The Influence of Rocker Bar Ankle Foot Orthosis on Gait in Patients with Chronic Hemiplegia

Farzad Farmani, PhD,*† Mohammad-Ali Mohseni-Bandpei, PhD,‡ Mahmood Bahramizadeh, PhD,† Gholamreza Aminian, PhD,† Ali Abdoli, MD,§ and Mohammad Sadeghi-Goghari, PhD‖

Background: This study aimed to evaluate the effect of rocker bar ankle foot orthosis (RAFO) on the spatiotemporal characteristics of gait in chronic hemiplegic patients compared with the effect of solid ankle foot orthosis (SAFO). *Methods:* Following ethical approval, 18 patients with chronic hemiplegia, at least 6 months post stroke, were investigated in barefoot condition, with SAFO and RAFO in random sequences. Their spatiotemporal characteristics were examined by 2 force platforms and a Vicon motion analysis system. *Results:* There were significant changes in spatiotemporal outcome measures between barefoot condition and using SAFO and RAFO ($P < .05$). Compared with SAFO, RAFO resulted in significantly more step length, faster gait velocity, and less preswing time ($P < .05$), although no significant differences were seen regarding step width and cadence ($P > .05$). Furthermore, RAFO led to significant increases in hip extension and knee flexion at toe-off, whereas SAFO did not change these parameters ($P < .05$). *Conclusion:* Findings of the present study showed that RAFO further improves gait abilities in chronic hemiplegic patients compared with SAFO, which could be due to the positive effect of added rocker bar on push-off function during the late stance phase of gait. **Key Words:** Rocker bar ankle foot orthosis—gait—patients—hemiplegia.

Introduction

Stroke is a main cause of disability worldwide.[1] Hemiplegia secondary to stroke may lead to functional difficulties in standing and walking.[2] Hemiplegic patients usually suffer from impaired and uncoordinated limb movements. Weak muscles, abnormal synergic movements, and spasticity contribute to poor balance, impaired gait, and enhanced energy consumption in stroke patients during gait.[3] Generally, a gait cycle starts when 1 foot contacts the ground and terminates when the same foot contacts the ground again, and includes 2 phases: the stance phase, which is approximately 60% of the gait cycle, and the swing phase, which includes about 40% of the gait cycle. Stance is a part of the gait cycle that the foot is in contact with the ground, and swing is the part that the foot is in the air.[4] Insufficient dorsiflexion at the ankle during swing, mediolateral ankle instability during swing and stance, and inappropriate push-off at late stance negatively change the gait pattern and lead to decreased speed,

From the *Department of Orthotics & Prosthetics, School of Rehabilitation Sciences, Hamadan University of Medical Sciences, Hamadan, Iran; †Department of Orthotics & Prosthetics, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran; ‡Department of Physiotherapy, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran; §Department of Neurosurgery, School of Medicine, Hamadan University of Medical Sciences, Hamadan, Iran; and ‖Department of Physiotherapy, School of Paramedical Sciences, Kerman University of Medical Sciences, Kerman, Iran.

Received September 19, 2015; revision received February 7, 2016; accepted February 13, 2016.

Address correspondence to Mohammad-Ali Mohseni-Bandpei, PT, PhD: Professor, Iranian Research Centre on Aging, Department of Physiotherapy, University of Social Welfare and Rehabilitation Sciences, Evin, Tehran, Iran, AND Visiting Professor, University Institute of Physical Therapy, Faculty of Allied Health Sciences, University of Lahore, Lahore 1985713834, Pakistan. E-mail: Mohseni_bandpei@yahoo.com.

1052-3057/$ - see front matter

http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2016.02.021

diminished cadence, shorter steps, and lack of sufficient toe clearance.[5]

Ankle foot orthosis (AFO) is mostly prescribed for hemiplegic patients to improve their balance and walking ability.[6,7] Generally, an AFO is utilized to provide mediolateral ankle stability during the stance phase, to facilitate foot clearance during swing phase, and to improve initial contact at early stance.[8]

Regarding walking, Perry and Burnfield[4] have described normal function of the foot and ankle as the combination of 3 sequential rockers: the first rocker (heel rocker), the second rocker (ankle rocker), and the third rocker (forefoot rocker). Hemiplegia damages the ankle–foot complex, and therefore, all of these 3 rockers are disrupted.[3] Previous research has mainly focused on evaluating the biomechanical, physiological, or musculoskeletal effect of AFOs on gait among people suffering from hemiplegia secondary to stroke. However, there have been some studies that have investigated the mechanisms of the AFO effectiveness. These studies have shown that a suitable AFO could successfully improve the first and the second rockers in hemiplegic patients during walking, while it has no positive effect on the third rocker or push-off.[9-11]

Thus, as improving push-off is an important function of the rocker bar modification in orthoses and prostheses,[12,13] it could be assumed that an AFO modified with a rocker bar is potentially able to improve push-off and to transfer body weight from the affected limb to the unaffected one. Consequently, the objective of the present study was to investigate the effect of rocker bar ankle foot orthosis (RAFO) on spatiotemporal characteristics of gait in patients suffering from chronic hemiplegia secondary to stroke compared with the effect of solid ankle foot orthosis (SAFO).

Materials and Methods

Patients

Table 1 shows the demographic and clinical characteristics of the patients. Eighteen chronic hemiplegic patients secondary to stroke (at least 6 months since onset) referred to rehabilitation centers, at the age of 40-70 (both men and women), voluntarily participated in the present study. All participants were able to walk independently for at least 10 m without assistive device. The spasticity in their calf muscles including gastrocnemius and soleus was maximally 2 according to the Modified Ashworth Scale. The participants had no history of surgery in their lower limbs, no deformities except for equinovarus in their affected limb that resulted from hemiplegia, and no severe cardiorespiratory or cognitive problems that negatively influence the participants' ability to perform instructed tasks. The patients were assessed for hemiparesis according to the Brunnstrom stage of lower limbs. The level of mobility of the patients was defined according to the Functional Ambulation Category.

Table 1. *Demographic and clinical characteristics of the patients (N = 18)*

Gender	Age (year), mean ± SD	Type of stroke	Weight (kg), mean ± SD	Height	Affected side	Site of the stroke lesion	Ankle joint passive ROM, (degree)	The type of AFO daily used	Sensory impairment (NIHSS score)	Months after stroke, mean ± SD	Br.s stage of lower limbs	FAC of the patients
Male: 10 Female: 8	57.86 ± 10.44	13 ps: Isch 5 ps: Hem	72.95 ± 13	168.66 ± 13.21	L: 11 R: 7	18 ps: Hemisph.	18	13 ps: solid 5ps: hinged	+1	25.31 ± 16	15 ps: IV 3 ps: V	16 ps: IV 2 ps: V

Abbreviations: AFO, ankle foot orthosis; Br.s, Brunnstrom stage; FAC, Functional Ambulation Category; Hem, hemorrhagic; Hemisph., hemispheres; Isch, ischemic; L, left; NIHSS, National Institutes of Health Stroke Scale; ps, patients; R, right; ROM, range of motion; SD, standard deviation.