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Original Article

Differences in activities of daily living between people with subacute stroke who received knee-ankle-foot and ankle-foot orthoses at admission

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Abstract. [Purpose] This study aimed to identify the preferential factor of activities of daily living disabilities for selecting between knee-ankle-foot orthosis and ankle-foot orthosis prescription in the early stage after admission. [Participants and Methods] This study included 442 inpatients who had a subacute stroke and received either knee-ankle-foot orthosis or ankle-foot orthosis after admission (mean age, 69 years). The functional independence measure was investigated within 1 week after admission. [Results] Inpatients who had a stroke and received knee-ankle-foot orthosis had significantly lower scores for all individual functional independence measure items than those who received ankle-foot orthosis. Logistic regression analysis revealed that functional independence measure transfer (bed, chair, and wheelchair) was closely associated with the difference in the prescribed lower limb orthosis after multivariate adjustment. [Conclusion] Compared with ankle-foot orthosis, knee-ankle-foot orthosis was prescribed to inpatients with more-severe disabilities, and the difference in the disability related to performing transfer activities was more noticeable than that in disability related to mobility between inpatients for whom knee-ankle-foot orthosis was prescribed and those for whom ankle-foot orthosis was prescribed. To provide effective rehabilitation for people who had a subacute stroke, for whom use of knee-ankle-foot orthosis or ankle-foot orthosis is recommended. The evaluation and intervention focused on standing performance related to performing transfer such as sit-to-stand, standing, moving while standing, and stepping might be a priority in the early stage after admission.

Key words: Stroke, Lower-limb orthosis, Activities of daily living

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INTRODUCTION

Knee-ankle-foot orthosis (KAFO) and ankle-foot orthosis (AFO) are used in stroke rehabilitation mainly to enable individuals with stroke to perform standing and walking exercise early after onset in order to facilitate recovery from impairments after stroke and improve the ability to perform activities of daily living (ADL) by compensating for the impairments in the paretic lower limb. The guidelines for the management of stroke reported by the Heart and Stroke Foundation[1)], Royal College of Physicians[2)], National Stroke Foundation[3)], Stroke Foundation of New Zealand[4)], Healthcare Improvement Scotland[5)], and American Heart Association/American Stroke Association[6)] recommend the use of AFO for individuals

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with stroke, especially for those who have foot drop while walking to improve foot drop. In addition, the use of AFO has been reported to improve not only balance and walking abilities[7] but also abilities to perform ADL at discharge from the rehabilitation hospital[8].

In contrast, KAFO prevents knee collapse or buckling while standing and walking and is used to help stabilize the paretic lower limb. KAFO has been reported to improve walking speed in individuals with stroke who have genu recurvatum while walking[9]. Walking exercise with KAFO early after onset for severe stroke may improve impairments after stroke. Thus, AFO and KAFO are used differently depending on the clinical conditions and disabilities that need to be improved.For more effective and efficient rehabilitation using lower-limb orthosis, individually prescribing appropriate lower-limb orthosis early after onset is important. However, reports on the criteria for the prescription of lower-limb orthosis are limited. For selecting KAFO or AFO, the assessment of motor paralysis of the paretic lower limb and of standing and walking performance has been recommended[10]. However, how to select lower-limb orthosis for individuals with subacute stroke early after onset is unclear.

Furthermore, because lower-limb orthosis is used to enable individuals with stroke to perform standing exercise early after onset and to regain walking ability impaired by stroke, disabilities related to standing and walking would reflect ADL disabilities. However, in our knowledge, there are no reports that difference in ADL disabilities between individuals with subacute stroke who are prescribed KAFO and AFO.

The aim of this study was to identify the preferential factor of ADL disabilities for selecting KAFO or AFO prescription, and we investigated the characteristics of ADL disabilities in inpatients with subacute stroke who were prescribed KAFO or AFO in the early stage after admission.

PARTICIPANTS AND METHODS

This study included 442 inpatients with subacute stroke (mean age, 69 ± 13 years; mean post-stroke interval at admission, 35 ± 12 days) who were prescribed a metal KAFO or a metal AFO after admission. The participants were admitted to the rehabilitation hospital between 2006 and 2011. Inclusion criteria was post-stroke interval at admission within 60 days. This study excluded inpatients who were diagnosed with subarachnoid hemorrhage. KAFO and AFO were prescribed mainly to enable inpatients with stroke to stand and walk early after onset at the hospital where all inpatients were admitted (mean period from admission to lower-limb orthosis prescription, 11 ± 11 days). Doctor, physical therapist and prosthetist evaluated whether to provide inpatient with a KAFO or AFO early after admission. Lower-limb orthosis was prescribed based on the results of evaluation of standing and walking performance with or without the use of lower-limb orthosis similar to other institutions[11]. KAFO was provided when (1) the patient was able to undergo standing or walking training but the knee and ankle joints were unstable due to severe motor impairments; (2) the patient exhibited spasticity patterns predominantly in the flexor muscles and could not keep a knee extension position while standing or walking; and (3) the patient displayed insufficient knee control or knee instability and an AFO was insufficient to adequately control knee instability[11]. All of KAFO or AFO provided inpatients were traditional. The inpatients were divided into two groups: KAFO and AFO groups. The KAFO group comprised participants who were prescribed KAFO (n=290), whereas the AFO group comprised participants who were prescribed AFO (n=152). This study was approved by the institutional review board of Hatsudai Rehabilitation Hospital (H27-85) and Kyorin University (28-4). All participants provided written informed consent.

Outcome measures were basic characteristics, physical function at admission, and abilities to perform ADL at admission. For basic characteristics, age, gender, stroke type, lesion side, post-stroke interval at admission or lower-limb orthosis prescription, and period from admission to lower-limb orthosis prescription were investigated. For physical function at admission, Brunnstrom stage (BS)[12] of the paretic lower limb was assessed by physical therapists. For abilities to perform ADL at admission, functional independence measure (FIM)[13] was assessed by the medical staff (nurse, care worker, physical therapist, occupational therapist, or speech therapist) trained on this assessment. All assessments were performed within 1 week after admission.

The FIM consists of 18 items divided into motor and cognitive domains[13]. The motor domain includes 13 items composed of four subscales: self-care, sphincter control, transfer, and mobility. The cognitive domain includes five items composed of two subscales: communication and social cognition. All items are scored using a 7-point ordinal scale. A score of 1 indicates complete dependence, whereas a score of 7 indicates complete independence. Higher FIM scores indicate higher levels of independence. The total functional independence measure (tFIM) score, which is the sum of all scores for the 18 items, the motor domain of functional independence measure (mFIM) subscore, which is the sum of the scores for the 13 items of the motor domain, and the cognitive domain of functional independence measure (cFIM) subscore, which is the sum of the scores for the 5 items of the cognitive domain, were calculated.

To compare the basic characteristics (gender, stroke type, lesion side) and physical function (BS of the paretic lower limb) at admission between the KAFO and AFO groups, a χ^2 test was performed. To compare age, post-stroke interval at admission or lower-limb orthosis prescription, and period from admission to lower-limb orthosis prescription between the two groups, a two-sample t-test was also performed. To compare FIM scores between the two groups, Mann-Whitney U test was conducted.

Forward stepwise logistic regression analysis was used to identify factors determining abilities to perform ADL associated with difference in prescribed lower-limb orthosis (0: KAFO, 1: AFO) after adjusting for confounding factors (i.e., age, gender

[0: female, 1: male], lesion side [0: left, 1: right], period from admission to lower-limb orthosis prescription). First, tFIM score and BS of the paretic lower limb were entered into the regression model (step 1). Second, mFIM and cFIM subscores and BS of the paretic lower limb were entered (step 2). Finally, scores for the three items of the FIM transfer subscale and two items of the FIM mobility subscale and BS of the paretic lower limb were entered (step 3).

The statistical significance level was set at 0.05. All analyses were conducted using IBM SPSS version 23.0 (IBM Corp., Chicago, IL, USA).

RESULTS

With respect to the comparison of basic characteristics between the two groups, the two-sample t-test indicated that the participants in the KAFO group were significantly older than those in the AFO group. Further, the χ^2 test indicated that the proportion of participants who were female and had infarction was greater in the KAFO group, whereas the proportion of participants who were male and had hemorrhage was greater in the AFO group (Table 1).

Regarding the comparison of physical function at admission between the two groups, the chi-square test indicated that the proportion of participants with BS I and II was greater in the KAFO group, whereas the proportion of participants with BS III was greater in the AFO group (Table 2).

With respect to the comparison of abilities to perform ADL at admission, the two-sample t-test indicated that the participants in the KAFO group had significantly lower tFIM score, mFIM and cFIM subscores, and scores for all FIM items than those in the AFO group (Table 3).

The logistic regression analysis indicated that tFIM score in step 1, mFIM subscore in step 2, and score for the FIM transfer (bed, chair, wheelchair) item in step 3 were significantly associated with difference in prescribed lower-limb orthosis. In all steps of the logistic regression analysis, BS of the paretic lower limb was also significantly associated with difference in prescribed lower-limb orthosis (Table 4).

Table 1. Comparison of basic characteristics between the KAFO and AFO groups

	KAFO group (n=290)	AFO group (n=152)	p
Age, years[a]	73 ± 11	63 ± 14	<0.001
Gender (female/male), n[b]	140/150	40/112	<0.001
Stroke type (infarction/hemorrhage), n[b]	165/125	68/84	0.015
Lesion side (left/right), n[b]	177/113	82/70	0.151
Post-stroke interval at admission, days[a]	35 ± 13	34 ± 12	0.591
Post-stroke interval at lower-limb orthosis prescription, days[a]	46 ± 18	46 ± 17	0.941
Period from admission to lower-limb orthosis prescription, days[a]	11 ± 11	12 ± 11	0.621

[a]Two-sample t-test was used to compare the differences between the KAFO and AFO groups.[b]χ^2 test was used to compare the differences between the KAFO and AFO groups. The threshold for significance was $p<0.05$. KAFO: knee-ankl-foot orthosis; AFO: ankle-foot orthosis.

Table 2. Comparison of Brunnstrom stage of the paretic lower limb at admission between the KAFO and AFO groups

Brunnstrom stage		KAFO group	AFO group	All participants
I	n	14	0	14
	Adjusted residuals	2.75	−2.75	
II	n	163	29	192
	Adjusted residuals	7.48	−7.48	
III	n	94	105	199
	Adjusted residuals	−7.36	7.36	
IV	n	15	15	30
	Adjusted residuals	−1.86	1.86	
V	n	4	3	7
	Adjusted residuals	−0.48	0.48	
All participants	n	290	152	442

$p<0.001$, $\chi^2=72.226$. KAFO: knee-ankle-foot orthosis; AFO: ankle-foot orthosis.

Table 3. Comparison of FIM scores at admission between the KAFO and AFO groups

	KAFO group	AFO group	p	Difference between mean scores
tFIM	35.1 ± 14.5	57.4 ± 18.6	<0.001	22.4
mFIM	21.4 ± 8.8	36.5 ± 12.5	<0.001	15.1
cFIM	13.7 ± 7.2	20.9 ± 8.2	<0.001	7.2
Eating	2.8 ± 1.9	5.1 ± 1.7	<0.001	2.3
Grooming	2.1 ± 1.3	3.9 ± 1.6	<0.001	1.8
Bathing	1.5 ± 0.8	2.5 ± 1.0	<0.001	1.0
Dressing, upper body	1.5 ± 0.7	2.5 ± 1.3	<0.001	1.0
Dressing, lower body	1.2 ± 0.5	1.9 ± 1.2	<0.001	0.7
Toileting	1.2 ± 0.5	2.1 ± 1.4	<0.001	0.9
Bladder management	1.9 ± 1.6	3.9 ± 2.4	<0.001	2.1
Bowel management	2.3 ± 1.8	4.3 ± 2.1	<0.001	2.0
Transfer (bed, chair, wheelchair)	1.7 ± 0.7	2.9 ± 1.2	<0.001	1.2
Transfer (toilet)	1.6 ± 0.8	2.8 ± 1.2	<0.001	1.2
Transfer (tub, shower)	1.4 ± 0.6	2.2 ± 1.0	<0.001	0.7
Walk/wheelchair	1.1 ± 0.4	1.4 ± 1.0	<0.001	0.3
Stairs	1.0 ± 0.0	1.1 ± 0.3	0.002	0.1
Comprehension	3.3 ± 1.8	4.6 ± 1.9	<0.001	1.3
Expression	3.1 ± 2.0	4.3 ± 2.1	<0.001	1.1
Social interaction	3.3 ± 2.1	5.1 ± 2.0	<0.001	1.8
Problem solving	2.1 ± 1.5	3.7 ± 2.0	<0.001	1.5
Memory	1.9 ± 1.2	3.3 ± 1.9	<0.001	1.5

KAFO: knee-ankle-foot orthosis; AFO: ankle-foot orthosis; tFIM: total functional independence measure; mFIM: motor domain of functional independence measure; cFIM: cognitive domain of functional independence measure.

Table 4. Association of BS of the paretic lower limb and FIM with difference in prescribed lower-limb orthosis

	Step 1			Step 2			Step 3		
Variable	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Age	0.985	0.963–1.008	0.193	0.99	0.968–1.014	0.417	0.971	0.951–0.992	0.007
Gender	3.128	1.771–5.525	<0.001	2.952	1.666–5.231	<0.001	2.16	1.264–3.694	0.005
Lesion side	0.353	0.202–0.618	<0.001	0.499	0.29–0.861	0.013	0.731	0.434–1.230	0.238
Post-stroke interval at lower-limb orthosis prescription	1.019	1.003–1.035	0.023	1.017	1.001–1.033	0.041	1.011	0.996–1.026	0.144
BS of the paretic lower limb	2.117	1.416–3.164	<0.001	2.332	1.569–3.466	<0.001	2.449	1.679–3.572	<0.001
tFIM	1.080	1.059–1.101	<0.001						
mFIM				1.128	1.095–1.163	<0.001			
cFIM									
Transfer (bed, chair, wheelchair)							2.965	2.156–4.077	<0.001
Transfer (toilet)									
Transfer (tub, shower)									
Walk/wheelchair									
Stairs									
Hosmer–Lemeshow test			0.162			0.162			0.162

OR: odds ratio; CI: confidence interval; tFIM: total functional independence measure; mFIM: motor domain of functional independence measure; cFIM: cognitive domain of functional independence measure; BS: Brunnstrom stage.

DISCUSSION

We hypothesized that severity of ADL affects assessments and interventions for using lower limb orthoses because lower limb orthoses are used to improve ADL. However, in our knowledge, there is no reports about the difference in ADL disabilities between individuals with subacute stroke who are prescribed KAFO and AFO. Thus, in order to identify the preferential factor of ADL disabilities for selecting KAFO or AFO, we investigated the differences in characteristics of ADL disabilities in inpatients with subacute stroke who were prescribed KAFO or AFO in the early stage after admission. This study's results indicated that motor paralysis of the paretic lower limb and ADL disabilities assessed by FIM were associated with difference between inpatients with subacute stroke who were prescribed KAFO or AFO. In particular, the ability to perform transfer was closely associated with the difference between patients with subacute stroke who were prescribed KAFO or AFO.

Because the assessment of motor paralysis of the paretic lower limb was recommended for selecting KAFO or AFO[10], motor paralysis of the paretic lower limb, assessed by BS, was compared between groups. It was recommended that KAFO be prescribed to individuals with stroke who had BS I or II or who had BS III and could not stand using a rail or perform straight leg raise[10]. Sugimoto et al. reported that the proportion of individuals with BS I and II was higher in those with stroke who were prescribed KAFO than in those with stroke who were prescribed AFO[14]. Thus, the severity of motor paralysis in participants who were prescribed KAFO in this study would be comparable with that in individuals in whom KAFO prescription was recommended.

BS, which was used to assess the motor paralysis of the paretic lower limb, was significantly associated with a difference between inpatients with subacute stroke who were prescribed KAFO or AFO in all steps of the logistic regression analysis. Lower-limb orthosis is mainly used to compensate for the impairments in the paretic lower limb; the assessment of BS was recommended for selecting KAFO or AFO, as reported by Otake[10]. BS I and II, which were frequent in patients with subacute stroke who were prescribed KAFO, represent the stages of flaccid paralysis and appearance of spasticity in the paretic lower limb, respectively, and may indicate that both voluntary movement and stability of the paretic lower limb are markedly reduced. In contrast, BS III, which was frequent in patients with subacute stroke who were prescribed AFO, refers to the stage of increased spasticity with synergistic voluntary movement and may indicate that weight-bearing on the paretic lower limb is possible without knee collapse compared with BS I and II. Thus, BS may reflect the function of the paretic lower limb while moving and was associated with difference between inpatients with subacute stroke who were prescribed KAFO or AFO.

With respect to the characteristics of ADL disabilities at admission, tFIM score, mFIM and cFIM subscores, and scores for all items of FIM were significantly lower in inpatients with subacute stroke who were prescribed KAFO than in those who were prescribed AFO. Based on the severity of FIM early after onset, tFIM scores of ≥81 points, 40–80 points, and ≤39 points were classified as mild, moderate, and severe, respectively[15]. In this study, the mean tFIM score and mFIM subscore of the KAFO group were 35.1 and 21.4 points, respectively, and the mean scores for all individual items of mFIM were 1.0 to 2.8 points. Most inpatients who were prescribed KAFO required complete and moderate assistance with ADL, which was assessed by FIM. In contrast, the mean tFIM score of the AFO group was 57.4 points. Based on these results, several inpatients who were prescribed KAFO in this study might have severe motor paralysis and ADL disabilities.

In all steps of the logistic regression analysis, motor paralysis of the paretic lower limb and tFIM score and mFIM subscore indicating ADL disabilities were associated with differences between inpatients with subacute stroke who were prescribed KAFO or AFO. Because activities required to regain and rehabilitation programs were different depending on the severity of ADL disabilities, it may be reasonable that the lower-limb orthosis used to improve ADL disabilities by compensating for impairment is also different. Therefore, ADL disabilities might be associated with a difference in prescribed lower-limb orthosis.

In the logistic regression analysis in which scores for the three items of the FIM transfer subscale, two items of the FIM mobility subscale, and BS of the paretic lower limb were entered, the FIM transfer (bed, chair, wheelchair) item was closely associated with a difference in the prescribed lower-limb orthosis. Several inpatients who were prescribed KAFO or AFO required complete assistance with mobility at admission to the rehabilitation hospital, and the difference in mobility independence between the groups was less. Two items of the FIM mobility subscale were not associated with difference in prescribed lower-limb orthosis. In contrast, for items of the FIM transfer subscale that were associated with a difference in the prescribed lower-limb orthosis, several inpatients who were prescribed KAFO required complete and maximal assistance, whereas those who were prescribed AFO needed moderate assistance in this study. Because the difference in transfer independence between groups was more than that in mobility independence, the FIM transfer (bed, chair, wheelchair) item might be associated with a difference in the prescribed lower-limb orthosis.

The main structural difference between KAFO and AFO is whether the knee joint is immobilized. For selecting KAFO or AFO, assessment of the stability of the paretic lower limb while standing and walking has been recommended[10]. In fact, transferring involves motions that require voluntary movement, such as extension and flexion of the knee joint while standing, and stability to maintain the extension position of the knee joint while standing. Because of these performance characteristics of transferring, the FIM transfer item might be associated with a difference in the prescribed lower-limb orthosis.

For selecting KAFO or AFO, assessment of motor paralysis of the paretic lower limb and of standing and walking per-

formance was recommended[10]. In this study, BS was also associated with a difference in the prescribed lower-limb orthosis. However, the odds ratio for the FIM transfer (bed, chair, wheelchair) item was higher than that for BS in the logistic regression analysis. To provide effective rehabilitation for people with subacute stroke who were recommended to use KAFO or AFO, evaluation and intervention focused on standing performance related to performing transfer, such as sit-to-stand, standing, moving while standing, and stepping, and standing balance might be prior in the early stage after admission. Although these results of this study were based on data from one facility, it might be clarified the characteristics of ADL disabilities in people with subacute stroke who are prescribed KAFO or AFO in clinical setting.

A limitation of this study is that it did not address the effect of types of orthosis joints on the characteristics of ADL disabilities in inpatients with subacute stroke who were prescribed KAFO or AFO, although preferential selection of joint types was required. Additionally, impairments except for BS were not investigated, while we were unable to identify whether any particular impairments might affect the difference in the disability related to performing transfer and mobility activities between inpatients prescribed KAFO and AFO.

Conflict of interest

None.

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