Discrimination of Walking Ability Using Knee Joint Extension Muscle Strength in Stroke Patients

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Abstract. The isometric knee joint extension muscle strength required for walking was investigated in stroke patients. The subjects were a group of 17 patients who could walk outside parallel bars with a T-cane (ambulation group) and a group of 13 patients who could not walk outside parallel bars with a T-cane (impossible group). The proportion of muscle strength in the affected side to body weight (%) in the ambulation group, 29.7 ± 9.29%, was significantly larger than the impossible group, 9.68 ± 6.94%, at p<0.01. In addition, the non-affected side muscle strength (%) in the ambulation group, 40.9 ± 11.1%, was significantly larger than the impossible group, 32.0 ± 8.80%, at p<0.05. The discrimination point of the affected side muscle strength (%) was 18.3% for the discrimination of ambulation group and impossible group by Mahalanobis distance using only 1 factor, and the positive discrimination rate was 93.3%. In the discrimination using non-affected side muscle strength (%) by Mahalanobis distance, the discrimination point was 36.0%, and the positive discrimination rate was 66.7%. In the discriminant analysis using affected side muscle strength (%) and non-affected side muscle strength (%), using 2 factors, the positive discrimination rate was 93.3%, and it was equal to the discrimination using only the affected side muscle strength (%). Thus, walking outside parallel bars with a T-cane was possible in patients with knee joint extension muscle strength over 20% body weight on the affected side. Key words: Stroke, Walking, Discriminant analysis.

INTRODUCTION

The recovery of walking ability is important for the rehabilitation of stroke patients. There is a close relation between the recovery of walking ability and knee joint extension muscle strength, and there is a significant correlation between the maximum walking speed and knee joint extension muscle strength of stroke patients on the affected side1–6) and the non-affected side4). Thus, there is a close relation between the affected side lower extremity muscle strength improvement in stroke patients and the improvement of walking speed7). However, the knee joint extension muscle strength required for walking in stroke patients has not yet been investigated.

The purpose of this study was to investigate the lower limit of isometric knee joint extension muscle strength in stroke patients who could walk outside parallel bars with a T-cane.
SUBJECTS AND METHODS

The subjects were 30 stroke patients (mean ± standard deviation: age, 76.5 ± 6.22 years old; body weight, 49.5 ± 8.99 kg; period from onset of stroke, 107.7 ± 177.4 months), and included 8 men and 22 women. The Brunnstrom’s recovery stage (Br. stage) of the lower extremities in the subjects was III in 8 patients, IV in 4 patients, V in 11 patients and VI in 7 patients. With regard to the walking ability of the subjects, 17 patients (ambulation group) could walk outside parallel bars with T-cane (the use of the orthosis was permitted), and there were 13 patients who could not (impossible group). The objectives of this research was explained to the subjects, and their prior informed consent was obtained.

The isometric knee joint extension muscle strength was measured twice with Power Track II (JTECH Co., USA), which is a hand-held dynamometer, in the sitting position at 90 degrees of knee joint flexion. The maximal value of the two measurements were used for analysis. The muscle strength was displayed in newtons, and then converted to kilograms, and the muscle strength of both the affected and non-affected sides were converted to body weight proportion (%).

The muscle strength (%) of the affected and non-affected sides in both groups was compared using Student’s t test (p<0.05). The discriminant analysis of the ambulation group and impossible group by Mahalanobis distance using only 1 factor was performed for both the affected side muscle strength (%), and the non-affected side muscle strength (%). The discriminant analysis of the ambulation group and impossible group using 2 factors was performed for the affected side and non-affected side muscle strength (%) and the positive discrimination rate was calculated.

RESULTS

The muscle strength value (%) of the affected side in the ambulation group was significantly larger, 29.7 ± 9.29% than in the impossible group, 9.68 ± 6.94% (p<0.01). In the non-affected side, the muscle strength in the ambulation group was significantly larger, 40.9 ± 11.1% than in the impossible group 32.0 ± 8.80% (p<0.05) (Fig. 1).
muscle strength (%) by Mahalanobis distance, the discrimination point was 18.3%, and the positive discrimination rate was 93.3% (Fig. 2). In the discriminant analysis using non-affected side muscle strength (%) by Mahalanobis distance, the discrimination point was 36.0%, and the positive discrimination rate was 66.7% (Fig. 3). In the discriminant analysis using both the affected side muscle strength (%) and non-affected side muscle strength (%), a 93.3% positive
discrimination rate was calculated for the ambulation group and impossible group using the following formula (Fig. 4):

\[ \text{Affected side muscle strength (\%)} = 0.17 \times \text{Non-affected side muscle strength (\%)} + 13.6 \]

**DISCUSSION**

The improvement of the lower extremity muscle strength in both the non-affected and affected sides of stroke patients is possible\(^9\). However, it has not been possible to evaluate the muscle strength required for ambulation. From the results of this study, walking is possible when the patients have a knee joint extension muscle strength over 20\% of the body weight on the affected side, and the positive discrimination rate is 93.3\%. Therefore, there is a high possibility that muscle strengthening exercises for the knee joint extension muscle are necessary in order for the patient to strengthen muscles sufficiently to become ambulatory.

At first we considered that it might be necessary to calculate discrimination, using two factors: both the affected side and non-affected side muscle strength. However, the positive discrimination rate, which used only the affected side muscle strength (\%), was as useful as the discrimination calculated using two factors. Although our finding that the non-affected side muscle strength is unrelated contradicts the findings in a previous report\(^9\) this may be due to differences in the period from the onset: Takahashi et al.\(^9\) reported a significant relation between walking ability and non-affected side muscle strength at a mean of 79 days. However, it has been reported that the relationship between walking ability and the period from onset of stroke showed that although the coefficient of determination of the non-affected side muscle strength for walking ability was 0.15 within the half year from onset, it decreases after 6 months to 0.06\(^10\). Thus, we speculate that the non-affected side muscle strength has no influence on the findings in this study, since the patients in this study had passed two years since the onset of stroke.

In the present study, there were two cases in which the discrimination was incorrect. In one case the affected side muscle strength was 19\%, and the patient was part of the impossible group. The discrimination point in this case was 18.3\%, and
discrimination is not possible near the boundary. Although one other patient had 11% affected side muscle strength, independent gait was possible using a T-cane and a short leg brace. The Br. stage of this patient was III and as such, there may be no relation between knee joint extension muscle strength measured in the sitting position and knee joint extension muscle strength in walking, since pathological synergy is predominant. Thus, further investigation of patients with Br. stage III will be necessary in the future.

CONCLUSION

Isometric knee joint extension muscle strength required for stroke patients to walk was investigated. Walking using a T-cane outside parallel bars was possible in patients with knee joint extension muscle strength over 20% body weight on the affected side.

REFERENCES