J. Phys. Ther. Sci.
27: 815–818, 2015

Original Article

Contribution of abdominal muscle strength to various activities of daily living of stroke patients with mild paralysis

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Abstract. [Purpose] The trunk muscles frequently become weak after stroke, thus impacting overall activities of daily living. However, activities of daily living items closely related with trunk strength remain unclear. This study aimed to clarify the influence of trunk muscle weakness on activities of daily living items. [Subjects] The subjects were 24 stroke patients who fulfilled the following inclusion criteria: first stroke and the absence of severe paralysis, marked cognitive function deterioration, unilateral spatial neglect or apathy. [Methods] According to abdominal strength, the 24 patients were divided into a nonweakness group and a weakness group. For the assessment, we used the stroke impairment assessment set, the Berg balance scale, a simple test for evaluating hand function, grip strength, and functional independence measure scale scores and the results were compared between the groups. [Results] The Berg balance scale score and scores for dressing, toilet use, transfer to bed, and walk items of the functional independence measure were significantly lower in the weakness group than in the nonweakness group. [Conclusion] Our results suggest that weakness of the abdominal muscles adversely impacts the balance of patients with mild stroke as well as their ability to dress, use a toilet, transfer, and walk. Trunk training, including abdominal muscle exercises, can effectively improve the performance of these activities of daily living items.
Key words: Stroke, Activities of daily living, Abdominal muscles

(This article was submitted Sep. 17, 2014, and was accepted Oct. 24, 2014)

INTRODUCTION

Trunk stability is essential for maintaining antigravity postures such as sitting and standing, and the smooth execution of limb movements[1–3)]. Transcranial magnetic stimulation and electrical stimulation studies[4–6)] have revealed that the trunk muscles are innervated by fibers from both brain hemispheres. Therefore, the impairment of trunk muscle function is less than that of the affected side limb muscle function in patients with unihemispheric stroke[6)]. However, previous studies have shown that trunk muscle strength is lower in patients with stroke compared with that of healthy age-matched subjects[7–11)]. Bohannon et al.[8)] reported that stroke patients demonstrated weakness during lateral and forward flexion of the trunk. Weakness of the trunk muscles influences balance and activities of daily living (ADL)[11)]. Karatas et al.[11)] reported a significant positive correlation of trunk muscle strength with balance and ADL, suggesting that exercise of the trunk muscles is important for the improvement of ADL.

Although previous studies have reported that overall ADL is related to trunk muscle strength[11)], the relationships of ADL items (e.g., eating, grooming, dressing, etc.) and trunk strength remain unclear. In addition, ADL independence is reportedly related to not only trunk muscle strength but also to the motor function of the paretic limbs[12–14)], sensory deficits[15, 16)], cognitive disorders[17, 18)], apathy[19)], and unilateral spatial neglect[13, 20)]. Accordingly, to clarify the influence of trunk strength on ADL, these factors should be evaluated individually whenever possible. Therefore, the present study evaluated the influence of trunk muscle strength on individual ADL items among mild stroke patients without severe motor or cognitive disorders, or apathy.

SUBJECTS AND METHODS

This was a retrospective secondary analysis of a database. The study protocol was approved by the Institutional Ethics Review Board of Northern Fukushima Medical Center (Fukushima, Japan; No.56).

The study cohort included 24 stroke patients (12 men and 12 women) who were admitted to the Northern Fukushima Medical Center from April 2011 to November 2013 and fulfilled the following inclusion criteria: first stroke; unilat-

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Table 1. Demographic and stroke-related characteristics of the study subjects

	Nonweakness group (n=15)	Weakness group (n=9)
Age (yrs)	66.2 ± 13.3*	77.7 ± 14.4
Days post-stroke	62.7 ± 15.5	64.9 ± 15.5
Women (%)	53	44
Right side hemiparesis (%)	60	67

*Significant difference between groups

eral supratentorial hemispheric lesion; and the absence of severe paralysis (a maximum of 4 motor function items of the Stroke Impairment Assessment Set[21, 22] (SIAS), severe sensory deficits (a maximum of 2 sensory items of SIAS), marked cognitive function deterioration [≤5 cognitive items of the Functional Independence Measure[23] (FIM)], unilateral spatial neglect (unilateral spatial neglect item of SIAS, 3), and apathy [vitality index[24], ≥8]. The mean patient age was 70.5 years, and the mean time from stroke onset was 63.5 days.

We evaluated SIAS[21, 22], the Berg balance scale (BBS)[25], and FIM scores[23], conducted a simple test for evaluating hand function (STEF)[26, 27], and measured grip strength. SIAS is a tool for measuring stroke impairment and includes the following items: motor function, muscle tone, sensory function, range of motion, pain, trunk function, visuospatial function, speech, and unaffected side function. The BBS[25] (score range, 0–56) is designed to measure the balance of the elderly and consists of 14 items, including balance while sitting and standing on one leg, which requires a high level of balance ability. The STEF[26, 27] (score range, 0–100) is a standardized test for assessing upper extremity function. The grip strength of the affected and unaffected hands was recorded two times in the sitting position using a squeeze dynamometer. The highest grip strength was recorded as the subject's grip strength. The FIM[23] evaluates 18 activities in the motor and cognitive domains. The motor domain has 13 items in the areas of self-care, sphincter control, transfer, and locomotion. The cognitive domain includes 5 items in communication and social cognition subscales.

The 24 stroke patients were divided into 2 groups according to the score for abdominal strength on the SIAS: a nonweakness group, including patients with a score of 3 (n = 15), and a weakness group, including patients with a score of ≤2 (n = 9). Subject characteristics are listed in Table 1. Although there were no significant differences in the time since stroke onset, gender, and the side of the affected limb, there was a significant difference in age between the two groups.

The t-test was used to compare age, time since stroke, and time since admission between the nonweakness and weakness groups. Gender, side of the affected limb, and type of CVA were compared using the χ^2 test. SIAS, BBS, STEF, grip strength, and FIM scores were compared between the two groups using the Mann-Whitney test. SPSS for Windows software (version 22) was used for all statistical analyses. A probability (p) value of <0.05 was considered statistically significant.

Table 2. Comparison of the two groups' stroke impairment assessment set

Items	Nonweakness group		Weakness group	
	Median	Range	Median	Range
Motor function				
Knee-mouth test	4	4–5	5	4–5
Finger-function test	4	4–5	5	4–5
Hip-flexion test	5	4–5	5	4–5
Knee-extension test	5	4–5	5	4–5
Foot-pat test	5	4–5	5	4–5
Muscle tone				
U/E muscle tone	3	2–3	3	2–3
L/E muscle tone	3	2–3	3	2–3
U/E deep tendon reflex	2	1–3	3	2–3
U/E deep tendon reflex	3	1–3	3	2–3
Sensation				
U/E light touch	3	2–3	3	2–3
L/E light touch	3	2–3	3	2–3
U/E position	3	3	3	2–3
U/E position	3	3	3	2–3
Range of motion				
U/E ROM	3	2–3	3	2–3
L/E ROM	3	2–3	3	2–3
Pain	3	2–3	3	2–3
Trunk function				
Verticality test	3	3	3	2–3
Unaffected side function				
Grip strength	2	1–3	2	2–3
Quadriceps strength	3	2–3	3	1–3
Visuo-spatial deficit	3	3	3	3
Speech	3	2–3	3	1–3
Total score	71	61–75	68	64–74
Abdominal muscle strength	3*	3	2	1–2

*Significant difference between groups
There was a significant difference in the abdominal muscle strength because subjects were divided into two groups according to it.
U/E: upper extremity; L/E: lower extremity; ROM: range of motion

RESULTS

As shown in Tables 2 and 3, scores for abdominal muscle strength on the SIAS and BBS were significantly lower in the weakness group than in the nonweakness group. However, there were no significant differences in SIAS items except abdominal muscle strength, grip strength, and STEF score between the two groups.

With respect to ADL, dressing the upper and lower body, toilet use, transfer to bed, and walk items as well as the motor domain score and total score on the FIM were significantly lower in the weakness group than in the nonweakness group (Table 4). There were no significant differences in cognitive items and cognitive domain scores on the FIM between the two groups.

Table 3. Comparison of the two groups' grip strength and STEF

Outcome	Nonweakness group		Weakness group	
	Mean	SD	Mean	SD
Affected side grip strength	18.4	12.8	17.7	9.3
Unaffected side grip strength	27.8	11.9	22.3	7.6
Affected side STEF	80.4	18.5	75.7	18.3
Unaffected side STEF	93.0	5.9	89.0	9.2

STEF: a simple test for evaluating hand function.
There was no statistically significant difference in grip strength and STEF between the two groups.

Table 4. Comparison of the two groups' Berg balance scale and functional independence measure scores

Items	Nonweakness group		Weakness group	
	Median	Range	Median	Range
Berg balance scale	50.2*	6.8	41.2	11.8
FIM				
Self-care				
Eating	7	6–7	7	5–7
Grooming	7	6–7	7	5–7
Bathing	7	5–7	5	1–7
Dressing upper body	5*	6–7	5	3–7
Dressing lower body	7*	6–7	5	2–7
Toileting	7*	5–7	6	4–6
Sphincter control				
Bladder management	7	5–7	6	5–7
Bowel management	7	5–7	6	5–7
Transfer				
Bed, chair, wheelchair	7*	6–7	6	5–7
Toilet	7	5–7	6	5–7
Tub, Shower	5	3–7	5	1–7
Locomotion				
Walk/wheelchair	6*	4–7	5	1–7
Stairs	5	1–7	5	1–7
Communication				
Comprehension	7	5–7	6	5–7
Expression	7	5–7	7	5–7
Social cognition				
Social interaction	7	7	7	6–7
Problem solving	6	5–7	6	5–7
Memory	7	5–7	7	5–7
FIM motor score	84*	73–91	66	50–91
FIM cognitive score	34	27–35	32	28–34
FIM total score	116*	100–126	100	78–125

FIM indicates functional independence measure.
*Significant difference between groups

DISCUSSION

Trunk strength weakness as well as motor paralysis and sensory deficits frequently occur after stroke[7–11]. Disuse may be one of the causes of muscle weakness[9–11]. In this study, the relationships between ADL items and the abdominal muscle strength of stroke patients were investigated.

Our results revealed significant differences in the scores for balance and the ADL items of independent dressing, toilet use, transfer, and locomotion between the weakness and nonweakness groups. We reasoned that the major factor influencing these differences in scores was abdominal muscle strength, because there were no differences in scores for the motor and cognitive items other than abdominal muscle strength. Although the correlation of abdominal muscle strength with transfer and locomotion has been reported[11, 28], this is the first report, to our knowledge, to identify the relationship of abdominal muscle strength with the ability to dress and use the toilet. Dressing requires a high level of trunk stabilization because it involves limb movements and shifts in the center of gravity while sitting without back support or standing. With regard to toilet use, adjustment of clothing before and after toilet use while standing and maintaining perineal hygiene requires the ability to control the trunk. On the other hand, it is believed that eating, grooming, and bathing require neither abdominal muscle strength nor balance because these activities can be performed even in a seated position using a backrest.

There were a number of limitations to our study. First, there was a significant difference in mean age between the two groups. Although there was no significant difference in motor and cognitive functions between groups, the possibility that ADL are influenced by age-induced deterioration (e.g., agility and endurance) cannot be overlooked. Second, this study had a small sample size. Third, although the subjects in this study were mild stroke patients, the influence of abdominal muscle strength on ADL would be different in severe stroke patients, such as those with severe paralysis and cognitive disorders. Finally, although the present study clarified some of the relationships between abdominal muscle strength and ADL items, it is unknown whether or not exercise to build abdominal muscle strength can improve balance and the ability to dress, use the toilet, transfer, or walk. However, several authors have reported that trunk stabilization exercises improve the abdominal muscle strength and balance of stroke patients[29, 30]. Therefore, there's a possibility that such exercises could improve the performance of these ADL items by stroke patients with mild paralysis. Further research is required.

ACKNOWLEDGEMENT

This work was supported by JSPS KAKENHI (Grant Number 26893250).

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