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Postural Stability and Balance Training Program in Hemiparetic Stroke Patients

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Abstract

Aim: To compare limits of stability (LOS) between stroke patients and control group and to evaluate the effects of balance training program on hemiplegic stroke patients.

Setting: Balance clinic, physical medicine and rehabilitation hospital, Kuwait.

Materials and Methods: A total of 36 ambulatory hemiplegic stroke patients and 34 age-matched healthy individuals as control group were recruited in this study. All patients and healthy individuals were evaluated by the LOS test.

Results: There were a significant increased RT (sec), a significant decreased MVL (deg/sec), a significant decreased EPE (%), a significant decreased MXE (%) and a significant decreased directional control(DCL) (%) in stroke patients compared to control group ($p < 0.01$). Moreover, a significant decreased RT, a significant increased MVL (deg/sec), a significant increased EPE (%) and a significant increased MXE(%) after training compared to results before training in stroke patients ($p < 0.01$). However, no significant difference of DCL (%) after training compared to results before training in stroke patients ($p > 0.05$).

Conclusion: There were significantly worse in parameters of LOS test in stroke patients. Moreover, significant enhancement of some parameters of LOS test after training in stroke patients was found.

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Key words: Postural stability; limits of stability; reaction time; movement velocity and stroke.

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Introduction

Stroke has been identified as the most prevalent diagnosis among adults who fall [1]. One third to one half of all people over the age of 65 years fall at least once per year [2, 3]. Hemiparesis is the most frequent neurological deficit after stroke [4]. Hemiparetic stroke patients frequently present balance abnormalities. Balance impairments increase fall risk, resulting in high economic costs and social problems [4-5].

Balance problems in hemiparetic patients after stroke can be caused by different impairments in the physiological systems involved in postural control, including sensory afferents, movement strategies, biomechanical constraints, cognitive processing, and perception of verticality [6]. Balance is diminished in patients with hemiplegia and hemiparesis [7]. Postural sway for patients with hemiplegia can be twice that of their age-matched peers [8, 9]. Symmetry of weight bearing is also impaired following stroke, with patients bearing as much as 61 to 80% of their body weight through their non-paretic lower extremity [10]. Postural instability, or impaired balance, is common in patients with stroke, especially as the disease severity advances [11].

The Berg Balance Scale (BBS) was developed to measure balance among people with impairment in balance function by assessing the performance of functional tasks. It is a valid instrument used for evaluation of the effectiveness of interventions and for quantitative descriptions of function in clinical practice and research. The BBS has been evaluated in several reliability studies [12]. Also, dynamic posturography has become an important tool for understanding standing balance in clinical settings. The limits of stability (LOS) test quantifies the maximum distance a person can intentionally displace their Center of Gravity (COG). The measured parameters are reaction time, COG movement velocity, directional control, end point excursion, and maximum excursion [13].

Thus, the aims of this study is to compare parameters of LOS test between stroke patients and control group and to evaluate the effects of balance training program on stroke patients.

Materials and Methods

A total of 36 ambulatory hemiparetic stroke patients with mean ± SD of with age about 54 ± 7.5 years, disease duration about 21.76 ± 6.63 months, and BMI about 23.68 ± 3.53 kg/m^2. A total of 22 males/14 females, left hemiparesis about 26 cases (72.2%), right hemiparesis about 10 cases (27.8%) and 34 age-matched healthy individuals with mean ± SD of age about 51 ± 6.6 years, 21 males/13 females BMI about 24.56 ± 3.52 kg/m^2 as control group were recruited into this study. All patients and healthy individuals were clinically evaluated with a brief neurological examination. All patients underwent image studies such as brain computed tomography to identify their stroke diagnosis. Visual feedback balance training (twice weekly for three months) with the SMART Balance Master and conventional physical therapy (three times weekly) were used for training the stroke patients. All patients were evaluated by LOS test before and after the training program. Inclusion criteria were the following: ability to ambulate 25 ft independently; and mild to moderate stroke deficits defined by BBS of 0 to 56 [12].

Those with recurrent strokes, cerebellar lesions, severe spasticity, cognitive deficit, or peripheral neuropathy were excluded. The patients gave their informed voluntary consent to participate in the study according to the protocol approved by the local ethics committee and in accordance with the ethical standards of the Helsinki declaration.

Postural stability of stroke patients and healthy individuals were evaluated by using LOS test [13]. The five parameters of LOS test are reaction time (RT), COG movement velocity (MVL), end point excursion (EPE) and maximum excursion (MXE) and directional control (DCL). RT was defined as the time in seconds between the signal to move and the initiation of movement; MVL was defined as the average speed of COG movement between 5% and 95% of the distance to the primary endpoint; EPE was defined as the distance traveled by the COG on the primary attempt to reach the target; MXE was defined as the furthest distance traveled by the COG; and DCL was defined as a comparison of the amount of movement toward the target [13,14].

Statistical Analysis

Study data were analyzed using the SPSS statistical package (SPSS, version 16.0) for data processing. Quantitative data were presented as mean (± SD). The Student's t test indicates the magnitudes of the differences of means (± SD) between patients and control group. Prior to data analysis, the level of significance was established at $p<0.05$.

Results

These results were significantly worse in parameters of LOS test in stroke patients as compared to control group as shown in Table 1. There was a significant increased RT (sec) in stroke patients compared to control group (1.15 ± 0.58 vs. 0.88 ± 0.28) ($p<0.01$); a significant decreased MVL (deg/sec) in stroke patients compared to control group (56.25 ± 5.91 vs. 69.49 ± 9.53) ($p<0.001$); a significant decreased EPE (%) in stroke patients compared to control group (56.25 ± 5.91vs. 69.49 ± 9.53) ($p<0.001$); a significant decreased MXE (%) in stroke patients compared to control group (46.64 ± 4.49 vs. 66.14 ± 7.24) ($p<0.001$) and a significant decreased DCL (%) in stroke patients compared to control group (52.04 ± 3.31 vs. 61.21 ± 9.47) ($p<0.001$).

Table 1: Comparison of parameters of limits of stability test between stroke patients and control.

Parameters	Stroke patients	Control	p-value
Composite Reaction Time (RT) (sec)	1.24 ± 0.58	0.88 ± 0.28**	p < 0.01
Composite Movement Velocity (MVL), (deg/sec)	1.04 ± 0.62	2.06 ± 0.70**	p < 0.01
Composite Endpoint Excursion (EPE), (%)	56.25 ± 5.91	69.49 ± 9.53**	p < 0.01
Composite Maximum Excursion (MXE), (%)	46.64 ± 4.49	66.14 ± 7.24**	p < 0.01
Directional Control (DCL), (%)	52.04 ± 3.31	61.21 ± 9.47**	p < 0.01

** p< 0.01= significant.

Significant enhancement of parameters of LOS test after training as compared to before training were detected in stroke patients as shown in Table 2. There was a significant decreased RT after training (sec) compared to results before training (1.24 ± 0.58 vs. 1.15 ± 0.58) ($p< 0.01$), significant increased MVL (deg/sec) after training compared to results before training (1.86 ± 0.50 vs. 1.04 ± 0.62) ($p<0.01$), significant increased EPE (%) after training compared to results before training (58.77 ± 6.59 vs. 56.25 ± 5.91) (p<0.01), significant increased MXE (%) after training compared to results before training (83.92 ± 21.16 vs. 46.64 ± 4.49) (p<0.01). However, no significant difference of DCL (%) after training compared to results before training was observed (52.13 ± 3.39 vs. 52.04 ± 3.31) (p>0.05).

Table 2: Correlation of parameters of limits of stability test before and after training in stroke patients.

Parameters	Before training	After training	p-value
Composite Reaction Time (RT) (sec)	1.24 ± 0.58	1.15 ± 0.58**	p < 0.01
Composite Movement Velocity (MVL), (deg/sec)	1.04 ± 0.62	1.86 ± 0.50**	p < 0.01
Endpoint excursion) (EPE), (%)	56.25 ± 5.91	58.77 ± 6.59**	p < 0.01
Maximum point excursion (MXE), (%)	46.64 ± 4.49	83.92 ± 21.16**	p < 0.01
Directional Control (DCL), (%)	52.04 ± 3.31	52.13 ± 3.39	P >.05

** p< 0.01= significant.

Discussion

Decreased equilibrium in standing and walking is a common problem associated with hemiplegic stroke patients. Stroke patients with balance problems are prone to falls. In addition to spatial recognition, the appropriate pattern of muscle activity to preserve balance depends on sensory and motor processes [5].

The present study show that there were significantly worse in parameters of limited of postural stability including increased reaction time (RT), decreased movement velocity (MVL), decreased composite endpoint excursion (EPE), and decreased composite maximum excursion (MXE), decreased directional control (DCL) as compared to normal subjects in unilateral chronic stroke patients. Other authors reported similar findings. Brown et al [15] demonstrated increased reaction times among stroke persons during various postural tasks compared to healthy older adults. Ikai T *et al* [16] suggest that decreased postural stability is a common problem associated with stroke. De Haart M *et al* [17] suggest that balance recovery in post-acute stroke is characterized by a reduction in postural sway. Additionally, Ikai T et al [16] suggest that decreased postural stability is a common problem associated with hemiparesis secondary to stroke. Furthermore, significant differences in postural sway were found among different stances after stroke [16]. In addition, Niam S *et al* [18] found that the dynamic postural control was impaired in stroke patients. Additionally, Corriveau H *et al* [19] found that there were abnormalities of static posturography in stroke compared with healthy controls. Furthermore, Bonan IV *et al*. [20] reported that parameters of posture stability in stroke patients were significantly lower than those from normal subjects. Marigold DS *et al* [21] reported that postural sway was increased in the stroke group.

Similarly, Dault MC *et al* [22] showed frontal plane deficits in postural sway in acute stroke survivors. Marigold DS and Eng JJ [23] found that medial-lateral sway was compromised in chronic stroke. However, some study disagrees with our study, Chen IC *et al* [5] found that right hemispheric stroke patients had better balance function than left hemispheric patients.

Other authors reported that enhancement of balance by training in stroke patients [17]. Corriveau H *et al* [19] found that balance training improves balance in chronic phase after stroke. Hu and Woollacott [24] found the use of multi-sensory training could improve balance performance. Winstein *et al* [25] revealed that stability were better in those with feedback training. Walker and colleagues [26] found the relative effectiveness of visual feedback training with conventional physical therapy following acute stroke. However, Sackley CM and Lincoln NB [27] reported that the enhanced effects of training on dynamic functional balance ability were still inconclusive.

Explanation of the posture sway after stroke may be related to multifactorial mechanisms. Chen IC *et al* [5] found that right hemispheric stroke patients had better balance function than left hemispheric patients. This result suggests that the motor function of the healthy limbs of stroke patients may play an important role in their balance function. De Haart M *et al* [17] reported that impaired dynamic equilibrium reflects a disruption of sensory, visual and vestibular input or motor weakness. In addition, Niam S *et al* [18] explained that postural sway after stroke was related to visual condition, stance position, and proprioception. Additionally, Bonan IV *et al* [20] reported that patients with hemiplegia seem to rely on visual input and sensory input deprivation.

To our knowledge, this study represents the first attempt to use of LOS as a tool in quantitatively assessment of postural stability in stroke patients. There were significantly worse in parameters of LOS test in stroke patients and improvement of some parameters of LOS test after training in stroke patients.

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References

1. Mayo NE, Korner-Bitensky N, Becker R, and Georges P. Predicting falls among patients in a rehabilitation hospital. Am J Phys Med Rehabil. 1989; 8:139-46.
2. Berg KO. Balance and its measure in the elderly: a review.

Physiotherapy Canada. 1989; 41:240-46.

3. Rubenstein LZ, Robbins AS, Schulman BL, et al. Falls and instability in the elderly. J Am Geriatr Soc. 1988; 36(3):266-78.

4. Lamb SE, Ferrucci L, Volapto S, Fried LP, Guralnik JM. Risk factors for falling in home-dwelling older women with stroke: The Women's Health and Aging Study. Stroke. 2003; 34(2):494–501.

5. Chen IC, Cheng PT, Hu AL, Liaw MY, Chen LR, Hong WH, Wong MK. Balance evaluation in hemiplegic stroke patients. Chan Gung Med J. 2000; 23(6):339–47.

6. de Oliveira CB, de Medeiros IR, Frota NA, Greters ME, Conforto AB. Balance control in hemiparetic stroke patients: main tools for evaluation. J Rehabil Res Dev. 2008; 45(8):1215-26.

7. Baker SP, Harvey AH. Fall injuries in the elderly. Clin Geriatr Med. 1985; 1:501-12.

8. Bohannon RW. Gait performance of hemiparetic stroke patients: selected variables. Arch Phys Med Rehabil. 1987; 68(11):777-81.

9. Liston RA, Brouwer BJ. Reliability and validity of measures obtained from stroke patients using the Balance Master. Arch Phys Med Rehabil. 1996; 77(5):425-30.

10. Nichols DS. Balance retraining after stroke using force platform biofeedback. Phys Ther. 1997; 77(5):553-58.

11. Sackley CM, Baguly BI. Visual feedback after stroke with balance performance monitor: two single case studies. Clin Rehabil. 1993; 7:189-95.

12. Bogle Thorbahn LD, Newton RA. Use of the Berg balance test to predict falls in elderly persons. Phys Ther. 1996; 76(6):576-83.

13. Clark S, Rose DJ. Evaluation of dynamic balance among community- dwelling older adult fallers: a generalizability study of the limits of stability test. Arch Phys Med Rehabil. 2001; 82:468-74.

14. Wallmann HW. Comparison of elderly nonfallers and fallers on performance measures of functional reach, sensory organization, and limits of stability. J Gerontol A Biol Sci Med Sci. 2001; 56(9): M580-3.

15. Brown LA, Sleik RJ, Winder TR. Attentional demands for static postural control after stroke. Arch Phys Med Rehabil. 2002; 83(12): 1732–5.

16. Ikai T, Kamikubo T, Takehara I, Nishi M, Miyano S. Dynamic postural control in patients with hemiparesis. Am J Phys Med Rehab. 2003; 82:463-69.

17. de Haart M, Geurts AC, Huidekoper SC, Fasotti L, van Limbeek J. Recovery of standing balance in postacute stroke patients: a rehabilitation cohort study. Arch Phys Med Rehabil. 2004; 85(9):886-95.

18. Niam S, Cheung W, Sullivan PE, Kent S, Gu X. Balance and physical impairments after stroke. Arch Phys Med Rehabil. 1999; 80(10):1227–33.

19. Corriveau H, Hebert R, Raiche M, Prince F. Evaluation of postural stability in the elderly with stroke. Arch Phys Med Rehabil. 2004; 85(7):1095-101.

20. Bonan IV, Colle FM, Guichard JP, Vicaut E, Eisenfisz M, Tran Ba Huy P, Yelnik AP. Reliance on visual information after stroke. Part I: Balance on dynamic posturography. Arch Phys Med Rehabil. 2004; 85(2):268-73.

21. Marigold DS, Eng JJ, Tokuno CD, Donnelly CA. Contribution of muscle strength and integration of afferent input to postural instability in persons with stroke. Neurorehabil Neural Repair. 2004; 18(4):222-9.

22. Dault MC, de Haart M, Geurts ACH, Arts IMP, Nienhuis B. Effects of visual center of pressure feedback on postural control in young and elderly healthy adults and in stroke patients. Hum Mov Sci. 2003; 22(3):221–36.

23. Marigold DS, Eng JJ. The relationship of asymmetric weight-bearing with postural sway and visual reliance in stroke. Gait Posture. 2006 ;23(2):249-55.

24. Hu MH, Woollacott MH. Multisensory training of standing balance in older adults: I. Postural stability and one-leg stance balance. J Gerontol. 1994; 49(2) :M52–61.

25. Winstein CJ, Gardner ER, McNeal DR, Barto PS, Nicholson DE. Standing balance training: effect on balance and locomotion in hemiparetic adults. Arch Phys Med Rehabil. 1989; 70 (10):755-62.

26. Walker C, Brouwer BJ, Culham EG. Use of visual feedback in retraining balance following acute stroke. Phys Ther. 2000; 80(9):886-95.

27. Sackley CM, Lincoln NB. Single blind randomized controlled trial of visual feedback after stroke: effects on stance symmetry and function. Disabil Rehabil. 1997; 19 (12): 536-46.