BRIEF REPORT

Effects of intervention with back-lying exercises with bent knees pointing upwards to prevent disuse muscle atrophy in patients with post-stroke hemiplegia

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Abstract The present study measured lower extremity muscle mass using DXA（Dual energy X-ray Absorptiometry）in order to verify the effectiveness of intervention with a series of movements, including lying hip raise exercise with bent knees pointing upwards, among bedridden patients with post-stroke hemiplegia in the acute post-stroke period. Subjects in the intervention group were required to perform 10 repetitions of a series of back-lying exercises once a day with researchers, in addition to the exercises performed by those in a control group. The first measurement of muscle mass was conducted at three to five days after onset, and the second measurement was conducted seven days after the first. Muscle mass in the lower extremities was reduced by approximately 600 g（decrease rate：9％）on the paralyzed side and by 280g on the non-paralyzed side（decrease rate：5％）in one week in the Brunnstrom stage ≤ Ⅱ subgroup（site of measurement： lower extremities）（n＝8）of the control group（n＝23）. The decrease in muscle mass in the Brunnstrom stage ≤ Ⅱ subgroup（n＝4）of the intervention group（n＝15）was approximately 260g on the paralyzed side（decrease rate：5％）and approximately 280 g（decrease rate：5％）on the non-paralyzed side. Thus, muscle mass decreased on both sides, and this occurred regardless of degree of paralysis. Comparison of the Brunnstrom stage ≥ Ⅲ subgroups between the control and intervention groups also confirmed that the decease in muscle mass was smaller in the latter group. Thus, it was confirmed that back-lying exercises combining lower extremity movements, including hip raises with bent knees pointing upwards, prevented the decrease in lower extremity muscle mass on the paralyzed side in post-stroke patients. The present study also suggests that these exercise movements can be applied to preventive care for bedridden patients with other severe diseases.

Key words ： effects of intervention, acute post-stroke period, lower extremity muscle, prevent disuse muscle atrophy, hip raise exercises

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Introduction

The issue of disuse syndromes, particularly disuse muscle atrophy （muscle mass decrease）, in bedridden patients with severe diseases has long been discussed[1, 2].

It has been suggested that developing a rehabilitation program that focuses on the issue of muscle atrophy in the lower extremities during the bedridden period is necessary in order to facilitate early recovery from the bedridden status[3]. Nurses generally provide care, such as daily postural change and maximizing range of motion upon changing clothes, to such bedridden patients.

Although there are many reports on lower extremity muscle atrophy in patients with cerebrovascular disorders[4-9], most of these have evaluated cross sections of the lower extremities using CT and ultrasound echo, and only one study evaluated the whole muscle mass in the lower extremities[10]. Although the need for patient rehabilitation in the acute period has been recognized[3], no standardized practical methods have been established[11].

By establishing a method to prevent the decrease in lower extremity muscle mass, it is possible to not only contribute to QOL improvement in post-stroke patients, but also to help solve the problem of disuse muscle atrophy in bedridden patients with severe diseases. Conducting such a study in the field of nursing should therefore be highly meaningful.

In the present study, we instructed and assisted patients with acute post-stroke hemiplegia in a series of back-lying exercises that combined lower extremity movements, such as hip raises with bent knees pointing upwards. The effectiveness of the intervention was confirmed by examining changes in lower extremity muscle mass.

Objective

In order to verify the effectiveness of a series of exercises we had developed, such as back-lying hip raises with bent knees pointing upwards, to preventing disuse muscle atrophy in patients with post-stroke hemiplegia, we compared changes in lower extremity muscle mass measured using DXA (Dual energy X-ray Absorptiometry) between an intervention group, in which the exercises were introduced during the acute bedridden period, and a control group not performing such exercises.

Definitions of terms

In the present study, the following terms are defined as below : In the acute post-stroke period : This refers to the period "within two weeks from the onset of stroke."

Lower extremity muscle mass : This refers to "the muscle mass in the lower extremities, as measured using DXA." The weight of all muscles from the inguinal region to the toe was measured.

Method

1. Subjects

Subjects consisted of 38 patients who were urgently admitted to hospital "A" due to stroke between May 2005 and July 2006. In these patients without impaired consciousness, hemiplegia was observed, and it was possible to carry out the first measurement at three to four days after onset and the second measurement at 10 to 11 days after onset.

2. Method and Analysis

Disease progress in subjects was managed using the clinical path for strokes at hospital "A." In order to avoid confusion between the control and intervention groups, the study was first conducted in the control group, and subsequently in the intervention group.

Three types of back-lying exercise, including torso twists with bent knees pointing upwards, hip raises with bent knees pointing upwards, and upward kicks with bent knees pointing upwards, in addition to the exercises performed in the control group were each performed ; ten repetitions were performed once a day (at around 4 pm) for approximately 10 minutes in the intervention group. These exercises were introduced with the expectation that contraction of the flexor and extensor muscles in the lower extremities would be facilitated by such movement. The actual movements in these exercises include isotonic muscle contraction (kick up) and closed kinetic chain (hip raise)[12]. The time of exercise was set as above in order to avoid conflict with examinations and treatments, and taking meals. The hip raise exercise with bent knees pointing upwards is shown in Figure 1. An exercise assistant fixes the knee joints in order to prevent the bottom of the leg on the paralyzed side from sliding, and maintains the angle of knee joint flexion at around 90 to 100°. An angle of knee joint flexion ranging from 90 to 100° allows patients to remain in the easiest posture and prevents the

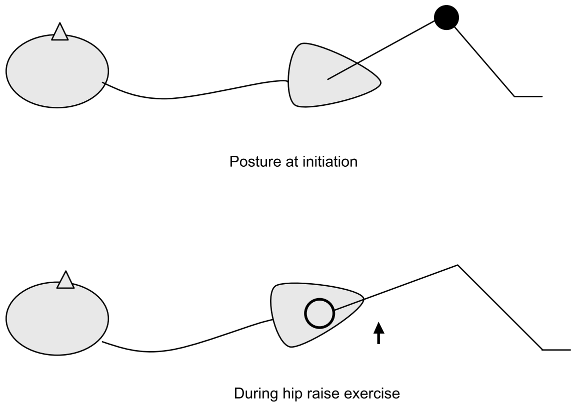

Figure 1. Scheme of hip raise exercise with bent knees pointing upwards in patients with post−stroke hemiplegia
1) The angle of knee joint flexion (●) at initiation should be kept around 90 to 100°.
2) The height of hip elevation should be 5 cm between the trochanteric region on the non- paralyzed side (○) and the bed surface.

paralyzed leg from sliding. The hip was raised until the trochanteric region on the non-paralyzed side was elevated to 5 cm. In order to ensure consistency and accuracy, we practiced this exercise program in healthy individuals prior to using it with patients. One researcher was exclusively involved in providing intervention exercises in order to eliminate differences in the contents and methods of the study. Furthermore, persons in charge of examinations, including DXA and Brunnstrom, and exercise supporters concealed individual test results and status of patients in order to maintain a clear border between researchers and evaluators. Thus, bias in the research results was minimized.

DXA (QDR Delphi (Hologic Inc. USA)) was used for measurement of muscle mass in the left and right lower extremities. Muscle mass evaluation was performed by one researcher who was skilled in DXA. The first measurement was conducted at 3 to 5 days after onset, and the second measurement was conducted on the 7th day after the first measurement. Brunnstrom stage was determined by one researcher for all subjects on the day of the first DXA measurement.

For data analysis, subjects were divided into Brunnstrom stage I to II subgroup with mostly immobile patients (Brunnstrom stage ≤ II group) and a Brunnstrom stage III to V subgroup with relatively mobile subjects (Brunnstrom stage ≥ III group), based on degree of motion of the paralyzed lower extremity. Regarding the difference between the first and second measurements of muscle mass, average values and decrease rates were calculated for the paralyzed and non-paralyzed side in each group. Decrease rates were calculated based on the following formula: (muscle mass on first measurement − muscle mass on second measurement) / muscle mass on first measurement × 100. A Wilcoxon matched-pair signed-rank test was performed to analyze the data using SPSS 11.5 for Windows, with statistical significance being set at $P<0.05$.

3. Ethical considerations

The present study was conducted after receiving the approval of the Ethics Committee for Clinical Research at Tokushima University Hospital. The contents of the study were explained to the subjects and their families. Upon verbal and written explanation that participation was voluntary, that nobody would be disadvantaged in medical treatment and nursing due to discontinuation or lack of participation in the study, and that privacy would be protected, agreement to participate was obtained in writing.

Results

Table 1 shows the clinicodemographic background data of the 38 subjects (23 in the control group and 15 in the intervention group). In the control group, the average age of the subjects was 65.1 years (SD 13.2). Cause of stroke (primary disease) was cerebral infarction in 12 subjects, and intracranial hemorrhage in 11. Hemiplegia was left-sided in 14 subjects, and right-sided in nine. The Brunnstrom stage ≤ II subgroup comprised eight subjects, while the Brunnstrom stage ≤ III subgroup comprised 15 subjects. In the intervention group, the average age of the subjects was 67.0 years (SD12.0).

Cause of stroke was cerebral infarction in 12 patients and intracranial hemorrhage in three. Hemiplegia was left-sided in 11 subjects, and right-sided in four. The Brunnstrom stage ≤ Ⅱ subgroup comprised four subjects, while the Brunnstrom stage ≥ Ⅲ subgroup comprised 11 subjects.

Changes in muscle mass and decrease rates for each Brunnstrom subgroup in the intervention and control groups are shown in Table 2. The decrease in muscle mass in the control group was 292g (SD 239) on the paralyzed side and 123 g (SD 277) in the Brunnstrom stage ≥ Ⅲ subgroup. The decrease rate was 5.0% (SD 4.2) on the paralyzed side and 2.0% (SD4.5) on the non-paralyzed side; thus, a significant difference was observed ($P<0.05$). In the Brunnstrom stage ≤ Ⅱ subgroup, the decrease was 609g (SD 233) and 316 g (SD 303) on the paralyzed and non-paralyzed sides, respectively. Although the difference in decrease rate between the paralyzed and non-paralyzed sides, 9.0% (SD 3.5) and 5.0% (SD4.2), respectively, was not significant, a clear trend ($P=0.07$) was observed.

On the other hand, the decrease in muscle mass was only 77 g (SD 295) on the paralyzed side and 131 g (SD 334) on the non-paralyzed side in the Brunnstrom stage ≥ Ⅲ subgroup of the intervention group. The decrease rate was almost identical between the paralyzed and non-paralyzed sides (1.6% (SD4.4) and 1.9% (SD 5.0), respectively), and no significant difference was observed. The same trend was observed in the Brunnstrom stage ≤ Ⅱ subgroup; no significant difference was observed between the paralyzed and non-paralyzed sides in decrease in muscle mass, 267g (SD 203) and 282 g (SD 406), or in decrease rate, 4.8% (SD 4.0) and 4.8% (SD6.5), respectively.

Table 1 Background of subjects

	control group N=23	intervention group N=15	Total N=38
Gender Male	14	10	24
Female	9	5	14
Age 40−49	3	1	4
50−59	7	3	10
60−69	2	3	5
70−79	7	6	13
Above 80	4	2	6
Average (SD)	65.1 (SD13.2)	67.0 (SD12.0)	
Primary disease Cerebral infarction	12	12	24
Intracranial hemorrhage	11	3	14
Side of paralysis Right	9	4	13
Left	14	11	25
Degree of hemiplegia Brunnstrom stage (lower extremities)			
stage Ⅲ ~ Ⅴ	15	11	26
stage Ⅰ ~ Ⅱ	8	4	12

Table 2 Average decrease and rate of decrease of lower extremity muscle mass

	Brunnstrom stage		Muscle amount decrease (g) Mean (SD)	Decrease rate (%) Mean (SD)	Wilcoxon matched-pair signed-rank test
control group	stage Ⅲ or above				
	Paralyzed side	15	292 (239)	5.0 (4.2)	*
	Non-paralyzed side	15	123 (277)	2.0 (4.5)	
	stage Ⅱ or below				
	Paralyzed side	8	609 (233)	9.0 (3.5)	n.s.
	Non-paralyzed side	8	316 (303)	4.8 (3.9)	
intervention group	stage Ⅲ or above				
	Paralyzed side	11	77 (295)	1.6 (4.4)	n.s.
	Non-paralyzed side	11	131 (334)	1.9 (5.0)	
	stage Ⅱ or below				
	Paralyzed side	4	267 (203)	4.8 (4.0)	n.s.
	Non-paralyzed side	4	282 (406)	4.8 (6.5)	

(*; $P<0.05$ n.s.: not significant)

Discussion

With the recent progress in our understanding of rehabilitation programs for post-stroke patients in the acute period, the importance of providing such rehabilitation in the acute period is being recognized. However, post-stroke bedridden patients in the acute period after onset to are treated according to 2 contradicting methods, rest based on the acute period management and exercise for prevention of disuse syndromes, and thus tend to be maintained in the bedridden status. Furthermore, the need for rehabilitation has been recognized[10] according to the actual situation of disuse muscle atrophy in the lower extremity muscles in post-stroke patients[3,10]. However, no standardized practical methods have been established. By actively providing a rehabilitation program for bedridden patients in the acute stage, it is possible to break the vicious circle of disuse syndromes[13], and contribute to improvement of QOL of patients by helping to reduce the hospitalization period and return to work.

Studies using several conventional evaluation methods for disuse muscle atrophy in post-stroke patients have been reported, including methods to estimate the decrease in lower extremity muscle mass based on muscle cross sections using CT[3,9] and ultrasound echo[6,7], and a method to measure muscle mass only on the healthy side using a dynamometer[4]. The DXA method utilized in the present study was originally used to measure bone density. Because the method allows measurement of individual body components (bone, muscle and fat) in the right and left lower extremities[14], and the measurement error is as low as 0.2-2.2%[14,15], it is possible to accurately evaluate the entire muscle mass of left and right lower extremities.

For intervention, exercises were designed to facilitate muscle contraction of flexor and extensor muscles in the lower extremities, and to consist of movements in the daily lives of bedridden patients. By including the series of movements described above, which are associated with movements with bent-knees pointing upwards and kick-up movements, it was expected that isotonic muscle contraction (kick up) and closed kinetic chain (hip raise)[12] would be activated. Although a short period of time, 10 minutes a day, was spent on exercise, the exercise load was not insufficient according to the report by Hettinger, et al.[16], which suggested that performing muscle contraction exercises for 6 seconds a day increased muscle mass, and was equivalent to the level of training reported by Ichihashi, et al.[17].

In the intervention group, changes in muscle mass on the paralyzed and non-paralyzed sides were almost equivalent in both the Brunnstrom stage ≥ Ⅲ subgroup and the Brunnstrom stage ≤ Ⅱ subgroup, and the decrease rate was as low as 2 % and 5 % in the Brunnstrom stage ≥ Ⅲ subgroup and Brunnstrom stage ≤ Ⅱ subgroup, respectively. On the other hand, differences in muscle mass decrease were observed between the paralyzed side, approximately 609 g (9.0%), and non-paralyzed side, approximately 300 g (5.0%), in the Brunnstrom stage ≤ Ⅱ subgroup of the control group. Standard deviations were large in the present study. This was assumed to be because muscle changes were expressed as a difference between the muscle mass in the first measurement and second measurement, and there were some cases in which muscle mass increased. Such cases were particularly observed in the Brunnstrom stage ≥ Ⅲ subgroup of the intervention group, and increase rates were highly diverse. Such issues should be examined in future research.

Having post-stroke patients with hemiplegia perform a series of back-lying exercises, including hip raises with bent knees pointing upwards, in intervention makes them realize that such movements are "preferable movements;" therefore, it was assumed that the activity level of the lower extremities with bent knees pointing upwards was increased in bedridden patients. Because objective observation of activity levels of the lower extremities with bent knees pointing upwards was not achieved in the present study, further study investigating this issue is needed. The present study revealed that intervention reduced the loss of muscle mass in the lower extremities; however, it remains unclear which parts exhibited less reduction in muscle mass. This should also be investigated in future research.

It is expected that the series of exercises used in the present study is applicable to not only post-stoke patients but also to bedridden patients with severe diseases. By conducting further studies in which frequency and intensity of the series of back-lying movements are observed in daily life, better movement support methods could be designed.

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