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RESEARCH PAPER

The impact of changes in physical activity on functional recovery for older inpatients in post-acute rehabilitation units

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Key summary points

Aim We investigated the relationship between physical activity and functional recovery in post-acute rehabilitation units.

Findings Decreased sedentary behavior time and increased total physical activity time were associated with high functional recovery.

Message Interventions for physical activity duration may be effective in improving activities of daily living in post-acute and subacute older patients.

Abstract

Purpose The effect of increased physical activity duration on functional recovery in older inpatients in subacute settings is not well established. This study aimed to investigate the relationship between physical activity and functional recovery in older patients receiving post-acute and subacute care.

Methods We analyzed cohort data of hospitalized older patients (age $\geq$ 65 years) in the post-acute rehabilitation units. The main outcome was functional independence measure (FIM) gain. Physical activity was measured using a triaxial accelerometer. Changes in sedentary behavior and total physical activity time from admission to discharge were measured as changes in each physical activity time. Logistic regression analysis was performed to examine the relationship between changes in physical activity and FIM gain.

Results A total of 210 patients were eligible for analysis. The mean age of the study patients was 83.6 $\pm$ 7.2 years, and 63.8% ($n = 134$) were female. According to the multivariate regression analysis, changes in sedentary behavior time were significantly associated with high recovery of FIM gain (odds ratio [OR] 0.996, 95% confidence interval [CI]: 0.993–1.000; $p = 0.026$), and changes in total physical activity time also showed a similar association (OR 1.006, 95% CI 1.000–1.011; $p = 0.041$).

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Conclusion Decreased sedentary behavior time and increased total physical activity time were significantly associated with high functional recovery in post-acute rehabilitation units. These results suggest that interventions for physical activity duration may be effective in improving activities of daily living in older post-acute and subacute patients.

Keywords Post-acute · Subacute · Rehabilitation · Community-based integrated care units · Older patients · Physical activity · Functional recovery

Introduction

Functional decline during hospitalization, which is called "hospital associated disability" is a huge problem especially for older patients. In the acute ward, one-third to one-half of older patients experience functional decline [1–5], and many patients remain restricted in activities of daily living (ADL) a year after discharge [3]. Furthermore, functional decline during hospitalization is associated with institutionalization [6] and mortality [3]. Therefore, post-acute care for functional recovery has become important owing to the increasing aging population [7].

In Japan, community-based integrated care units were established in 2014 to provide post-acute rehabilitation [8]. The primary objective of these units is to facilitate functional recovery in older patients. However, in addition, they provide respite care and other services. Nevertheless, achieving sufficient functional recovery is difficult because many patients experience negative factors for functional improvement such as older age, requiring long-term care, cognitive decline, physical inactivity, and malnutrition [9, 10] in post-acute rehabilitation units. Therefore, it is necessary to improve or support variable factors among these negative factors during early hospitalization.

Reducing sedentary time and promoting physical activity are important for improving functional recovery in older patients. It is well known that hospitalized older patients become inactive from the time of admission [11–13], and this lifestyle leads to adverse health outcomes, such as muscle wasting [14, 15] and declining cardiovascular health [16], and even has a negative impact on functional recovery [17]. Among them, the effect of promoting increased activity time/decreased inactivity time on functional recovery is well established for some diseases, such as stroke [18, 19] and postoperative lower extremity [20, 21]. In addition, recent studies have shown that even light-intensity physical activity may effectively improve physical function in patients with poor physical function [22, 23]. However, this has not been established for older inpatients in post-acute settings with a variety of primary conditions and negative factors.

Therefore, this study aimed to investigate the relationship between changes in physical activity and functional improvement in older patients in post-acute rehabilitation units. We believe that the current study provides novel information that will help in the functional improvement of older patients in the post-acute and subacute phases.

Methods

Study design and participants

This prospective cohort study included older patients admitted to the community-based integrated care units of Shonan Keiiku Hospital, Fujisawa, Japan, from October 2020 to January 2022. The inclusion criteria were patients aged 65 years and older. The exclusion criteria were patients who did not intend to improve ADL; who were not intended for post-acute rehabilitation, independent ADL at admission, ADL limitations due to rest management, difficulty in communication, hospitalization for less than one week, readmission during the study period, hospital transfer, missing data, and death during hospitalization. The determination of "patients not intending to improve ADL" was made via a pre-admission interview with the patient, family, and medical staff. This study was conducted in accordance with the Declaration of Helsinki, and the study protocol was reviewed and approved by the Ethics Committee of Shonan Keiiku Hospital. Written informed consent was obtained from all the participants or their families.

Rehabilitation program

All patients underwent rehabilitation for 40–60 min daily during hospitalization under the medical insurance system. Rehabilitation programs were individually designed according to health conditions and goals for each patient and included gait training, balance exercises, strength exercise, self-care skills training, and swallowing training by physical, occupational, and speech therapy.

Measurements

Outcome

The outcome of the current study was functional independence measure (FIM) gain. The FIM is an indicator of ADL and consists of a motor domain of 13 sub-items and a cognitive domain of five sub-items [24]. The scores were evaluated on a 7-point scale ranging from 1 (total assistance) to 7 (complete independence). The total FIM scores range from 18 to 126, with lower scores indicating greater dependency. The FIM gain was obtained by subtracting the admission scores from the discharge scores [25]. We operationally defined the third quartile or higher for FIM gain as a high level of recovery for ADL. In this study, well-trained physical therapists assessed the FIM.

Physical activity

We investigated the amount of 3 days' physical activity at two time points: immediately after admission and immediately before discharge. Physical activity was measured using a triaxial accelerometer (Active Style Pro HJA-750C; Omron Healthcare Co. Ltd. Kyoto, Japan; 52 × 40 × 12 mm, weighing approximately 23 g, and including a battery), which can estimate metabolic equivalents (METs) from a wide range of body movements during ADL [26, 27]. The accelerometer was worn on the waist for 24 h, excluding the dressing and bathing times. We analyzed the acceleration data between 5:00 AM and 0:00 AM each day and estimated the METs every 60 s. From the estimated METs data, we calculated time (min/day) spent in sedentary behavior (≤ 1.5 METs) [28] and in total physical activity (≥ 1.6 METs). We defined total physical activity as an accumulation of light-intensity (1.6 < 3.0 METs), moderate (3.0–6.0 METs), and vigorous (> 6.0 METs) physical activity [29]. We defined the changes in sedentary behavior and total physical activity time from admission to discharge as the change in each physical activity time.

Other variables

Demographic and clinical characteristics, including age, sex, body mass index (BMI), reason for admission to the acute ward, comorbidities, length of hospital stay, requirement for long-term care, cognitive function, depression, physical function and nutritional intake were investigated. Comorbidity was assessed using the Charlson comorbidity index (CCI) [30], and we defined scores 3 or more as disease severity [31]. We defined requiring long-term care as all care need levels (one to five) according to the standards for long-term care requirement certification in Japan [32]. Cognitive function was assessed using the Mini-Mental State Examination (MMSE) [33], which ranges from 0 to 30; we defined scores of 23 or less as cognitive dysfunction [34]. Depression was assessed using the 15-item Geriatric Depression Scale (GDS-15) [35]. Physical function was assessed using the Berg balance scale (BBS), which ranges from 0 to 56; we defined a score of 45 or less as low physical function [36]. Nutritional intake was estimated as the average calorie intake per actual body weight per day based on the intake rate of the main and side dishes recorded by the nurse during the three days (9 meals) immediately after admission [10].

Statistical analysis

We compared all variables between the high recovery of FIM gain group and the low recovery group using the chi-square test, t-test, or Mann–Whitney U test for categorical or continuous variables. Logistic regression analysis was used to estimate the odds ratios (OR) and 95% confidence intervals (CI) of the relationships between changes in physical activity (sedentary behavior and total physical activity) and FIM gain. Demographic details and level of physical activity were used as covariates to adjust for confounding factors in the multivariate logistic regression models (model 1: adjusted for age, sex, CCI, MMSE, and BBS; model 2: model 1 + changes in sedentary behavior or changes in total physical activity). All statistical analyses were performed using the IBM SPSS for Mac (version 27.0; IBM Japan, Tokyo, Japan). Statistical significance was set at $p < 0.05$.

Results

Of the 620 patients enrolled in the study, 410 were excluded based on the aforementioned exclusion criteria, resulting in 210 eligible patients for analysis (Fig. 1). Most of the excluded patients were those not intending to improve ADL, such as those in respite care or for whom rehabilitation was not prescribed because ADL had not declined. The clinical and demographic characteristics of patients in the high recovery (FIM gain) and low recovery groups are shown in Table 1. The mean age of the study patients was 83.6 ± 7.2 years, and 63.8% (n = 134) of them were female. The comparison between the two groups showed significant differences in sex ($p = 0.041$), requirement for long-term care ($p = 0.002$), MMSE ($p = 0.027$), BBS ($p < 0.001$) and FIM scores at discharge ($p < 0.001$).

FIM gain, changes in sedentary behavior, and total physical activity time are shown in Table 2. The median FIM gains (interquartile range [IQR]) in the high and low recovery groups were 26 and 9 (3–14), respectively ($p < 0.001$). The high recovery group showed a significant decrease in sedentary behavior time ($p < 0.001$) and a significant increase in total physical activity time ($p < 0.001$) compared with the low recovery group. According to the multivariate logistic regression analysis, changes in sedentary behavior time were significantly

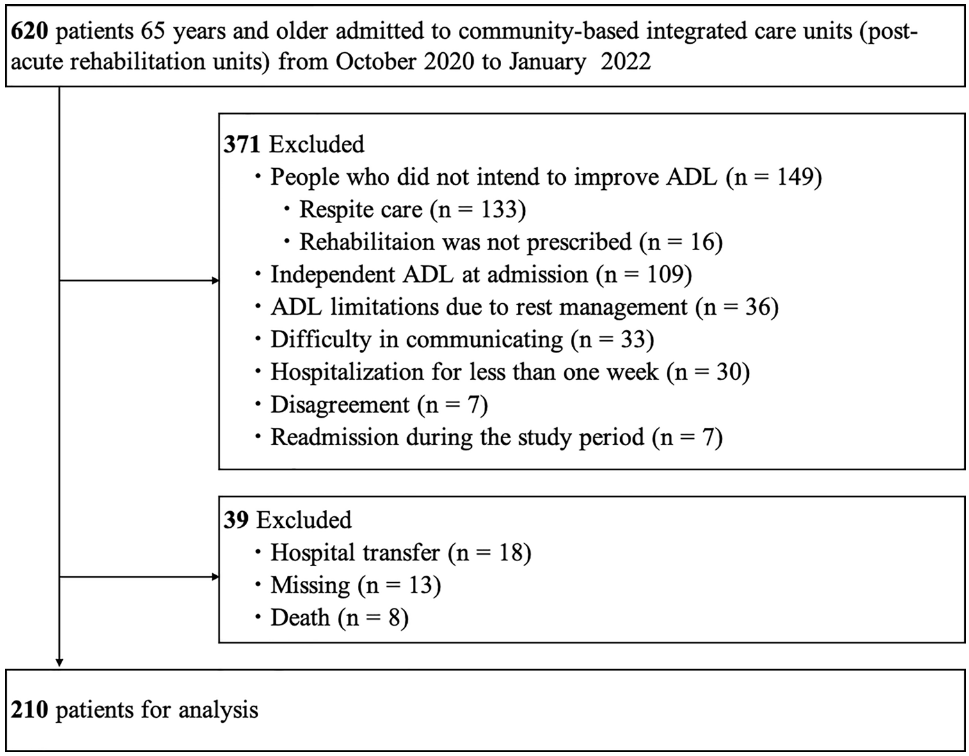

Fig. 1 Diagram of the selection process for participants. ADL, activities of daily living

associated with high recovery of FIM gain (OR 0.996, 95% CI 0.993–1.000; $p = 0.026$), and changes in total physical activity time also showed a similar association (OR 1.006, 95% CI 1.000–1.011; $p = 0.041$) (Table 3).

Discussion

This prospective cohort study investigated the relationship between changes in physical activity and functional recovery in subacute and post-acute older patients. We found that greater changes in sedentary behavior time and amount of physical activity were significantly associated with high functional recovery after adjusting for covariates. This result suggests that reducing sedentary behavior time and increasing amount of physical activity may be valuable factors for functional recovery in older patients in post-acute rehabilitation units.

Two characteristic differences were observed in the group comparisons. First, the high functional recovery group had significantly more female than male patients, similar to previous surveys [37]. In acute rehabilitation units, it has been suggested that women may be more active in physical exercises [38]. Thus, women may experience a better effect of physical activity on functional recovery than men. Second, no group differences were found in comorbidities. Although the CCI indicates the extent of complications, its content does not necessarily contribute to functional recovery. This is because the CCI does not adequately assess geriatric syndrome, which significantly affects functional recovery in older patients.

The amount of physical activity for these study participants was only 1.5 h/day, which is similar to that of patients in acute care wards [39, 40]. It is well known that this inactivity leads to functional decline in acute patients but is not well established in post-acute patients. In the high functional recovery group, part of the sedentary time was replaced with physical activity time during the post-acute hospitalization period. These results suggest the need to promote physical activity for functional recovery in post-acute patients.

The current findings suggest that replacing sedentary time with physical activity may help prevent or improve functional decline caused by disuse. Reducing sedentary behavior in acute care units is important to prevent disuse syndrome [41, 42], and increasing the amount of physical activity leads to the recovery of lower extremity muscle strength and the cardiovascular system after the acute phase [43, 44]. Thus, sedentary and physical activity durations may be more likely to promote ADL recovery. In particular, post-acute patients are more likely to have limited physical activity owing to several impairments, psychological aspects, and disease management [45, 46] and disease management; therefore, replacing sedentary behavior with mild physical activity may have been successful.

Table 1 Comparison between the high and low recovery groups

	Overall (n = 210)	High recovery group (n = 53)	Low recovery group (n = 157)	*P*-value
Age, mean ± SD	83.6 ± 7.2	83.5 ± 7.2	83.6 ± 7.2	0.934
Female, n (%)	134 (63.8)	40 (75.5)	94 (59.9)	0.041
BMI, kg/m^2, median [IQR]	20.3 [17.9–23.1]	20.4 [17.9–23.2]	20.1 [17.6–23.0]	0.420
Reason for admission to acute ward				
Musculoskeletal system diseases, n (%)	80 (38.1)	25 (47.2)	55 (35.0)	0.116
Nervous system diseases, n (%)	52 (24.8)	9 (17.0)	43 (27.4)	0.129
Nutritional and metabolic diseases, n (%)	18 (8.6)	5 (9.4)	13 (8.3)	0.795
Genitourinary system diseases, n (%)	16 (7.6)	5 (9.4)	13 (8.3)	0.565
Circulatory system diseases, n (%)	13 (6.2)	3 (5.7)	10 (6.4)	0.853
Digestive system diseases, n (%)	12 (5.7)	2 (3.8)	10 (6.4)	0.481
Respiratory system diseases, n (%)	10 (4.8)	3 (5.7)	10 (6.4)	0.722
Others, n (%)	9 (4.3)	1 (1.9)	8 (5.1)	0.319
CCI, score, median [IQR]	2 [1–3]	2 [1–3]	2 [1–3]	0.856
Length of stay				
Acute ward, days, median [IQR]	9 [1.3–22.8]	8 [1–24]	11 [3–21]	0.433
Post-acute rehabilitation units, days, median [IQR]	51 [40–57]	52 [41–57]	51 [40–57]	0.490
Requiring long-term care, yes (%)	98 (46.7)	15 (28.3)	83 (52.9)	0.002
MMSE, score, median [IQR]	22 [16–25]	23 [19–26]	21 [16–25]	0.027
GDS-15, score, median [IQR]	5 [3–8]	5 [3–8]	5 [3–8]	0.656
BBS, score, median [IQR]	27 [12.3–38.0]	34 [23.0–44.0]	24 [11.0–37.0]	< 0.001
Nutritional intake, kcal/kg/day, mean ± SD	24.4 ± 8.6	25.3 ± 9.1	24.1 ± 8.5	0.371
Physical activity				
Sedentary behavior (≤ 1.5 METs), min/day, median [IQR]	1016.0 [942.0–1068.1]	1016.0 [949.3–1068.3]	1016.0 [938.7–1067.3]	0.874
Total physical activity (≥ 1.6 METs), min/day, median [IQR]	82.0 [42.4–143.3]	116.3 [49.0–167.7]	75.0 [38.7–134.3]	0.073
FIM				
At admission, score, median [IQR]	78 [60–94]	80 [69–96]	74 [57–94]	0.129
At discharge, score, median [IQR]	93 [71–110]	109 [101–118]	84 [63–104]	< 0.001

SD standard deviation, *IQR* interquartile range, *BMI* body mass index, *CCI* Charlson comorbidity index, *MMSE* Mini-Mental State Examination, *GDS-15* Geriatric Depression Scale-15, *BBS* Berg balance scale, *METs* metabolic equivalents, *FIM* functional independence measure

Table 2 Changes in physical activity time and FIM during hospitalization

	Overall (n = 210)	High recovery group (n = 53)	Low recovery group (n = 157)	*P*-value
FIM gain, score, median [IQR]	12 [4–19.8]	26 [23–32]	9 [3–14]	< 0.001
Changes in physical activity time				
Sedentary behavior (≤ 1.5 METs), min/day, mean ± SD	− 54.6 ± 129.4	− 121.7 ± 115.5	− 32.0 ± 126.2	< 0.001
Total physical activity (≥ 1.6 METs), min/day, mean ± SD	34.5 ± 79.7	79.1 ± 91.2	19.4 ± 69.6	< 0.001

SD standard deviation, *IQR* interquartile range, *FIM* functional independence measure, *METs* metabolic equivalents

This cohort study had two major strengths. First, we used an objective measure of physical activity levels in older post-acute patients. Because many previous studies on physical activity in post-acute older patients used a number of steps and questionnaires [47, 48], it was difficult to apply them clinically based on several findings. Among these, we measured physical activity in detail, as it suggests that encouraging a change from sedentary to active behavior contributes to ADL recovery. Second, this study included patients with ambulatory difficulties and mild to moderate

Table 3 Results of logistic regression analysis for FIM gain

	Crude			Model 1			Model 2		
	OR	95% CI	*P*	OR	95% CI	*P*	OR	95% CI	*P*
Changes in sedentary behavior time (per 1 min/day)	0.994	0.991–0.997	< 0.001	0.994	0.991–0.997	< 0.001	0.996	0.993–1.000	0.026
Changes in total physical activity time (per 1 min/day)	1.010	1.005–1.014	< 0.001	1.009	1.004–1.013	< 0.001	1.006	1.000–1.011	0.041

Note: Sedentary behavior, ≤ 1.5 METs; Total physical activity, ≥ 1.6 METs

Crude: Changes in sedentary behavior time / Changes in total physical activity time

Model 1: Crude + Age + Sex + Charlson comorbidity index + Mini-Mental State Examination + Berg balance scale

Model 2: Model 1 + Changes in sedentary behavior time or changes in total physical activity time (Those not crude)

FIM functional independence measure, *OR* odds ratio, *CI* confidence interval, *METs* metabolic equivalents

cognitive impairment, which are common in post-acute care units. Previous studies examining physical activity and functional changes have excluded cases of cognitive impairments [4, 17]. The findings of this study can be widely applied to post-acute and subacute older patients.

This cohort study had two limitations. First, patients had a wide range and severity of acute illnesses. The degree of functional recovery varied with the disease type and disease severity and needed to be included as an adjustment variable. Second, physical activity and FIM were measured simultaneously, and this study was cross-sectional; therefore, it was not possible to refer to a causal relationship. In other words, it is possible that the amount of physical activity may have improved as a result of functional recovery. However, several previous studies have indicated that physical activity is related to functional recovery, particularly in individuals with impaired physical functioning [17–21, 23, 47]. Therefore, a similar relationship may be hypothesized in the present study. A larger sample size that considers diseases and interventions is required to clarify these limitations.

Conclusion

In conclusion, decreased sedentary behavior time and increased total physical activity time were significantly associated with high functional recovery in post-acute rehabilitation units. These results suggest that interventions for physical activity duration may be effective in post-acute and subacute older patients with negative factors for functional recovery. Nevertheless, due to the cross-sectional nature of this study and the absence of a definitive causal relationship, further investigation is necessary to elucidate the relationship between physical activity and functional recovery such as multicenter cohort or intervention studies.

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Availability of data and materials The data generated and analyzed during this study are not publicly available but are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare that there are no conflicts of interest.

Ethical approval This study was approved by the Committee of Ethics of Shonan Keiiku Hospital (No. 20-012).

Informed consent Taken from all patients or their caregivers/relatives.

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