Reabilitacijos mokslai: slauga, kineziterapija, ergoterapija, 2 (27) 2022, 89–97;
ISSN 2029-3194 / eISSN 2538-8673;DOI: https://doi.org/10.33607/rmske.v2i27.1265

Physiotherapy on the Biodex Balance System Device is More Effective Than Wobble Board Exercises for Regaining Balance, but not the Lower Limb Muscle Strength, in Stroke Patients

Eglė Lendraitienė, Laura Urbonienė, Daiva Petruševičienė, Rasa Šakalienė

Lithuanian University of Health Sciences, Department of Rehabilitation, Kaunas, Lithuania

ABSTRACT

Background. Balance control and restoration of movements are among the most important rehabilitation goals for stroke survivors. There are many techniques used to restore lost function, but there is little research demonstrating the effectiveness of specific equipment in improving balance.

The aim. To compare balance and lower limb muscle strength in stroke patients when applying different methods of physiotherapy.

Methods. The study included 40 stroke patients with hemiparesis and impaired balance. The subjects were divided into two groups: the first group (n=20) underwent physiotherapy on the Biodex balance system device (with visual feedback), the second group (n=20) – wobble board exercises. Both groups underwent 45-minute physiotherapy sessions 5 times a week (in total, 20 procedures). The subjects were tested at baseline and after physiotherapy. Balance was evaluated by applying the Best Evaluation Systems Test (BEST), and lower limb muscle strength – by using the Oxford muscle strength scale.

Results. Physiotherapy on the Biodex balance system device as well as wobble board exercises improved balance and muscle strength in stroke patients. Furthermore, the balance results of the first group (Biodex) was significantly greater than those of the second group (wobble board). No difference in muscle strength parameters was found between the groups.

Conclusion. Physiotherapy using the Biodex balance system device (with visual feedback) was superior to wobble board exercises for improving the balance abilities, but not the lower limb muscle strength, in stroke patients.

Keywords: stroke, physiotherapy, Biodex, balance, muscle strength, lower limb

INTRODUCTION

Deficits in balance influences self-selected walking speeds at the time of discharge, and also affects the ability of stroke survivors to change from self-selected to fast walking speeds (Madhavan & Bishnoi, 2017). Motor dysfunctions are among the main residual effects of stroke. Balance control and restoration of

movements rank among the most important aims of stroke patients' rehabilitation. Postural control is maintained via the combined effect of several factors, such as the vestibular system, vision, the somatosensory system, and trunk muscle strength (Chena et al., 2018). Several techniques have been tried for balance improvement, including jumping on a trampoline, visual feedback, and exercising with resistance bands to increase trunk muscle strength (Hahn, Shin, Lee, 2015; Anson et al., 2013; Chun et al., 2016). There are a number of technologies used to restore the lost functions, yet studies that prove the efficacy of specific equipment in balance improvement are scarce. Chun et al. (2016) conducted a study whose aim was to use a 3D device for strengthening deep lumbar paraspinal muscles, thus improving balance and postural control in stroke patients with hemiplegia. It has been stated that performing motor exercises increases stroke patients' visual dependency (Archera et al., 2017). For this reason, it is important to evaluate the effect of visual feedback on motor functions and to determine whether this technique is superior to the wobble board exercises, which are often used in physiotherapy. Thus, the aim of the study was to evaluate changes in the parameters of balance and lower limb muscle strength in stroke patients when applying different methods of physiotherapy.

METHODS

Participants. The study included 40 stroke patients who were randomly assigned into two groups, each consisting of 20 individuals. The groups were homogeneous concerning the subjects' age and sex. The subjects of both groups experienced hemiparesis and balance impairment (Tinetti Gait and Balance Examination score ≥19 points (a slight risk of falling)). The subjects' level of independence was assessed with the Barthel index: only subjects who scored at least 65 points were included in the study. The subjects were required to understand the tests used in the study, and thus had to score over 21 points on the Mini-Mental State Exam (MMSE) to be included in the study.

Outcome measures. Changes in balance were evaluated by applying the Balance Evaluation Systems Test (BEST). The test consists of six parts that evaluate different balance-related aspects. The first part evaluates bio-mechanical systems, the second part evaluates limits of stability and verticality, the third part evaluates anticipatory postural adjustments, the fourth part focuses on automatic postural responses, the fifth part evaluates sensory orientation, and the sixth part evaluates stability in gait. The test consists of 27 tasks, and the maximal score is 108 points. The tasks are evaluated in points. Correct performance of the tasks is evaluated with 3 points, 2 points mean a mild disorder, 1 point – a moderate disorder, and 0

points means that the subject failed to perform the task. The overall result of the test is the percentage of the total score of 108 points (Chinsongkram et al., 2014).

Muscle strength was evaluated by using the 5-point Oxford scale for manual muscle strength testing, where 1 point corresponds to a flicker or trace of contraction, 2 points – to the full range of active movement, with gravity eliminated, 3 points – to active movement against gravity, 4 points – to active movement against gravity and resistance, and 5 points correspond to normal power (O'Neill et al., 2017).

Ethical approval. The study was performed at a rehabilitation hospital with the permission of the LSMU Bioethics Center No. BEC–SR(M)–51. All subjects confirmed their agreement to participate in the study by signing the informed consent forms. The subjects were evaluated twice: at a baseline and upon the completion of the rehabilitation.

Interventions. Group 1 subjects underwent physiotherapy via the application of the Biodex balance system device, where various tasks or games were used to perform balance exercises that involved transferring body weight. The subjects of this group received feedback on screen immediately after the completion of the task, as they were shown the trajectory of their movement. Depending on the patient's condition, different levels of task performance may be selected on the device, and the balance disruption mode may be activated.

Group 2 patients, also depending on the condition, underwent balance-enhancing physiotherapy by applying various wobble boards. In patients of this group, muscle strength of the legs was increased by using resistance bands. In both groups, the subjects underwent physiotherapy sessions 5 times per week, each session lasting 45 minutes. In total, the course consisted of 20 procedures.

Statistical data analysis was performed using SPSS 22 for Windows statistical software package and Microsoft Excel 2007 software. The assumption of normality was not met, so the data were described as a median (minimal, maximal, and mean values) (me (min; max; m). To compare two independent samples, the Mann-Whitney-Wilcoxon test was used and the Wilcoxon test was used to compare two dependent samples. The difference was considered to be statistically significant when $p<0.05$.

RESULTS

Balance. The evaluation of the results of the balance test BEST prior to physiotherapy did not reveal any statistically significant difference ($p=0.167$; $U=150.5$) between the groups (Group 1 subjects – 64(57; 96; 70.8) *vs.* Group 2 – 61(34; 96; 61.8) points). Results of balance test after physiotherapy significantly increa-

sed in both groups (p=0.001; Z=3.46 and p=0.001; Z=3.47), furthermore, the balance results of the Group 1 (Biodex) was significantly (p=0.004; U=93) greater (92(82;96; 90.25) points) than those of the Group 2 (wobble board) (78.5(59;96; 77.45) points).

We evaluated the results of the balance test BEST in each separate category prior to and after physiotherapy in both groups. In all six categories ("Biomechanical Constraints", "Stability Limits", "Anticipatory Postural Adjustments", "Postural Responses", "Sensory Orientation" and "Stability in Gait") there was no statistically significant difference between the groups prior to physiotherapy, while after physiotherapy, the results in Group 1 were statistically significantly better than in Group 2 (Table 1).

Table 1. **Comparison of the Balance Evaluation Systems Test in each separate category in between the two groups after physiotherapy**

Categories of the Balance Evaluation Systems Test (BEST)	Score after physiotherapy (points)		P-value	U-value
	Group 1 (Biodex)	Group 2 (wobble board)		
Biomechanical Constraints	13(11;15;13.4)	11(6;15;11.05)	0.006	100
Stability Limits	12(9;12;11.4)	9(6; 12; 9.3)	0.001	84.5
Anticipatory Postural Adjustments	18(14;18;17.05)	14.5(10;18;14.5)	0.003	95
Postural Responses	14(11;15;13.9)	11.5(8;15;11.8)	0.012	109.5
Sensory Orientation	14.5(13;15;14.4)	13.5(10;15;13.1)	0.022	119
Stability in Gait	20(18;21;20.1)	18(14;21;17.8)	0.005	98

Muscle strength. The comparison of muscle strength in the affected legs of the subjects between the groups prior to and after physiotherapy did not reveal any statistically significant differences.

The evaluation of muscle strength in Group 1 prior to and after physiotherapy revealed a statistically significant increase in the strength of all except knee extensor and trunk extensor muscles (Table 2).

Table 2. **Results of muscle strength in Group 1 subjects prior to and after physiotherapy**

Muscle group	P-value	Z-value	Score before physiotherapy	Score after physiotherapy
Hip flexors	0.004	2.92	2(2;3;2.25)	3.5(2;5;3.1)
Hip extensors	0.001	3.26	2(1;3;2.15)	4(2;4;3.25)
Hip abductors	0.006	2.76	2.5(2;3;2.5)	3(2;4;3.1)

Muscle group	P-value	Z-value	Score before physiotherapy	Score after physiotherapy
Knee flexors	0.006	2.76	2.5(2;3;2.5)	3(2;4;3.1)
Knee extensors	1	0	2.5(2;3;2.5)	2.5(2;3;2.5)
Ankle dorsiflexors	0.003	2.9	2(2;3;2.25)	3.5(2;4;3.15)
Ankle plantar flexors	<0.001	3.6	2(2;3;2.25)	4(2;4;3.4)
Trunk flexors	0.003	3	3(3;4;3.25)	4(3;5;3.7)
Trunk extensors	1	0	3.5(3;4;3.5)	3.5(3;4;3.5)
Right lateral trunk flexors	0.008	2.6	3(3;4;3.25)	4(3;4;3.6)
Left lateral trunk flexors	0.008	2.6	3.5(3;4;3.5)	4(3;5;3.85)
Right trunk rotators	0.024	2.3	3.5(3;4;3.5)	4(3;5;3.95)
Left trunk rotators	0.003	3	3(3;4;3.25)	4(3;5;3.7)

The evaluation of the results in Group 2 prior to and after physiotherapy revealed statistically significant differences in all muscle groups, except for trunk extensors, knee extensors, left lateral trunk flexors, and right trunk rotators (Table 3).

Table 3. **Results of muscle strength in Group 2 subjects prior to and after physiotherapy**

Muscle group	P-value	Z-value	Score before physiotherapy	Score after physiotherapy
Hip flexors	0.006	2.74	2(1;3;2.25)	3(2;4;2.9)
Hip extensors	0.004	2.88	2(2;3;2.3)	3(2;4;3)
Hip abductors	0.014	2.45	3(2;3;2.65)	3(2;4;2.95)
Knee flexors	0.014	2.45	3(2;3;2.65)	3(2;4;2.95)
Knee extensors	1	0	3(2;3;3)	3(2;4;3)
Ankle dorsiflexors	0.006	2.74	2(2;3;2.3)	3(2;4;3)
Ankle plantar flexors	0.003	2.97	2(2;3;2.3)	3.5(2;4;3.2)
Trunk flexors	0.025	2.24	3(3;4;3.3)	4(3;4;3.55)
Trunk extensors	1	0	4(3;4;3.65)	4(3;4;3.65)
Right lateral trunk flexors	0.023	2.27	3(3;4;3.3)	4(3;5;3.7)
Left lateral trunk flexors	0.059	1.9	4(3;4;3.65)	4(3;5;3.9)
Right trunk rotators	0.069	1.86	4(3;4;3.65)	4(3;5;3.95)
Left trunk rotators	0.01	2.5	3(3;4;3.3)	4(3;5;3.7)

The evaluation of muscle strength between the groups after physiotherapy revealed a statistically significant difference only in the strength of hip flexors (Group1 – 3.5(2;5;3.1) vs. Group 2 – 3(2;4;2.9) points, ($U=60,5$; $p<0.001$)) and knee flexors (Group1 – 3(2;4;3.1) vs. 3(2;4;2.95) points, ($U=40$; $p<0.001$)).

DISCUSSION

The comparison of the results in the two groups prior to and after physiotherapy showed that balance improved in subjects of both groups, yet the improvement was greater in Group 1 subjects. Amiri et al. (2019) conducted a study where they also used the Biodex Balance System device for ten weeks in a sample of patients with neurological disorders in order to improve the subjects' static and dynamic balance. The results of that study, like those of ours, showed an improved static and dynamic balance in subjects who received visual feedback. Silva-Batista et al. (2018) conducted a study involving the use of the Biodex Balance System device in a group of patients with neurological disorders, and evaluated the subjects' balance using the BEST scale. The researchers found that the application of visual feedback significantly improved scores in all six categories of the BEST test. In our study, we obtained analogous results. Our results showed that the BEST category scores in the subject group that underwent physiotherapy with visual feedback were statistically significantly superior to those observed in the group that did wobble board exercises. Such results indicate that visual feedback helps to improve such balance-dependent functions as getting up from a chair, walking over an obstacle, climbing stairs, and maintaining balance on unstable surfaces.

Two most common stroke-related disorders that cause gait and balance impairment in post-stroke patients with hemiparesis are knee stiffness and reduced stride length. Stiff-knee gait develops due to reduced knee flexion angle, resulting in an impaired knee flexion phase, while reduced calf muscle strength increases the risk of falling (Cherry-Allen et al., 2018). In the subjects of our study, muscle strength in the leg of the affected side was inferior to that in the healthy leg – i.e. they had hemiparesis. Prior to physiotherapy, muscle strength in both groups of subjects was lower than that after physiotherapy, but we did not find any statistically significant difference in lower limb muscle strength between the groups. Kim et al. (2019) conducted a randomized study using a "Morning Walk" robotic device that also provided feedback about various gait parameters and provided a possibility of disturbing the balance by, e.g. imitating stair climbing, etc. The results of this study showed that the muscle strength and balance parameters were superior in the studied group (Kim et al., 2019). Martins et al. (2016) identified the principal functions that are impaired in case of the reduction of lower limb muscle strength.

These include walking, climbing up and down the stairs, and standing up from the sitting position. The author not only indicated the subjects' inability to perform such movements, but also mentioned the need for additional energy consumption in cases when the subjects were capable of performing such tasks (Martins et al., 2016).

The results of the study showed that physiotherapy improved balance and muscle strength in stroke patients despite the method chosen. The balance results of the Group 1 (Biodex) was significantly greater than those of the Group 2 (wobble board), whereas no difference in muscle strength parameters was found between the groups.

CONCLUSION

Physiotherapy using the Biodex balance system device (with direct visual feedback) was superior to wobble board exercises for improving the balance abilities, but not the lower limb muscle strength, in stroke patients.

Declaration of funding source – no funding.
Disclosure of interests – none.

REFERENCES

Amiri B., Sahebozamani M., Sedighi B. (2019). The effects of 10-week core stability training on balance in women with Multiple Sclerosis according to Expanded Disability Status Scale: a single-blinded randomized controlled trial. *European Journal of Physical and Rehabilitation Medicine*, 55(2), 199–208. doi: http://doi.org/10.23736/S1973-9087.18.04778-0

Anson, E., Rosenberg, R., Agada, P., Kiemel, T., & Jeka, J. (2013). Does visual feedback during walking result in similar improvements in trunk control for young and older healthy adults? *Journal of Neuroengineering and Rehabilitation*, 10(1), 1–8. http://www.jneuroengrehab.com/content/10/1/110

Archer, D. B., Kang, N., Misra, G., Marble, S., Patten, C., & Coombes, S. A. (2018). Visual feedback alters force control and functional activity in the visuomotor network after stroke. *NeuroImage: Clinical*, 17, 505–517. doi: https://doi.org/10.1016/j.nicl.2017.11.012

Chen, X., Xie, P., Zhang, Y., Chen, Y., Cheng, S., & Zhang, L. (2018). Abnormal functional corticomuscular coupling after stroke. *NeuroImage: Clinical*, 19, 147–159. doi: https://doi.org/10.1016/j.nicl.2018.04.004

Cherry-Allen K.M., Statton M.A., Celnik P.A. et al. (2018). A Dual-Learning Paradigm Simultaneously Improves Multiple Features of Gait Post-Stroke. *Neurorehabilitation and Neural Repair*, 32(9), 810–820. doi: https://doi.org/10.1177/1545968318792623

Chinsongkram B., Chaikeeree N., Saengsirisuwan V., Viriyatharakij N. et al. (2014). Reliability and Validity of Balance Evaluation Systems Test (BESTest) in People With Subacute Stroke, *Physical Therapy*, 94(11), 1632–1643. doi: https://doi.org/10.2522/ptj.20130558

Chun J.Y., Seo J.H., Park S.H. et al. (2016). Effects of 3-Dimensional Lumbar Stabilization Training for Balance in Chronic Hemiplegic Stroke Patients: a Randomized Controlled Trial, *Annals of Rehabilitation Medicine*, 40(6), 972–980. doi: https://doi.org/10.5535/arm.2016.40.6.972

Hahn J., Shin S., Lee W. (2015). The effect of modified trampoline training on balance, gait, and falls efficacy of stroke patients. *Journal of Physical Therapy Science*, 27(11), 3351–3354. doi: https://doi.org/10.1589/jpts.27.3351

Kim J., Kim D.Y., Chun M.H.et al. (2019). Effects of robot-(Morning Walk®) assisted gait training for patients after stroke: a randomized controlled trial, *Clinical Rehabilitation*, 33(3), 516–523. doi: https://doi.org/10.1177/0269215518806563

Madhavan S., Bishnoi A. (2017). Comparison of the Mini-Balance Evaluations Systems Test with the Berg Balance Scale in relationship to walking speed and motor recovery post stroke. *Top Stroke Rehabilitation,* 24(8), 579–584. doi: https://doi.org/10.1080/10749357.2017.1366097

Martins J.C., Aguiar L.T., Lara E.M. et al. (2016). Assessment of the strength of the lower limb muscles in subjects with stroke with portable dynamometry: a literature review. *Fisioterapia em Movimento*, 29(1), 193–208. doi: https://doi.org/10.1590/0103-5150.029.001.AR04

O'Neill, S., Jaszczak, S. L. T., Steffensen, A. K. S., & Debrabant, B. (2017). Using 4+ to grade near-normal muscle strength does not improve agreement. *Chiropractic & manual therapies*, 25(1), 1–9. doi: https://doi.org/10.1186/s12998-017-0159-6

Silva-Batista C., Corcos D.M., Kanegusuku H., Piemonte M.E.P., Gobbi L.T.B., de Lima-Pardini A.C., et al. (2018). Balance and fear of falling in subjects with Parkinson's disease is improved after exercises with motor complexity. *Gait Posture*, 61, 90–97. doi: https://doi.org/10.1016/j.gaitpost.2017.12.027

Kineziterapija su „Biodex" įranga veiksmingesnė nei pratimai ant nestabilių plokštumų, atgaunant patyrusiųjų galvos smegenų infarktą pusiausvyrą, bet ne apatinių galūnių raumenų jėgą

Eglė Lendraitienė, Laura Urboniene, Daiva Petruševičienė, Rasa Šakalienė

Lietuvos sveikatos mokslų universitetas, Reabilitacijos katedra, Kaunas, Lietuva

SANTRAUKA

Tyrimo pagrindimas. Atgauti kūno padėties valdymą ir paciento judesius yra vienas svarbiausių patyrusiųjų galvos smegenų infarktą (GSI) reabilitacijos tikslų. Prarastoms funkcijoms atkurti, naudojama daugybė metodų, tačiau tyrimų, įrodančių konkrečios įrangos veiksmingumą gerinant pusiausvyrą, yra nedaug.

Tikslas – įvertinti pacientų, patyrusių GSI, pusiausvyros ir apatinių galūnių raumenų jėgos parametrus, taikant skirtingus kineziterapijos metodus.

Metodai. Tyrime dalyvavo 40 GSI patyrusių pacientų, kuriems nustatyta hemiparezė ir sutrikusi pusiausvyra. Tiriamieji buvo suskirstyti į dvi grupes: pirmajai grupei (n=20) buvo atlikta kineziterapija, naudojant „Biodex" įrangą (su vizualiniu grįžtamuoju ryšiu), antrajai grupei (n=20) – pratimai ant nestabilių plokštumų. Abiejų grupių tiriamiesiems penkis kartus per savaitę buvo atliktos 45 min. trukmės kineziterapijos procedūros (iš viso 20 procedūrų). Tiriamieji buvo tiriami prieš kineziterapijos procedūrų ciklą ir po jo. Pusiausvyra buvo vertinama taikant „Geriausių vertinimo sistemų testą" (BEST), o apatinių galūnių raumenų jėga – Oksfordo raumenų jėgos skalę.

Rezultatai. Tiek kineziterapija naudojant „Biodex“ prietaisą, tiek ir pratimai ant nestabilių plokštumų pagerino pacientų, patyrusių galvos smegenų infarktą, pusiausvyrą ir raumenų jėgą. Tačiau pirmosios grupės („Biodex“) pusiausvyros rezultatai buvo žymiai geresni nei antrosios grupės (nestabilios plokštumos). Raumenų jėgos parametrai tarp grupių nesiskyrė.

Išvada. Kineziterapija naudojant „Biodex“ įrangą (su vizualiniu grįžtamuoju ryšiu) yra pranašesnė už pratimus ant nestabilių plokštumų, lavinant patyrusiųjų GSI pusiausvyrą, bet ne apatinių galūnių raumenų jėgą.

Raktažodžiai: galvos smegenų infarktas, kineziterapija, Biodex, pusiausvyra, raumenų jėga, apatinė galūnė.

Gauta 2022 09 15

Priimta 2022 09 29