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Restoration of the Gravity Center with Computerized Dynamic Posturography in Post Stroke Rehabilitation

[*1,2]Işıl DOĞANER, M. Sc., PT

[1]Prof. Z. Candan Algun, PhD, PT

ABSTRACT

Purpose: To know the effect of a personalized rehabilitation program on balance parameters was examined according to the balance test results in chronic stroke hemiparetic patients with and without a fall history.

Methods: 70 patients aged 45 (+/- 5)-70 (+/- 5) years who had stroke history 6-18 months ago were included in the study. We applied both rehabilitation and custom training to the group with a fall history. Only rehabilitation was applied to the group without any history of falls. Rehabilitation included active-assistive joint movements, strengthening program, neuromuscular electrical stimulation, balance training in parallel bars. The rehabilitation program was administered for 1 hour, five days a week for eight weeks. Balance evaluation was performed by using Computerized Dynamic Posturography (BDP) device (NeuroCom Balance Manager®), and Sensory Organization Test (SOT), Stability Limits Test (LOS), Rhythmic Weight Shifting Test (RWS) results obtained for both groups.

Results: In the chronic stroke group with a fall history, statistically significant improvement was observed in SOT composite and RWS-F/B after treatment compared to pre-treatment ($p = 0.035$ and $p = 0.031$). In the chronic stroke group without a history of falling, the statistical significance was observed in the SOT5, SOT composite, and RWS-F/B after treatment ($p = 0.045$; $p = 0.014$ and $p = 0.009$).

Conclusion: We think that BDP balance assessment and personalized rehabilitation in chronic stroke patients are essential in guiding strategies for coping with the balance disorders encountered in chronic stroke patients with and without a history of falls.

Keywords: Computerized Dynamic Posturography; Fall; Stroke; Rehabilitation.

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[1]Istanbul Medipol University, Institute of Health Sciences, Department of Physical Theraphy and Rehabilitation.
[2]İstanbul Yeniyüzyıl University Gaziosmanpaşa Hospital, Physical Therapy and Rehabilitation Unit, Merkez Mahallesi Çukurçeşme Caddesi No:51, Gaziosmanpaşa/ İstanbul,Turkey.
E-mail: isil.doganer@gmail.com

CORRESPONDING AUTHOR

[*1,2]Işıl DOĞANER, M. Sc., PT

INTRODUCTION

Stroke is also a significant health problem affecting all areas of life, resulting in neurological insufficiency and functional disability. As a result of developing intensive care and other health services, the chance of survival of stroke patients has increased, increasing patients with stroke and rehabilitation needs in the community [1].

Patients focus on how this will affect their future lives rather than rehabilitation in the first two weeks after stroke. In this period, the patient and his/her future life should be handled from a holistic perspective [2].

Balance is a condition provided by the coordination and integration of the body systems in the inner ear, including the vestibular system, visual system, motor, and high cortical levels (4,6).

Severe losses occur in balance, coordination, and position sensation after stroke. Because in stroke patients, due to sensorimotor dysfunction, loss of power, loss of sensation, vision problems, walking difficulties may frequently develop [2,5]. Since these affected systems and organs are in the centers involved in maintaining balance, in stroke patients, disruption of the body balance and observation of falls are natural [2,7]. Post-stroke falls are frequent, at rates of up to 25%, both in the acute phase, in the rehabilitation phase, and in the long term [2].

Pain causes limitations in daily life activities and negatively affects the quality of life (9.10). When shoulder pain develops in a stroke patient, inhibition of rehabilitation occurs, motor masks recovery and shoulder-hand-pain syndrome develops at a rate of 67%.

After the patient's condition has stabilized, evaluations with standardized, valid assessment tools are essential for developing a comprehensive treatment plan. These measurements help provide reliable documentation on the patient's neurological status, disability level, functional independence, family support, quality of life, and development over time [2].

The purpose of physiotherapy and rehabilitation in stroke patients is to raise the person to the maximum level of independence that he/she can reach physically, psychologically, socially, and professionally and improve the quality of life of the person [3]. Active rehabilitation programs applied to patients should be physiotherapy for 1 hour 5 days a week [2].

Physical therapy and rehabilitation methods in stroke patients include traditional exercise programs, neurophysiological approaches, functional electrical stimulation (FES), walking assistive devices such as Reflex-Afo [8].

In 1978, he performed the sensory control of posture in individuals with normal and vestibular deficits using BDP (Computerized Dynamic Posturography). His studies led to the development of the BDP used in the clinic [11,12].

BDP (Computerized Dynamic Posturography); contains the isolation and measurement of quantities for (I) orientation of inputs from visual, vestibular, and somatosensory systems, (II) central integration mechanisms for the selection of functionally appropriate orientation senses, (III) movement strategies that are functionally appropriate in different controlled task conditions, and (IV) motor output mechanisms to create postural movements timely and effectively [13,14].

SOT; is a frequently used assessment in populations in which different deficits of postural control are observed, such as Parkinson's disease [15], peripheral vestibular deficits [16], hearing loss [13], peripheral neuropathy [17], or stroke [22] and falling and non-falling patients [18], which are also the subject of our study.

In studies, the importance of using training programs to improve balance skills in reducing and preventing falling in chronic stroke patients was emphasized [19,21].

METHOD

Randomly selected 70 patients aged 45 (+/- 5)-70 (+/- 5) years who had stroke history 6-18 months ago and came to Istanbul Yeni Yüzyıl University Gaziosmanpaşa Hospital, Physical Therapy, and Rehabilitation Unit between August 2019 and May 2020, for rehabilitation and physiotherapy purposes after stroke, were included in the study. The sample volume was determined by power analysis. As a result of the analysis, it was determined that at least 66 patients be reached with a 5% error level and 80% power for a 10% unit change with rehabilitation after stroke. This is a prospective study in which the training of gravity center with a personalized planned rehabilitation program is conducted and groups with and without a history of falling are compared in terms of results in the light of the results of balance testing in chronic hemiparetic patients with and without a history of falling after stroke

The Physiotherapist collected the data with Computerized Dynamic Posturography (BDP). The study's purpose was explained, and evaluations were applied to the patients who filled out the written consent form. Seventy patients aged 45 (+/- 5)-70 (+/- 5) years who had stroke history 6-18 months ago were included in the study. Seventy hemiparetic patients were evaluated, with a fall history (n = 35) and the group without a fall history (n = 35). Criteria for inclusion in the study was determined as 6-18 month history of chronic stroke, apart from hemiparesis, patients without any neurological and orthopedic problems, using "Reflex Afo" in their daily life, without cognitive problems, with and without fall history, without any visual, auditory and vestibular problems. Exclusion criteria from the study included patients with shoulder pain having Visual Analog Score (VAS)> 6, a different neurological problem other than stroke, having orthopedic surgery, or using a prosthesis, having respiratory distress or similar breathing problems, having spasticity at the value of 4 according to Modified Ashworth Scale.

Among the patients included in the study, five were excluded from the study for various reasons, and two patients were excluded from the study as "Ex." With this,

among the outpatients who came to the Physical Therapy Unit, patients in line with the research criteria were selected again. The targeted 70 patients criteria were reached by filling in the written consent forms.

Our study was approved by the Istanbul Medipol University non-invasive clinical research ethics committee (19.08.2019 / 10840098-604.01.01-E.41152).

TEST PROTOCOL

SENSORY ORGANIZATION TEST (SOT)

SOT, which can be evaluated with Computerized Dynamic Posturography (BDP), is a test that provides information about the static and dynamic balance that determines the individual's ability to control the location of the center of gravity when the visual and proprioceptive data is broken. This test consists of six sections that objectively identify abnormalities in the somatosensory, visual, and vestibular systems that provide postural control (24,25). SOT 1. Eyes open platform and surrounding cabinet is fixed; SOT 2. Eyes closed platform, and surrounding cabin is fixed; SOT 3. Eyes are open; the platform is fixed; the surrounding cabin is swinging; SOT 4. Eyes are open; the platform is swinging; surrounding cabinet is fixed; SOT 5. Eyes are closed, the platform is swinging, the surrounding cabinet is fixed; SOT 6. Eyes are open, and the platform is swinging, the surrounding cabinet is swinging.

STABILITY LIMITS (LOS) TEST

LOS, another test that can be examined with BDP, is also defined as the area where a person can lie leaning with his body without changing the support surface. Suppose the body swings beyond the LOS limit. In that case, various protective reactions (postural swings, ankle, hip, and stepping strategy) should be used to restore the support surface and restore balance, or falling will occur.

RHYTHMIC WEIGHT TRANSFER (RWS) TEST

RWS, which can be evaluated with BDP, is designed to evaluate the center of gravity's reciprocal movements. The patient's ability to transfer weight rhythmically to the left-to-right and front-to-back between two fixed points on the screen is tested [25].

Both conventional rehabilitation and "Custom Training" were given to the group with a history of falling; only conventional rehabilitation was applied to the group without a history of falling. This program was applied for 1 hour 5 days a week and continued for eight weeks. "Custom Training," which was applied only to the group with a falling history, was held 20 minutes 3 days a week. In addition to conventional rehabilitation, a 20-minute balance exercise program was applied in each session. "Custom Training" was held in BDP, and patients were subjected to 4 different 5-minute training sessions, and no rest period was given between the studies. The training's difficulty started at 50% and increased up to 80%, and the difficulty of the training was increased by 10% every two weeks.

STATISTICAL ANALYSIS

In the data analysis of our non-invasive clinical study, the "Statistical Package for Social Sciences" (SPSS) Version 22 statistics program was used. Since the data did not show normal distribution according to the results of the analysis, the Wilcoxon test, which is one of the non-parametric tests, was used in the comparison of the groups (Group 1: chronic stroke patient group with a history of falling; Group 2: chronic stroke patient group without a history of falling) before and after the treatment. SOT, LOS, RWS scores included the comparison of pre-treatment and post-treatment values. In our study, SOT's lower digits, SOT1, SOT2, SOT3, SOT4, SOT5, SOT6, and composite values were compared. In the intra-group analysis, statistical significance was evaluated at the level of $p < 0.05$.

SOT IN CHRONIC STROKE PATIENT GROUP WITH A HISTORY OF FALLING

In our study, when the results of SOT of chronic stroke patients with a history of falling were examined; no statistically significant difference was found in the results of SOT1 ($p = 0,509$), SOT2 ($p = 0,973$), SOT3 ($p = 0,729$), SOT4 ($p = 0,339$), SOT5 ($p = 0,877$) and SOT6 ($p = 0,094$). Statistically significant difference ($p = 0.035$) was found only at COMP (composite) value (Table 1).

Table 1: SOT in chronic stroke patients with a history of falling

SOT in chronic stroke patients with a history of falling		Mean+ /-Std. D.	Min	Max	Median	Z	P
SOT1 (Eyes open platform and surrounding cabinet fixed)	Pre-treatment	91.20+ /-3.08	83.67	96.00	92.00	-0.660	0.509
	Post-treatment	90.93+ /-3.11	83.33	95.00	91.67		
SOT2 (Eyes closed platform and surrounding cabin fixed;	Pre-treatment	88.53+ /-4.37	77.00	96.67	89.00	-0.034	0.973
	Post-treatment	88.37+ /-4.32	77.00	95.00	89.67		
SOT3 Eyes are open, platform is fixed, surrounding cabin is swinging)	Pre-treatment	86.52+ /-5.00	71.00	94.00	87.00	-0.346	0.729
	Post-treatment	86.34+ /-5.40	70.67	88.33	88.33		
SOT4 (Eyes are open, platform is swinging, surrounding cabinet is fixed)	Pre-treatment	75.40+ /-8.77	46.67	87.67	78.00	-0.957	0.339
	Post-treatment	76.30+ /-11.42	46.67	91.00	79.33		
SOT5 (Eyes are closed, platform is swinging, surrounding cabinet is fixed)	Pre-treatment	60.17+ /-13.51	17.00	85.00	60.00	-0.154	0.877
	Post-treatment	60.55+ /-13.26	36.00	90.33	59.00		
SOT6 (Eyes are open, platform is swinging, surrounding cabinet is swinging)	Pre-treatment	56.50+ /-10.71	35.33	75.67	57.67	-1.676	0.094
	Post-treatment	59.50+ /-13.77	34.67	78.00	63.00		
COMP	Pre-treatment	68.10+ /-8.36	50.00	83.00	71.57	-2.110	0.035
	Post-treatment	71.57+ /-8.34	52.00	84.00	74.00		
p≤ 0.05 Wilcoxon							

p ≤ 0.05, Wilcoxon Test, "SOT:" Sensory Organization Test

LOS IN CHRONIC STROKE PATIENT GROUP WITH A HISTORY OF FALLING

In chronic stroke patients with a history of falling, two different values were recorded from the LOS test before and after treatment, RT, and MVL. RT (Reaction Time); the time (seconds) between the patient's command to move and the patient's first movement. MVL (Movement Velocity) is the average speed (degree per second) of gravity center movement. As a result of LOS-RT, LOS (F) (p = 0,380) and LOS (B) (p = 0,151) values were calculated and no significant difference was found. In LOS-MVL values, it was not statistically significant as LOS (F) (p = 0.48) and LOS (B) (p = 0.57).

RWT IN CHRONIC STROKE PATIENT GROUP WITH A HISTORY OF FALLING

In chronic patients with a history of falling, two different values were recorded from the RWS test before and after treatment as L (Left) / R (Right) and F (Front) / B (Back). The change in L / R value (p = 0.737) was not statistically significant. A significant improvement was found in F / B value (p = 0.031) (Table 2).

Table 2: RWS in chronic stroke patients with a history of falling

RWS in chronic stroke patients with a history of falling (Limits of Stability-Movement Velocity)		Mean+ /-Std. D.	Min	Max	Median	Z	P
L/R	Pre-treatment	4.63+ /-1.23	2.90	7.40	4.60	-0.336	0.737
	Post-treatment	4.70+ /-0.88	2.90	6.47	4.67		
F/B	Pre-treatment	2.57+ /-0.76	1.43	5.57	2.43	-2.162	0.031
	Post-treatment	2.84+ /-0.67	1.60	4.60	3.07		
p ≤ 0.05 Wilcoxon							

p ≤ 0.05, Wilcoxon Test, ‘’ RWS: ‘’ Rhythmic Weight Transfer, ‘’ L : ‘’ Left, ‘’ R: ‘’ Right," F: ‘’, Front,

‘’ B: ‘’ Back

SOT IN CHRONIC STROKE PATIENT GROUP WITHOUT A HISTORY OF FALLING

When the results of SOT before and after treatment of chronic stroke patients without a history of fall were examined; no statistically significant difference was found in the results of SOT1 (p = 0.216), SOT2 (p = 0.553), SOT3 (p = 0.212), SOT4 (p = 0.132) and SOT6 (p = 0.670). Statistically significant difference was found at the value of SOT5 (p = 0.045) and COMP. (composite) (p = 0.014) (Table 3).

Table 3: SOT in chronic stroke patients without a history of falling

SOT in chronic stroke patients without a history of falling		Mean+ /-Std. D.	Min	Max	Median	Z	P
SOT1 (Eyes open platform and surrounding cabinet fixed)	Pre-treatment	92.71+ /-2.68	85.00	97.30	93.00	-1.238	0.216
	Post-treatment	93.31+ /-2.45	85.00	97.70	93.33		
SOT2 (Eyes closed platform and surrounding cabin fixed;	Pre-treatment	90.36+ /-3.11	83.30	98.70	90.33	-0.594	0.553
	Post-treatment	91.15+ /-3.26	84.30	98.70	91.33		
SOT3 Eyes are open, platform is fixed, surrounding cabin is swinging)	Pre-treatment	88.25+ /-4.88	73.30	99.00	88.33	-1.247	0.212
	Post-treatment	89.33+ /-4.77	73.30	99.00	90.00		
SOT4 (Eyes are open, platform is swinging, surrounding cabinet is fixed)	Pre-treatment	80.82+ /-8.32	64.67	98.00	81.00	-1.506	0.132
	Post-treatment	83.45+ /-8.93	64.67	99.00	87.67		
SOT5 (Eyes are closed, platform is swinging, surrounding cabinet is fixed)	Pre-treatment	71.94+ /-10.05	51.00	99.00	71.67	-2.000	0.045
	Post-treatment	75.54+ /-11.22	51.00	100.00	73.00		
SOT6 (Eyes are open, platform is swinging, surrounding cabinet is swinging)	Pre-treatment	67.83+ /-10.62	45.00	97.33	68.50	-0.426	0.670
	Post-treatment	69.58+ /-11.97	45.00	97.33	69.00		
COMP	Pre-treatment	78.00+ /-5.92	69.00	98.00	79.00	-2.463	0.014
	Post-treatment	81.49+ /-6.43	72.00	98.00	81.00		
p≤ 0.05 Wilcoxon							

p ≤ 0.05, Wilcoxon Test, ‘’ SOT: ‘’ Sensory Organization Test, ‘’ COMP: ‘’ Composite

LOS IN CHRONIC STROKE PATIENT GROUP WITHOUT A HISTORY OF FALLING

In chronic stroke patients without a history of falling, two different values were recorded from the LOS test before and after treatment, RT and MVL. LOS-RT values as LOS (F) (p = 0,179) and LOS (B) (p = 0,254) did not reach statistical significance. LOS-MVL values as LOS (F) (p = 0.227) and LOS (B) (p = 0.247) were not statistically significant .

RWS IN CHRONIC STROKE PATIENT GROUP WITHOUT A HISTORY OF FALLING

In chronic stroke patients without a history of falling, two different values were recorded from the RWS test before and after treatment as L / R and F / B. The change in L / R value (p = 0.080) was not statistically significant. A significant improvement was observed in the L / R value (p = 0.009) (Table 4).

Table 4: RWS in chronic stroke patients without a history of falling

RWS in chronic stroke patients without a history of falling (Rhythmic Weight Transfer)		Mean+ /-Std. D.	Min	Max	Median	Z	P
L/R	Pre-treatment	4.53+ /-1.26	2.3	8.1	4.50	-1.749	0.080
	Post-treatment	4.83+ /-1.42	2.7	8.1	4.76		
F/B	Pre-treatment	2.36+ /-0.87	1.0	4.8	2.17	-2.615	0.009
	Post-treatment	2.65+ /-0.77	1.6	4.9	2.47		
p≤ 0.05 Wilcoxon							

p ≤ 0.05, Wilcoxon Test, ‘’ RWS: ‘’ Rhythmic Weight Transfer, ‘’ L: ‘’ Left, ‘’ R: ‘’ Right,” F: ‘’ Front,

‘’ B” Back

RESULTS

In the chronic stroke patient group with a history of falling, statistically significant improvement was observed in SOT composite and RWS-F / B after treatment compared to pre-treatment (p = 0.035 and p = 0.031).

In the chronic stroke patient group without a history of falling, statistical significance was observed in SOT5, SOT composite and RWS-F / B after treatment (p = 0.045; p = 0.014 and p = 0.009).

In conclusion, based on the study’s findings, we think that the personalized planned rehabilitation with BDP in chronic stroke patients with a history of falling is vital in guiding strategies for coping with balance disorders frequently encountered in chronic stroke patients with and without a history of falling.

DISCUSSION

Our study aimed to examine the effect of personalized planned training on balance recovery in stroke rehabilitation with Computerized Dynamic Posturography (BDP) in chronic stroke patients with and without a history of falling. In our 8-week study, chronic stroke patients with a history of falling for whom we applied rehabilitation together with “Custom Training,” and chronic stroke patients without a history of falling for whom we only applied rehabilitation practice. With BDP analysis, we compared the groups as pre-treatment and post-treatment.

In 1978, Dr. Nashner performed the sensory control of posture in individuals with normal and vestibular deficits using BDP. His studies led to the development of the BDP used in the clinic (11,12). BDP includes the isolation and measurement of quantities for (I) orientation of inputs from visual, vestibular, and somatosensory systems, (II) central integration mechanisms for the selection of functionally appropriate orientation senses, (III) movement strategies that are functionally appropriate in different controlled task conditions, and (IV) motor output mechanisms to create postural movements timely and effectively [13,14].

In our study, according to the results of SOT, which is the first step of the BDP evaluation, a statistically significant improvement in the SOT composite value was observed in the chronic stroke patient group with a history of falling compared to pre-treatment (p = 0.035). SOT5 and SOT composite values were also statistically significant in the chronic stroke patient group without a history of falling (p = 0.045; p = 0.014, respectively).

With the BDP device’s help, the SOT evaluation provides information on which sensorial system may be responsible for the balance disorder. With this test, somatosensory, visual, and vestibular systems are gradually disabled, and the person’s ability to adapt to the new difficult situation is evaluated. SOT examines the person’s ability to maintain the posture position when the sensory inputs (visual, somatosensory, vestibular) are restricted. It reveals the information that a person has difficulty utilizing from which sensory system it is coming to maintain postural control. In clinical studies, it has been reported that the majority of abnormal patterns resulting from the test occur with the vestibular dysfunction pattern, and the second typical pattern is the visual-vestibular dysfunction pattern (13,14,15). In our clinical study, statistically significant improvement in SOT composite value, in other words, SOT average value after eight weeks of treatment in chronic stroke patients with a history of falling, shows that “Custom Training” plus rehabilitation affects the visual, somatosensory, vestibular system as a whole. Besides, in our chronic stroke patient group without a history of falling, where we only rehabilitated without “Custom Training,” there was a statistically significant improvement in SOT5 value, in which eyes were closed, a platform was swinging, and the surrounding cabin was fixed after treatment; shows that patients in this group are successful in maintaining balance by using vestibular and somatosensory systems without visual input. Thus, the positive effects of rehabilitation alone are observed in the chronic stroke patient group who do not currently have a falling history. In their study to compare balance in stroke patients and healthy individuals, Oliveira et al. found that SOT values of stroke patients were lower than healthy ones. These researchers stated that insufficient sensory information significantly affected stroke patients’ balance and expressed the importance of planning effective rehabilitation training [22]. We also planned rehabilitation training in our study, we observed an improvement in SOT composite value after eight weeks of rehabilitation in chronic stroke patients who did not have a history of falling and having only rehabilitation, and in chronic stroke patients with a history of falling and having both rehabilitation and “Custom Training.” Besides, similar to our study, Pierchala et al. found that rehabilitation has significantly improved both composite values of SOT4-6 and SOT in both falling and non-falling groups, in their studies to evaluate the effect of rehabilitation with individuals who have fallen only once and those who have fallen more than once [18].

LOS, in which we examined how far the center of gravity

can move without losing the person's balance and changing the support surface, the change after treatment was not statistically significant compared to pre-treatment in both groups (p> 0.05). Studies have shown that stroke patients have insufficient end-point distance, maximum deviation, and linear directional controls. The inability to transfer sufficient weight to the affected extremity may be one reason for this insufficiency instability limits. The reasons for not transferring sufficient weight are related to decreased somatosensory sensation in the foot-ankle, insufficient foot contact with the ground, and failure to make proper tonus regulation during the weight transfer in this region's muscles [19, 21]. LOS-RT is the time between the command to move the patient and the patient's first movement. LOS-MVL is the average speed of gravity center movement (25). In our study, no statistically significant difference was found in both LOS-RT and LOS-MVL values than pre-treatment in our chronic stroke patient group with and without a history of falling. It suggests that patients in our study groups might have compensated the movements in these tests with their unaffected sides.

Our RWS Test data showed a significant improvement in RWS-F / B compared to pre-treatment in the chronic stroke patient group with a history of falling and in the group without falling ($p = 0.031$ and $p = 0.009$). When stroke patients' ability to maintain balance in different directions during RWS compared to controls, the direction control and speed in transferring weight back and forth were lower than the healthy ones; while these differences were not observed in right-to-left weight transfer, the difference in weight transfer between front and back suggested that the ability to transfer weight back and forth in stroke patients was more affected [22-27]. In a study by Lynch et al., it was shown that stroke patients had difficulty transferring weight in front of and behind the foot with decreased under-floor sensation [22]. Similar to our study, Tsaklis et al. found that rehabilitation improved the balance control in their studies conducted to examine the effect of weight transfer training on weight distribution and balance control in chronic stroke patients [27]. De Haart et al. observed that the 12-week rehabilitation program in subacute stroke patients improved weight transfer data [26]. Liao et al. examined the effects of different weight transfer exercises on balance control in chronic stroke patients and observed improvement after six weeks [25].

Suttiwong et al. stated in their studies on evaluating the problems experienced by stroke patients that balance, motor function, functionality, and walking performance need to be improved [27]. Our study may come to mean that in chronic stroke patients with and without a history of falling, we can help improve the balance problem highlighted in the Suttiwong study [27] due to the positive results of our "Custom Training" program and rehabilitation training.

In their study, Mustafaoğlu et al. compared the effects of conventional combined training and isolated body weight-supported treadmill training on balance, mobility, and fear of falling in stroke patients. They found that combined training had significant effects on balance, mobility, and fear of falling [28]. Although we used different rehabilitation and training methods, we found that applying rehabilitation with "Custom Training" simultaneously in chronic stroke patients with a history of falling was more effective than applying only rehabilitation in chronic stroke patients without a history of falling. We think that personalized planned training in chronic stroke patients with a history of falling is vital in improving patients' lives.

40% of patients with stroke leave the hospital with a moderate disability [1]. However, despite all the rehabilitation developments, both the risk of falling and fall-related injuries continue in chronic stroke patients [29]. In the study conducted by Schmid et al. in 2013, the frequency of falling was observed as 70% at home and 21% during daily life activities and mobility, more importantly, 72% of chronic stroke patients were reported to have injuries ranging from bruising and crushing to fractures [29].

CONCLUSION

Based on the study's findings, we think that the personalized planned rehabilitation with BDP in chronic stroke patients with a history of falling is essential in guiding strategies for coping with balance disorders frequently encountered in chronic stroke patients with and without a history of falling.

Limitations and Recommendations

In our clinical study, selecting the sample by probable random sampling method, small sample size, and generalizing the research results only to patients in this sample group are the limitations of the study.

We think that the evaluation of balance will contribute to the study as one of the most critical problems. The other issue is that putting an assessment scale about fear of falling will bring a different perspective on the results. More studies are needed to investigate the short- and long-term effects of physiotherapy and rehabilitation practices combined with a higher number of cases.

As far as is known, no study has been conducted similar to our study in which chronic stroke patients with a history of falling having rehabilitation with "Custom Training" simultaneously compared with chronic stroke patients without a history of falling having only rehabilitation in terms of BDP parameters.

DISCLOSURE

The author declares that there is no conflict of interest.

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