ORIGINAL ARTICLE

Impact of exercises administered to stroke patients with balance trainer on rehabilitation results: a randomized controlled study

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Abstract

Objective: The objective of this study was to determine the efficacy of the exercises administered to stroke patients with the balance trainer (BALANCE-trainer, art.nr. 07001-001™) on balance, level of independence and ambulation parameters.

Material and method: Fifty patients with hemiplegia were randomized into either study group or control group. Patients in the control group received 30 sessions of conventional rehabilitation program and patients in the study group were trained with balance trainer in addition to conventional rehabilitation program. Balance level and postural control were evaluated with Berg Balance Scale (BBS) and Timed-Up and Go Test (TUG). Their functional statuses were evaluated using Functional Independence Measure (FIM). Evaluations were repeated following the six-week rehabilitation program.

Results: Of the 50 participants, 19 were women (38%) and 31 were men (62%). The mean age was 57.1 ± 9.2 years. The time that elapsed after stroke was 87.3 ± 26.3 days. Statistically significant improvements were noted in BBS, TUG and FIM in intra-group evaluations for both groups. Statistically significant improvements were documented in BBS and TUG levels for inter-group evaluation (respectively $p = 0.038$, $p = 0.025$), while the difference in FIM levels was not statistically significant ($p > 0.05$).

Conclusion: Positive impact of balance trainer on balance and postural control was demonstrated in stroke patients in the current study. Hippokratia 2015; 19 (2):125-130.

Keywords: Balance trainer, stroke, balance, functional independence

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Introduction

Worldwide, there are about 4.8 million stroke survivors, of whom about 1.1 million suffer lasting functional disabilities[1]. The specific disabilities caused by stroke vary greatly, depending on the area of brain that is damaged. Hemiparesis, a paralysis that characteristically affects the arm and leg on one side of the body, is one of the most common stroke induced impairments[2].

Paralysis and balance disorders caused by stroke, have a significant portion among the chronic diseases causing physical incapacity and increasing the risk of fall[3]. Decrease in muscle strength and proprioception, more load on non-paretic extremity and increase in postural oscillation are among the factors causing distortion of balance, in such patients[3,4]. It is reported that upper extremity dysfunction may affect the balance significantly in stroke patients, as well as the relation between lower extremity weakness and balance disorder following stroke. Accordingly, some forces and moments occur during the movement of the upper extremity, depending on the weight and dynamics of that arm and such forces and moments may distort the balance, affecting standing still and sitting posture and ability to change position[5]. Au-Yeung et al[6] indicated that distorted upper extremity functions, disrupt body kinematics and affect locomotor functions.

Fall is one of the most common complications in stroke patients[7], and balance disorder is the major risk factor predisposing to fall. Fifty to 70 % of these patients experience fall at hospital or at home[8]. The fear of fall caused by balance disorder, or femur fractures after fall cause a decrease in physical activity[7].

Postural control and balance are required components for walking and mobility after stroke. Particularly, training for weight-bearing on the affected side is essential. Sensory stimulation and neuro-developmental treatment, ensuring weight-bearing on the affected side, are among the conventional treatments[9,10]. Postural control is reported to be the best indicator of independence in walking and daily life activities, in stroke patients[11-13]. Therefore, improvement of stable standing position in hemiplegic patients and betterment of postural control is a critical step in the rehabilitation process[13-15]. Correction of standing balance was found to be much more important than strengthening lower extremity muscles in improvement of daily life activities and walking capacity in the studies conducted[14].

Nowadays, biofeedback systems such as balance master and balance trainer are successfully used in the development of standing balance and postural control, as well as in functional walking training[10]. Such systems are considered to bring an additional contribution to increasing the independence levels of the patients.

The objective of the study was to determine the efficacy of the exercises administered to stroke patients with the balance trainer (BALANCE-trainer, art.nr. 07001-001, Blumenweg, Germany™) on balance, level of independence and ambulation parameters.

Material and method

Fifty patients with hemiplegia related to stroke and who were able to understand and follow the instructions (Mini Mental Test score >23) and walk without any support, were included in the study. Patients with other neurological diseases or those who had history of drug use that could affect the balance, such as antiepileptic or antihistaminic medications, were excluded. Patients were divided into two groups using "Permuted Block Randomization" method by using MedCalc 11.5.1 program. Due to small sample size we selected this method of randomization. Also this method increases the probability that each arm will contain equal number of individuals by sequencing participant assignments by block.

Study protocol

Age, gender, education status, lesion side, duration of disease, Mini Mental Test score and stroke risk factors of the patients were recorded. Patients allocated in the control group were included in a 30-session conventional rehabilitation protocol. This program covered the range of motion exercises, balance, coordination and postural control exercises, walking training and occupational therapy. Patients allocated in the study group were trained for 20 minutes a day, five days a week for a total of six weeks (30 sessions/600 minute in total) with the balance trainer (BALANCE-trainer, art.nr. 07001-001™) in addition to this program, under the supervision of an experienced staff (Figure 1). Visual feedback balance training with the balance trainer was used in the study group. There were no drop outs in any of the groups. Balance training was performed while standing on a Balance trainer. Subjects in the study group were encouraged to maintain their posture steadily and symmetric while weight bearing and adapting to different static sensory conditions, through verbal and tactile cues.

Figure 1: Patients in the study group were trained for 20 minutes a day, five days a week for a total of six weeks (30 sessions/600 minute in total) with balance trainer. Exercises administered to the only study group with BALANCE-trainer, art.nr. 07001-001™ device.

Conventional rehabilitation program

Patients of both groups performed the conventional rehabilitation program under the supervision of a physician, five days a week for six weeks. Before rehabilitation program, patients were given five minutes to warm up, as well as stretching exercises in order to increase soft tissue flexibility and range of motion. All patients performed strengthening, balance, and endurance exercises of three sets for each session. Each set lasted 10 minutes, sixty-second resting was allowed between each set. Detailed explanations of each program are given in Table 1[16-17].

Balance and postural controls of the patients, before and after the rehabilitation program, was evaluated with the Berg Balance Scale (BBS) and the Timed-Up and Go test (TUG) and their functional situations were evaluated using the Functional Independence Measure (FIM).

Table 1: The protocol of rehabilitation program performed by both groups. Conventional rehabilitation program performed five days a week for six weeks, total of 30 sessions by both groups.

Warm up (5 min) • Range of motion and flexibility: range of motion and stretching to the shoulder, elbow, wrist, fingers and ankle
Exercises (30 min) • *Strengthening*: Active motion in proprioceptive neuromuscular facilitation unilateral patterns with manual resistance progressing to Theraband repetitions (2 sets of 10) in anatomical planes. • *Balance:* Step-ups: repeated stepping anteriorly and laterally onto a step Chair-rises: repeated rising from a seated position Toe rises: repeated rising up on toes • *Endurance:* Riding a stationary bike, progressing in time up to 30 min with increasing speed and resistance

Berg Balance Scale

BBS is a scale commonly used to evaluate balance disorders. It contains 14 articles. The functions of standing up from sitting position, standing without support, sitting without support, sitting from standing position, transfers, standing with eyes closed, standing with legs united, reaching out while standing, picking an object from ground, turning back to look, 360-degrees rotation, healthy side standing on a stool, standing with one foot forward and standing on one foot are evaluated. Each article is rated between 0-4, according to success of fulfilling the relevant function or the time spent. The lowest level of the function is defined as 0 while the highest level is defined as 4, maximum score is 56. Scores 0 to 20 mean high risk of fall, 21 to 40 mean moderate risk of fall and 41 to 56 means low risk of fall. The validity reliability of BBS which was translated into Turkish and adopted interculturally was performed by Sahin et al[18].

Timed-Up and Go test

The TUG test was carried out by the same investigator for each patient. As proposed by several authors[19-22] the test was executed as follows: 1) Patients were required to stand up from a chair with armrests, walk three meters, turn around, return to the chair, and sit down again, as fast as possible[20,23], 2) Time taken to complete this task was recorded in seconds using a stopwatch and 3) Three trials were recorded per patient to reduce the variability. TUG is a test of functional mobility in stroke patients.

Functional Independence Measure

FIM indicates patient's level of independence in his/her daily basic physical and cognitive activities. FIM is a scale comprised of 13 physical and 5 social-cognitive states and gives evaluation scores from 18 to 126. It includes a gradual scale to evaluate self-care, sphincter control, transfer, movement, communication, social relation and cognitive status. Scoring does not indicate the patient's capacity but his/her true performance. The validity reliability of FIM which was translated into Turkish and adopted interculturally was performed by Kucukdeveci et al[24].

Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 10 software (SPSS Inc., Chicago IL, USA). Compliance of the data obtained from measurements to normal distribution was examined by Kolmogorov-Smirnov test and it was observed that the data of the both groups were normally distributed. Wilcoxon signed rank test was used to compare dependent variables, the Mann Whitney U-test was used to compare inter-group parametric data and the Yates-corrected chi-squared test was used to compare the nominal data. The level of significance was set at $p < 0.05$ in all calculations.

Results

Of the 50 participants, 19 were women (38%) and 31 were men (62%). The mean age was 57.1 ± 9.2 years. The time that elapsed after stroke was 87.3 ± 26.3 days. Demographic characteristics and clinical parameters of the patients are given in Table 2. No statistically significant difference was found in terms of descriptive features of the patients included in the control and the study groups ($p > 0.05$) (Table 2).

No statistically significant difference was found between the groups in follow-up parameters before treatment ($p > 0.05$) (Table 3).

A statistically significant improvement was observed in FIM motor, FIM cognitive and FIM total parameters in both groups after the treatment ($p < 0.05$) (Table 3). Also statistically significant improvement was observed in BBS and TUG parameters in both groups after the treatment ($p < 0.05$) (Table 3).

No difference was found in terms of FIM parameters between the groups in comparison of differences between the groups before and after the treatment ($p > 0.05$) (Table 3). However, improvement in BBS and TUG parameters in the study group was statistically significant (respectively $p = 0.038$, $p = 0.025$) (Table 3) (Figure 2).

Discussion

The typical hemiparetic gait post-stroke is associated with a reduced walking velocity, cadence and stride length, with gait asymmetry and with a prolonged double-support and stance- phase duration of both lower extremities[25,26]. Good balance skill is an important determinant of walking performance while impaired balance ability is assumed to be related to a decreased locomotor function[27,28]. A frequently used clinical test to assess functional mobility is

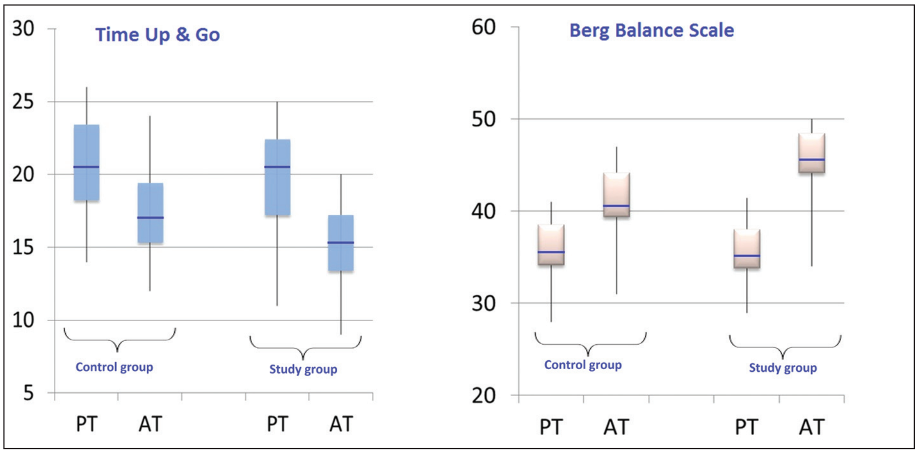

Figure 2: Assessment of functional walking with Time up & Go test and balance parameter with Berg Balance Scale. There were statistically significant improvements in study group in Time up & Go test and Berg Balance Scale parameters.

PT: Pre-treatment, AT: After-treatment.

Table 2: Demographic characteristics and clinical parameters of control (n=25) and study group (n=25). There is no significant chance in baseline characteristics of the study population.

	Control group (n=25)	Study group (n=25)	p
Age (yr)	57.6 ± 9.4	56.7 ± 8.9	0.52
Gender (%)			0.41
Female	10 (40)	9 (36)	
Male	15 (60)	16 (64)	
Education (%)			0.27
Illiterate	5 (20)	6 (24)	
Elementary/secondary school	15 (60)	14 (56)	
High school	4 (16)	3 (12)	
University	1 (4)	2 (8)	
Risk factors for stroke (%)			0.34
Hypertension	17 (68)	17 (68)	
Diabetes mellitus	8 (32)	8 (32)	
Hypercholesterolemia	8 (32)	9 (36)	
Atrial fibrillation	7 (28)	8 (32)	
Coronary artery disease	7 (28)	8 (32)	
Family history	5 (20)	5 (20)	
Smoking	9 (36)	10 (40)	
Affected hemisphere ***(%)***			0.42
Right	15 (60)	14 (56)	
Left	10 (40)	11 (44)	
Stroke type ***(%)***			0.38
Ischemic stroke	20 (80)	21 (84)	
Intraparenchymal hemorrhage	5 (20)	4 (16)	
Duration after stroke (day)	84.6 ± 27.6	90.1 ± 24.6	0.12
Mini Mental Test score	21.5 ± 4.2	22.4 ± 4.3	0.65

Data are presented as mean ± standard deviation, number (%) or median (minimum-maximum), where appropriate. yr: year.

Table 3. Assessment of Functional Independence Measure (FIM), Berg Balance Scale (BBS) and Time up & Go test (TUG) parameters among groups. A statistically significant improvement was observed in FIM motor, FIM cognitive and FIM total parameters in both groups after the treatment. Also statistically significant improvement was observed in BBS and TUG parameters in both groups after the treatment. Improvement in BBS and TUG parameters in the balance group was statistically significant.

	Control group (n:25)		Study group (n:25)		CG group vs SG group
	Mean ± SD	P	Mean ± SD	P	P
FIM motor					
Baseline	56.7 ± 8.7		56.9 ± 8.8		0.760
After treatment	61.2 ± 9.2	**0.038** †	61.1 ± 9.1	**0.039** †	0.684
Amount of Change	*4.5*		4.2		0.451
FIM cognitive					
Baseline	17.9 ± 3.7		18.4 ± 2.9		0.811
After treatment	24.4 ± 4.1	**0.034** †	25.6 ± 3.8	**0.028** †	0.773
Amount of change	*6.5*		7.2		0.254
FIM total					
Baseline	74.6 ±1 2.7		75.3 ± 13.2		0.811
After treatment	85.6 ± 14.2	**0.020** †	86.7 ± 16.4	**0.018** †	0.773
Amount of change	*11.0*		11.4		0.254
BBS					
Baseline	36.4 ± 5.7		36.9 ± 4.8		0.811
After treatment	41.5 ± 4.2	**0.020** †	45.6 ± 6.4	**0.018** †	0.773
Amount of change	*5.1*		8.7		**0.038***
TUG					
Baseline	21.2 ± 2.7		20.8 ± 2.7		0.811
After treatment	17.4 ± 1.2	**0.020** †	15.2 ± 1.1	**0.018** †	0.773
Amount of change	*3.4*		5.6		**0.025***

Data are presented as mean ± standard deviation. CG: Control group, SG: Study group. †: Baseline versus after treatment, *: p significant at <0.05 (Control group versus Balance group), FIM: Functional Independence Measure, BBS: Berg Balance Scale, TUG: Timed-Up and Go Test.

the TUG test[29]. TUG performance is reduced following stroke[22]. The TUG has been shown to be valid, and to identify the risk of falling in patients with stroke[23,29].

Therefore, specific methods are implemented with respect to imposing weight and stance weight bearing to the affected lower extremity during treatment of posture, balance and walking function in hemiparetic adults[30,31].

Improvements in motor function following a stroke occur as the result of spontaneous recovery, learning and practice due to reorganization of the brain. Studies suggest that this process is strengthened by specific intensive tasks. Visual biofeedback is a rehabilitation method that can be used during static balance training, offering to the patient visual information on the position of the center of gravity within the range of stability, as the patients stands on a pressure plate. The proposed concept of balance training consists of increasing the activity of the receptor organ in the inner ear during exercises, activating the integrating mechanism in the central nervous system by offering varying sensory inflow, including visual information and training the neuromuscular effecter system[32].

Although the stance weight bearing was more symmetric after visual feedback training when compared with conventional therapy, the enhanced effects on dynamic functional balance ability were still inconclusive[31,33,34]. Evidences concerning that Force Plate Visual Feedback treatment correcting the functional activity performance such as walking significantly are insufficient[35,36].

Srivastava[37] administered Balance Master program to forty-five stroke patients for four weeks, five times a week, with each session lasting twenty minutes. Balance and functional status of the patients were evaluated using Berg Balance Scale, Balance Index and Barthel Index. It was demonstrated that significant improvements occurred in balance and functional results, right after the treatment and three months following the treatment. Chen et al[38] evaluated late period impacts of balance training program on balance functions of hemiplegic stroke patients. They found significant improvement in balance functions in patients receiving feedback training, compared to patients receiving only conventional therapy. Activities of daily living (ADL) function in self-care also had significant improvements at six months of followed-up in the trained group. On the other hand, they did not find a significant difference between the patient groups in terms of static balance functions. However, although Geiger et al[33] found significant improvement in both groups in terms of BBS and TUG test in a randomized controlled study performed with visual feedback training, they did not find a significant difference in the inter-group evaluation. No additional useful impact of visual feedback training was shown. A latter study of Yavuzer et al[29] reported that an additional 15 minutes of balance training with the Force Plate Visual Feedback, produced superior results in pelvic excursion as compared to neurodevelopmental training alone, but not in walking velocity. Additionally, Eser et al[39] did not find any statistically significant difference between two treatment regimes in their study performed using more conventional tests such as Brunnstrome stage, Rivermead Mobility Index, and FIM. Similarly, while Winstein et al[31] obtained better results in terms of weight bearing, stability and standing in the group receiving special augmented feedback training, they did not find any significant difference between two groups in terms of locomotor control performance. In accordance with the previous studies, we found that static balance function showed significant improvements in the visual feedback study group when compared to the control group. But, no improvement has been documented in FIM scores. Our results showed that although balance training was beneficial for standing balance and posture, insufficient improvement was obtained for the functional activities of the stroke patients.

When the results in the literature are considered as a whole, it seems that although the additional improvement obtained in balance parameters upon additional exercise with balance trainer is important, it is disappointing that this improvement is not reflected on the daily life activities and independence levels. It is possible to perform horizontal exercises with balance trainer and previous treatments is performed only in the horizontal plane[29,39], even though many ADL, for example the 'sit to stand' process, are performed in the vertical plane[40].

Dwelling upon the possible impacts of this situation, Lee et al[40] developed a new balance trainer, a Balance Control Trainer. This system allows exercise on both horizontal and vertical plane. Forty stroke patients were evaluated before balance trainer therapy and in the second and fourth weeks with functional tests of ambulation categories, 10-meter walking test, TUG test, the BBS and the Modified Barthel Index. Statistically significant improvement was found in all parameters in the 4th week. They showed that training chronic stroke patients with a newly developed balance trainer is a feasible and potentially effective intervention to improve balance and mobility[40].

Shumway-Cook et al[41] demonstrated that body oscillation increases in the frontal plane as a result of postural asymmetry which occurs due to imposing less weight on lower extremity in hemiparetic stroke patients[41].

Similarly, Dault et al[42] suggested that frontal plane imbalance led to postural problems in stroke patients. They suggested that visual feedback studies could be useful in improving the frontal plane asymmetry and imbalance of stroke patients[42].

Horak et al[43] showed that the balance retraining was context- or task-specific. The weight shifting tasks performed in the study could be helpful in improving stance symmetry but did not necessarily correspond to improvements in gait or other higher level mobility and balance tasks[43].

In conclusion, significant improvement was found in balance and postural control in stroke patients when balance trainer is compared with conventional therapy. The impact of the exercises administered with balance trainer on the dynamic balance functions is still disputed. Further studies are needed for its impact on dynamic balance functions.

Conflict of interest

Authors declare no conflict of interest.

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