Research Article

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The effects of robotic and conventional gait training in addition to neurodevelopmental treatment on balance, mobility, and health-related quality of life in patients with stroke

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Abstract

Objective: The aim of this study was to investigate the effects of robotic and conventional gait training in addition to neurologic rehabilitation programs based on neuro-developmental therapy (NDT-Bobath) principles on balance, mobility, and quality of life in patients with stroke.

Methods: A total of 64 patients with chronic stroke were included in the study. All patients participated in the neurologic rehabilitation program based on NDT-Bobath principles. Thirty-two patients had robotic gait training in addition, whereas the other 32 patients had conventional gait training in addition. After recording the demographic data, the Timed-Up and Go Test, Rivermead Mobility Index, Berg Balance Test, and Nottingham Health Profile were used to assess the balance, mobility, and quality of life. All patients had 30 sessions of NDT-Bobath therapy. In addition to the NDT-Bobath therapy, patients in the robotic gait group participated in total of 15 sessions of robotic gait training, 3 times per week, and the other group had 15 sessions of conventional gait training, 3 times per week. All assessments were repeated after the treatment.

Results: There were significant improvements ($p<0.05$) in balance, mobility, and quality of life between baseline and after treatment in both groups. After comparing the obtained differences in all parameters between baseline and after treatment, no difference was found between the groups ($p>0.05$).

Conclusions: Both conventional and robotic gait training in addition to NDT-Bobath therapy are effective in the rehabilitation of patients with stroke in terms of balance, mobility, and quality of life, and their application in clinical setting is reliable.

Keywords: Gait training, NDT-Bobath, rehabilitation, robotic gait, stroke

INTRODUCTION

Stroke is described as a neurologic status and/or cerebrovascular accident that develops after the sudden loss of brain functions due to occlusion or rupture of vessels feeding the brain, and lasts over 24 hours. It is known as the most frequent cause of disability and loss of work force and the second most frequent cause of death (1).

The basic approach in stroke treatment is being able to achieve maximal sensory, motor, functional, and psychosocial recovery by using neural plasticity, whatever the patient's limitations and impacts. Neuro-developmental therapy (NDT-Bobath) includes motor learning studies with the patient's active involvement, appropriate handling methods, facilitation of active movement, and methods that are repetition-based, goal oriented, and problem-focused (2).

Gait training with a robotic device aims to enable the patient to adapt to normal walking patterns with motor learning principles. Robotic walking devices are an improved form of body-weight supported treadmill (BWST) treatment, which is frequently used in clinics. As in BWST systems, the patient is connected to the device with transport systems, the weight on the extremity is taken in the desired ratio, and the external skeleton worn on the legs helps the patient to move within the normal gait parameters (3).

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This study was planned to investigate the effect of gait training applied with a robotic device in addition to neuro-developmental treatment in patients with stroke on stability, mobility, and quality of life, and compare it with conventional gait training applied in addition to neuro-developmental treatment. The fact that few studies have investigated the effectiveness of robotic devices on patients with chronic stroke provided the intent for this study.

METHODS

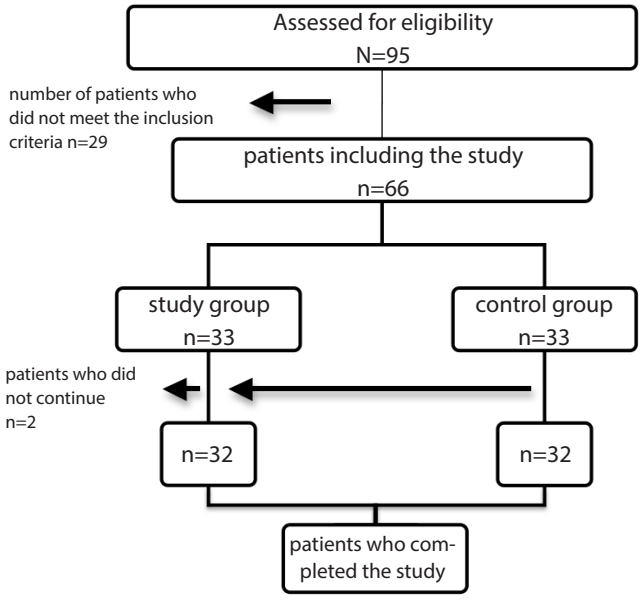
Subjects

As a result of the power analysis performed with the G-Power 3.1 program, the number of patients required to be included in the study was found as 64, 32 in each group, with an alpha error margin of 0.05 and 80% power.

The patients included in the study were diagnosed as having stroke by a specialist physician, had a stroke for the first time in their lives, were aged over 18 years, had stroke at least 6 months previously, were able to walk independently before the stroke, were able to walk independently or with a supporting device after the stroke, and agreed to participate in the study. Patients with acute internal disorders, who received Botulinum toxin injection in the last 6 months, were not cooperative enough to participate in the evaluations, had involvement of both sides, and had neglect syndrome were not included in the study. Patients who did not want to continue and who did not regularly participate in the study were excluded.

Ninety-five patients with stroke were evaluated between January 2016 and April 2016. Twenty-nine of these patients were not included in the study because they did not meet the inclusion criteria. Two patients were excluded from the study because they left the hospital before the specified time for the treatment. Among the patients who were excluded from the study, 9 patients had more than one stroke, 9 patients had less than six months since the stroke, 1 patient was not able to walk before the stroke, 6 patients had a head trauma or brain tumor, and 4 patients did not cooperate in the evaluations. The patients were divided into two groups as "NDT-Bobath therapy and gait training with robotic device" and "NDT-Bobath therapy and conventional gait training." The patients who were trained to walk with the robotic device constituted the study group, and patients who were trained to walk in conventional method served as the control group; 32 patients were evaluated in each group. Patients were randomly assigned to the groups after being examined by a physician and written informed consents were obtained prior to the beginning of the any study procedures (Figure 1). Approval for this study was obtained from the Gazi University Clinical Investigations Ethics Committee (Date: 11.01.2016).

Figure 1. Flowchart of the study



Outcome Measurements

Each patient was evaluated before and after the treatment. At the initial evaluation, the patients' demographic data and histories were recorded. The Rivermead Mobility Index (RMI) was used to assess the patients' mobility levels. The Berg Balance Test (BBT) was used to evaluate balance. The Nottingham Health Profile (NHP) questionnaire was administered to assess the health-related quality of life from the point of view of the patient perception. The Timed Up and Go Test (TUGT) was performed to evaluate functional capacity. After the patients completed their 30 sessions, the evaluation program consisting of the same tests and criteria was repeated.

Demographic Information

The demographic characteristics and histories of the patients were recorded. The patient's age, height, weight, education level, smoking status, alcohol use, dominant side, affected side, duration of illness, and the status of using assistive devices were recorded. The presence of systemic discomfort, diabetes mellitus (DM), hypertension, and cardiac disorders were investigated.

Mobility Assessment

The RMI was used to assess the mobility. It consists of a total of 15 questions. In 14 questions, the patient's answers are taken into consideration; and in 1 question (standing without support), the patient is evaluated through observation. The RMI hierarchically evaluates the motor functions of the patients ranging from in-bed activities to running. Increasingly difficult activities such as turning in bed, turning into the sitting position while lying in the bed, transfers, balance, walking, going up and down stairs, bathing, and running are evaluated. One point is given for each activity that the patient says they can do, and 15 points is the highest score. Fifteen points indicate that there is no problem with functions, and 14 points and below indicate that the functioning is problem-

atic. As the score decreases, it indicates that the problem is increasing. The test takes 2-3 minutes to complete. The Turkish validity and reliability study was conducted in an elderly population and the test-retest coefficient was 0.98 (4-7).

Balance Assessment

The BBT was used to evaluate balance. It aims to measure the ability of the patient to maintain balance. It includes 14 tasks, in which the performance is directly observed. It measures the static and dynamic balance required during various movements. Each task aims to evaluate a function used in daily-living activities, scored between 0 and 4 in 5 steps. The task is scored with 4 when the duty is performed in the best way, and not performing the task is scored zero. Tasks measure function in terms of time or distance. The highest score one can achieve is 56; a score between 0 and 20 represents bad balance, a score between 21 and 40 means acceptable balance, and a score between 41-56 represents good balance. Consistency, validity and reliability studies have shown good results for Berg's balance test in patients with stroke (4, 8, 9).

Assessment of Health-Related Quality of Life

The NHP was used to assess disease-related quality of life in terms of patient perception. It was developed primarily to assess how patients perceived the impact of the disease on their quality of lives and their health levels. It measures the functional, emotional, situational, and social aspects of the disease on the person. It consists of 38 questions evaluating sub-segments of pain, social isolation, physical activity, energy level, emotional state, and sleep. Patients respond to questions as yes or no. Each given "yes" answer is added to the score of the related sub-segment and the sub-segments are evaluated within themselves. The points for each question are different from the each other. The highest score that can be achieved from each sub-section is 100. Higher scores indicate that the patient is experiencing more serious problems. Completion takes 5 to 10 minutes. Turkish validity and reliability studies have been performed (4, 10-12).

Timed Up and Go Test

This TUGT evaluates balance and functional gait together. The patient rises from a chair on command, walks 3 meters, returns to the chair by turning from right or left, and sits on the chair again. The elapsed time between the "go" command and sitting back on the chair is recorded. An auxiliary device may be used during the test. The test is repeated twice and the best time is recorded. Prolongation of the time means that the patient does not have good gait function and should use walking assistance. A 3-m flat area, a chair with arm support at a sufficient height, and a chronometer are required for the test (4, 13-15).

Treatment Program

All patients were admitted to the neurologic physiotherapy rehabilitation program for 6 days per week, for 5 weeks. In addition to the neurologic rehabilitation program, the study group received 3 sessions of robotic gait training each week, and completed 15 sessions over a period of 5 weeks. The control group patients received conventional gait training under the supervision of a physiotherapist 3 days per week for 15 sessions, in addition to the neurologic rehabilitation program.

Neuro-developmental Treatment

A neuro-developmental treatment program was performed for the patients by physiotherapists who were experienced in their field. Prior to the treatment, a physician and physiotherapist assessed the functional status of the patient and identified long and short-term goals. A physiotherapy program with the NDT-Bobath principles was identified according to the goals, which were evaluated individually for each patient. Patients were treated for 30 to 45 minutes in each session. Every patient was trained by the same physiotherapist for continuity in all sessions of their treatment. The treatment program involved the use of both the affected and less-affected side. Efforts of trunk control, weight transfer strategies, and upper extremity arm oscillations, which constitute the basis for walking, were performed with the patients in both groups. Gait-specific exercises such as symmetry in gait, improving kinetics and kinematics in gait, working on temporal-spatial parameters of gait, and trunk control in gait were not included in the neurologic rehabilitation program.

Gait Training with a Robotic Device

Patients in the study group who received a gait training program with a robotic device, which took 40 minutes except the preparation phase, 3 days per week. Each patient received 15 sessions of gait training with the robotic device throughout the study. In every session, there was an experienced physiotherapist, who evaluated the patient's walking performance with feedback. The patients experienced the correct function and strategy of the gait by the device because robotic gait devices work within the kinetic and kinematics of the healthy human gait rhythm. Correct joint positions and muscle activations were transmitted to the patient both by the device and verbally by the physiotherapist at all phases of walking. Virtual reality applications were used to facilitate proper weight transfer in gait. In this study, the patients were asked to move with the virtual reality game, which is reflected on the screen of the robotic gait device in front of the patient. They were instructed to walk in a park full of trees without hitting the trees. This game included the patients' progress toward weight bearing to the extremities on the track, and problems in transferring weight to the affected side, which leads to moving in the direction of the less affected side. Using this visual feedback, facilitation of symmetric weight transfer is provided. The heel touch and full plantar-contact of the foot was facilitated on the affected side. Normal temporal and spatial parameters of gait were maintained by the symmetric involvement of both extremities. By facilitating hip and knee flexion, pelvic elevation and circumduction were prevented.

Muscle synergies are facilitated in order to provide adequate muscle strength during the stance and swing phase.

Conventional Gait Training

Patients in the control group with conventional gait training were included in a 40-minute gait training program 3 days per week. A physiotherapist informed the patient about gait parameters and gait strategies. Appropriate joint positions and muscle activations were observed by the physiotherapist during gait and errors were corrected through verbal feedback. Balance and postural control exercises were performed during gait. The treatment program consists of standing up while sitting at different heights, weight transfer and balance training on one foot with and without support in a parallel bar, increasing the angle of knee flexion with squats at a parallel bar, and controlled knee extension exercises, weight bearing on the feet, stepping up and down at different heights; right, left, front, back and cross walking; walking through different heights of obstacles; right hip-knee flexion, heel contact and weight transfer exercises while walking under the supervision of a physiotherapist; increasing step width and avoidance of circumduction, and providing awareness of space orientation.

Statistical Analysis

The research data were uploaded and evaluated in a computer environment using the Statistical Package for the Social Sciences (SPSS) for Windows 22.0 (SPSS IBM Corp.; Armonk, NY, USA). Descriptive statistics are presented as mean ± standard deviation, median (25-75%), frequency distribution, and percentage. Pearson's Chi-square test, Yates's corrected Chi-square test, and Fisher's exact test were used to evaluate categorical variables. The normal distribution conformity of variables was evaluated using visual (histogram and probability plots) and analytical methods (Shapiro-Wilk test). Student's t-test was used to find the statistical significance between two independent groups for variables of which normal distribution conformities were identified. For variables that did not fit to normal distribution, the Mann-Whitney U test was used to find the statistical significance between two independent groups, and the Wilcoxon signed-rank test was used for two dependent groups.

RESULTS

A total of 64 patients were evaluated within the scope of the study. The mean age of the patients was 59.64±12.57 (min: 18, max: 79) years; 64.1% (n=41) were male and 35.9% (n=23) were female. Body mass index (BMI) was calculated by measuring the height and weight of the patients. Accordingly, the mean BMI for 64 patients was 26.88±3.98 (min: 18.36, max: 36.44) kg/m^2.

The distribution of demographic and clinical characteristics among the study groups is shown in Table 1. There was a statistically significant difference in terms of age between patients undergoing conventional and robotic walking training ($p<0.05$). Sex, education status, height, body weight, BMI, DM, hypertension, cardiac disease and family history, smoking and alcohol use, disease duration, dominant and affected sides, and status of device use were similar between the groups ($p>0.05$) (Table 1).

The distribution of the test scores applied between the study groups and within each group are presented in Table 2. There was no difference between the TUGT, RMI, BBT, and NHP, energy levels, pain, emotional status, sleep, social isolation, and physical activity sub-factor scores in either group before and after the treatment ($p>0.05$) (Table 2).

There were statistically significant differences ($p<0.05$) between the pre-treatment and post-treatment scores in conventional gait training group in terms of TUGT, RMI, BBT, NHP energy levels, pain, emotional status, sleep and physical activity sub-factor scores, whereas there was no difference regarding the score of NHP-social isolation sub-factor ($p>0.05$). The RMI and BBT scores of the patients who underwent conventional walking training significantly increased after the treatment regarding the pre-treatment scores, whereas the sub-factor scores of NHP energy levels, pain, emotional status, sleep, and physical activity and TUGT time were significantly decreased after treatment (Table 2).

There was a statistically difference in terms of TUGT, RMI, BBT, NHP, energy levels, pain, emotional status, social isolation, and physical activity sub-factor scores in the group that had gait training with the robotic device ($p<0.05$), whereas there was no difference regarding the scores of the NHP-sleep sub-factor ($p>0.05$). The RMI and BBT scores of patients who received gait training with the robotic device significantly increased after the treatment regarding the pre-treatment scores, whereas the TUGT time and sub-factor scores of NHP, energy levels, pain, emotional status, social isolation, and physical activity were significantly decreased after treatment (Table 2).

A comparison of the scores of the groups on pre-treatment and post-treatment assessment scales is shown in Table 3. The score changes of all the tests applied were calculated as delta (Δ) values; there was no statistically difference between the groups ($p>0.05$) (Table 3).

DISCUSSION

Although many studies in the literature have examined the effects of gait training in the acute and sub-acute phase of rehabilitation using robotic devices, it is noteworthy that few studies have examined their effects in the chronic period. As a result of this single-blind study, both gait training methods were found to be effective in improving balance, mobility, and quality of life in the rehabilitation of patients with stroke.

The socio-demographic characteristics of a total of the 64 evaluated patients were in line with epidemiologic studies in

the literature and patient populations in similar studies (1, 16, 17). Although the sociodemographic characteristics of the patients were distributed homogeneously in both groups, only the patient age was significantly lower in the study group.

In a study in which there was no control group and the effectiveness of gait training with a robotic device in 10 patients with chronic stroke was investigated by means of motion analysis, it was shown that treatment provided a significant increase in walking speed, step length, single and double-foot support times, and improved knee kinematics (18). In a study by Calabro et al. in which a single patient who had chronic stroke gained motor improvement and psychological status after the gait training with a robotic device, it was observed that the treatment improved the patient's walking and balance problems as well as warned about cognitive state, which helped in the development of coping strategies for the patient's emotional state (19). In the majority of controlled studies that evaluated gait training with robotic devices for patients in acute and sub-acute periods with higher numbers of patients, no difference could be found between the control groups and gait training groups with robotic devices, similar to our findings. In the study by Hidler et al. involving 72 patients, and 63 patients were followed up long term after the end of the 3 months, 33 of whom were included in the robotic gait training and the other 30 patients were received conventional gait training for 3 days per week over 8 weeks. There was no difference between the groups in the post-treatment evaluations; patients in both groups showed significant improvement (16). Husemann et al. also found no difference between gait training of 14 patients with acute-phase stroke with a robotic device compared with 14 patients who had conventional gait training; the 10-m walking test and functional evaluations showed improvement in both groups (20).

Table 1. Distribution of demographic and some clinical features among the study groups

	Conventional (n=32)	Robotic (n=32)	p
Age (years)	63.81±10.04	55.47±13.58	0.013[c]
Sex			
Male	21 (65.6)	20 (62.5)	0.999[a]
Female	11 (34.4)	12 (37.5)	
Education			
None	7 (21.9)	5 (15.6)	0.748
Primary School	14 (43.7)	17 (53.1)	
Mid School	5 (15.6)	3 (9.4)	
High School	4 (12.5)	3 (9.4)	
University	2 (6.3)	4 (12.5)	
Height (cm)	165.47±9.19	168.47±7.79	0.164[d]
Body Weight (kg)	74.03±9.94	75.50±11.87	0.593[d]
BMI (kg/m^2)	27.17±4.18	26.60±3.81	0.793[c]
DM	13 (40.6)	9 (28.1)	0.430[a]
HT	26 (81.3)	20 (62.5)	0.164
Cardiac Disease	7 (21.9)	10 (31.3)	0.571
Family History	9 (28.1)	11 (34.4)	0.787
Smoking	7 (21.9)	7 (21.9)	0.999
Alcohol use	1 (3.1)	0	0.999[b]
Duration of Disease (month)	34.97±38.68	29.09±20.64	0.501[c]
Dominant Side			
Right	29 (90.6)	31 (96.9)	0.613[b]
Left	3 (9.4)	1 (3.1)	
Involved Side			
Right	19 (59.4)	11 (34.4)	0.080[a]
Left	13 (40.6)	21 (65.6)	
Device			
None	13 (40.6)	11 (34.4)	0.796[a]
Yes	19 (59.4)	21 (65.6)	

Continuous variables are presented as "mean ± standard deviation" and categorical variables are presented as "number (column percentage)"

[a]Yates's Corrected Chi-square Test; [b]Fisher's Exact Test; [c]Mann-Whitney U Test; [d]Student's T Test

BMI: body mass index; HT: hypertension; DM: diabetes mellitus

The improvements in balance, mobility, and quality of life in both groups after treatment are attributed to the effectiveness of NDT-Bobath as well as the positive effect of staying in a rehabilitation and research hospital that was designed for

Table 2. Comparison of balance, mobility, and quality of life scores within and between the groups

		Conventional (n=32)	Robotic (n=32)	
		Median (25-75%)	Median (25-75%)	p*
Timed Up and Go Test	Pre-Treatment	30.46 (16.14-44.00)	19.96 (12.18-33.77)	0.107
	Post-Treatment	21.24 (13.58-38.69)	19.00 (9.86-29.34)	0.202
	p**	<0.001	<0.001	
Rivermead Mobility Index	Pre-Treatment	10.5 (6.25-12.00)	11 (8-13)	0.499
	Post-Treatment	12 (10-13)	12 (10-14)	0.467
	p**	<0.001	<0.001	
Berg Balance Test	Pre-Treatment	42 (24.00-49.75)	46 (32.50-49.75)	0.484
	Post-Treatment	50.5 (36.75-54.00)	51 (45.25-53.75)	0.545
	p**	<0.001	<0.001	
NHP-Energy Level	Pre-Treatment	60.8 (6-100)	39.2 (22.9-72.8)	0.918
	Post-Treatment	24 (0-62.6)	12 (0-60.8)	0.569
	p**	0.012	0.016	
NHP- Pain	Pre-Treatment	12.06 (0-58.21)	11.22 (0-32.03)	0.364
	Post-Treatment	0 (0-14.32)	0 (0-18.58)	0.561
	p**	0.001	0.044	
NHP-Emotional Status	Pre-Treatment	35.58 (19.89-59.79)	33.73 (17.69-52.90)	0.610
	Post-Treatment	18.38 (0-42.98)	10.12 (1.77-26.41)	0.497
	p**	0.001	<0.001	
NHP-Sleep	Pre-Treatment	52.44 (12.57-77.63)	22,04 (12.57-55.93)	0.068
	Post-Treatment	12.57 (12.57-50.52)	12,57 (12.57-34.94)	0.414
	p**	0.004	0.063	
NHP-Social Isolation	Pre-Treatment	22.53 (0-44.54)	22.53 (4.84-37.32)	0.539
	Post-Treatment	20.68 (0-37.24)	22.01 (0-22.53)	0.754
	p**	0.062	0.041	
NHP-Physical Activity	Pre-Treatment	46.02 (33.18-76.12)	45.28 (23.50-57.86)	0.394
	Post-Treatment	29.00 (12.69-45.70)	18.25 (10.89-45.17)	0.270
	p**	<0.001	<0.001	

$\bar{x}$: Mean; S: Standard Deviation

*Mann-Whitney U Test; **Wilcoxon signed-rank Test

NHP: Nottingham Health Profile

Table 3. Comparison of pre-treatment and post-treatment differences (Δ values) between the groups

	Conventional (n=32)	Robotic (n=32)	
Differences Between Pre-Treatment and Post-Treatment	Median (25-75%)	Median (25-75%)	p*
Timed Up and Go Test	3.16 (1.56-10.64)	3.92 (1.92-5.65)	0.667
Rivermead Mobility Index	-1 (-2 - 0)	-1 (-2 - 0)	0.838
Berg Balance Test	-5 (-9.5 – -3.0)	-5 (-8 – -3)	0.741
NHP-Energy Level	0 (0-38.6)	18.86 (0-39.20)	0.596
NHP-Pain	8.96 (0-24.95)	0 (0-14.32)	0.339
NHP-Emotional Status	15.92 (0.18-30.04)	12.21 (5.16-33.99)	0.984
NHP-Sleep	12.57 (0-43.36)	0 (0-20.3)	0.164
NHP-Social Isolation	0 (0-22.40)	0 (0-22.01)	0.854
NHP-Physical Activity	11.94 (0-29.57)	16.28 (9.62-23.99)	0.741

*Mann-Whitney U Test

NHP: Nottingham Health Profile

these purposes. The fact that the physiotherapists practicing in the hospital concentrating on neurologic diseases are experienced in this area, and the availability of the devices used in treatment is high, also increases the effectiveness of the treatment.

In a study by Schwartz et al. with 67 patients with sub-acute stroke, the effectiveness of gait training with a robotic device was examined (13). Taveggia et al. performed a NDT-Bobath treatment program for a period of 60 minutes in a study with 28 patients with stroke and compared its efficacy with that of conventional training with gait training with a robotic device (21). Schwartz et al. found a statistically significant improvement in functional status and independence, daily life activities, and mobility scores in the group that received gait training with a robotic device compared with the control group, whereas Taveggia et al. showed significant improvement in balance, motor performance, mobility, quality of life, functional independence and gait in both groups (13, 21). This demonstrates that rehabilitation programs based on NDT-Bobath principles are effective (22). These findings are in line with our study. The results of both gait training combined with the program according to the NDT-Bobath principles showed that both gait training methods could improve the functioning of patients, which is similar to the results in the literature.

In this study, the adaptation to daily living activities supported the use of virtual reality applications in gait training with robotics. Gatica-Rojas demonstrated that plasticity and motor learning increased with virtual reality and that sensory feedback improved the reorganization of neural networks (23). Lee et al., and Corbetta et al. concluded that virtual reality was especially more effective on balance, walking speed, duration of TUGT, and lower extremity muscle strength in their studies (24, 25). Chen et al. and Shin et al. emphasized that patients were more motivated, and cognitive functions and emotional status were improved with virtual reality applications, thus, their quality of life increased in this respect (26, 27). In a study by Simsek, who compared NDT-Bobath treatment with virtual reality, it was concluded that virtual reality had a positive impact on quality of life in patients with stroke as much as with NDT-Bobath therapy (28). In the present study, the use of virtual reality in therapy improved both the affected and less-affected side by increasing the patient's motivation and active participation in the treatment.

The relationship between activities of daily living and quality of life with functional status will change in a positive direction with treatment. In this study, the improvement of NHP sub-factors in both groups was related with the treatment, which is in parallel with the results of studies by Mercier et al. and Studenski et al. (29, 30).

The implementation of intensive NDT-Bobath therapy, and the advantages of the robotic rehabilitation program and conventional gait training enabled the patients in both groups to achieve maximal results from the interventions, as stated in the study by Bacchini (31). It could also be concluded that there was no difference between the results of the applications of robotic gait training 3 days per week and/or every day of the week (18-20, 32). This shows that robotic gait training applied every other day may be effective in reducing fatigue. Revealing information that conventional gait training is not less effective than gait training with robotic devices, we can say that conventional gait training is still a safe and effective method, especially in centers where robotic gait treatment is not available. However, in the study by Taveggia et al. who compared the effects of conventional and robotic gait training in patients with sub-acute stroke, there was no difference between the groups immediately after the treatment, whereas the robotic gait training was more effective in the long term (21). The results of our study also showed that there was no difference in the short-term period between the groups. However, the lack evaluation of the long-term effects is one of the limitations of our study. Mazzoleni et al. concluded that, patients responded significantly positively to questions about comfort, fun, and awakening with therapy using robotic devices (33). As a result of our study, the significant effectiveness of gait training with a robotic device in addition to NDT-Bobath therapy indicates that these devices can be used safely in the rehabilitation of patients with stroke. Furthermore, this intervention method was effective in improving balance, mobility, and health-related quality of life in patients with stroke.

It is recommended that the long-term results of gait training in addition to NDT-Bobath therapy should be investigated in follow-up studies of patients with chronic stroke.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Gazi University.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – E.K., B.E.; Design – E.K., B.E., M.F.K.; Supervision – E.K., B.E.; Resources – İ.A., M.Ö., E.K.; Materials – İ.A.; Data Collection and/or Processing – E.K., M.Ö., İ.A.; Analysis and/or Interpretation – M.F.K., E.K.; Literature Search – E.K., M.Ö., M.F.K., İ.A., B.E.; Writing Manuscript – E.K., B.E.; Critical Review - E.K., M.Ö., M.F.K., İ.A., B.E.

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