Disability and Rehabilitation, 2011; 33(15–16): 1433–1439

informa
healthcare

RESEARCH PAPER

Evaluation of the effect of ankle-foot orthosis use on balance and mobility in hemiparetic stroke patients

ASUMAN DOĞAN, MÜNIRE MENGÜLLÜOĞLU & NESE ÖZGIRGIN

Ankara Physical Medicine Rehabilitation Education and Research Hospital, Ankara, Turkey

Accepted October 2010

Abstract
We evaluated the effect of ankle-foot orthosis (AFO; articulated, plantar flexion stopped) use on balance and mobility in hemiparetic stroke patients in this study. Fifty-one hemiplegic patients who had completed the rehabilitation programme were included in the study. Subjects were assessed during the Ashburn walking and stair test, the time Up & Go test, the Berg Balance Scale (BBS) and the mobility subscale of the stroke rehabilitation assessment of movement (STREAM) in the presence and absence of AFO. The patients were asked about their evaluations of AFO in terms of its desirability/undesirability. All the subjects showed improvements in gait speed, balance and mobility with AFO use. However, there was no statistically significant difference between the durations of stair climbing with or without AFO; 45.1% of the subjects indicated that their gait speed increased; 35.3% indicated that they step on more confidently and 60.8% indicated that they consider AFO unaesthetic. It was determined that the use of an AFO resulted in improvements in both balance and ambulation activities of hemiparetic patients.

Keywords: *Ankle-foot orthosis, balance, mobility, hemiplegia*

Introduction

Ankle-foot orthoses (AFO) are commonly used for patients with hemiparesis and weak ankle dorsiflexion and may stabilise the ankle in the frontal and transverse planes during balance and gait activities. A large number of studies have shown that they can have beneficial effects on patients with hemiplegia [1] though with some limitations [2]. In particular, AFO may increase walking speed [3,4] and have positive effects on hemiplegic gait parameters [4,5] and result in reduction of energy cost [6]. While the effectiveness of AFO have been reviewed, distinct AFO models were also compared with respect to each other in the related studies [4,5,7–9]. Although there are a number of studies demonstrating the effect of AFO on walking parameters, studies related to AFO's effect on balance and mobility are few [10–12]. Balance is deteriorated in people with hemiplegia and hemiparesis. Postural sway and symmetry of weight bearing are impaired following a stroke. In addition, hemiplegia can cause a reduction in a patient's 'limits of stability', which is defined as the maximal distance that an individual can shift his or her weight in any direction without loss of balance [13,14]. The reduction of mobility in hemiplegic patients is associated with walking disorders (postural sway, weight bearing, etc.) and deterioration of the balance mechanism. Mobility is essential for developing an independent lifestyle after stroke and is perhaps the determinate ability that the patients consider as the most important [15]. Therefore, improving mobility is one of the major goals of stroke rehabilitation [16]. The gait speed test (e.g. 10-m walking speed test, 6-min walking distance) is commonly used to measure mobility after a stroke in both the clinical and the research setting. However, the gait speed test is not appropriate for all patients with stroke. Mobility, by nature, is complex and multi-factorial, whereas the gait speed test simply reflects one unique and specific dimension of mobility [17]. We have, therefore, investigated whether AFO has an effect on stair climbing, balance and mobility while improving the walking parameters.

Correspondence: Dr. Asuman Doğan, Ankara Physical Medicine Rehabilitation Education and Research Hospital, Ankara, Turkey. E-mail: asudogn@yahoo.ca

ISSN 0963-8288 print/ISSN 1464-5165 online © 2011 Informa UK, Ltd.
DOI: 10.3109/09638288.2010.533243

Methods

Fifty-nine patients that had developed hemiplegia as a result of intracranial cerebral hemorrhage and ischemia were included in the study. The patients underwent conventional and neurophysiologic treatments. Conventional methods include the preservation of joint mobility, exercises for muscle strengthening and mobility activities. Neurophysiologic methods aim the restoration of lost motor abilities. Nero-muscular re-education techniques and therapeutic exercises are used to stimulate neural and physiological structures. The most commonly used techniques used in our hospital are Brunnstrom, Bobath, Rood and Proprioceptive neuro-muscular facilitation. In our clinic, these rehabilitation modalities were used in combination in line with the patients' recovery periods. The patients unable to ambulate and who have co-morbidity which can affect ambulation speed after the rehabilitation programme were not included in our study. In addition to this, uncooperative patients, those that had no additional orthopaedic or neurological deficits impairing ambulation, those with defects in vision or proprioception, patients with contractures in the lower extremities and those with sensory disorders or morbid obesity were also not included. The patients had ambulation and stair descending/ascending therapies during their rehabilitation. They were prescribed AFO (articulated AFO with 90° plantar flexion stopped) after the rehabilitation period. Then, they had rehabilitation with AFO. Patients were tested first with their sports shoes or orthopaedic shoes used during their rehabilitation and then with AFO specially designed for each patient before their discharge from the hospital. The patients were exposed to the tests under the supervision of the same physician with 5 min intervals between the tests. Only 53 patients who completed the rehabilitation programme and gained ambulation were evaluated. Two subjects that were outliers for each parameter in the statistical analyses were excluded from the study. One of them was an outlier for age and the other for walking speed. Statistical analyses were carried out on 51 mild-to-moderate patients.

The age, gender, disease duration, aetiology, hemiplegic side and Barthel Index (BI) of the patients were recorded. The BI is a weighted scale that uses 10 variables describing basic activities of daily living [18]. Ashworth scale was used in hemiplegic tonus evaluation [19]. The patients had tests always under the supervision of the same physician. Fifteen meters walking duration and then 7 stairs ascending duration first with AFO then without AFO is tested by means of Ashburn battery test because it is accepted as a predictive parameter showing walking, mobility and balance activities. The initial tests were not recorded but the second tests were. Third tests were not conducted since it would be tiring for the patients. As the second test, the time Up & Go test was applied to evaluate the mobility. Berg Balance Scale (BBS) used to measure balance was taken as the third test. Finally, the patients were evaluated with the mobility subscale of the Stroke Rehabilitation Assessment of Movement Measure (STREAM).

Lastly, the patients were asked to evaluate AFO and their consideration of AFO as a desirable/undesirable device. They were asked to choose among the personally appropriate reason from a list. They were told to select one choice and a second one if necessary.

Measures

Ashburn walking and stairs test. The assessment battery developed by Ashburn (1982) was used. This measured the patients' range of movement on the affected side in such a way as to provide a numerical value. The battery included measurement of the time taken to walk 15 m and to climb 7 stairs as part of a functional score. This test has been used to assess the efficacy of various treatments of patients with stroke [20,21].

The time Up & Go. It is a frequently used parameter in the measurement of balance and mobility [22]. The time Up & Go test provides valid measurements of mobility and it has acceptable concurrent validity with the measurements of balance, gait speed and functional abilities [23,24]. It has been shown that the intra-rater and inter-rater reliability of the time Up & Go test was high and that it was well correlated with the BI and the BBS [13,23,24].

Berg Balance Scale. In addition to giving information about the mobility, it more specifically evaluates balance. The BBS consists of a hierarchical series of daily life activities that tests one's ability to maintain balance in various positions, in transfers between positions, and during voluntary movements like turning around and stepping. The rating of performance in each item is according to a 5-point ordinal scale, with the lowest score as 0. The BBS full score is 56. BBS has been shown to yield data that have validity and intra-rater and inter-rater reliability. This scale is widely used as an outcome measure for balance performance [13,24–27]. BBS score correlates well with measurements obtained with other clinical balances and with measurements of gait speed in patients with hemiplegia: BI, the Postural Assessment Scale for Stroke Patients, Functional

Reach Test, the balance subscale of Fugl-Meyer Assessment, the Functional Independence Measure (RMI), the Rivermead Mobility Index (RMI) and gait speed [27]. However, the BBS also has limitations because it may have a ceiling effect for patients with higher neurological impairments, lacks a gait assessment component, and measures primarily anticipatory but not reactive, postural responses necessary for balance [13]. The score 45 is taken as a cut-off score in a total score of 56. A higher score indicates a greater balance ability and functional independence [24–26].

The Stroke Rehabilitation Assessment of Movement Measure. It is used to measure motor and mobility problems in patients who have experienced a stroke and is sufficient for the evaluation of hemiplegic patients, including those who have weak mobility [28,29]. We also utilised STREAM's mobility subscale in the evaluation of our patients' mobility as STREAM shows correlation with balance measurement scales and with daily activity indexes and is an easily implemented method. This consists of 30 items that are equally distributed among three subscales: upper-limb movements, lower-limb movements and basic mobility items. Basic mobility items are scored on a 4-point scale similar to the one used for scoring limb movements except that a category has been added to allow for independence with the help of a mobility aid. It contains 10 items: rolling, bridging, going from supine to sitting, changing from sitting to standing, standing for 20 counts, placing the affected foot onto first step, 3 steps backward, 3 steps to the affected side, walking 10 m and walking down 3 stairs. STREAM inter-rater, intra-rater reliability and validity studies were conducted. The literature shows that it has correlation with other mobility and daily life activity scales [17,28,29].

SPSS 10.0 program is used for the statistical analysis of our study. Paired *t*-test is applied to determine the difference between the scores of patients while using AFO and not using AFO. Wilcoxon test is used to evaluate if the score differences of patients while using AFO and not are meaningful in BBS and Stream sub-scales.

Results

Fifty-one hemiparetic stroke patients (24/27 female/male) that had completed the rehabilitation programme were included in the study. The mean time of rehabilitation program of the group was 35 (21–85) days. The mean hemiplegia time of the patients was 69 days. The hemiplegia time of three patients was more than 6 months, but there were no patients with more than 7 months (maximum 218 days).

The mean AFO education time was 4 days (minimum 1 and maximum 9 days). Twelve patients had a mild degree of spasticity (modified Ashworth grade 1) and eight patients had a moderate degree of spasticity (modified Ashworth grade 2–3). The tonus in the lower extremities was normal in the rest of the patients. The demographic and clinical characteristics of the patients are given in Table I.

The periods of completion of the Ashburn walking, stair climbing and the time Up & Go tests of the patients with and without the AFO and the statistical differences between them are shown in Table II. While the Ashburn walking periods and the period for completing the Up–go test showed a statistically significant difference with and without the AFO, there was no statistically significant difference between the Ashburn stair climbing periods.

The BBS total scores of the patients with and without the AFO are shown in Table III. There was a statistically significant difference between the two groups ($p = 0.000$). The patient scores, in the presence or absence of the AFO, obtained for every item of the BBS are shown in Table IV. Except for the first five items, all the BBS scores that measure the balance-coordination performance showed a statistically significant difference.

The mobility sub-scales of the STREAM points of the patients obtained with and without the AFO are shown in Table V. The total points for the patients obtained with the AFO were found to be higher in terms of statistical significance. Except, the first four items showed a statistically significant difference between the AFO-assisted and AFO-absent states (Table VI).

The patient evaluation of AFO in terms of its desirability/undesirability is given in Table VII. 45.1% of the subjects indicated that their gait speed increased, 35.3% indicated that they step on more confidently and 60.8% indicated that they consider AFO unaesthetic.

Table I. Demographic and clinical characteristics of the subjects.

	Frequencies specified except	
Characteristics	Mean ± SD	Min–max
Age	60.7 ± 12.5	(43–75)
Days after onset	69.2 ± 30.2	(21–218)
Rehabilitation time	35 ± 13	(21–85)
Barthel Index	66.1 ± 9.3	(46–84)
Gender	*n*	%
Female	27	52.9
Male	24	47.1
Diagnosis	*n*	%
Infarction	33	64.7
Hemorrhage	18	35.2
Hemiplegic side	*n*	%
Right	29	56.8
Left	22	43.1

Table II. Ashburn walking, climbing stairs time and time Up & Go with and without AFO in hemiplegic patients.

	Without AFO (s)	AFO (s)	t	p
Ashburn walking time (15 m)	51.12 ± 29.34	46.27 ± 25.36	2.880	0.007*
Ashburn climbing stairs time (7 stairs)	17.68 ± 7.45	17.41 ± 7.09	0.242	0.810
Time Up & Go test	35.490 ± 14.59	31.28 ± 15.13	3.026	0.005*

*Significant difference ($p < 0.05$).

Table III. BBS total scores of the hemiplegic patients with and without AFO.

	Without AFO	AFO	t	p
BBS total	41.28 ± 8.61	46.26 ± 5.27	7.01	0.000

Table IV. BBS subscores of the hemiplegic patients with and without AFO.

Item description	z	p
BBS 1 – Sitting to standing	−2.11	0.065
BBS 2 – Standing unsupported	−1.63	0.08
BBS 3 – Sitting unsupported	0.65	0.51
BBS 4 – Standing to sitting	−1.92	0.12
BBS 5 – Transfers	0.991	0.09
BBS 6 – Standing with eyes closed	−2.264	0.024*
BBS 7 – Standing with feet together	−2.97	0.003*
BBS 8 – Reaching forward with an outstretched arm	−2.81	0.005*
BBS 9 – Retrieving object from floor	−3.21	0.001*
BBS 10 – Turning to look behind	−3.69	0.000*
BBS 11 – Turning 360°	−3.69	0.000*
BBS 12 – Placing alternate foot on stool	−3.35	0.001*
BBS 13 – Standing with one foot in front of the other foot	−3.74	0.000*
BBS14 – Standing on one foot	−4.60	0.000*

*Significant difference ($p < 0.05$).

Table V. STREAM score of the hemiplegic patients with and without AFO.

	Without AFO	AFO	t	p
STREAM score	15.93 ± 2.68	18.12 ± 1.95	−5.24	*0.000

Table VI. STREAM subscale scores score of the hemiplegic patients with and without AFO.

STREAM basic mobility subscale	z	p
Rolling	0.982	0.09
Bridging	−1.84	0.07
Supine to sitting	−2.49	0.061
Sitting to standing	−1.92	0.12
Standing for 20 counts	−0.632	0.527
Placing affected foot onto first step	−3.162	0.002*
3 steps backward	−3.116	0.002*
3 steps to affected side	−2.063	0.040*
Walks 10 m	−2.121	0.034*
Down 3 stairs	−2.646	0.008*

*Significant difference ($p < 0.05$).

Table VII. Patients' evaluation of AFO.

	Number	%
Why I prefer AFO		
Step on more confidently	18	35.3
I don't stumble	16	31.4
Better balance	15	29.4
Improvement in gait speed	23	45.1
Improvement in stepping forward	3	5.9
Why I don't prefer AFO		
Difficulty in walking as a result of device weight	8	15.7
Unaesthetic	31	60.8
Difficulty in getting accustomed to using	4	7.8

Discussion

Walking is the main function indicative of both mobility and balance in hemiparetic patients. Although gait speed constitutes a parameter of good predictive value in reflecting recovery in hemiparetic patients, it remains inadequate by itself in the measurement of mobility and balance [1,30,31].

Several studies have demonstrated that AFO has positive effects on gait parameters [1–9], but studies on its effects on balance and mobility are limited in number [10,11]. In our study, we aimed at testing the effect of AFO on balance and mobility by means of measurements other than gait speed. Despite the use of numerous sophisticated quantitative measurement methods (motion analysis system, Balance Master system, Cybex dynamometry, kinesiological electromiogram recordings of the leg muscles) [4,10,30,32]) that have demonstrated the efficacy of AFO use in hemiparetic patients, other functional measurement methods that are not as expensive or require technical specialisation or equipment are also frequently used [12,13,17,29]. We investigated the effect of AFO use on mobility and balance using functional measurement methods that are easy to administer and require no equipment in this study.

Although there is general consensus on AFO's positive effect on walking parameters, no such consensus exists on which AFO model is more efficient [3–5,8,9,12]. Similarly, our study also demonstrated that the patients covered the 15 m in a shorter period of time when using an AFO in the Ashburn test. However, according to Fatone et al., AFO which has the same features of the ones we used (articulated, plantar flexion stopped), has positive effects on gait parameters but does not increase gait speed. In addition to this, the study by Fatone et al. evaluated the walking parameters in the absence or presence of three different types of AFO and found that all AFO's decreased plantar flexion at initial contact and mid-swing and changed the peak knee moment in early stance from flexor to extensor compared with the no AFO condition [8]. Another study comparing the efficacy of AFO to both barefoot and with shoes states found that while shoes increased the stepping length by 5 cm, the AFO increased this by an additional 5 cm [33]. Like Gök and Fatone, according to our clinical experiences we believe that articulated plantar flexion stopped, and AFO's provided better stabilisation of the ankle, allowing improved heel strike and push-off. In our study, we preferred articulated plantar flexion stopped AFO with shoes which we prescribe most in our clinic. There are studies which provide AFO efficiency by means of hemiplegia periods. While Wang found that AFO increased gait speed in patients of hemiplegia in less than 6 months but had minimal effects in patients with hemiplegia in more than 12 months, De Wit et al. showed that AFO has positive effects on gait speed in patients of chronic hemiplegia [10,34]. We recorded significant improvements in gait speed with AFO in our patients in an acceptable short time (approximately 69 days). The studies of De Wit and Teasell et al. demonstrated that hemiplegic patients were more successful in the stairs test with an AFO [12,34]. Nevertheless, in our study, there was no detectable difference between AFO-assisted and AFO-absent states. The fact that we recorded stair ascending duration rather than the function of stair ascending resulted in difference between our study and the related literature. Other reason may have been caused by patients' use of healthy leg first while ascending.

Balance is diminished in people with hemiplegia and hemiparesis. Postural sway and symmetry of weight bearing are impaired following stroke. In addition, hemiplegia can cause a reduction in patients' limits of stability, which is defined as the maximal distance that an individual can shift his or her weight in any direction without loss of balance [13,14]. Deterioration of the postural sway and symmetry of weight bearing during walking disrupts balance [13,14]. AFO has positive effects on balance and mobility by regulating the postural sway and symmetry of weight bearing. We tested AFO's effect by means of Time Up & Go. Adults who do not have neurological disorders (those with good mobility skills and balance) are able to complete the time Up & Go test in a period of less than 10 s. Adults who need more than 30 s to complete the time Up & Go test were found to be dependent on their mobility skills in many activities of their daily lives [13,24]. The average Up & Go periods of hemiplegic patients in our study was determined to be 35.49 ± 14.59 s without an AFO and 31.28 ± 15.13 s with an AFO. In our study, we did not find any significant differences between AFO-assisted and AFO-absent states even though the tests lasted more than 30 s in each case. De Wit et al. found a significant difference in the timed up & go test with AFO in his study with chronic stroke patients [34].

We then evaluated the balance of the patients with or without the AFO once again, using the BBS. The BBS total scores showed a statistically significant difference between the two states ($p = 0.000$). When the patients were re-evaluated for each item, improved performances in all other activities except for the first five items were statistically demonstrated for the AFO-assisted state ($p < 0.05$). This was an expected outcome since the first five items were not only concerned with lower extremity function. While Teasell et al. found meaningful increase in BBS scores of patients using AFO, Wang et al. found meaningful score increase only with patients of short time (<6 months) but found minimal increase with patients of long time (>12 months) [10,12]. However, we demonstrated a significant improvement in activities like standing with eyes closed, standing with feet together, reaching forward with an outstretched arm, retrieving object from floor, turning to look behind, turning 360°, placing alternate foot on stool, standing with one foot in front of the other foot and standing on one foot with an AFO.

We evaluated the effect of AFO on mobility by means of STREAM because it shows high correlation with other tests and has validity and reliability. We could not find studies evaluating the effect of AFO on mobility by means of STREAM in the literature. In our study, we found that the total STREAM mobility sub-score grades of the patients showed a statistically significant difference between AFO-assisted and absent states. Furthermore, a one-to-one comparison for every item demonstrated higher scores in the AFO-assisted state ($p = 0.000$) for placing the affected foot on the first step, 3 steps backward, 3 steps to the affected side, walk 10 m and down 3 stairs activities.

In Tyson's study, the subjects' response was positive; 24 (96%) of them felt they walked better with the AFO and found it comfortable. Twenty-three

(92%) were unbothered by the appearance and 16 (64%) could doff and don it [35]. In De Wit's study, 65% of the patients experienced less difficulty and 70% of the patients felt more self-confident while wearing the AFO [34]. Most of the patients in our study stated that they would prefer AFO, while 60.8% of them found AFO unaesthetic and 15.7% found it heavy.

The Limitations of the study

The fact that the subjects of our study were evaluated only by one physician and that the evaluations were not repeated apart from the walking test may be considered as a limitation of this study. Since the reliability and validity of evaluation methods (time Up & Go, BBS, STERAM) were frequently proved by studies mentioned in this article, we did not apply reliability and validity tests.

Since the patients repeated daily the activities of walking, stair ascending–descending and other daily activities such as standing, turning around, standing up on one foot, we did not find it necessary to repeat them over and over in our study. However, we accept that it is a limitation of our study.

In conclusion, AFO showed a positive effect on balance activities and mobility in addition to walking speed but had no effect on the stair climbing activity in our study.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

1. Edelstein JE. Orthotic assessment and management. In: O'Sullivan SB, Schmitz TJ editors. Physical rehabilitation: assessment and treatment. Philadelphia: FA Davis Co. 2001. pp 1025–1060.
2. Lehmann JF, Condon SM, Price R, deLateur BJ. Gait abnormalities in hemiplegia: correction by ankle-foot orthoses. Arch Phys Med Rehabil 1987;68:763–771.
3. Butler PB, Farmer SE, Major RE. Improvement in gait parameters following late intervention in traumatic brain injury: a long-term follow-up report of a single case. Clin Rehabil 1997;11:220–226.
4. Gök H, Küçükdeveci A, Altinkaynak H, Yavuzer G, Ergin S. Effects of ankle-foot orthoses on hemiparetic gait. Clin Rehabil 2003;17:137–139.
5. Pohl M, Mehrholz J. Immediate effects of an individually designed functional ankle-foot orthosis on stance and gait in hemiparetic patients. Clin Rehabil 2006;20:324–330.
6. Franceschini M, Massucci M, Ferrari L, Agosti M, Paroli C. Effects of an ankle-foot orthosis on spatiotemporal parameters and energy cost of hemiparetic gait. Clin Rehabil 2003;17: 368–372.
7. Chen CL, Yeung KT, Wang CH, Chu HT, Yeh CY. Anterior ankle-foot orthosis effects on postural stability in hemiplegic patients. Arch Phys Med Rehabil 1999;80: 1587–1592.
8. Fatone S, Gard SA, Malas BS. Effect of ankle-foot orthosis alignment and foot-plate length on the gait of adults with poststroke hemiplegia. Arch Phys Med Rehabil 2009;90: 810–818.
9. Lehmann JF. Biomechanics of ankle foot orthoses, prescription and design. Arch Phys Med Rehabil 1979;60:200–207.
10. Wang RY, Yen L, Lee CC, Lin PY, Wang MF, Yang YR. Effects of an ankle-foot orthosis on balance performance in patients with hemiparesis of different durations. Clin Rehabil 2005;19:37–44.
11. Wang RY, Lin PY, Lee CC, Yang YR. Gait and balance performance improvements attributable to ankle-foot orthosis in subjects with hemiparesis. Am J Phys Med Rehabil 2007;86:556–562.
12. Teasell WR, McRae PM, Sc M. Physical and functional correlations of ankle foot orthosis use in the rehabilitation of stroke patients. Arch Phys Med Rehabil 2001;82:1047–1049.
13. Geiger AR, Allen BJ, O'Keefe J, Hicks RR. Balance and mobility following stroke: effects of physical therapy intervention with and without biofeedback/forceplate training. Phys Ther 2001;81:995–1005.
14. Liston RA, Brouwer BJ. Reliability and validity of measures obtained from stroke patients using the Balance Master. Arch Phys Med Rehabil 1996;77:425–430.
15. Chiou I, Burnett CN. Values of activities of daily living: a survey of stroke patients and their home therapists. Phys Ther 1985;65:901–906.
16. Lennon S, Johnson L. The modified Rivermead Mobility Index: validity and reliability. Disabil Rehabil 2000;22:833–839.
17. Hsueh I-P, Wang C-H, Sheu C-F, Hsieh C-L. Comparison of psychometric properties of three mobility measures for patients with stroke. Stroke 2003;34:1741–1745.
18. Mahoney F, Barthel D. Functional evaluation: The Barthel Index. Md State Med J 1965;14:61–65.
19. Bohannon RW, Smith MB. Interrater reliability on a modified Ashworth scale of muscle spasticity. Phys Ther 1987;67: 206–207.
20. Ashburn A. A physical assessment for stroke patients. Physiotherapy 1982;68:109–113.
21. Janina J. Failure of electrical myofeedback to augment the effect of physiotherapy in stroke. Int J Rehabil Res 1986;9:35–45.
22. States RA, Pappas E, Salem Y. Overground physical therapy gait training for chronic stroke patients with mobility deficits. Cochrane Database Syst Rev 2009;3:CD006075.
23. Podsiadlo D, Richardson S. The time 'Up and Go': a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991;39:142–148.
24. Berg K, Maki BE, Williams JI, Holliday PJ, Wood-Dauphinee SL. Clinical and laboratory measures of postural balance in an elderly population. Arch Phys Med Rehabil 1992;73:1073–1080.
25. Berg KO, Wood-Dauphinee S, Williams JI, Maki B. Measuring balance in the elderly: validation of an instrument. Can J Public Health 1992;83:7–11.
26. Berg K, Wood-Dauphinee S, Williams JI. The balance scale: reliability assessment with elderly residents and patients with acute stroke. Scand J Rehabil Med 1995;27:27–36.
27. Blum L, Korner-Bitensky N. Usefulness of the Berg Balance Scale in stroke rehabilitation: a systematic review. Phys Ther 2008;88:559–566.
28. Daley K, Mayo N, Danys I, Cabot R, Wood-Dauphinee S. The Stroke Rehabilitation Assessment of Movement (STREAM): refining and validating the content. Physio Can 1997;49:269–278.

29. Wang CH, Hsieh CL, Dai MH, Chen CH, Lai YF. Inter-rater reliability and validity of stroke Assessment of Movement (STREAM) instrument. J Rehabil Med 2002;34: 20–24.
30. Hesse S, Wermer C, Matthias K, Stephen K, Bertenau M. Non-velocity-related effects of a rigid double-stopped ankle foot orthosis on gait and lower limb muscle activity of hemiparetic subject with an equinovarus deformity. Stroke 1999;30:1855–1861.
31. Suzuki K, Imada G, Iwaya T, Handa T, Hirohiko KMS. Determinants and predictors of maximum walking speed during computer-assisted gait training in hemiparetic stroke patients. Arch Phys Med Rehabil 1999;80: 179–182.
32. Hsu A-L, Tang P-F, Jan M-H. Analysis of impairments influencing gait velocity and asymmetry of hemiplegic patients after mild to moderate stroke. Arch Phys Med Rehabil 2003;84:1185–1193.
33. Churchill Andrew JG, Halligan PW, Wade DT. Relative contribution of footwear to the efficacy of ankle-foot orthoses. Clin Rehabil 2003;17:553–557.
34. De Wit DC, Buurke JH, Nijlant JM, Ijzerman MJ, Hermens HJ. The effect of an ankle-foot orthosis on walking ability in chronic stroke patients: a randomized controlled trial. Clin Rehabil 2004;18:550–557.
35. Tyson SF, Thornton HA. The effect of a hinged ankle foot orthosis on hemiplegic gait: objective measures and users' opinions. Clin Rehabil 2001;15:53–58.