Effect of Rocker Bar Ankle Foot Orthosis on Functional Mobility in Post-Stroke Hemiplegic Patients: Timed Up and Go and Gait Speed Assessments

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ABSTRACT

Objectives: Ankle Foot Orthoses (AFOs) are widely utilized to improve walking ability in hemiplegic patients. The present study aimed to evaluate the effect of Rocker bar Ankle Foot Orthosis (RAFO) on functional mobility in post-stroke hemiplegic patients.

Methods: Fifteen hemiplegic patients (men and women) who were at least 6-months post-stroke and able to walk without an assistive device for at least 10 meters voluntarily participated in this study. The patients were examined for three conditions: shoes only, with SAFO and with RAFO. Their functional mobility was evaluated through 10-meter walk test and Timed Up and Go (TUG) test. In addition, paired t-test was used to analyze the obtained data.

Results: When the patients used RAFO, their gait speed significantly increased ($P<0.05$). Moreover, the time of performing TUG test experienced a significant decrease using RAFO compared with utilizing shoe only ($P<0.05$).

Discussion: RAFO led to a significant improvement in functional mobility in hemiplegic patients post stroke. This may be due to the positive effect of rocker modification on improving push off and transferring weight during the stance phase of gait.

1. Introduction

Hemiplegia secondary to stroke contributes to problems associated with standing and walking. Hemiplegic patients suffer from poor balance, slow walking, and weak muscles, and their lower limb is often accompanied with an equinovarus deformity in ankle-foot complex [1-3]. Ankle Foot Orthoses (AFOs) are widely prescribed for patients with hemiplegia to improve balance and facilitate gait. Various studies have reported the positive effects of AFOs on the walking ability in hemiplegic pa-

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tients [4, 5]. AFOs also help patients in both stance and swing phases of gait by stabilizing ankle-foot complex and preventing abrupt foot drop [6, 7].

For hemiplegic patients, gait speed is a key factor that can directly affect their daily activities. Therefore, enhancing walking speed is an important goal regarding prescribing AFO for individuals with hemiplegia [8]. Preferred walking speed in healthy subjects is 1.18 m/s for men above 64 years and 0.96 m/s for women above 60 years. Although Solid AFO (SAFO) enhances walking speed in hemiplegic patients, the acquired speed is far less than that of the healthy subjects [9]. Thus, some efforts have been done to increase gait velocity with common SAFO [7, 10-12]. Considering the positive effect of rocker bar modification added to orthoses on walking velocity reported in previous studies [13-15], we hypothesized that adding rocker bar to a SAFO could potentially improve walking speed in hemiplegic patients. Timed Up and Go test (TUG) is a valid and reliable test, which could evaluate several tasks concurrently, for examining the acquired functional ability in patients [16-18]. Hence, we used TUG to investigate the effectiveness of Rocker bar AFO (RAFO) on functional mobility in hemiplegic patients, in addition to using the 10-meter walk test to investigate gait speed [19-21]. Thus, the aim of this study was to evaluate the effect of RAFO on functional mobility in post-stroke hemiplegic patients.

2. Methods

Patients

Fifteen post-stroke hemiplegic patients including ten men and five women voluntarily participated in this study. Inclusion criteria were as follows: age between 40 to 70 years, having the ability to walk without an assistive device for at least ten meters, and having a maximum spasticity of 3 according to the Modified Ashworth Scale. Exclusion criteria were having a deformity in spine or lower limbs (except for equinovarus in ankle join in paretic side), having a history of surgery in the spine or lower limbs, and having severe cardiovascular, respiratory or cognitive problems. Table 1 indicates the demographic characteristics of the patients.

Orthosis

Patients were provided with a custom-made SAFO and RAFO. In order to provide RAFO, SAFO was modified with a rocker sole added below the footplate. The rocker modification had a height of 2 cm. The rocker bar started slightly proximal to metatarsal heads, and its angle was 15 degrees. Orthoses were prepared and fitted to the patients' limb by an expert orthotist.

All the patients were examined in three conditions including shoe only, with SAFO and with RAFO in random sequences. Moreover, all the participants used the same shoes.

Measurements

- **Preferred Gait Speed (PGS):** The participants were instructed to walk for 10 meters at their self-selected speed. The time of doing task was recorded and divided into passed distance to obtain gait speed (m/s).

- **TUG test:** The patients were asked to stand up from a standard chair, walk for 3 meters, turn, walk back to the chair, and sit down again. The time of task was recorded in seconds.

All the measurements were done three times, and the average data was considered for final analysis. Means and standard deviation of the performed measurements were recorded. All participants signed informed consent prior to performing the tests. Furthermore, the current study received ethical approval from the Medical Ethics Board at the University of Social Welfare and Rehabilitation Sciences.

Data analysis

We used repeated measures analysis of variance test (ANOVA) to analyze the differences among measurements. Tukey Honestly Significance Difference (THSD) post hoc tests were used to identify the specific difference between two groups. We utilized SPSS statistical software version 16.0 (SPSS Inc., Chicago, IL) to analyze obtained data. The level of α=0.05 was considered statistically significant.

3. Results

Table 2 shows the data regarding functional test parameters including Preferred Walking Speed and TUG test in three conditions: shoes only, with SAFO and with RAFO. There were significant differences between shoes only condition and using SAFO or RAFO ($P<0.05$). Both SAFO and RAFO led to faster gait speed and less timed TUG test compared with shoes only condition. Moreover, RAFO significantly resulted in higher gait speed and less time in doing TUG compared to SAFO ($P<0.05$).

4. Discussion

The aim of the present study was to investigate the effect of RAFO on functional mobility parameters in-

Table 1. Demographic characteristics of the patients (N=15).

Gender	Age mean (year) (mean±SD)	Weight (kg) (mean±SD)	Paretic side	Months after stroke (mean±SD)
Male: 10 Female: 5	54.23±9.65	66.95±11	Left: 11 Right: 4	22.13±14

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Table 2. The Mean±SD of functional mobility parameters in three conditions: Shoes only, with SAFO and with RAFO.

	Shoes only	SAFO	RAFO	P1	P2	P3
PGS (m/s)	0.36±0.11	0.54±0.26	0.73±0.24	0.033	0.018	0.029
TUG (s)	28.06±4.06	23.18±3.55	20.36±3.81	0.021	0.006	0.045

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P1: Comparison between shoes only condition and SAFO.

P2: Comparison between shoes only condition and RAFO.

P3: Comparison between SAFO and RAFO.

SAFO: Solid Ankle Foot Orthosis, RAFO: Rocker bar Ankle Foot Orthosis, PGS: Preferred Gait Speed, TUG: Timed Up and Go, m: meter, s: second, $P<0.05$.

cluding gait speed and TUG in post-stroke hemiplegic patients compared with SAFO. The results of this study showed that SAFO led to significant improvement in functional mobility. This was consistent with previous research that showed SAFO increased gait speed and decreased TUG time compared to shoes only condition. In addition, RAFO contributed to further more improved functional mobility in patients. On comparing RAFO to SAFO, there were significant differences in both gait speed and the time of performing TUG test.

According to Perry and Burnfield [22], the normal function of the foot consists of three sequential rockers: heel rocker (first rocker), ankle rocker (second rocker), and third rocker (forefoot rocker). Research has indicated that SAFO enhances gait speed by improving first and second rockers while it has no positive effect on the third rocker [23-25]. In some cases, it has been shown that AFO disturbs forefoot rocker in late stance [25, 26].

On the other hand, it is proved that rocker bar could improve weight progression on foot and change the kinetic and kinematic functions of the ankle-foot complex [15, 27]. Therefore, it has been suggested to be used in cases in which ankle-foot complex has been immobilized such as utilizing orthoses [15]. It seems that in the current study, modifying AFO in the forefoot part resulted in improving forefoot rocker and therefore, push-off and body weight transferring in late stance. This finding was consistent with previous research, which showed that rocker modification changes the biomechanical function of the foot and ankle during walking [14, 15]. Similarly, it was recorded that lower limb orthoses modified with forefoot rocker increased gait speed in other neurologically disabled patients [13]. However, the precise mechanism of this improvement should be evaluated in future studies.

5. Conclusion

The finding of this study suggests that RAFO could potentially improve gait ability compared to SAFO or shoes only condition in post-stroke hemiplegic patients. One limitation of the present study was the lack of investigation of the kinematic and kinetic characteristics of the participants' gait that is highly suggested to be done in the future. In addition, future studies should also evaluate the RAFO effectiveness. The short sample size was another limitation of the current study. Examining the effects of RAFO on hemiplegic gait in a study with a larger sample size could further prove the results obtained in this study.

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Conflict of Interest

The authors of the present study report no conflict of interest.

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