# Effects of Forced Induced Weight Support Training on Unstable Surface for the Walking a Patients with Hemiplegia

**Hyun-Chang Park[1], PT, Sang-Ho Lee, PT, PhD[2], Byong-Yong Hwang, PT, PhD[*3]**

[1]*Dept. of Physical Therapy, Bronco memorial hospital,*

[2]*Dept. of Physical Therapy, Seonam University,*

[*3]*Dept. of Physical Therapy, Yongin University*

***Purpose*** The study objective was to investigate the effects of forced induction weight-supported training conducted on an unstable surface on the gait of stroke patients. ***Methods*** Fifteen hemiplegic patients diagnosed with stroke, the onset of which had occurred ≥ 6 months, were included in the study. Forced induction weight-supported training was performed on an unstable surface (patients) and on stable surface (the control group). The training was performed over six weeks, five times a week, for a duration of 30 minutes using an FDM-T Treadmill System® for Biomechanical Gait Analysis (Zebris Medical, Cuxhaven, Germany) and the 10 Metre Walk Test (10MWT). ***Results*** Statistically significant differences between the non-paralyzed side stance phase and non-paralyzed side swing phase ($p<.05$), and between stance and swing symmetry ($p<.05$) in the study group, were found. A statistically significant difference was also observed between the paralyzed side stance phase and paralyzed side swing phase in the control group ($p<.05$). ***Conclusion*** The use of forced induction weight-supported training, conducted on unstable surface, was effective in improving symmetry and speed in the gait of hemiplegic patients.

***Key words*** forced induction, weight support, unstable, gait, hemiplegia

***Corresponding author*** Byong Yong Hwang (bobathkorea@hanmail.net)

***Received date*** 14 December 2016
***Revised date*** 20 January 2017
***Accepted date*** 24 February 2017

## Ⅰ. Introduction

Muscle weakness, sensory impairment, abnormal muscle activity, and the inability to exert postural control are the consequences of a stroke.[1-2] Most stroke patients experience challenges with balance adjustment.[3] It has been proposed that improving the ability to balance is a criterion for the recovery of function in stroke patients.[4] Balance impairment and increased postural fluctuation are known to be associated with abnormal weight support of the lower limbs.[5] Asymmetric weight support and balance impairment may also result in the loss of weight-bearing capacity in the paralyzed limb.[6] Asymmetrical weight support of the bilateral lower limb causes an unstable posture, which is the cause of slow and functional behavior during daily living activities due to asymmetrical posture and decreased posture control in stroke patients.[7] Shumway-Cook and Horak reported that body sensory information input from the foot when making contact with the ground during postural control is important to maintain balance.[8] Therefore, it is suggested that balancing training on an unstable surface, rather than that on a stable surface, might increase external perturbation and postural control. Hocherman et al. (1984) argued that body weight-transfer training for stroke patients using a moving plate (platform) increased weight load more so than a weight-shifting exercise involving static symmetry training.[9] Elsewhere, healthy adults were asked to perform balanced training exercises on stable and unstable surfaces. Postural control was observed to increase significantly in the group who practiced on unstable ground.[10-11]

Constraint-induced movement therapy improved

doi : http:dx.doi.org/10.17817/2017.03.25.5623

paralyzed upper limb function following restriction to the use of the non-paralyzed upper limb in a stroke patient.[12] However, constraint-induced movement therapy was not used in gait training for hemiplegic patients because it was impossible to walk when the paralyzed leg was restricted. Thus, a method of inducing forced weight bearing to the paralyzed side, by raising the non-paralyzed lower limb in order to provide normal weight support to the paralyzed lower limb and reduce learned non-use, was applied.[13-15] Symmetrical mobility and gait speed in relation to body weight increased during the treatment period in a single subject following forced weight-transfer exercises. A significant increase in paralyzed weight shift and gait speed was observed in chronic stroke patients who had engaged in forced weight-transfer exercises.

However, few studies have been conducted on forced induction weight-supported training carried out on an unstable surface. Thus, the objective of the current study was to investigate the effect of forced induction weight-supported training performed on unstable surface on the gait of stroke patients.

## II. Materials and Mehtods

### Participants

Fifteen patients diagnosed with hemiplegia at B Hospital, Hwaseong, Gyeonggi-do, Korea, between August and September 2016 were included in the study. The selection criteria for the study subjects were stroke patients: 1) Person who has stroke onset 6 months or more. 2) person who can stand alone and can stand an independent clerical posture for more than 1 minute. 3) person who can walk more than 10m using independent or auxiliary tools. 4) person who do not have orthopedic diseases that can affect the therapeutic effect. 5) The Korean Mini Mental State Examination (K-MMSE) score of 24 or more. 6) person who have never been involved in similar research in the past. 7) Person who understood the purpose of the study and agreed to the participation agreement. The demographic characteristics of the study participants are detailed in Table 1.

### Study design

Fifteen study participants were randomly assigned in a controlled trial to forced induction weight-supported training on an unstable surface (Group A) or on stable surface (Group B, control group). Gait cycle, gait speed, and length of step were assessed prior to the intervention and re-evaluated after six weeks.

### Outcome Measures

1) 10M Walk Test: 10MWT

The participants walked for 14 m at maximum speed. The first and last 2 m were excluded from the measurements. When the speed of the stroke patients

**Table 1. Demographic characteristics of the study participants.**

| | | study group (n=7) | control group (n=8) | *p* |
|---|---|---|---|---|
| Gender (%) | Male | 5(71.43) | 3(37.50) | 0.78 |
| | Female | 2(28.57) | 5(62.50) | |
| Age | | 56±11.91 | 52.71±9.78 | 0.458 |
| Stroke type | hemorrhage | 3(42.86) | 2(25.00) | 0.604 |
| | infarction | 4(57.14) | 6(75.00) | |
| Hemiplegic side (%) | Rt | 4(57.14) | 2(25.00) | 0.200 |
| | Lt | 3(42.86) | 6(75.00) | |
| Onset | | 22.57±4.75 | 35.14±11.38 | 0.373 |
| MMSE-K | | 27.00±2.58 | 28.43±2.07 | 0.304 |

Note. Values are mean ± standard deviation was assessed, high reliability of r = 0.87 in both the test and retest were demonstrated(16).

2) Gait analysis

The FDM-T Treadmill System® for Biomechanical Gait Analysis was used for the gait analysis. It consists of a measuring sensor and a treadmill measuring device. Pre - and post-test tools were used in this study to determine changes to the pre- and post-step length symmetry indices and gait cycle (stance phase, swing phase and double stance phase).

### Interventions

Seven subjects were randomly assigned to the unstable surface forced induction weight-supported training group (Group A, study group) and eight were randomly allocated to the stable surface forced induction weight-supported training (Group B, control group). A 10 mm high insole was used to lift the non-paralyzed side to ensure contact with the ground for 30 minutes. When the subjects were tired, they rested while seated, continuing with the exercises in a standing position once rejuvenated.

### Statistical analysis

The results were analyzed using SPSS® Statistics for Windows® (version 20.0). The mean and standard deviation were calculated for the demographic characteristics. Homogeneity was verified by performing an independent sample t-test. The Wilcoxon signed-rank test was used to investigate changes within the matched samples. Change between the groups was evaluated using the Mann-Whitney U test. The level of statistical significance level was set at $\alpha$ = 0.050.

## III. Results

### Gait cycle

The non-paralyzed stance phase of the gait cycle decreased significantly in Group A (the study group) from 75.12 ± 4.76 prior to the intervention to 72.91 ± 4.72 after it (p<.05)<Table 2>. The non-paralyzed swing phase was observed to be 24.87 ± 4.76 before the intervention and 27.09 ± 4.72 after it in this group (p<.05)<Table 2>. The paralyzed stance phase decreased significantly in Group B (the control group) from 70.59 ± 4.85 prior to the intervention to 68.79 ± 4.79 after it (p<.05). There was a significant increase in the paralyzed swing phase from 29.41 ± 4.85 before the intervention to 31.21 ± 4.79 after it in this group (p<.05)<Table 2>.

### Gait symmetry

In Group A (the study group), stance phase symmetry increased significantly from 93.21 ± 3.40 before the in-

**Table 2. A comparison of the baseline and post-intervention gait cycle in the study and control groups.**

| | study group (n=7) | | control group (n=8) | | |
|---|---|---|---|---|---|
| | pre | post | pre | post | *p* |
| Paralyzed stance phase (%) | 69.96±4.05 | 70.39±4.85 | 70.59±4.85 | 68.79±4.79* | .268 |
| non-paralyzed stance phase (%) | 75.12±4.76 | 72.91±4.72* | 75.49±5.40 | 74.80±6.24 | .306 |
| Paralyzed swing phase (%) | 30.04±4.05 | 29.61±4.85 | 29.41±4.85 | 31.21±4.79* | .268 |
| non-paralyzed swing phase (%) | 24.87±4.76 | 27.09±4.72* | 24.51±5.40 | 25.20±6.24 | .306 |
| Double stance phase (%) | 45.16±8.37 | 43.26±9.06 | 46.20±8.62 | 43.59±9.10 | .478 |

Note. Values are mean ± standard deviation, * $p<0.05$

tervention to 95.93 ± 3.48 after it (p <.05)<Table 3>. Swing phase symmetry also increased significantly from 82.60 ± 8.08 prior to the intervention to 90.10 ± 7.86 after it (p <.05)<Table 3>.

### Step length

Paralyzed step length increased from 30.71 ± 9.91 before the intervention to 33.86 ± 11.35 after it in Group A (the study group) but the difference was not statistically significant (p> .05)<Table 4>. Non-paralyzed step length increased from 26.86 ± 13.45 prior to the intervention to 30.29 ± 14.72 after it. Again, this difference was not statistically significant (p> .05)<Table 4>. Similarly, paralyzed step length increased from 23.50 ± 6.95 before the intervention to 26.63 ± 12.30 after it in Group B (the control group) but without reaching statistical significance (p> .05)<Table 4>. Non-paralyzed step length also increased from 18.50 ± 6.99 prior to the intervention to 20.75 ± 13.01 after it in this group, again in a way that was not of statistically significant value (p> .05)<Table 4>.

### 10MWT

The values obtained from the 10MWT significantly decreased from 17.43 ± 12.29 before the intervention to 15.43 ± 12.27 after it in Group A (the study group) (p <.05)<Table 5>. The result was similar for Group B (the control group), i.e., falling from 23.63 ± 18.12 prior to the intervention to 20.25 ± 15.17 after it (p <.05) <Table 5>.

## IV. Discussion

An increase in non-paralyzed stance, gait symmetry, and gait speed was observed in the current study following forced induction weight-supported training conducted on an unstable surface by hemiplegic patients. Training on unstable surface increased external perturbation, which helped to achieve more ef-

**Table 3. A comparison of baseline and post-intervention gait symmetry in the study and control groups.**

| | study group (n=7) | | control group (n=8) | | |
|---|---|---|---|---|---|
| | pre | post | pre | post | p |
| stance phase symmetry (%) | 93.21±3.40 | 95.93±3.48* | 93.17±6.64 | 92.16±7.71 | .232 |
| swing phase symmetry (%) | 82.60±8.08 | 90.10±7.86* | 84.44±17.06 | 80.92±18.71 | .198 |

Note. Values are mean ± standard deviation, *$P$<0.05

**Table 4. A comparison of baseline and post-intervention step length in the study and control groups.**

| | study group (n=7) | | control group (n=8) | | |
|---|---|---|---|---|---|
| | pre | post | pre | post | p |
| paralyzed step length (cm) | 30.71±9.91 | 33.86±11.35 | 23.50±6.95 | 26.63±12.30 | .167 |
| non-paralyzed step length (cm) | 26.86±13.45 | 30.29±14.72 | 18.50±6.99 | 20.75±13.01 | .100 |

Note. Values are mean ± standard deviation

**Table 5. A comparison of baseline and post-intervention 10MWT in the study and control groups.**

| | study group (n=7) | | control group (n=8) | | |
|---|---|---|---|---|---|
| | pre | post | pre | post | p |
| 10MWT (s) | 17.43±12.29 | 15.43±12.27* | 23.63±18.12 | 20.25±15.17* | .071 |

Note. Values are mean ± standard deviation, *$P$<0.05

fective postural control. When standing or walking on a surface, ramp, or moving ground, the input of somatosensory information causes confusion, thereby affecting neuromuscular activity and postural response.[18) Yang et al. (2012) demonstrated that symmetrical weight-bearing distribution increased with the application of an unstable plate on the non-paralyzed side of the body and a stabilizing one on the paralyzed side, with both lower limbs pushing down on the floor, thus affecting the weight distribution ratio. This suggests that the use of an unstable plate on the non-paralyzed side of the body causes confusion regarding the proper sensory receptive input, thereby promoting a weight shift to the paralyzed side supported by the stabilizer, with the result that symmetrical weight support and muscle activity in the paralyzed lower limb is achieved.[19) Chaudhuri et al. (2000) reported an increase in paralyzed lower limb muscle activity and reduced latency in the paralyzed lower limb when the non-paralyzed limb was elevated for external perturbation.[13) Raising the non-paralyzed lower limb shifted the center of gravity to the paralyzed lower limb, thus reducing the learned non-use of the paralyzed lower limb and facilitating the recovery of postural control.

The non-paralyzed stance phase decreased significantly in the current study when an unstable surface was utilized. This suggests that the center of gravity shifted to the paralyzed lower limb and increased the use of the paralyzed limb.

Post-stroke hemiplegic patients were found to have faster gait speed and to achieve longer paralyzed step length after weight training for both the paralyzed and non-paralyzed sides of their body using weight transfer in a study by Kim et al. (2011) In another study, Aruin et al. (2000) evaluated a single hemiplegic patient who participated in forced weight training for six weeks to elevate the non-paralyzed side. The result was a significant improvement in pre- and post-gait speed and weight-bearing ratio.[20) An increase in step length and a significant increase in gait speed were both observed in the current study although the results did not achieve statistical significance.

## V. Conclusion

Forced induction weight-supported training performed on an unstable surface significantly improved gait symmetry and speed in hemiplegic patients. Therefore, the study findings comprise useful data that can be used to achieve an improvement in the gait of such patients.

### References

1. Geurts AC, De Haart M, Van Nes IJ, et al. A review of standing balance recovery from stroke. Gait Posture. 2005;22:267-81.
2. Kleindorfer D, Lindsell CJ, Moomaw CJ, et al. Which stroke symptoms prompt a 911 call? a population-based study. Am J Emerg Med. 2010;28:607-12.
3. Bonan IV, Colle FM, Guichard JP, et al. Reliance on visual information after stroke. Part I: Balance on dynamic posturography. Arch Phys Med Rehabil. 2004;85:268-73.
4. Walker C, Brouwer BJ, Culham EG. Use of visual feedback in retraining balance following acute stroke. Phys Ther. 2000;80:886-95.
5. 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.
6. Aruin AS, Rao N, Sharma A, et al. Compelled body-weight shift approach in rehabilitation of individuals with chronic stroke. Top Stroke Rehabil. 2012;19(6):556-63.
7. Cameron DM, Bohannon RW, Garrett GE, et al. Physical impairments related to kinetic energy during sit-to-stand and curb-climbing following stroke. Clin Biomech (Bristol, Avon). 2003;18:332-40.
8. Shumway-Cook A, Horak FB. Assessing the influence of sensory interaction on balance: Suggestion from the field. Phys Ther. 1986;66(10):1548-50.
9. Hocherman S, Dickstein R. Platform training and postural stability in hemipelgia. Arch Phys Med Rehabil. 1984;65:588-92.
10. Anderson K, Behm DG. Trunk muscle activity increases with unstable squat movements. Can J Appl Physiol. 2005;30(1):33-45.
11. Taube W, Gruber M, Beck S, et al. Cortical and spinal

adaptations induced by balance training: Correlation between stance stability and corticospinal activation. Acta Physiol (Oxf). 2007;189(4):347-58.
12. Taub E, Uswatte G & Pidikiti R. Constraint-Induced Movement Therapy: A new family of techniques with broad application to physical rehabilitation - A clinical review. J Rehabil Res Dev. 1999;36(3):237-51.
13. Aruin A, Hanke T, Chaudhuri G, et al. Compelled weight bearing in patients with hemiparesis following stroke: The effect of a lift insert and goal-directed balance exercise. J Rehabil Res Dev. 2000;37:66-72.
14. Ibrahim AI, Alhusaini AA, Hegazy FA, et al. Effectiveness of foot wedge and carrying weighted bag on loading the paretic lower limb in children with hemiparetic cerebral palsy. Neuro Rehabilitation. 2013;32(3):563-71.
15. Rodriguez GM, Aruin AS. The effect of shoe wedges and lifts on symmetry of stance and weight bearing in hemiparetic individuals. Arch Phys Med Rehabil. 2002;83:478-82.
16. Green J, Forster A, Young J. Reliability of gait speed measured by a timed walking test in patients one year after stroke. Clin Rehabil. 2002;16(3):306-14.
17. Freeman MAR, Dean MRE, Hanham IMF. The etiology and prevention of functional instability of the foot. J Bone Joint Surg. 1965;47:678-85.
18. Chiang JH, Wu G. The influence of foam surfaces on biomechanical variables contributing to postural control. Gait Posture. 1997;5(3):239-45.
19. Yang YP, Roh JS. The effect of types of weight-bearing surfaces on muscle activities of lower limbs and weight distribution during semi-squat movement of patients with hemiplegia. PTK. 2012;19(1)
20. Kim KD. The effect of step length symmetry and walking speed in subjects with performance weight bearing training [dissertation]. City: Physical Therapy, Graduate School of Health and Rehabilitation Sciences, Yong In University, Korea, 2011.