THE "BUTTERFLY PARAMETERS" EFFECTED BY ANKEL-FOOT ORTHOSIS (AFOs) IN STROKE: A PILOT STUDY

Nutkritta Thitithunwarat and Warin Krityakiarana

Department of Rehabilitation of Persons with Disabilities, Ratchasuda College, Mahidol University, Thailand

ABSTRACT

The purpose of this pilot study was to evaluate the effect of ankle-foot orthosis (AFOs) on the balance control during walking in stroke patients. Butterfly parameters (Anterior/posterior variability, Lateral variability and Lateral symmetry) were used to compare the balance control between warring AFOs and non-warring AFOs (control). Five stroke patients who were diagnosed with hemiplegia were randomly selected. The sequence of walking between AFOs and control was random. The participants were asked to walk independently with their prefer speed via the Zebris FDM measuring system (Zebris Medical GmbH, Germany). There were significant different in butterfly parameters between AFOs and control ($p<0.05$). AFOs had effects on the balance and walking, however, the higher number of participant is require to fulfill the experiment.

INTRODUCTION

Stroke is a central nervous system disease, which often left with disabling motor impairments and gait dysfunction and lead to reduced function and quality of life.[1-2] Gait dysfunction is estimated to affect up to 80% of the stroke patients with some characteristic presentation, such as, prolonged swing time, decreased stance time on the affected limb and asymmetric posture.[3] These often exhibit an abnormal gait patterns. Many conventional treatments have been used to correct these issues.

Gait training is provided by a physical therapist using hands-on activities to facilitate normal movement patterns. One crucial risk in stroke patient is "risk of fall", which is very high among stroke patients. The falling is used to report as a major complication in stroke rehabilitation. Assistive devices in rehabilitation career are developing. Ankle-foot orthosis (AFOs) are often prescribed to stroke patients to deliver ankle stability during stance and adequate toe clearance during swing, and to promote heel strike.[4] The decrease of maximal excursion toward the affected side in stroke patients have been proved and report as a result of wearing an AFOs, which is reflected the better balance control during walking.[5] However, the parameter for postural control during walking has been developed and applied to clinical practice. Butter diagram or butterfly parameters, which is presented the repeated movement of the center of pressure (CoP) during walking on a walkway, capturing in a single frame many gait characteristics essential for efficient walking. Butterfly diagram are easier to use compared the progression of gait rehabilitation, especially in neurological rehabilitation settings. In present study, we focused on a unique outcome statistic of the "butterfly" diagram. We hypothesized that AFOs effected the butterfly gait variability parameters in stroke patients.

METHODS

Participants

This pilot study was an observational cross-sectional study comprising 5 stroke patients, aged 61.2 (S.D. = 5.63). Inclusion criteria included: (1) diagnosed as hemiplegia; (2) independent walking with or without assistive gait; (3) equivalent to the ability to walk at least 20 m without resting. Exclusion criteria included: (1) orthopedic disorders that could negatively affect mobility; (2) cognitive decline effected walking; (3) do not want to participate.

Gait assessment

Gait parameters were obtained using the Zebris FDM measuring system (Zebris Medical GmbH, Germany) fitted with an electronic mat. The walkway contact surface measures 1580 x 605 x 21 mm (L x W x H). The stroke patients were asked to walk as prefer speed. When the patients stands/walks on the walkway, the force exerted by their feet (the so-called reactive-normal force in directions x, y and z) is recorded by the sensors at a sampling rate of 120 Hz. Due to the high density of the sensors, 1440 x 560 mm (L x W).

The butterfly parameters (diagram)

The machine devoted software generates a graphic pattern termed the 'butterfly', which represents a continuous trace of the CoP trajectory during walking. The following set of parameters is automatically derived from the butterfly:

1) Anterior/posterior variability (mm): defined as the standard deviation of the intersection point in the anterior/posterior direction.

2) Lateral variability (mm): defined as the standard deviation of the intersection point in the lateral direction. Similarly as the ant/post variability parameter.

3) Lateral symmetry (mm): left/right shift of the intersection point.

Statistical Analysis

T-test was used for comparing the difference between AFOs and control in each parameter.

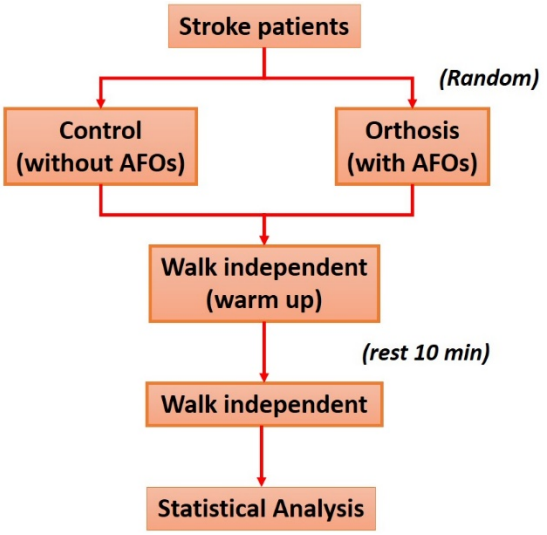

Figure 1 Presented the flow of method used in this study

RESULTS

The study used the butterfly parameters to present the patient's balance ability. The randomized for sequence of warring and non-warring was performed. Butterfly parameters were effected by the AFOs warring when compared to the control (Table 1). We found that lateral symmetry was increased when warring AFOs, but the lateral variability was decreased ($p<0.05$) (Fig 2). Moreover, the gait line length (sound side) and single support line (effected side) were increased when applied the AFOs ($p<0.05$) (Fig 3).

Table 1 Presented the Butterfly parameters compared between AFO and control.

Butterfly Parameters	Average		SD	
	Control	AFO	Control	AFO
Gait line length, sound side (mm)	180.20	245.20	31.28	44.18
Gait line length, effected side (mm)	185.00	253.60	46.22	85.00
Single support line, sound side (mm)	36.20	46.00	26.94	38.29
Single support line, effected side (mm)	1.60	11.60	3.58	3.56
Ant/post position (mm)	102.40	128.60	2.30	16.04
Lateral symmetry (mm)	41.20	30.00	9.78	11.18
Ant/post variability	7.00	17.20	6.75	13.36
Lateral variability	4.60	41.00	2.79	20.58

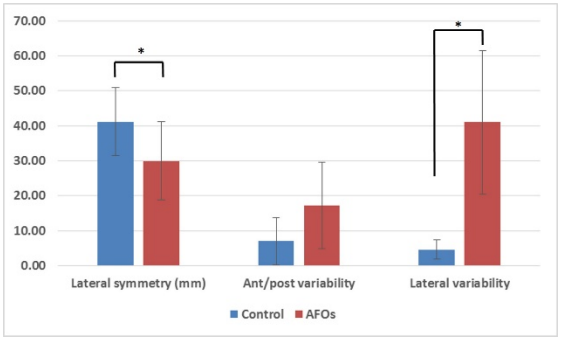

Figure 2 Butterfly parameters were significant different between control and AFOs in Lateral symmetry and Lateral variability ($p<0.05$)

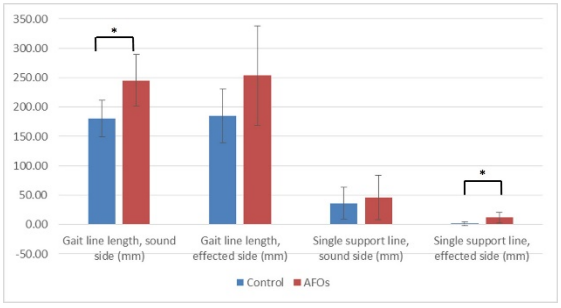

Figure 3 Gait line length (sound side) and single support line (effected side) were significant different between control and AFOs ($p<0.05$)

DISCUSSION

Stroke patients show a very large postural disturbance during walking. Since balance is the ability to control and maintain the balance of human (both static and dynamic). The key elements to control are involved in several factors, such as, the integration among sensorimotor feedback and feed forward.[6, 7]

Our pilot study shown that the applying of assistive device (AFOs) had effected the postural control of human body, presented via the butterfly parameters. This might come from the sensorimotor feedback[7, 8] of the AFOs via the somatosensory system and also the anticipatory reaction of patients.[9] However, the limitation to this study is the number of sample, which is a pilot study. The increase of number might show some significant in other parameters, which is crucial for further design AFOs for stroke patients in the future.

REFERENCES

1. Paolucci, S., Caltagirone, C., Mastrilli, F., Sandrini, G., & Nappi, G. (2003). Planning availability in stroke rehabilitation units. *Functional Neurology,* 18(4), 191–194.

2. Hackett, M. L., & Anderson, C. S. (2005). Predictors of depression after stroke: a systematic review of observational studies. *Stroke*, 36(10), 2296–2301.

3. Mun, B.M., Kim, T.H., Lee, J.H., Lim, J.Y., Seo, D.K., & Lee, D.J. (2014). Comparison of gait aspects according to FES stimulation position applied to stroke patients. *Journal of Physical Therapy Science,* 26(4), 563–566.

4. Lehmann, J.F., Condon, S.M., Price, R., & deLateur, B.J. (1987). Gait abnormalities in hemiplegia: their correction by ankle-foot orthoses. *Arch Phys Med Rehabil,* 68(11), 763-71.

5. Wang, R.Y., Lin, P.Y., Lee, C-C, & Yang, Y.R. (2007). Gait and balance performance improvements attributable to ankle–foot orthosis in subjects with hemiparesis*. Am J Phys Med Rehabil,* 86(7), 556–562.

6. Horak, F.B., Henry, S.M., & Shumway-Cook, A. (1997). Postural perturbations: new insights for treatment of balance disorders. *Phy ther,* 77(5), 517-533.

7. Nichols, D.S., Glenn, T.M., & Hutchinson, K.J. (1995). Changes in the mean center of balance during balance testing in young adults. *Phys Ther,* 75(8), 699-706.

8. Todorov, E. (2004). Optimality principles in sensorimotor control (review). *Nat Neurosci,* 7(9), 907–915.

9. Sahyoun, C., Floyer-Lea, A., Johansen-Berg, H., & Matthews, P.M. (2004). Towards an understanding of gait control: brain activation during the anticipation, preparation and execution of foot movements. *NeuroImage*, 21(2), 568 – 575.