Turk J Phys Med Rehab 2016;62(3):248-256
DOI: 10.5606/tftrd.2016.84770

Original Article / Özgün Araştırma

The impact of additional trunk balance exercises on balance, functional condition and ambulation in early stroke patients: Randomized controlled trial

Erken inmeli hastalarda gövde denge egzersizlerinin eklenmesinin gövde dengesi, fonksiyonel durum, gövde dengesi ve ambulasyona etkisi: Randomize-kontrollü çalışma

Raikan Büyükavcı,[1] Füsun Şahin,[2] Sinem Sağ,[3] Beril Doğu,[4] Banu Kuran[4]

[1]Department of Physical Medicine and Rehabilitation, Dr. Kemal Beyazıt Physical Medicine and Rehabilitation Center, Kahramanmaraş, Turkey
[2]Department of Physical Medicine and Rehabilitation, Medical Faculty of Pamukkale University, Denizli, Turkey
[3]Department of Physical Medicine and Rehabilitation, Yavuz Selim Bone Diseases Hospital, Trabzon, Turkey
[4]Department of Physical Medicine and Rehabilitation, Şişli Hamidiye Etfal Training and Research Hospital, İstanbul, Turkey

Received / *Geliş tarihi*: February 2015 Accepted / *Kabul tarihi*: October 2015

ABSTRACT

Objectives: This study aims to investigate the effect of additional trunk exercises to conventional exercise program on balance, functional condition and ambulation in early stage stroke patients.

Patients and methods: A total of 65 patients were included in this double-blinded randomized controlled study. Patients were assigned to two groups as experimental group (n=32) who performed trunk exercises two hours/day/three weeks accompanied by conventional exercise program, and control group (n=32) who received only conventional exercise program during the three weeks. Balance, trunk balance, functional level and ambulation were assessed by Berg Balance Scale, Trunk Impairment Scale, Functional Independence Measurement, Rivermead Mobility Index, respectively. Patients were evaluated pretreatment and on the third month after the treatment.

Results: There was no statistically significant difference between the outcome measurements between the groups at the pretreatment evaluation. All outcome measurements were improved significantly between pre- and post-treatment evaluation in general linear repeated measures model. The interaction parameter of "time x condition" according to time and recovery was significantly better in experimental group than in control group. The highest mean difference in efficacy between the two rehabilitation interventions was found for dynamic sitting balance in post hoc calculations.

Conclusion: According to the results of our study, in early stroke patients either conventional exercises or conventional exercises plus trunk balance exercises can provide significant improvement in balance, functional condition and ambulation. However, the level of the improvement is better for the group which was applied trunk balance exercises to conventional exercises. Trunk balance exercises that are easily applicable with simple mechanisms by the patients themselves can be added to the rehabilitation.

Keywords: Exercise; rehabilitation; stroke; trunk balance.

ÖZ

Amaç: Bu çalışmada erken dönem inmeli hastalarda konvansiyonel egzersiz programına eklenmiş gövde denge egzersizlerinin denge, fonksiyonel durum ve ambulasyona etkisi araştırıldı.

Hastalar ve yöntemler: Bu çift kör randomize kontrollü çalışmaya toplam 65 hasta dahil edildi. Hastalar iki saat/gün/üç hafta olmak üzere konvansiyonel egzersizlere ek gövde egzersizlerinin yaptırıldığı çalışma grubu (n=32) ve üç hafta boyunca konvansiyonel egzersizlerin yaptırıldığı kontrol grubu (n=32) olarak iki gruba ayrıldı. Denge, gövde dengesi, fonksiyonel düzey ve ambulasyon düzeyi sırasıyla Berg Denge Ölçeği, Gövde Bozukluk Ölçeği, Fonksiyonel Bağımsızlık Ölçütü, Rivermead Mobilite İndeksi ile ölçüldü. Hastalar tedavi öncesinde ve tedavi sonrası üçüncü ayda değerlendirildi.

Bulgular: Tedavi öncesi değerlendirmede sonuç ölçütleri açısından gruplar arasında istatistiksel olarak anlamlı fark yoktu. Tedavi öncesi ve sonrası tüm sonuç ölçütleri lineer tekrarlayan ölçümler modelinde anlamlı olarak iyileşmişti. Zaman ve düzelmeye göre "x süresi koşulu" etkileşim parametreleri çalışma grubunda kontrol grubuna kıyasla anlamlı olarak daha iyiydi. Post hoc hesaplamada iki rehabilitasyon girişimi arasındaki en yüksek ortalama etkinlik farkı dinamik oturma dengesinde bulundu.

Sonuç: Çalışmamızın sonuçlarına göre erken dönem inmeli hastalarda hem konvansiyonel egzersizler hem de konvansiyonel egzersizlere eklenen gövde dengesi egzersizleri denge, fonksiyonel durum ve ambulasyonda anlamlı iyileşme sağladı. Ancak iyileşme düzeyi konvansiyonel egzersizlere denge egzersizleri eklenen grupta daha iyi idi. Gövde dengesi egzersizleri hastaların kendilerinin basit düzeneklerle rahatlıkla uygulayabileceği egzersizler olarak rehabilitasyona eklenebilir.

Anahtar sözcükler: Egzersiz; rehabilitasyon; inme; gövde dengesi.

Corresponding author / *İletişim adresi*: Füsun Şahin, MD. Pamukkale Üniversitesi Tıp Fakültesi Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı, 20070 Kınıklı, Denizli, Turkey. e-mail / *e-posta*: drfusunsahin@yahoo.com.tr

Cite this article as:
Büyükavcı R, Şahin F, Sağ S, Doğu B, Kuran B. The impact of additional trunk balance exercises on balance, functional condition and ambulation in earlystroke patients: Randomized controlled trial. Turk J Phys Med Rehab 2016;62(3):248-56.

Balance is the basis of all daily functional activities which take place while sitting or walking. Trunk balance has been identified as an early predictor of the level of post-stroke daily activities.[1] Trunk balance is also an indicator of post-stroke motor and functional improvement.[2-4] Patients with balance disorders are known to require a longer time to achieve similar functional levels compared to patients who do not suffer from balance problems.[5]

Various studies have shown that improvement in functionality and mobility are achieved by performing different exercises that increase trunk balance, particularly those which are performed in a sitting position and computer-aided exercises.[6] A literature review shows that different methods including upper and lower trunk exercises, pelvic stabilization exercises, circuit training which comprises in-bed, sitting and standing exercises according to the patient's functional level, force platform training, circuit training for strengthening lower extremity muscles and increasing endurance, gym activities and task-oriented circuit training generally lead to more effective outcomes than conventional rehabilitation programs.[7-15] It has been reported that an exercise system which can easily be taken on by the patient with minimum support, which enhances the patient's motivation and includes enjoyable games can help to achieve better functional outcomes by improving the patient's participation and duration of exercises.[6-16]

The purpose of this study was to compose an oriented circuit training program with the aim of improving trunk balance in addition to conventional rehabilitation program in stroke patients, and to assess the impact of these exercises on balance, functional condition and ambulation.

PATIENTS AND METHODS

Sixty-five hemiplegic patients receiving inpatient rehabilitation were included in this prospective, randomized, assessor blinded and controlled study. The patients were hemiplegic patients for whom at least three weeks had passed since the usual time for admission following intracerebral infarction or hematoma.[17-19]

Exclusion criteria were determined as being a previous history of stroke, a present disease in the cerebellar system, dorsal column or vestibular system, lack of ability to understand instructions, presence of a major perceptual or cognitive disorder, serious visual defect, cardiorespiratory disease, neglect (determined by star cancellation test),[20] lack of sitting balance, orthopedic diseases hindering exercises in reaching position. Patients who scored grade 5 or 6 according to Brunnstrom staging were also excluded since they were in good functional condition. Perceptual and cognitive condition was evaluated with a Mini-Mental test (MMT), and patients with a score of 16 and higher were included in the study.[21]

The study was conducted with approval of the Şişli Hamidiye Etfal Training and Research Hospital Local Ethical Committee. After obtaining "written informed consent forms," patients were randomized into two groups using the "Random Number Generator Program". The study was conducted in accordance with the principles of the Declaration of Helsinki. Following randomization, 33 patients were chosen as the control group (conventional rehabilitation group-neurodevelopmental facilitation techniques, occupational therapy) and the remaining 33 patients were sorted into the intervention group (exercise programs to increase trunk balance in addition to conventional rehabilitation program). One patient in the intervention group discontinued the study on the 12th day of admission due to femoral fracture and 32 patients completed the study (Figure 1).

While being hospitalized, all patients received conventional stroke rehabilitation for approximately 2-3 hours per session each day for five days, while the intervention group was also made to perform trunk exercises for at least two hours a day for three weeks.

Examinations were administered by an author who was blind to the treatment. When trunk balance exercises were administered they were also supervised by another author as well.

Intervention

Trunk balance oriented circuit training

The training was organized by the authors who drew inspiration from trunk balance exercises.[2,5,8,13,15] The exercise program was planned as station exercises improving trunk balance. All exercises were performed while sitting in an armless chair in front of a table. Patients were asked to sit with their hips and knees flexed at 90 degrees, feet open and aligned with hips and soles of the feet fully touching the ground. The hemiparetic arm was rested on the leg or positioned in an arm sling. The patients performed the exercises by following detailed instructions.

The patients

1. Repetitively pushed forward and caught a ball with a diameter of 10 cm which was hanging from the ceiling at the end of a cord (Figure 2a).

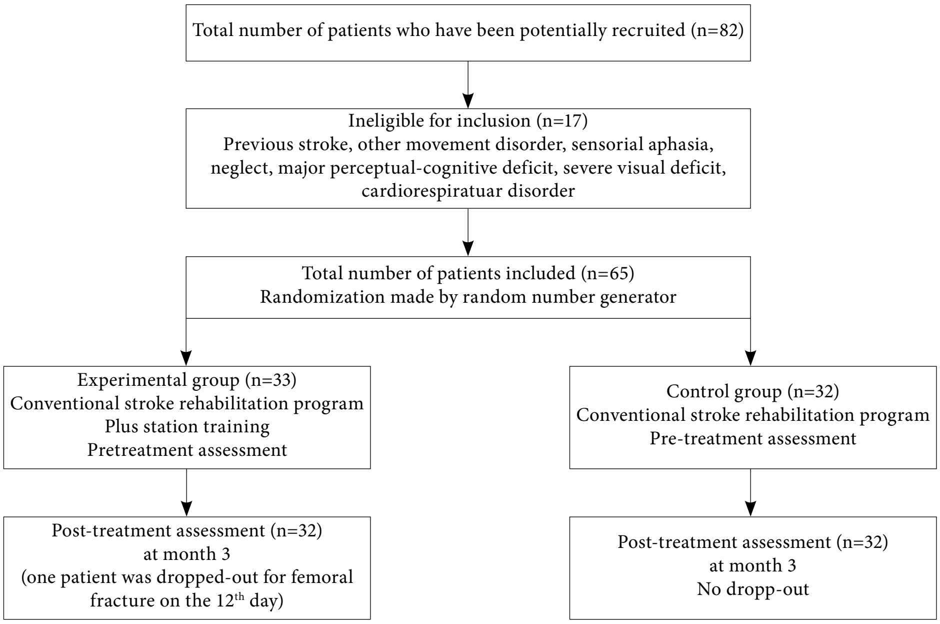

Figure 1. Flow chart for subject assigment.

2. Nine different objects were placed on the table and the patients covered these with other objects that they had to grasp (Figure 2b).
3. On a plate of 70x50 cm placed across from the patients, six different colored markers with a diameter of 5 cm were arranged, and the patients were asked to touch the object of the specified color with their hands and similarly, touch the object of the specified color on the plate placed in front of their feet with their foot (Figure 2c, d).
4. Performed computer-aided balance exercises (Nintendo Wii Fit-heading, table tilt, balance bubble). With the patient in sitting position, a pressure-sensitive balance platform was placed under both feet so that the platform contacted the feet. The patient played balance games by tilting with his/her trunk to the right and to the left and shifting his/her weight between positions (Figure 2e).

Assessment parameters: Age, gender, education level, dominant extremity, hemiplegic side, duration of stroke and concomitant diseases were recorded for all patients. Etiology of hemiplegia and location of lesion was recorded.

Evaluation of motor recovery: The Brunnstrom staging system which is a motor and tonus analyzing system was used, which specifies six possible grades for the upper extremity, hand and lower extremity.[22]

Evaluation of trunk balance: The Trunk Impairment Scale (TIS) was used. This scale evaluates motor impairment of the trunk after hemiplegia and comprises three main categories, i.e. static and dynamic sitting balance and coordination.[23] Scores are calculated over 23: 7 for static sitting balance, 10 for dynamic sitting balance and 6 for coordination. Scoring is made three times for each component of the test and the highest score is recorded.

Tests were administered to the patient during application, and demonstrated if necessary.

Evaluation of balance: The Berg Balance Scale (BBS) was used, BBS, which was developed for the evaluation of functional balance in the elderly, can be used in many areas of rehabilitation including stroke.[24,25] This scale comprises 14 items. Scoring is made over five points depending on the patient's ability to perform the task independently and/or against time. A score of Zero points means an inability to perform the task, earning four points means an ability to perform the task confidently and independently, and the total score is calculated over a range of 0-56. The validity and reliability of the Turkish version of BBS was studied by Sahin et al.[26]

Evaluation of functional condition: The Functional Independence Measurement (FIM) scale was used. The FIM focuses on six functional areas including self-care, sphincter control, mobility, locomotion, communication and social perception. Each measurement comprises 18 items evaluated on a scale of 7 and the total score is 126. The validity and reliability of the Turkish version of the scale was studied by Kucukdeveci et al.[27]

Evaluation of ambulation: The Rivermead Mobility Index (RMI) was used. The RMI is a single-dimensional index focused on measuring mobility which comprises basic mobility activities.[28] It includes 14 questions and one observation fulfilling Guttmann scaling criteria that extend from turning over in bed to running. The RMI was developed mainly for evaluating the results of physiotherapy interventions following head trauma or stroke. A score of 1 is given for each "yes" response and a total score of 0-15 is possible. Fifteen points means there is no problem with mobility and 14 points or less means there is a mobility problem. The validity and reliability of the Turkish version of RMI was shown by Akın and Emiroğlu.[29]

Statistical analysis

Scales were completed to evaluate eight patients to determine the number of patients in the intervention group and a power analysis was made. Assuming a difference of 50%, 32 patients were included in each group for a significance level of $p<0.05$.

The data from this study was transferred to SPSS 15.0 version software package (SPSS Inc., Chicago, IL, USA) and statistical analyses were made by using this program. Mann-Whitney U tests were used to compare the mean values of both groups,

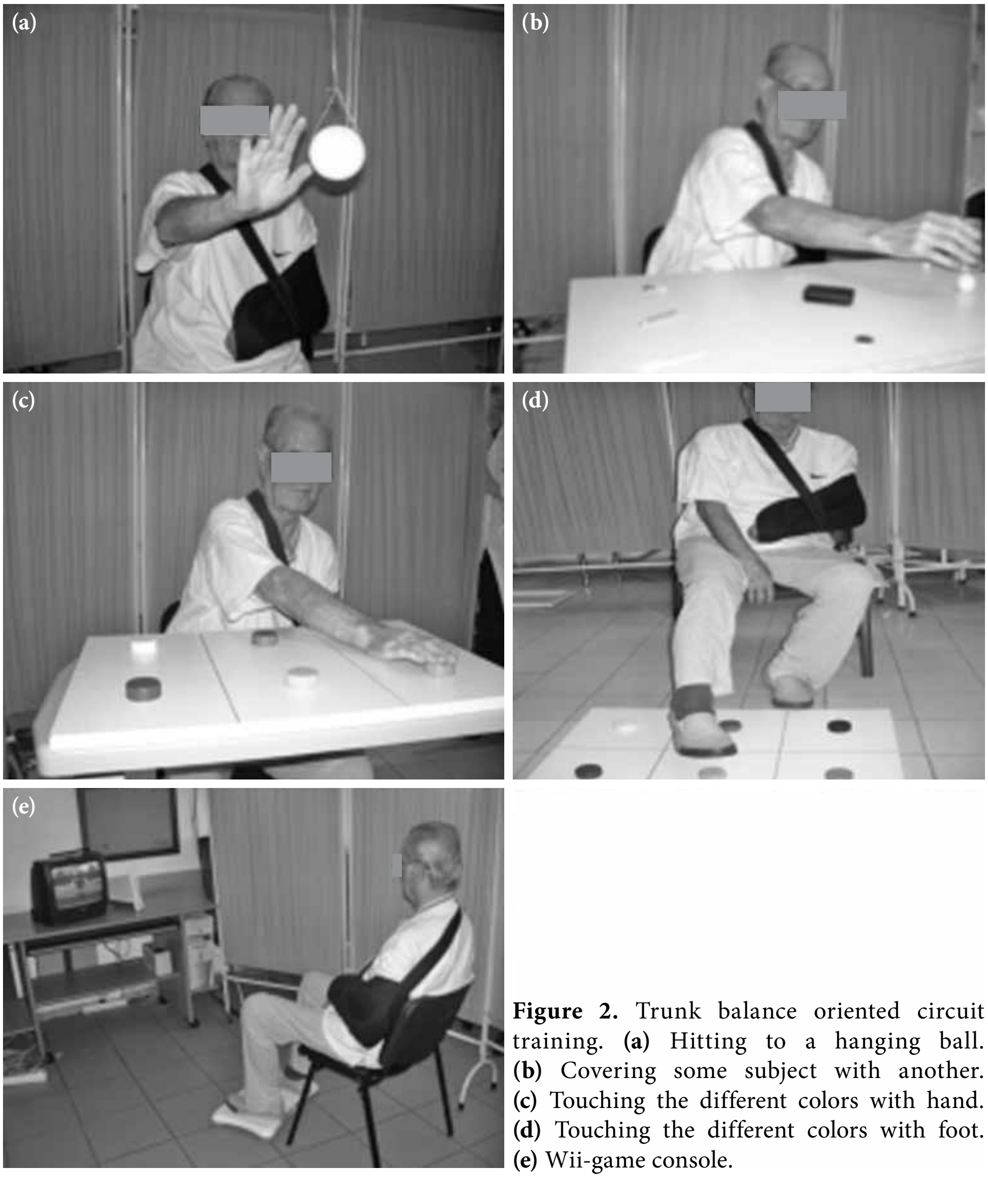

Figure 2. Trunk balance oriented circuit training. **(a)** Hitting to a hanging ball. **(b)** Covering some subject with another. **(c)** Touching the different colors with hand. **(d)** Touching the different colors with foot. **(e)** Wii-game console.

Table 1. Comparison of age, duration of stroke, gender, etiology between intervention and control groups

	Intervention group		Control group		
	n	Mean±SD	n	Mean±SD	*p*
Age (years)		62.6±10.5		63.6±10.4	0.72
Duration of stroke (days)		33.4±11.4		38.5±19.9	0.22
Gender					0.08
Female/Male	16/17		17/15		
Etiology					0.39
(T/ICH/SAH)	28/3/1		24/7/1		

SD: Standard deviation; T: Thromboembolic; ICH: Intracerebral hemorragie; SAH: Subarachnoid hemorragie.

and chi-square was used to compare the categorical data for the two groups. Wilcoxon test was used to evaluate the improvement of each group between pretreatment and control.

RESULTS

There was no difference between groups in terms of the patients' mean age, time since stroke and gender distribution (Table 1). As far as etiology of stroke was concerned, thromboembolism became significant in both groups (77% in the control group and 86% in the intervention group). The dominant side was affected in 18 patients in the control group and 17 patients in the intervention group; there was no difference between the groups (p=0.802).

As for the patients' comorbidities, 32.8% of the patients had no concomitant diseases associated with stroke, 17.2% had hypertension (HT), 14.1% had diabetes mellitus (DM) and 29.7% had HT and DM. One patient had a history of transient ischemic attack and two had ischemic heart disease. There was no significant difference between groups in terms of comorbidities (p>0.05).

There was no difference between the RMI, BBS, FIM motor, cognitive and total scores and TIS (static, dynamic, coordination and total) scores of the two groups on pretreatment assessments (p>0.05) (Table 2). All outcome measurement scores (Brunnstrom staging, TIS, BBS, FIM motor scores, RMI) in both intervention and control groups were significantly improved at third month evaluation compared to the pretreatment scores (p<0.001) (Table 3, Table 4).

The intervention group showed significant improvements in the scores of Brunnstrom lower extremity, BBS, FIM motor and RMI compared to control group at third month evaluation (p<0.001) (Table 5).

DISCUSSION

The effect of these exercises on overall balance, trunk balance, functional condition and ambulation

Table 2. Comparisons of Brunnstrom staging, Trunk impairment scale, Berg balance scale, Functional independence measurement, Rivermead mobility index scores in pre-treatment evaluation between groups

	Intervention group (n=33)	Control group (n=32)	
	Mean±SD	Mean±SD	*p*
Brunnstrom upper extremity score	2.6±0.9	2.2±1.2	0.182
Brunnstrom hand score	2.1±1.3	2.1±1.3	0.802
Brunnstrom lower extremity score	3.5±0.7	3.0±1.1	0.057
Trunk impairment scale static sitting balance	5.9±1.1	5.3±1.3	0.071
Trunk impairment scale dynamic sitting balance	4.9±1.9	4.3±2	0.241
Trunk impairment scale coordination	1.6±0.8	1.2±1.5	0.208
Trunk impairment scale total	12.8±2.8	11±3.9	0.311
Berg balance scale	17.8±14.7	14.6±10.7	0.396
Functional independence measurement motor score	43.8±14	41.2±14.2	0.477
Functional independence measurement total score	79.8±18.2	67.6±13.9	0.405
Rivermead mobility index	4.4±2.1	3.9±1.4	0.256

SD: Standard deviation.

Table 3. Pre- and post-treatment comparisons of Brunnstrom staging, Trunk impairment scale, Berg balance scale, Functional independence measurement, Rivermead mobility index scores in intervention group

	Pre-treatment	Post-treatment 3rd months	
	Mean±SD	Mean±SD	*p*
Brunnstrom-upper extremity	2.6±0.9	4.2±1.0	0.001
Brunnstrom-hand	2.1±1.3	3.5±1.5	0.001
Brunnstrom-lower extremity	3.5±0.7	4.9±1.0	0.001
Trunk impairment scale static sitting balance	5.9±1.2	7.0±0.2	0.001
Trunk impairment scale dynamic sitting balance	5.0±1.9	8.7±1.4	0.001
Trunk impairment scale coordination	1.7±0.9	3.1±1.4	0.001
Trunk impairment scale total score	12.8±2.9	18.7±2.7	0.001
Berg balance scale	18.4±14.8	42.3±14.2	0.001
Functional independence measurement motor score	47.1±16.4	73.8±14.5	0.001
Rivermead mobility index	4.5±2.2	10.9±2.3	0.001

SD: Standard deviation.

was evaluated, and it was found that trunk balance oriented circuit exercises led to more significant improvement in balance, function, motor control and ambulation compared to conventional rehabilitation methods.

Hemiplegic patients tend to shift their center of weight to the hemiplegic side in both sitting and standing position.[30,31] Postural deficits have a negative impact on functional independence and are one of the most important risk factors causing falls in case of task demand.[1,32,33] The ability to keep one's balance in sitting and standing positions is essential for functional activities such as transfer, transportation and walking and postural stability is considered as a prognostic factor for functional recovery in stroke patients.[5,34-38] The studies conducted on this subject emphasize that the ability to shift weight to the hemiplegic side depends particularly on the coordination of lower trunk rotation.[1,39,40] and it is more difficult for stroke patients to rotate this part of their body.[30] Also, proximal pelvic control has an effect on the mobility of lower extremity and stepping balance.[40,41] Therefore, trunk training in early stages of stroke enhances weight symmetry. Stabilization of proximal body segments is ensured during the voluntary movement of both lower and upper extremities.[42]

In trunk training, various exercises were performed to strengthen the trunk and connected muscles and enhance their stabilization. These exercises led to improvements particularly in dynamic sitting balance.[7,8] Saeys et al.[7] carried out a trial with stroke patients in whose time since stroke was a maximum of four months. The patients performed the exercises to improve the trunk's selective movements, coordination and muscle power in supine and sitting positions (+16 hours) in addition to conventional therapy. Assessments made after eight weeks of therapy program, showed that there was significantly more improvement in all subscores of TIS and Tinetti scales compared to the conventional group. In another study, a similar exercise program was applied for 10 hours

Table 4. Pre- and post-treatment comparisons of Brunnstrom staging, Trunk impairment scale, Berg balance scale, Functional independence measurement, Rivermead mobility index scores in control group

	Pre-treatment	Post-treatment 3rd months	
	Mean±SD	Mean±SD	*p*
Brunnstrom-upper extremity	2.2±1.2	3.4±1.5	0.001
Brunnstrom-hand	2.1±1.3	3±1.7	0.001
Brunnstrom-lower extremity	3.0±1.1	3.7±1.2	0.001
Trunk impairment scale static sitting balance	5.3±1.4	6.1±1.0	0.001
Trunk impairment scale dynamic sitting balance	4.4±2.0	6.2±2.3	0.001
Trunk impairment scale coordination	1.3±1.5	2.0±1.5	0.001
Trunk impairment scale total score	11.0±4.0	14.3±4.1	0.001
Berg Balance scale	14.7±10.7	25.8±13.2	0.001
Functional independence measurement motor score	38.5±9.9	56.8±13.3	0.001
Rivermead mobility index	3.9±1.5	7.5±2.3	0.001

SD: Standard deviation.

Table 5. Comparisons of Brunnstrom staging, Trunk impairment scale, Berg balance scale, Functional independence measurement, Rivermead mobility index scores in post-treatment evaluation between groups

	Intervention group	Control group	
	Mean±SD	Mean±SD	*p*
Brunnstrom upper extremity score	4.2±1.0	3.4±1.5	0.058
Brunnstrom hand score	3.5±1.5	3±1.7	0.172
Brunnstrom lower extremity score	4.9±1.0	3.7±1.2	0.001
Trunk impairment scale static sitting balance	7.0±0.2	6.1±1.0	0.739
Trunk impairment scale dynamic sitting balance	8.7±1.4	6.2±2.3	0.661
Trunk impairment scale coordination	3.1±1.4	2.0±1.5	0.838
Trunk impairment scale total	18.7±2.7	14.3±4.1	0.772
Berg Balance scale	42.3±14.2	25.8±13.2	0.001
Functional independence measurement motor score	73.8±14.5	56.8±13.3	0.001
Rivermead mobility index	10.9±2.3	7.5±2.3	0.001

SD: Standard deviation.

accompanied by a conventional exercise program and significant improvement was reported in the intervention group compared to the conventional group only in dynamic sitting balance.[8] In our study, we planned game-like exercises which included reaching activities, rather than muscle specific exercises, to improve the upper and lower trunk balance, coordination of trunk movements and proprioception. Our main target was to provide an exercise environment that patients could set up in their own homes and complete the exercises without losing interest. Significant improvement was observed in all parameters of balance, function and ambulation with the addition of these 30-hour exercises compared to conventional exercises.

Studies on improving trunk balance highlight the importance of the duration of the exercises for the benefits achieved in trunk balance and indicate that it is not known if these benefits are long-term or not.[8] In our study, the results, which were taken after three months, of a 30-hour exercises are presented. The patients were asked not to set up a similar environment in their homes between the end of the program and the assessment.

Trunk muscles are innervated by both cerebral hemispheres. Therefore, unilateral strokes may cause both contralateral and ipsilateral impairment of body muscle functions. In fact, isokinetic dynamometer and electromyography studies have shown weakness, impairment of synchronization and deficiencies in symmetrical movements in the trunk muscles of stroke patients.[3,43-47] Existing problems may cause a lack of stability and function although no abnormalities are found in a manual trunk muscle test in such cases.[48] Another problem is an altered sense of trunk position.[49] We suggest that although the trunk balance oriented circuit training could be transferred to daily life, such as stability, repositioning of trunk and shortening of reaction time, better functional outcomes are obtained than through conventional exercises. It has also been reported that benefits of impairment-focused programs such as biofeedback, electrical stimulation and muscle strengthening do contribution sufficiently to functional recovery while functional training such as treadmill training, constrained-induced movement therapy and external auditory feedback yields successful results in increasing activity levels.[50]

Interactive video games are also used in stroke rehabilitation as a method where patient compliance is good and movement patterns can be applied to the targeted task. This method was also shown to lead to a more significant improvement in patients' daily life compared to conventional rehabilitation.[51] One of the exercise stations was Wii-Fit game console. One study describes Nintendo Wii balance board as a valid tool for assessing standing balance and recommends it to be used in clinical practice to evaluate balance due to its ease of use and cost-effectiveness particularly in comparison with other laboratory platforms.[52] Although no statement is made in our study on the effectiveness of the game console, we think that the game console station was the most enjoyable station for the patients and it increased the patients' compliance to the therapy.

One of the limitations of our study was that both patient and therapist were familiar with each other, due to the nature of the interventions in the intervention group; only the assessor remained blinded. We are also of the opinion that it is necessary to continue with the designed exercises at home as well and evaluate long-term results.

In conclusion, the results of our study show that trunk balance exercises which can be performed by the patients easily have a positive impact on functional condition, ambulation and balance, which are important outcome parameters of stroke rehabilitation. Further studies are still warranted to identify the long-term results of functional and task-specific exercises to help patients continue with their rehabilitation process without dependency on other people or location.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Verheyden G, Vereeck L, Truijen S, Troch M, Herregodts I, Lafosse C, et al. Trunk performance after stroke and the relationship with balance, gait and functional ability. Clin Rehabil 2006;20:451-8.
2. Sandin KJ, Smith BS. The measure of balance in sitting in stroke rehabilitation prognosis. Stroke 1990;21:82-6.
3. Verheyden G, Nieuwboer A, De Wit L, Feys H, Schuback B, Baert I, et al. Trunk performance after stroke: an eye catching predictor of functional outcome. J Neurol Neurosurg Psychiatry 2007;78:694-8.
4. Hsieh CL, Sheu CF, Hsueh IP, Wang CH. Trunk control as an early predictor of comprehensive activities of daily living function in stroke patients. Stroke 2002;33:2626-30.
5. Franchignoni FP, Tesio L, Ricupero C, Martino MT. Trunk control test as an early predictor of stroke rehabilitation outcome. Stroke 1997;28:1382-5.
6. Eser F, Yavuzer G, Karakus D, Karaoglan B. The effect of balance training on motor recovery and ambulation after stroke: a randomized controlled trial. Eur J Phys Rehabil Med 2008;44:19-25.
7. Saeys W, Vereeck L, Truijen S, Lafosse C, Wuyts FP, Heyning PV. Randomized controlled trial of truncal exercises early after stroke to improve balance and mobility. Neurorehabil Neural Repair 2012;26:231-8.
8. Verheyden G, Vereeck L, Truijen S, Troch M, Lafosse C, Saeys W, et al. Additional exercises improve trunk performance after stroke: a pilot randomized controlled trial. Neurorehabil Neural Repair 2009;23:281-6.
9. Rose D, Paris T, Crews E, Wu SS, Sun A, Behrman AL, et al. Feasibility and effectiveness of circuit training in acute stroke rehabilitation. Neurorehabil Neural Repair 2011;25:140-8.
10. Garland SJ, Willems DA, Ivanova TD, Miller KJ. Recovery of standing balance and functional mobility after stroke. Arch Phys Med Rehabil 2003;84:1753-9.
11. van Nes IJ, Latour H, Schils F, Meijer R, van Kuijk A, Geurts AC. Long-term effects of 6-week whole-body vibration on balance recovery and activities of daily living in the postacute phase of stroke: a randomized, controlled trial. Stroke 2006;37:2331-5.
12. Stibrant Sunnerhagen K. Circuit training in community-living “younger” men after stroke. J Stroke Cerebrovasc Dis 2007;16:122-9.
13. van de Port IG, Wevers LE, Lindeman E, Kwakkel G. Effects of circuit training as alternative to usual physiotherapy after stroke: randomised controlled trial. BMJ 2012;344:2672.
14. van de Port IG, Wevers L, Roelse H, van Kats L, Lindeman E, Kwakkel G. Cost-effectiveness of a structured progressive task-oriented circuit class training programme to enhance walking competency after stroke: the protocol of the FIT-Stroke trial. BMC Neurol 2009;9:43.
15. Combs SA, Kelly SP, Barton R, Ivaska M, Nowak K. Effects of an intensive, task-specific rehabilitation program for individuals with chronic stroke: a case series. Disabil Rehabil 2010;32:669-78.
16. Yavuzer G, Senel A, Atay MB, Stam HJ. “Playstation eyetoy games” improve upper extremity-related motor functioning in subacute stroke: a randomized controlled clinical trial. Eur J Phys Rehabil Med 2008;44:237-44.
17. Kim GW, Won YH, Park SH, Seo JH, Ko MH. Can motor evoked potentials be an objective parameter to assess extremity function at the acute or subacute stroke stage? Ann Rehabil Med 2015;39:253-61.
18. Koh CL, Pan SL, Jeng JS, Chen BB, Wang YH, Hsueh IP, et al. Predicting recovery of voluntary upper extremity movement in subacute stroke patients with severe upper extremity paresis. PLoS One 2015;10:126857.
19. Lee SY, Kim BR, Han EY. Association Between Evoked Potentials and Balance Recovery in Subacute Hemiparetic Stroke Patients. Ann Rehabil Med 2015;39:451-61.
20. Wilson B, Cockburn J, Halligan P. Development of a behavioral test of visuospatial neglect. Arch Phys Med Rehabil 1987;68:98-102.
21. Gungen C, Ertan T, Eker E, Yasar R, Engin F. Standardize mini mental test’in Turk toplumunda hafif demans tanısında geçerlik ve güvenilirliği. Turk Psik Derg 2002;13:273-81.
22. Sawner K, Lavigne J. Brunnstrom’s movement therapy in hemiplegia: a neurophysiological approach. Philadelphia: JB Lippincott Company; 1992.
23. Verheyden G, Nieuwboer A, Mertin J, Preger R, Kiekens C, De Weerdt W. The Trunk Impairment Scale: a new tool to measure motor impairment of the trunk after stroke. Clin Rehabil 2004;18:326-34.
24. Berg KO, Wood-Dauphinee SL, Williams JI, Maki B. Measuring balance in the elderly: validation of an instrument. Can J Public Health 1992;83:7-11.
25. Berg K, Wood-Dauphinee S, Williams JI. The Balance Scale: reliability assessment with elderly residents and patients with an acute stroke. Scand J Rehabil Med 1995;27:27-36.
26. Sahin F, Yilmaz F, Ozmaden A, Kotevolu N, Sahin T, Kuran B. Reliability and validity of the Turkish version of the Berg Balance Scale. J Geriatr Phys Ther 2008;31:32-7.
27. Küçükdeveci AA, Yavuzer G, Elhan AH, Sonel B, Tennant A. Adaptation of the Functional Independence Measure for use in Turkey. Clin Rehabil 2001;15:311-9.
28. Wade DT. Personal physical disability. In: Wade DT, editor. Measurement in Neurological Rehabilitation. Oxford: Oxford University Pres; 1992. p. 71-82.

29. Akın B, Emiroğlu ON. Rivermead mobilite indeksinin Türkçe Formunun Yaşlılarda Geçerlilik ve Güvenilirliği. Turkish Journal of Geriatrics 2007;10:124-30.
30. van Nes IJ, Nienhuis B, Latour H, Geurts AC. Posturographic assessment of sitting balance recovery in the subacute phase of stroke. Gait Posture 2008;28:507-12.
31. Chern JS, Lo CY, Wu CY, Chen CL, Yang S, Tang FT. Dynamic postural control during trunk bending and reaching in healthy adults and stroke patients. Am J Phys Med Rehabil 2010;89:186-97.
32. Barclay-Goddard R, Stevenson T, Poluha W, Moffatt ME, Taback SP. Force platform feedback for standing balance training after stroke. Cochrane Database Syst Rev 2004;4:004129.
33. Nyberg L, Gustafson Y. Fall prediction index for patients in stroke rehabilitation. Stroke 1997;28:716-21.
34. Sandin KJ, Smith BS. The measure of balance in sitting in stroke rehabilitation prognosis. Stroke 1990;21:82-6.
35. Juneja G, Czyrny JJ, Linn RT. Admission balance and outcomes of patients admitted for acute inpatient rehabilitation. Am J Phys Med Rehabil 1998;77:388-93.
36. Bohannon RW, Leary KM. Standing balance and function over the course of acute rehabilitation. Arch Phys Med Rehabil 1995;76:994-6.
37. Prescott RJ, Garraway WM, Akhtar AJ. Predicting functional outcome following acute stroke using a standard clinical examination. Stroke 1982;13:641-7.
38. Brosseau L, Potvin L, Philippe P, Boulanger YL. Post-stroke inpatient rehabilitation. II. Predicting discharge disposition. Am J Phys Med Rehabil 1996;75:431-6.
39. Davis PM. Problems associated with the loss of selective trunk activity in hemiplegia. Right in the middle. Selective trunk activity in the treatment of adult hemiplegia. 6th ed. Heidelberg: Springer; 2003.
40. Verheyden G, Nieuwboer A, Feys H, Thijs V, Vaes K, De Weerdt W. Discriminant ability of the Trunk Impairment Scale: A comparison between stroke patients and healthy individuals. Disabil Rehabil 2005;27:1023-8.
41. Karthikbabu S, Nayak A, Vijayakumar K, Misri Z, Suresh B, Ganesan S, et al. Comparison of physio ball and plinth trunk exercises regimens on trunk control and functional balance in patients with acute stroke: a pilot randomized controlled trial. Clin Rehabil 2011;25:709-19.
42. Mudie MH, Winzeler-Mercay U, Radwan S, Lee L. Training symmetry of weight distribution after stroke: a randomized controlled pilot study comparing task-related reach, Bobath and feedback training approaches. Clin Rehabil 2002;16:582-92.
43. Taoka M, Toda T, Iwamura Y. Representation of the midline trunk, bilateral arms, and shoulders in the monkey postcentral somatosensory cortex. Exp Brain Res 1998;123:315-22.
44. Tanaka S, Hachisuka K, Ogata H. Trunk rotatory muscle performance in post-stroke hemiplegic patients. Am J Phys Med Rehabil 1997;76:366-9.
45. Tanaka S, Hachisuka K, Ogata H. Muscle strength of trunk flexion-extension in post-stroke hemiplegic patients. Am J Phys Med Rehabil 1998;77:288-90.
46. Dickstein R, Heffes Y, Laufer Y, Ben-Haim Z. Activation of selected trunk muscles during symmetric functional activities in poststroke hemiparetic and hemiplegic patients. J Neurol Neurosurg Psychiatry 1999;66:218-21.
47. Dickstein R, Sheffi S, Ben Haim Z, Shabtai E, Markovici E. Activation of flexor and extensor trunk muscles in hemiparesis. Am J Phys Med Rehabil 2000;79:228-34.
48. Karatas M, Cetin N, Bayramoglu M, Dilek A. Trunk muscle strength in relation to balance and functional disability in unihemispheric stroke patients. Am J Phys Med Rehabil 2004;83:81-7.
49. Ryerson S, Byl NN, Brown DA, Wong RA, Hidler JM. Altered trunk position sense and its relation to balance functions in people post-stroke. J Neurol Phys Ther 2008;32:14-20.
50. Van Peppen RP, Kwakkel G, Wood-Dauphinee S, Hendriks HJ, Van der Wees PJ, Dekker J. The impact of physical therapy on functional outcomes after stroke: what's the evidence? Clin Rehabil 2004;18:833-62.
51. Laver K, George S, Thomas S, Deutsch JE, Crotty M. Cochrane review: virtual reality for stroke rehabilitation. Eur J Phys Rehabil Med 2012;48:523-30.
52. Clark RA, Bryant AL, Pua Y, McCrory P, Bennell K, Hunt M. Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance. Gait Posture 2010;31:307-10.