeks. The very composition of the exercise program can explain the impact of the group chair exercises on walking ability. Body weight-bearing by the lower limbs, body weight-shifting, and multi-directional step exercises are essential for functional mobility and independence in ADL [34]. The chair exercises included weight-bearing exercises on the affected leg in sitting and standing positions, which could increase proprioceptive awareness and sensorimotor integration, necessary for adaptive and anticipatory aspects of postural control. Another explanation of the chair exercise's influence on walking ability is about their implementation in a sitting and standing position, which contributes to faster recovery and restoration of function after a stroke, as was also reported by Logan et al. [35]. It should be noted that all patients in our study, according to the inclusion criteria, were able to walk for at least 10 m without assistance before rehabilitation.

Previous studies showed that different therapy approaches are beneficial for balance after a stroke [9–15]. Madhuranga et al. [36] concluded that wobble board exercises, in combination with standard physiotherapy, can restore balance function in stroke patients. Various exercises were applied as individual therapy, such as intensive trunk training exercises in multiple planes, as implemented in the study by Ahmed et al. [37].

However, in our research, we introduced exercises organized in small groups, which is not the usual approach in stroke rehabilitation. Unlike individual exercises, group exercises involve a smaller number of physiotherapists and are therefore more economical. Group exercises using chairs require no additional investment and can be easily integrated into the existing workflow of a rehabilitation department, making this approach particularly advantageous. Furthermore, it is important to underline the socialization achieved through group exercises. The participants provided mutual support and motivation, which is the obvious advantage of exercising in a group. The adherence rate was optimal, probably due to the group nature of the exercises.

The presence of a physiotherapist at each session played a crucial role in achieving the observed results and must be emphasized as essential in the exercise organization. Demonstration, active participation, and explanation of each exercise by the physiotherapist were essential for the process of motor learning, proper performance, adherence, safety, and motivation. Social interaction and mutual support are unique to group exercise [38], and are another benefit of these exercises.

Our research has demonstrated that chair exercises are safe and effective in the rehabilitation of patients with mild and moderate stroke. These group exercises can be easily applied and organized in various institutions and offices dealing with post-stroke rehabilitation. This method promotes recovery with minimal use of resources and can effectively enhance standard physical therapy; therefore, it can be potentially used in addition to conventional rehabilitation or as an extension following inpatient rehabilitation. The chair exercise program promotes balance recovery and functional recovery with minimal resources and can effectively improve standard stroke rehabilitation.

As an advantage of our research, we highlight the randomization in the distribution of subjects and the homogeneity, and thus the comparability of the examined groups. However, the limitation of our research is that no long-term follow-up was conducted to determine the stability of the achieved outcomes, which is recommended for future research. The research physiotherapist conducted daily group exercises and performed the final assessment, knowing the distribution of the subjects by group; therefore, they were not blinded to the participants' group assignments. This limitation, although unavoidable, must be highlighted as a weakness and bias in the research.

Conclusion

The results of our research suggest that post-stroke rehabilitation effectively improves balance, but also that it is significantly more effective with the addition of daily 30-min group chair exercises. We sincerely hope that the results of this study will be used to develop recommendations or guidelines for best practices in post-stroke balance rehabilitation.

Conflict of interest

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