Hong Kong Physiotherapy Journal (2017) 37, 19–24

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.hkpj-online.com

Hong Kong Physiotherapy Journal

RESEARCH PAPER

Relationship between dynamic balance and spatiotemporal gait symmetry in hemiplegic patients with chronic stroke

Chang-Man An, MSc, PT [a,b,*], Young-Lan Son, MSc, PT [a], Young-Hyun Park, MSc, PT [a,b], Sung-Jun Moon, MSc, PT [a,c]

[a] *Department of Physical Therapy, Chonbuk National University Hospital, Chonbuk, Republic of Korea*
[b] *Department of Physical Therapy, Graduate School, Hanseo University, Republic of Korea*
[c] *Department of Rehabilitation Science, Graduate School, Daegu University, Republic of Korea*

KEYWORDS
dynamic balance;
heel-to-heel base of support;
spatiotemporal gait symmetry;
stroke

Abstract *Background:* Poor dynamic balance, which is common after stroke, may affect gait function. In particular, spatiotemporal asymmetrical gait patterns may occur in hemiplegic patients after stroke.
Objective: This study aimed to assess the relationship between dynamic balance and spatiotemporal gait symmetry in patients with chronic hemiplegic stroke.
Methods: To calculate symmetry ratios for step length (spatial parameter) and swing time (temporal parameter), 41 patients with chronic stroke walked at a comfortable speed. The dynamic balance measures included limit of stability (LOS) during standing and heel-to-heel base of support (H-H BOS) during gait. Analysis of correlations between various measures was performed.
Results: The overall LOS score correlated with temporal gait symmetry ($r = 0.66$). The forward, backward, paretic, and non-paretic direction LOS scores were related to temporal gait symmetry ($r = 0.38$–0.62). The H-H BOS was correlated with temporal ($r = -0.63$) and spatial ($r = -0.36$) gait symmetries. Other dynamic balance variables were not significantly correlated with spatial gait symmetry.
Conclusion: Thus, control of dynamic balance abilities is related to the magnitude of temporal gait symmetry. This observation suggests that rehabilitation strategies that improve dynamic balance may enhance temporal gait symmetry in post-stroke patients.

* Corresponding author. Department of Physical Therapy, Chonbuk National University Hospital, Geonji-ro 21, Deokjin-gu, Jeonju-si, Chonbuk-do, 54907, Republic of Korea.
E-mail address: dks3597@hanmail.net (C.-M. An).

http://dx.doi.org/10.1016/j.hkpj.2017.01.002
1013-7025/

Introduction

The ultimate goal of gait therapy for stroke survivors is safe and efficient locomotion [1]. Improving gait function in stroke patients ensures independent daily living and social participation [2,3]. However, even after physiotherapy, many stroke survivors still experience muscle weakness, abnormal movement synergies, spasticity, and limited range of motion [4]. In addition, they may have increased asymmetry in body weight distribution between the non-paretic and paretic limb during quiet standing [5]. This tendency to maintain the centre of gravity (COG) shifted toward the non-paretic limb is also observed during gait [6]. As a result, spatiotemporal asymmetrical gait patterns may occur in hemiplegic patients after stroke [7,8]. Spatiotemporal gait asymmetry is associated with (1) impaired balance control; (2) gait inefficiencies and slower gait speed; and (3) musculoskeletal injury of the non-paretic lower limb [7—9].

Previous studies attempted to identify the determinants of gait asymmetry [4,7,9]. Spasticity, impaired proprioception, and muscles weakness were found to be correlated with spatiotemporal gait asymmetry [4,9,10]. Recent studies reported that, in addition to kinematic factors of the paretic lower limb, quiet standing balance function is associated with asymmetric gait patterns of stroke patients [11—13]. Hendrickson et al [12] reported that reduced weight bearing of the paretic limb during quiet standing increases spatiotemporal asymmetry gait patterns. Lewek et al [13] observed a significant relationship between standing balance function and spatiotemporal gait asymmetry. Reduced muscle strength on the paretic side of the lower limb resulted in a weight distribution towards the non-paretic side during quiet standing and increased medial-lateral (M-L) deviation of COG during gait in patients with stroke compared with that in an age-matched healthy group [11]. Although standing balance and gait are different levels of functional activities, they have a number of interdependencies and associations at many different levels of the central nervous system [14].

However, the scope of previous studies was limited to the association between static balance ability [11,12], i.e., the degree of weight distribution towards the unaffected limb, or clinical balance scale rather than data through computerised apparatus and asymmetric gait patterns during quiet standing or mobility [13], which, in contrast to dynamic balance data through computerised apparatus, does not involve body weight shifting in a specific direction (i.e., paretic side or non-paretic side) during standing or walking. The results did not fully explain the association between gait asymmetry and dynamic balance ability during standing or walking in hemiplegic stroke patients. Therefore, this study assessed the relationship between spatiotemporal gait symmetry during gait at a comfortable speed and measured the dynamic balance function during standing or walking in hemiplegic patients with chronic stroke. We hypothesised that spatial and temporal gait asymmetries are associated with impairments in dynamic balance control during standing and gait in these patients.

Materials and methods

Patients

A power analysis was performed using the G-power software version 3.1.2 (Franz Faul, University of Kiel, Kiel, Germany) to achieve a significant level of 0.05, power of 0.80, and effect size of 0.9 at the two-tails. The results of the power analysis showed that this study would require 38 patients. Our study included 41 patients with stroke (25 males; age, 49.39 ± 10.30 years) who were recruited while undergoing physiotherapy at the University's neurological rehabilitation outpatient department. The inclusion criteria were: (1) hemiplegic stroke that occurred more than 6 months before testing; (2) ability to walk independently without an assistive device for more than 10 m on a level surface; and (3) ability to follow verbal instructions. Patients were excluded for: (1) orthopaedic conditions (e.g., fracture, trauma, inflammation) or additional neurologic conditions (e.g., Parkinson's disease) that would influence gait; (2) cerebellar lesions; and (3) bilateral stroke lesions. All patients read and signed an informed consent document approved by the institution's Research Ethics Board and composed in accordance with the Declaration of Helsinki.

Outcome measures and data analysis

Measured dynamic balance function during standing

Dynamic balance function during standing was measured using a Biodex balance system (Biodex Medical System, NY, USA). Dynamic balance ability was assessed using the limit of stability (LOS) test. This test evaluates the ability of patients to move and control their COG within their base of support without losing balance or stepping. The LOS test measures the time and accuracy of transferring the estimated COG while moving a cursor to intercept each of eight successive targets on a display screen [15]. The eight targets were randomly highlighted, and the patient reached the target by leaning and returning to the centre position before the next target was selected and displayed on the screen. The test was complete when all the eight targets were reached. Patients were instructed to move the COG cursor as quickly and accurately as possible towards the highlighted target as soon as a visual signal, in the form of a circle, moved from the centre starting target without losing balance and stepping. A high LOS score signifies superior dynamic balance ability. Three trials were recorded for each patient, and the average was used for subsequent analysis. Averaged direction control scores for forward, backward, paretic, and non-paretic directions were used for statistical analysis. The formulas for calculating direction LOS (DLOS) scores and the overall LOS (OLOS) score are as follows [15]:

$$\text{DLOS score } (\%) = \frac{\text{straight line distance to target}}{\text{actual distance traveled}} \times 100$$

$$\text{OLOS score } (\%) = \sum_{i=1}^{i=4} (\text{DLOS score}) \div 4 \, (\text{average of four targets})$$