Original

The Physical Function of Stroke Patients Necessary for an Independent Gait with the Use of an Ankle Foot Orthosis

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(Received: September 26, 2016)

Abstract

Objectives: The aim of this study was to determine the relationship between the physical function and gait ability in stroke patients using an ankle foot orthosis.

Methods: Thirty-four stroke patients without higher cortical function disorders were involved in this study and all patients used ankle foot orthosis.

This study examined muscle strength of both the hemiplegic and non-hemiplegic limbs, the Brunnstrom stage of the lower limbs, the weight bearing rate on both the hemiplegic and non-hemiplegic limbs, and gait performance.

Results: Muscle strength and weight bearing rate of the hemiplegic limbs were significantly different between the independent group and the dependent group ($p < 0.05$). The results of the logistic regression analysis showed that the weight bearing rate on the hemiplegic limb was a significant predictor of the independent group ($p < 0.05$).

Conclusion: The weight bearing rate on the hemiplegic limb was the most useful predictor of independent gait with the use of an ankle foot orthosis in stroke patients.

(JJOMT, 65: 132—136, 2017)

—Key words—
muscle strength, balance, stroke

Introduction

Many patients have difficulties with walking after stroke. For example, 25–50% of stroke patients have walking difficulty, and 50% of patients have walking difficulty outside[1). The improvement of walking function is the goal most often stated by stroke patients.

The ankle foot orthosis (AFO) is a commonly used orthotic device used to restore ankle foot function and to improve the balance and gait in post-stroke hemiplegic patients. Several studies have shown that AFO improves gait parameters, such as walking speed[2)3) and gait pattern[4). In clinical practice, AFOs can be used by patients for both independent and dependent walking.

Factors identified as determinants of gait performance in stroke patients include balance[5)6), muscle strength[7)8), and motor control[9). Our study indicated that multiple factors influenced the gait of stroke patients; as followed, weight bearing rate (WBR) on the hemiplegic limb was the most important[10). There are few studies that have examined independent walking in the stroke patients using an AFO. If the physical function necessary for independent walking could be clarified, this would be useful information for physiotherapists selecting therapeutic exercises.

The aim of this study was to determine the relationship between the physical function and gait ability in stroke patients using an AFO.

Methods

Participants

Thirty-four stroke patients without higher cortical function disorders were involved in this study and all patients used AFO. Informed consent was obtained from all patients. The average ± standard deviation (SD) age at the time of the study was 66.0 ± 8.3 (range, 51–85) years. There were 14 men and 20 women; 19 patients were right hemiplegics, and 15 were left hemiplegics. The average time (± SD) from stroke onset was 112.5 ± 61.6 days. Of the participants, 31 patients were plastic shoe horn brace, and three patients were double upright AFO with an adjustable ankle joint.

Procedure

This study examined muscle strength of both the hemiplegic and non-hemiplegic limbs, the Brunnstrom stage of the lower limbs, the WBR on both the hemiplegic and non-hemiplegic limbs, and gait performance.

The WBR was taken using two commercially available scales (TANITA bathroom scales RAINBOW THA-528). Each scale had a precision of 1.0 kg, and the measurement range was 0–120 kg. The scales were placed next to each other. The measurement of the patients was taken on bare foot. The angle between the right and left feet was 15 degrees, and the distance between the two calcaneal regions was 10 cm. The patients were asked to stand evenly with one foot on each scale, first to shift as much of their weight as possible to the non-hemiplegic side, second to the hemiplegic side. The scale measured the value in 1-kg units during which the patient stood still for 5 seconds. The WBR was defined as the percentage of weight shown on each scale compared to the whole body weight.

To measure the muscle strength of the lower limb, quadriceps muscle strength was measured using a hand-held dynamometer (ANIMA, μ-Tas MT-01). The patients were asked to sit upright on a mat platform with both upper extremities crossing in front of the trunk without back support and, keeping the knees flexed 90 degrees, the dynamometer was attached to the front of the distal lower leg. The patients were then asked to make a maximum isometric contraction of the quadriceps for 5 seconds, twice, with a time interval of more than 30 seconds. The stronger value (kgf) of the two was divided by the body weight. This value (kgf/kg) was defined as the muscle strength of the lower limb.

For measurement of gait performance, the patients who could walk in the hospital independently and safely were categorized as the independent group (IG), and those who needed observation or any assistance by a staff were considered part of the dependent group (DG).

The differences between the IG and DG were compared using the Mann-Whitney U test. A logistic regression analysis was used to identify the optimal predictor variable in the IG.

Statistical analysis was performed using IBM SPSS statistics 22.0. The significance of relationships was evaluated at the p value < 0.05 level.

Results

Of the 34 patients, 7 were categorized as IG and 27 as DG.

The results of the univariate analysis are shown in Table 1. Muscle strength and WBR of the hemiplegic limbs were significantly different between the two groups ($p < 0.05$). The WBR on the hemiplegic limbs of the IG was 56–82%, and the WBR on the hemiplegic limbs of the DG was 4–81%.

The results of the logistic regression analysis showed that the WBR on the hemiplegic limb was a significant predictor of the IG ($p < 0.05$) (Table 2).

Discussion

The aim of this study was to determine the relationship between physical function and gait ability in stroke patients. The WBR on the hemiplegic limb was the most useful predictor of independent gait with the use of an AFO in stroke patients.

Table 1 Comparison of valuables between the independent and dependent groups (n = 34)

Variable	Independent group (n = 7)	Dependent group (n = 27)	p value
Muscle strength of the paretic limb (kgf/kg)[a]	0.27 (0.08)	0.12 (0.10)	.003
Muscle strength of the non-paretic limb (kgf/kg)[a]	0.50 (0.13)	0.42 (0.14)	.314
Brunnstrom stage of lower limbs (n)[b]	III: 4, IV:3	II: 3, III: 14, IV: 10	.647
Weight bearing rate on the paretic limb (%)[a]	70.4 (8.3)	40.5 (21.1)	p < 0.001
Weight bearing rate on the non-paretic limb (%)[a]	89.5 (6.1)	89.0 (7.0)	.934

[a]mean (SD), [b]proportion

Table 2 Predictors of gait ability (n = 34)

Variable	Odds Ratio (95%CI)	p value
Muscle strength of the paretic limb (kgf/kg)	1.132 (0.978–1.311)	.097
Weight bearing rate on the paretic limb (%)	1.124 (1.010–1.251)	.032

CI: confidence interval.

Numerous studies of stroke patients standing in balance have demonstrated a greater proportion of body weight distributed on the non-hemiplegic limb than on the hemiplegic limb[11)~13)]. Weight bearing on the hemiplegic side during standing has been found to correlate significantly with Barthel index scores of function in stroke patients[6)]. Richard and Bohannon showed that walking and stair performance in hemiplegic persons were significantly correlated with maximum weight bearing on the hemiplegic lower limb[14)15)]. We have also reported that WBR on the hemiplegic lower limb had an influence on indoor walking[10)]. The univariate analysis of the present study showed that muscle strength on the hemiplegic lower limbs and the WBR on the hemiplegic lower limbs were significantly different between the IG and DG. The logistic regression analysis showed that only the WBR on the hemiplegic lower limb was a critical factor influencing the ability for independent walking. Therefore, although multiple factors influenced independent walking in stroke patients, the WBR on the hemiplegic lower limb was the most useful indicator for predicting independent walking with the use of an AFO.

It has been reported that the majority of individuals with stroke bear less weight on the hemiplegic limb during the static task of quiet standing[16)~20)]. During the stance portion of the walking cycle, the hemiplegic patient typically demonstrates a relatively limited weight transfer to the hemiplegic lower limb; and single-stance duration is shorter for the hemiplegic lower limb than for the non-hemiplegic lower limb[20)21)]. An independent gait requires that a patient can maintain balance through stable support provided by both lower limbs. Therefore, in this study, it was considered that the WBR for the paralyzed side is most associated with walking with the use of an AFO in stroke patients.

Our study showed that the cut-off value for independent gait was a WBR on the hemiplegic limb of 70.2%, with a high sensitivity, predictive accuracy, and positive predictive value in stroke patients[10)]. The present study showed that the IG had a wide variation (56–82%) in the WBR on the hemiplegic limb, and 3 of 7 patients had less than 71% WBR on the hemiplegic limb. AFOs can help hemiplegic-side lower limbs to compensate in weight bearing when the support of paralysis side lower limbs decreases.

As with all studies, the present investigation had some limitations. We did not include patients with higher cortical function disorders; therefore, the results of our study are applicable only to patients without higher cortical function disorders. In addition, this study did not examine WBR at a dynamic walk because WBR is static balance. Further research is needed.

Acknowledgements

We would like to thank all of the patients who have participated for their cooperation.

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脳卒中患者における短下肢装具を用いた歩行の自立に必要な身体機能

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—キーワード—

筋力，バランス，脳卒中

目的：本研究は，下腿装具を使用している脳卒中患者の身体機能と歩行能力の関係を検討することを目的とした．

方法：高次脳機能障害を有していない脳卒中患者34名を対象とし，対象者は全例が下腿装具を使用していた．調査・測定項目は，麻痺側・非麻痺側下肢筋力，下肢 Brunnstrom stage，麻痺側・非麻痺側下肢荷重率，歩行能力とした．

結果：麻痺側下肢筋力，麻痺側下肢荷重率は，歩行自立群と歩行介助群間で有意差を認めた（$p<0.05$）．ロジスティック回帰分析では，麻痺側下肢荷重率のみ自立群に影響する要因として抽出された（$p<0.05$）．

結論：下腿装具を使用している脳卒中患者において，麻痺側下肢荷重率は歩行自立群を予測する上で有用であることが示唆された．

利益相反：利益相反基準に該当無し

（日職災医誌，65：132—136，2017）