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Original Article

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Effects of Gait Training Using a Shoulder-Back Orthosis on Balance and Gait in Patients with Stroke

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Purpose: The purpose of this study is to find out how gait training with shoulder-back assistive device affects dynamic and static balance, gait of patients with stroke and to help improve body alignment, balance, and gait ability in stroke patients.
Methods: Measurements were taken of the 20 subjects before intervention without shoulder-back assistive device, after intervention with device, and follow up after an hour compared. Berg balance scale used to evaluate dynamic balance; wii balance board was used to measure static balance; and gait ability were measured by timed up and go test and 10-meter walk test. To analyze the results, a one-way repeated measures analysis of variance was implemented to compare the measurements.
Results: The results showed that, after wearing the shoulder-back assistive device, the subjects' dynamic balance statistically significantly improved; no statistically significant difference was observed in static balance, although their balance ability was enhanced; and their increase in gait ability was statistically significant.
Conclusion: This study proved that gait training combined with a shoulder-back assistive device positively impacted dynamic and static balance, gait of patients with stroke.

Keywords: Balance, Gait, Stroke, Shoulder-back orthosis

INTRODUCTION

Stroke is an irreversible neurological injury caused by impaired blood flow to a localized area of the brain, resulting in a combination of neurological disorders, including sensory deficits, motor impairment, cognitive impairment, and speech impairment, depending on the location and extent of the brain lesion.[1] In addition, trunk muscles are damaged, which affects body alignment and balance.[2] Normal body alignment is necessary for stroke patients to perform independent activities and activities of daily living.[3] However, their overall motor control is reduced and their body alignment is asymmetrical, which affects their balance and walking ability.[4]

In stroke patients, abnormal body alignment leads to increased postural sway when shifting weight and difficulty maintaining a stable position within the ground plane.[5] These problems with body alignment can lead to poor balance and negatively impact functional activities. Abnormal body alignment also contributes to leg length discrepancies and asymmetrical pelvic tilt.[6] Asymmetries on both sides of the body, such as excessive trunk curvature and scoliosis, interfere with normal weight transfer and postural responses, and affect limb movement patterns. The trunk muscles that stabilize the spine also guide limb alignment, creating trunk stability.[7] Once trunk stabilization is established, activity in the pelvis, lower back, hip joints, and abdominal muscles is coordinated to help move the limbs.[8] On the other hand, if the asymmetrical posture persists, it leads to shortening of muscles and soft tissues and deterioration of antagonist muscles, both on the paralyzed side and on the non-paralyzed side.[9]

To prevent these secondary deformities, foot orthoses, arm orthoses, etc. are applied to stroke patients.[10] By reducing pressure on the shoulders and neck, upper extremity bracing reduces the load on the joints and muscles of the upper extremity and promotes proper alignment of the upper extremity. Studies have also shown the use of figure-of-eight shoulder braces to improve muscle activity, respiratory function, and reduce plantar pressure.[11] In addition, the effectiveness of spinal braces has been studied

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in patients with low back pain, but there is still a lack of research on the effects of applying shoulder and back braces to stroke patients on body alignment and balance and gait in stroke patients.

Patients with stroke experience a combination of functional impairments, including balance and gait disorders, that reduce their ability to walk, make it difficult to perform complex movements, and limit their ability to perform activities of daily living independently.[12] These balance and gait problems interfere with agile activities and make it difficult to react quickly in environments with stairs, inclines, and uneven surfaces.[13] This can be a barrier to performing activities of daily living, limiting overall socialization.[14] Balance, gait, and activities of daily living are closely correlated with body alignment, and trunk control is an important factor influencing the prognosis of rehabilitation in stroke patients.[15] However, even though many studies have discussed the need to improve body control after stroke, there is a lack of research analyzing the impact of body alignment on balance and gait.[16]

Although there are many treatments for body alignment in clinical practice, there is a lack of studies that have analyzed the effects of applying body alignment tools to gait training on body alignment, balance, and gait in stroke patients. In this study, we applied a shoulder-back orthosis to stroke patients and compared the results before, after, and when the orthosis was removed to determine the effects of applying a shoulder-back orthosis to stroke patients clinically on body alignment, balance, and gait.

METHODS

1. Subjects

This study was conducted on 20 patients diagnosed with stroke at Hospital D in Daegu, who were fully informed of the purpose and methods before participating in the study and agreed to participate voluntarily. The selection criteria for this study were: first, patients diagnosed with stroke within 2 years of onset; second, patients without orthopedic or internal diseases and visual field defects; third, patients with a score of 24 or more on the Korean version of the Mini-Mental State Examination; fourth, patients who understood the purpose of the study and agreed to participate in the study; and fifth, patients who could walk more than 10 meters without the help of a therapist or the use of tools. We excluded patients with bilateral paralysis, cerebellar disease, visual field defects, or those who were unable to communicate (Table 1).

Table 1. General characteristics of subjects (n=20)

	Subjects
Age (years)	59.6±13.3
Time since stroke (month)	13.1±8.1
Gender (male/female)	10/10
Paretic side (left/right)	11/9
Height (cm)	163.0±9.4
Weight (kg)	61.2±13.5

Values represent as mean±SD.

2. Experimental methods

1) Interventions

The pre-intervention test measures balance and walking ability before using the shoulder-back brace. Then, in a seated position in a chair, the shoulder-back orthosis strap is placed on the shoulder, and the strap is adjusted to fit the patient's body so that the bend of thoracic is extended and the shoulder is retracted, and the orthosis is secured to the patient's body. Before the post-intervention test, the patient is asked to sit and stand 10 times and walk 40 meters while wearing the orthosis to allow the patient to acclimate to the shoulder-back orthosis (Figure 1A, B). The follow-up test was performed 1hour after the shoulder-back orthosis was removed.

(1) Balance

The Berg Balance Scale (BBS) was used to assess the dynamic balance of the subjects. To assess static balance, we used Balancia (Mintosys, Korea), a measurement tool that analyzes center of pressure (COP) information using a Wii balance board in a standing position. Participants were asked to stand on the balance board with both feet and keep their arms in a relaxed position. They were asked to keep their eyes open and focus on a 15cm dot drawn 3 meters in front of them to prevent gaze-induced body movements. Measurements were taken after the patient had climbed onto the machine, stabilized in a stable position, and started when ready, with three 30-second repetitions. The variables used in this study were: sway distance, calculated by summing all the movements of the center of pressure about the X and Y axes; sway speed, calculated by dividing the sway distance of the center of pressure by the time; sway area, calculated by drawing an ellipse around the center to assess the spatial aspect of balance; and weight distribution on the paretic side.[17,18] The interpretation of the results is that the longer the sway distance, the faster the sway speed, the larger the sway area, and the lower the weight distribution on the paretic side, the more impaired the balance ability.

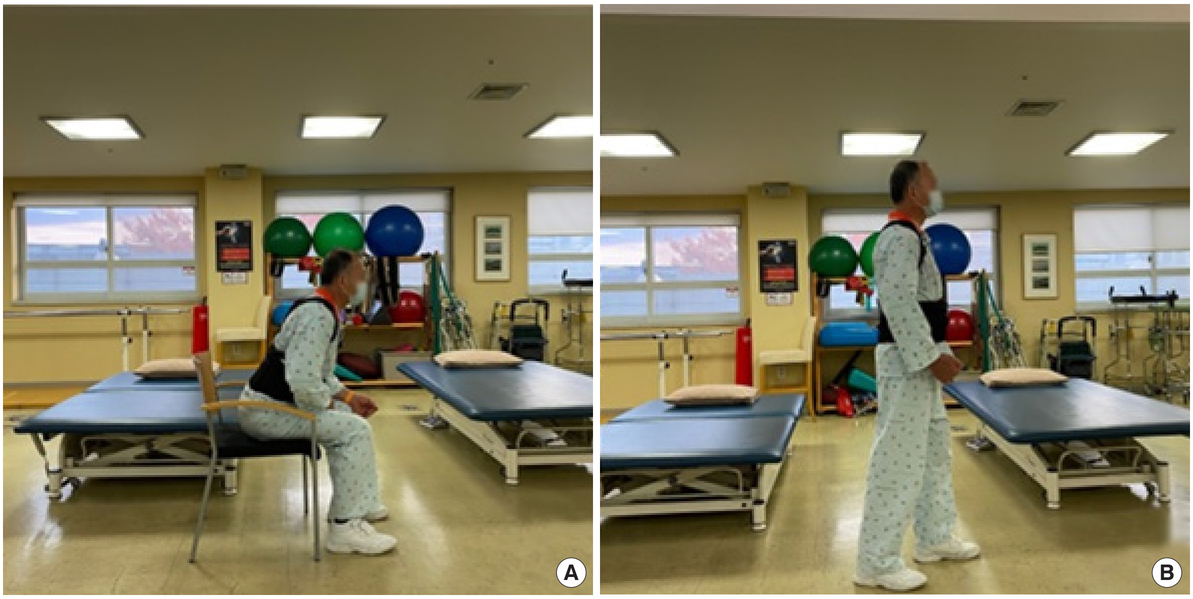

Figure 1. The picture of Intervention methods with shoulder-back assistive device. (A) Sit to stand with shoulder-back assistive device. (B) 40m gait training with shoulder-back assistive device.

(2) Gait

To evaluate the walking ability, the time taken for the stand-up and walk test (TUG test) was calculated and the corresponding distance was divided by the time taken to obtain the walking speed using the 10-meter walk test.

3. Statistical analysis

Statistical analysis of the measured data was performed using the SPSS version 26.0 (IBM Inc., Chicago, IL, USA) statistical program with three replicate measurements of pre-intervention, post-intervention, and follow-up with the removal of assistive devices in the same group, and the analysis of the study results was performed using a one-way repeated measures analysis of variance for time-to-time comparisons. The statistical significance level was set at $\alpha = 0.05$.

RESULTS

1. Comparison of balance abilities

The BBS to compare dynamic balance ability showed a significant increase of 8.24 points from pre-intervention to post-intervention and 6.65 points from pre-intervention to follow-up ($p < 0.05$), and a significant decrease of 1.6 points from post-intervention to follow-up ($p < 0.05$). The comparison of sway distance for static balance showed a decrease of 1.48cm after the intervention with assistive devices compared to before the intervention ($p > 0.05$). There was an increase of 0.35cm at follow-up compared to pre-intervention, but a decrease of 1.13cm at follow-up compared to pre-intervention ($p > 0.05$). Improvement in balance ability was evidenced by a decrease of 0.05cm/s when comparing pre-intervention and post-intervention sway speeds, and an increase of 0.01cm/s when comparing post-intervention and follow-up speeds, but a decrease of 0.04 cm/s when comparing pre-intervention and follow-up speeds ($p > 0.05$).

When comparing the sway area, there was a decrease of 0.79cm^2 after the intervention compared to before the intervention, a decrease of 0.15cm^2 from the pre-intervention to the follow-up, and a significant increase of 0.64cm^2 at the follow-up ($p < 0.05$). When comparing the weight distribution on the paralyzed side, the weight distribution on the paralyzed side increased significantly by 4.49% after the intervention compared to before the intervention ($p < 0.05$), and the weight distribution on the paralyzed side increased by 1.32% at the follow-up compared to before the intervention, but the difference was not significant ($p > 0.05$)(Table 2).

2. Comparison of walking ability

On the TUG test, there was a significant decrease of 1.7 seconds post-intervention compared to pre-intervention and 0.96 seconds from pre-intervention to follow-up ($p < 0.05$). In the 10-meter walk test, there was a significant increase in speed of 0.04m/s from pre-intervention to post-intervention and 0.06m/s from pre-intervention to follow-up ($p < 0.05$)(Table 3).

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Table 2. Comparison of balance ability among pre, post, and follow up test

		Pre	Post	F/U	F	p
DB	BBS (score)	42.50±7.81†,‡	50.75±4.52§	49.15±4.63	28.95	<0.001*
SB	Path length (cm)	82.92±15.44	81.43±15.99	81.78±16.81	0.69	0.500
	Velocity (cm/s)	2.76±0.51	2.71±0.53	2.72±0.56	0.71	0.500
	Area 95% (cm^2)	3.96±2.54	3.16±1.46$^{∥}$	3.80±1.67	2.59	0.090
	Weight distribution (%)	47.69±3.35¶	52.17±4.21**	49.01±3.51	7.68	<0.001*

Values represent as mean±SD. DB: Dynamic balance, SB: Static balance, F/U: follow up. $^{*}p<0.05$, †: Significant difference between pre and post, ‡: Significant difference between pre and F/U, §: Significant difference between post and F/U, $^{∥}$: Significant difference between post and F/U, ¶: Significant difference between pre and post, **: Significant difference between post and F/U.

Table 3. Comparison of gait ability among pre, post, and follow up test

	Pre	Post	F/U	F	p
TUG test (sec)	17.84±9.46†,‡	16.15±8.25	16.88±9.83	5.67	0.010*
10m walking test (m/s)	0.75±0.31$^{§,∥}$	0.79±0.30	0.80±0.34	6.60	<0.001*

Values represent as mean±SD. TUG: Timed up and go test, F/U: follow up. $^{*}p<0.05$, †: Significant difference between pre and post, ‡: Significant difference between pre and F/U, §: Significant difference between pre and post, $^{∥}$: Significant difference between pre and F/U.

DISCUSSION

This study aimed to investigate the effects of gait training with a shoulder-back assistive device on the body alignment, balance, and gait of stroke patients, and to compare the effects to verify whether the body alignment of stroke patients can help their dynamic and static balance and gait. Specifically, the Shoulder-Back Brace is a strap orthosis that passes over the subject's spine between both armpits and both scapulae. In order to correct the position of the subject's scapulae, we used adjustable retraction straps to properly adjust to the width of each subject's torso. We also checked whether the thoracic vertebrae were sufficiently corrected and fixed them in a comfortable state before conducting the experiment. Among stroke patients, hemiparesis involves more use of the non-paralyzed side than the paralyzed side, resulting in muscle weakness in the upper and lower limbs of the paralyzed side,[19] Due to the muscle imbalance between the paralyzed and non-paralyzed sides, the center of gravity of the body is biased towards the non-paralyzed leg, resulting in an asymmetrical posture. This makes it difficult for the patient to balance in a standing position, causing problems with equilibrium responses and impairing postural control.[20] This impaired gait in stroke patients results in kinematic gait asymmetry and increased energy expenditure,[21] making it difficult to efficiently control walking speed even during short distances.[22]

Among the previous studies that investigated balance changes due to postural alignment of trunk, we investigated the effect of posture adjustment based on augmented reality on the balance ability of stroke patients using the berg balance scale test and the timed up and go test and reported that posture adjustment was effective in improving balance ability.[23] Other studies have used the trunk control test and the trunk disability scale to examine the relationship between postural adjustment and balance and functional activities in stroke patients and have reported significant correlations between postural adjustment and balance.[24] They reported that the application of a shoulder-back brace applied to the cervical and thoracic helped to maintain the abnormal alignment of a person with a forward head posture in a correct alignment. They also reported that the correct alignment could restore muscle length in the surrounding muscles.[25] These studies are like our findings that positive changes in body alignment in stroke patients improve balance.

The results of the study showed a significant increase of 6.65 points in the BBS, a measure of dynamic balance, when comparing post-intervention and follow-up results. Although the scores decreased over time, a significant increase of 6.65 points from pre-intervention to follow-up showed improvement in dynamic balance. For stroke patients to maintain good balance, they must be able to control body alignment, static balance, and dynamic balance.[26] Loss of balance interferes with activities of daily living, reduces mobility, and increases the incidence of falls. Restoration of balance is important for daily activities such as standing, sitting, walking, turning, and stair walking.[27] Improving dynamic balance through assistive technology can help reduce the incidence of falls in stroke patients and ultimately improve ambulation.

Variables related to the balance board have been widely used to assess postural control through postural sway in the standing position and have been used as a tool to assess static balance ability.[28,29] There are many studies that have measured sway distance, speed, and area to compare changes in static balance with cognitive tasks.[30-32] In this study, sway distance, speed, area, and weight distribution on the paretic side were measured to compare changes in static balance with assistive devices. During the test for static balance, the distance and speed of swaying decreased from pre-intervention to post-intervention, and increased from post-intervention to follow-up, but the difference was not significant. When comparing the area of swaying, there was a decrease in the area after the intervention compared to the pre-intervention, and a decrease in the area after the intervention compared to the pre-intervention and follow-up. Reduced sway area indicates improved static balance ability.[33] Sway distance, speed, and area all improved in stroke patients' static balance ability after intervention with aids compared to pre-intervention, and although there was a decrease in ability at follow-up compared to pre-intervention, the overall improvement in ability compared to pre-intervention suggests that shoulder-back aids have a positive effect on static balance in stroke patients. There was a significant 4.49% increase in weight distribution on the paralyzed side after the intervention compared to before the intervention, and a 1.32% increase at follow-up compared to before the intervention, but the difference was not significant. Asymmetrical weight bearing is common in stroke patients, with as much as 80% of total body weight supported on the non-paralyzed side, creating postural imbalance.[34] Symmetrical weight distribution has a significant impact on posture and balance control.[35] In stroke patients, paralyzed side weight distribution is reduced in standing posture, leading to asymmetrical postural problems.[36] Analysis of weight distribution and center of gravity movement during trunk flexion using a force plate in stroke patients and the general population showed that the weight distribution to the paralyzed side was significantly reduced in the patient group.[37] This may be due to the fact that the intervention with the assistive device reduced the trunk flexion of the subjects and increased the weight distribution from the non-paralyzed side to the paralyzed side.

The TUG test for gait showed a significant decrease from pre-intervention to post-intervention and from pre-intervention to follow-up. The gait test showed a significant increase in speed from pre-intervention to post-intervention and from pre-intervention to follow-up. Previous studies have shown that gait speed is the most significant and reliable factor in assessing overall gait performance in stroke patients, and that as gait speed increases, so does speed per minute.[38] Studies have shown that as balance improves in stroke patients, gait speed increases and speed per minute increases, which is consistent with the results of this study, which showed an increase in gait speed as balance improved.[39]

Based on the results of this study, we aimed to suggest an effective clinical method for improving patients' balance and walking ability in the rehabilitation of stroke patients. The results showed that gait training with shoulder and back aids influenced improving dynamic and static balance and walking ability in stroke patients. Therefore, training with aids can improve balance and walking ability in a faster time compared to training without aids. However, this study was cross-sectional and focused only on the immediate effects of the aids, and there was not enough time for motor learning of muscle activity, so patients may not have had time to adapt to the changes in body alignment. In future studies, it is expected that comparing the effects of interventions with more subjects and aids over a longer period of time will provide a clearer picture of the effects of not only external changes but also internal changes in the body.

REFERENCES

1. Ji YH, Lee JK, Lee JK et al. Effect of uneven surface gait training on ankle muscle activation and balance in stroke patients. J Kor Phys Ther. 2022; 34(4):161-7.
2. Karatas M, Cetin N, Bayramoglu M et al. Trunk muscle strength in relation to balance and functional disability in unihemispheric stroke patients. Am J Phys Med Rehabil. 2004;83(2):81-7.
3. Patterson SL, Forrester LW, Rodgers MM et al. Determinants of walking function after stroke: differences by deficit severity. Arch Phys Med Rehabil. 2007;88(1):115-9.
4. Choi MS, Lee JS, Kim K et al. Effects of treadmill gait training according to different inclination on postural balance in patients with chronic stroke. J Kor Phys Ther. 2018;30(6):205-10.
5. Lim YJ, Kang SH. Effect of various lower extremity exercises using the swiss ball while standing on balance, muscle strength, gait and fall efficacy in stroke patients: a pilot study. J Kor Phys Ther. 2021;33(4):202-9.
6. Bache CE, Selber P, Graham HK. The management of spastic diplegia. Current Orthopaedics. 2003;17(2):88-104.
7. Majsak MJ. Application of motor learning principles to the stroke population. Top Stroke Rehabil. 1996;3(2):37-59.
8. DeRosa CP, Porterfield JA. A physical therapy model for the treatment of low back pain. Phys Ther. 1992;72(4):261-9.
9. Jeong HJ, Park SH, Jeon JY et al. Effects of applying a vibration stimulation to paretic side and non-paretic side on balance and gait in stroke patients: a pilot study. J Kor Phys Ther. 2022;34(5):193-7.
10. Abe H, Michimata A, Sugawara K et al. Improving gait stability in stroke hemiplegic patients with a plastic ankle-foot orthosis. Tohoku J Exp Med. 2009;218(3):193-9.
11. Park DH. Effects of push up plus exercise using 8-figure shoulder orthosis on pain, shoulder range of motion, and proprioception of patients with round shoulder posture. Korean Journal of Neuromuscular Rehabilitation. 2023;13(4):61-7.

https://doi.org/10.18857/jkpt.2023.35.6.200

12. Jørgensen L, Engstad T, Jacobsen BK. Higher incidence of falls in long-term stroke survivors than in population controls: depressive symptoms predict falls after stroke. Stroke. 2002;33(2):542-7.
13. Said CM, Goldie PA, Patla AE et al. Obstacle crossing in subjects with stroke. Arch Phys Med Rehabil. 1999;80(9):1054-9.
14. Cederfeldt M, Gosman-Hedström G, Sävborg M et al. Influence of cognition on personal activities of daily living (P-ADL) in the acute phase: the gothenburg cognitive stroke study in elderly. Arch Gerontol Geriatr. 2009;49(1):118-22.
15. Kang TW, Kim BR. The effects of task-oriented exercise program on balance ability in patients with acute stroke. J Kor Phys Ther. 2018;30(4):112-6.
16. Van CT, Saeys W, Hallemans A et al. Effectiveness of additional trunk exercises on gait performance: study protocol for a randomized controlled trial. Trials. 2017;18(1):249.
17. Clark RA, Bryant AL, Pua Y et al. Validity and reliability of the nintendo wii balance board for assessment of standing balance. Gait Posture. 2010;31(3):307-10.
18. Mazaheri M, Salavati M, Negahban H et al. Postural sway in low back pain: effects of dual tasks. Gait Posture. 2010;31(1):116-21.
19. Campbell FM, Ashburn AM, Pickering RM et al. Head and pelvic movements during a dynamic reaching task in sitting: implications for physical therapists. Arch Phys Med Rehabil. 2001;82(12):1655-60.
20. Ikai T, Kamikubo T, Takehara I et al. Dynamic postural control in patients with hemiparesis. Am J Phys Med Rehabil. 2003;82(6):463-9.
21. Um YH, Jang HY, Lee SM. Taping therapy simultaneously applied to the ankle and hip joint: effect on balance and gait in patients with chronic stroke. J Kor Phys Ther. 2019;31(1):49-55.
22. Eng JJ, Chu KS. Reliability and comparison of weight-bearing ability during standing tasks for individuals with chronic stroke. Arch Phys Med Rehabil. 2002;83(8):1138-44.
23. Yang YR, Tsai MP, Chuang TY et al. Virtual reality-based training improves community ambulation in individuals with stroke: a randomized controlled trial. Gait Posture. 2008;28(2):201-6.
24. Verheyden G, Vereeck L, Truijen S et al. Trunk performance after stroke and the relationship with balance, gait and functional ability. Clin Rehabil. 2006;20(5):451-8.
25. Park CJ, An DH. The effect of the weight of a backpack on craniovertebral angle and neck muscle activities on some university students. Physical Therapy Korea. 2020;27(1):45-52.
26. Mirelman A, Patritti BL, Bonato P et al. Effects of virtual reality training on gait biomechanics of individuals post-stroke. Gait Posture. 2010;31(4):433-7.
27. Eng JJ, Chu KS. Reliability and comparison of weight-bearing ability during standing tasks for individuals with chronic stroke. Arch Phys Med Rehabil. 2002;83(8):1138-44.
28. Baratto L, Morasso PG, Re C et al. A new look at posturographic analysis in the clinical context: sway-density versus other parameterization techniques. Motor Control. 2002;6(3):246-70.
29. Keshner EA, Kenyon RV. The influence of an immersive virtual environment on the segmental organization of postural stabilizing responses. J Vestib Res. 2000;10(4-5):207-19.
30. Andersson G, Hagman J, Talianzadeh, R et al. Effect of cognitive load on postural control. Brain Res Bull. 2002;58(1):135-9.
31. Lee Y, Goyal N, Aruin AS. Effect of a cognitive task and light finger touch on standing balance in healthy adults. Exp Brain Res. 2018;236(2):399-407.
32. Melzer I, Benjuya N, Kaplanski J. Age-related changes of postural control: effect of cognitive asks. Gerontology. 2001;47(4):189-94.
33. Shiravi, Z, Moghadam ST, Hadian MR et al. Effect of cognitive task on postural control of the patients with chronic ankle instability during single and double leg standing. J Bodyw Mov Ther. 2017;21(1):58-62.
34. Laufer Y, Dickstein R, Resnik S et al. Weight-bearing shifts of hemiparetic and healthy adults upon stepping on stairs of various heights. Clin Rehabil. 2000;14(2):125-9.
35. Han JT, Hwangbo G. Kinematic analysis of lower extremities during stairs and ramp climbing with older adults. Korean Journal of Sport Biomechanics. 2009;19(3):435-48.
36. Fabio RPD, Badke MB. Relationship of sensory organization to balance function in patients with hemiplegia. Phys Ther. 1990;70(9):542-8.
37. Messier S, Bourbonnais D, Desrosiers J et al. Dynamic analysis of trunk flexion after stroke. Arch Phys Med Rehabil. 2004;85(10):1619-24.
38. Jonsdottir J, Recalcati M, Rabuffetti M et al. Functional resources to increase gait speed in people with stroke: strategies adopted compared to healthy controls. Gait Posture. 2009;29(3):355-9.
39. Laufer Y, Dickstein R, Chefez Y et al. The effect of treadmill training on the ambulation of stroke survivors in the early stages of rehabilitation: a randomized study. J Rehabil Res Dev. 2001;38(1):69-78.