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Original Article

Influence of contralateral lower limb stabilization on hip abductor muscle strength measured by Hand-Held Dynamometer

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ABSTRACT
Tanikawa H, Mukaino M, Matsuda F, Inagaki K, Ohtsuka K, Kagaya H, Saitoh E, Kanada Y. Influence of contralateral lower limb stabilization on hip abductor muscle strength measured by Hand-Held Dynamometer. Jpn J Compr Rehabil Sci 2015; 6: 137−142.

Objective: To investigate the influence of contralateral lower limb function on hip abductor muscle strength using a hand-held dynamometer.

Method: Thirty healthy subjects and fifty-nine hemiplegic patients participated in this study. Hip abductor muscle strength was measured in the supine position with or without stabilization of the contralateral lower limb (stabilizing vs. nonstabilizing method, respectively). Strength as measured using both methods was compared on each side for the lower limb and correlation coefficients for the two methods were calculated. In addition, correlation coefficients between measurements of strength using the two methods on both sides were calculated. In the hemiplegic patients, multiple regression analysis was performed using the strength on the affected side as the dependent variable, and the strength on the unaffected side and the degree of paralysis as independent variables.

Results: Strength measured using the stabilizing method was significantly lower than when using the nonstabilizing method. The correlation between the strength on both sides was high in the healthy subjects despite contralateral lower limb stabilization, but low in the hemiplegic patients when using the nonstabilizing method. The strength on the affected side was strongly influenced by the unaffected lower limb function in measurements using the stabilizing method.

Discussion: Measurements of hip abduction strength when using the stabilizing method are not an accurate reflection of the strength due to the influence of contralateral lower limb function.

Key words: hip abductor muscle strength, Hand-held dynamometer (HHD), hemiplegia, contralateral lower limb, stabilization

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Introduction

In hemiplegic stroke patients, hip abductor muscle strength on the affected and unaffected sides correlates significantly with comfortable gait velocity, gait independence, and continuous gait distance [1]. Furthermore, in patients with unilateral coxarthrosis, the hip abductor muscle strength on the affected side is one of the determinants of maximum gait velocity [2] and the strength on both sides is correlated with gait speed [3]. In patients following total knee arthroplasty, hip abductor muscle strength on both sides strongly affects comfortable gait velocity and the time needed to climb stairs and to stand up [4]. For these reasons, hip abductor muscle strength is an important indicator of walking ability for predicting recovery potential.

Many earlier investigations employed a Hand-held dynamometer (HHD) to quantitatively measure muscle strength. Although there is no standardized method for measuring hip abductor muscle strength using an HHD [5−12], high intra-rater reliability was reported when measuring strength in the supine position with or without stabilization of the contralateral lower limb [5−7]. In healthy subjects, strength measured with stabilization of the contralateral lower limb was lower than without stabilization [13, 14]. This is because abduction of the contralateral lower limb helps to stabilize the pelvis [14]. However, if that is the case, strength measured in the supine position with stabilization of the contralateral lower limb might be affected by the functioning of that limb. Particularly in hemiplegic patients, there are cases of contralateral lower limb muscle weakness due to paralysis or disuse. Therefore, to clarify the influence of contralateral lower limb muscle strength, it is important to assess the reliability of the measurements. The purpose of this study was to investigate the influence of contralateral lower limb muscle function on hip abductor muscle strength in healthy subjects and hemiplegic patients by comparing HHD strength measurements with and without stabilization of the contralateral lower limb.

Subjects and Methods

1. Subjects

In total, 30 healthy subjects (16 males and 14 females) and 59 hemiplegic patients (43 males and 16 females) participated in this study. Subjects who complained of pain or had orthopedic medical histories were excluded. The healthy subjects were 26 ± 4 years of age, 167.3 ± 9.1 cm in height and 57.4 ± 12.3 kg in weight (mean ± SD). The hemiplegic patients were 60 ± 15 years of age, 163.3 ± 14.2 cm in height and 60.6 ± 11.2 kg in weight. The time from onset was 530 ± 1,063 days. Thirty-one patients had been diagnosed with cerebral infarction, 18 with cerebral hemorrhage, 4 with subarachnoid hemorrhage, 4 with brain tumor, 1 with cerebral abscess, and 1 with cerebral arteriovenous malformation.

This study was approved by the Institutional Review Board of Fujita Health University (14-271) and written informed consent was obtained from all subjects.

2. Methods

2.1 Equipment and procedures

An HHD (μTas F-1, Anima Co., Ltd., Tokyo, Japan) was used to measure muscle strength in this study. Two physical therapists as testers measured the subjects' hip abductor muscle strength in the supine position with stabilization of the contralateral lower limb (stabilizing method) and without (nonstabilizing method) in random order. For the stabilizing method, both of the subject's hip joints were in neutral abduction and rotation. One of the testers manually stabilized the subject's pelvis by holding it from the left and right sides. The tester also stabilized the subject's contralateral lower limb using his/her own lower limb to prevent contralateral hip abduction. For the nonstabilizing method, the subject's contralateral hip joint was in maximal abduction and neutral rotation. One of the testers manually stabilized the subject's trunk to prevent trunk movement by holding the ipsilateral proximal trunk near the axilla and the contralateral distal trunk near the lower end of the rib. Preliminary results showed that the pelvis could be stabilized using the stabilizing method, but not when the tester manually stabilized the pelvis alone. Therefore, we decided to stabilize only the trunk to prevent hip elevation. The force sensor of the HHD was placed at the lateral distal position of the thigh. An isometric test was used and subjects were asked to maintain maximum voluntary contraction for three seconds. Two trials were performed and adequate rest was allowed between trials.

2.2 Data analysis

The ratio of maximum hip abductor muscle strength to body weight (N/kg) was calculated by dividing the strength (N) by the body weight (kg). To investigate the intra-rater reliability of each method, correlation coefficients of the first and second measurement scores were calculated for the healthy subjects as well as for the hemiplegic patients. Strength measured using the stabilizing method vs. the nonstabilizing method was then compared by paired *t*-testing between the right and left sides of the lower limb in the healthy subjects, and between the affected and unaffected sides in the hemiplegic patients. Correlation coefficients for the two methods were calculated. In addition, correlation coefficients between the right and left sides of the lower limb in the healthy subjects, and between the affected and unaffected sides in the hemiplegic patients were calculated. In the hemiplegic patients, multiple regression analysis was used to identify the factors influencing the strength on the affected and unaffected sides using the former as the dependent variable, and the strength on the unaffected side and the degree of paralysis (hip flexion test in the Stroke Impairment Assessment Set; SIAS) as independent variables. Statistical analysis was carried out using JMP 10 software (SAS Institute Inc., Cary, NC, USA). $p < 0.05$ was considered statistically significant.

Results

1. Intra-rater reliability for each method

The correlation coefficient of the first and second measurement scores was 0.91 for the stabilizing method and 0.94 for the nonstabilizing method in the healthy subjects (both sides, $n = 60$ hip joints). In the hemiplegic patients, it was 0.97 and 0.96 for the stabilizing and nonstabilizing methods, respectively, on the unaffected side ($n = 59$), and 0.98 and 0.99, respectively, on the affected side ($n = 59$).

2. Comparison of strength measured using the stabilizing and nonstabilizing methods

In the healthy subjects, the ratio of maximum hip abductor muscle strength to body weight (N/kg) on the right and left sides was 1.6 ± 0.2 for both when using the stabilizing method and 1.3 ± 0.2 for both with the nonstabilizing method (mean ± SD). This difference was significant ($p < 0.01$). The correlation coefficient for the strength measured using the two methods was 0.84 (Figure 1).

In the hemiplegic patients, the ratio of maximum hip abductor muscle strength to body weight (N/kg) on the unaffected side was 1.5 ± 0.4 when using the stabilizing method and 1.2 ± 0.3 with the nonstabilizing method. On the affected side, it was 1.2 ± 0.4 and 0.9 ± 0.3, respectively. Thus, strength measured when using the nonstabilizing method was significantly lower ($p < 0.01$). The correlation coefficient for the two methods was 0.85 on the unaffected side and 0.88 on the affected side (Figure 2).

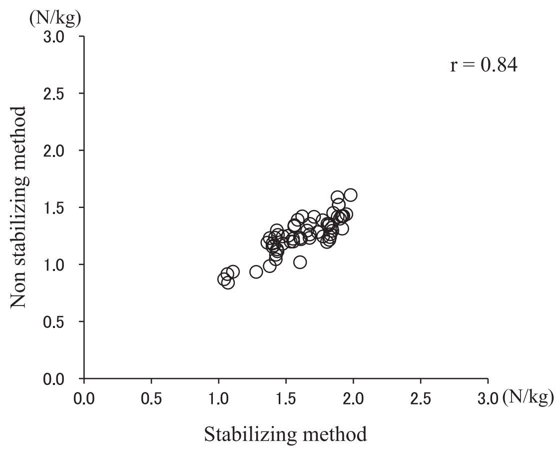

Figure 1. Influence of contralateral lower limb stabilization on hip abductor muscle strength−healthy subjects.
Comparison of hip abductor muscle strength measured using the stabilizing and nonstabilizing methods in healthy subjects. Right and left side strength is shown ($n = 60$).

3. Comparison of strength on the right and left sides in healthy subjects, and on the affected and unaffected sides in hemiplegic patients

For the healthy subjects, correlation coefficients for strength on the left and right sides were 0.81 when using the stabilizing method and 0.85 with the nonstabilizing method (Figure 3). In the hemiplegic patients, correlation coefficients for strength on the affected and unaffected sides were 0.67 with the stabilizing method and 0.32 with the nonstabilizing method (Figure 4).

4. Factors influencing measurement value of hip abductor muscle strength on the affected side

The standardized partial regression coefficient for the measurement value of strength on the unaffected side was higher than for the degree of paralysis when using the stabilizing method. However, when using the nonstabilizing method, this correlation was lower than the coefficient of the degree of paralysis. The coefficient of the measurement value of the strength on the unaffected side when using the nonstabilizing method was lower than when using the stabilizing method (Table 1).

Discussion

In this study, we determined the influence of stabilizing the contralateral lower limb on hip abductor muscle strength measurements in the supine position using an HHD in healthy subjects and hemiplegic patients. For the nonstabilizing method, the subject's contralateral hip joint was in maximal abduction to prevent abductor contraction, and the tester manually stabilized only the trunk. Intra-rater reliability of the two methods was high in both healthy subjects and hemiplegic patients, as shown by the strong correlation between the first and second measurement scores. As

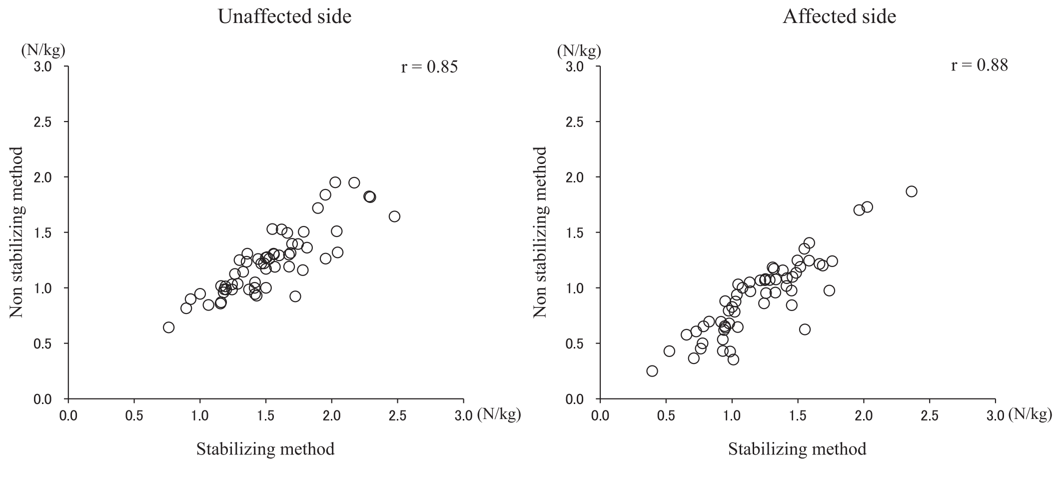

Figure 2. Influence of contralateral lower limb stabilization on hip abductor muscle strength−hemiplegic patients.
Comparison of hip abductor muscle strength measured using the stabilizing and nonstabilizing methods in hemiplegic patients.

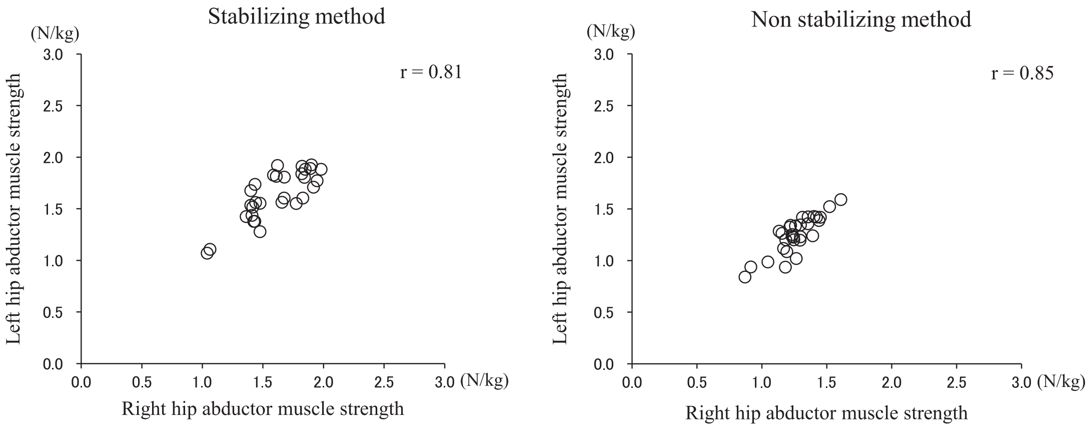

Figure 3. Relationship between right and left hip abductor muscle strength in healthy subjects.
Comparison of hip abductor muscle strength on the right and left sides measured using the stabilizing and nonstabilizing methods in healthy subjects (*n* = 30).

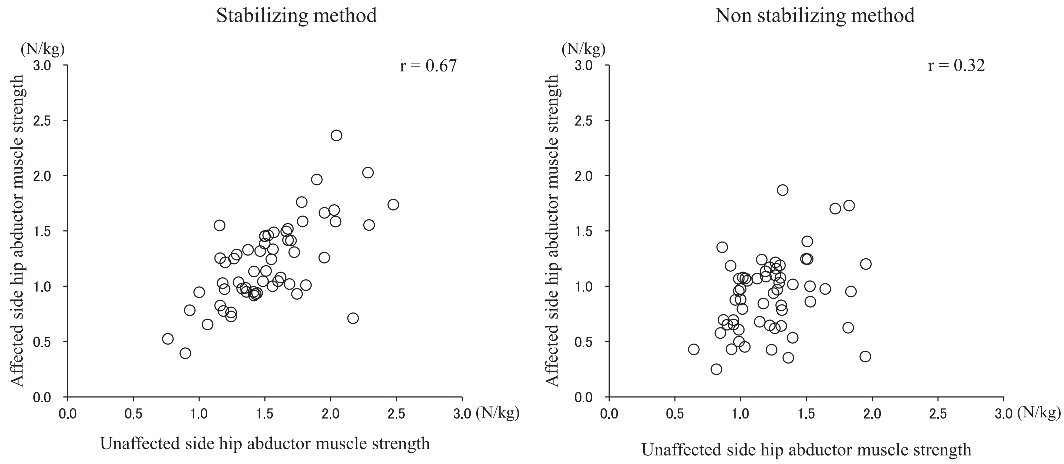

Figure 4. Relationship between unaffected and affected side hip abductor muscle strength in hemiplegic patients.
Comparison of hip abductor muscle strength on the unaffected and affected sides measured using the stabilizing and nonstabilizing methods in hemiplegic patients (*n* = 59).

Table 1. Factors influencing measurement value of the hip abductor strength of the affected side.

			Partial regression coefficient	Standardized partial regression coefficient	*p* Value
Hemiplegic patients (*n* = 59)	Stabilizing method	SIAS(H)	0.195	0.500	<0.01
		Hip abductor strength of the unaffected side	0.645	0.594	<0.01
	Non-stabilizing method	SIAS(H)	0.226	0.649	<0.01
		Hip abductor strength of the unaffected side	0.315	0.270	<0.01

SIAS (H), Stroke Impairment Assessment Set, Hip-flexion test.

in previous studies [13, 14], the results showed that strength measured when using the nonstabilizing method was lower than when using the stabilizing method. When hip abductor muscle strength was measured with contralateral lower limb stabilization, the contralateral lower limb muscle also contracted so that the pelvis was stabilized by the co-contraction of the hip abductor muscles on both sides [14]. Using the nonstabilizing method in the present study, the subject's trunk was stabilized but not the pelvis. Strength assessed in this way was lower than when using the stabilizing method because the pelvis was unstable during measurement. Generally, unilateral hip abductor muscle contraction causes contralateral hip abductor muscle contraction. The strength on the unaffected side caused by hip abduction on the affected side might be influenced by the degree of paralysis [15]. If that were the case, for the stabilizing method measurements in the present study, the strength of the affected side might not be an accurate reflection of the degree of paralysis because the stabilization strength of the pelvis could fluctuate. In addition, hip abduction on the affected side caused by abduction on the unaffected side as an associated reaction (Raïmiste sign, one of the pyramidal signs after a stroke) is observed in stroke patients [16]. During the measurement of hip abductor muscle strength on the unaffected side in hemiplegic patients, the contraction of the affected side caused by such associated reactions could stabilize the pelvis and thus influence measurements of the unaffected side.

In the hemiplegic patients studied here, when using the stabilizing method, the correlation between the strength of the unaffected and affected sides was high, and multiple regression analysis indicated that the strength of the affected side was more strongly influenced by the strength of the unaffected side than by the degree of paralysis. However, the contribution of the strength of the unaffected side to that of the affected side was lower so that the strength of the affected side reflected the degree of paralysis quite well. Therefore, in the hemiplegic patients, the strong correlation seen between the strength of the unaffected and affected sides when using the stabilizing method was caused by the method itself, which stabilizes the contralateral lower limb. Thus, the measurement scores obtained using this method did not accurately reflect the ipsilateral muscle strength. The finding that the contralateral hip abductor muscle strength strongly influenced the measured values indicates that the strength of the affected side influences the measurements more than the degree of paralysis when measuring the hip abductor strength of the unaffected side. On the other hand, it has been reported that hip abductor muscle measurement without contralateral lower limb stabilization causes unnecessary ipsilateral quadriceps femoris muscle contraction [13]. This might make it difficult to exert maximum voluntary contraction of hip abductor muscles without contralateral lower limb stabilization because of the instability of the pelvis. When using the nonstabilizing method in the present study, we also found that although the influence of the contralateral lower limb muscle strength could be excluded, it was difficult to exclude the influence of the strength of the trunk because the pelvis was not stabilized. Further research is required to establish a method for stabilizing the pelvis without contralateral lower limb stabilization, including the use of stabilizing equipment.

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