Title:

Early walking time is associated with recovery of activities of daily living during hospitalization in elderly patients with community-acquired pneumonia: a single-center prospective study

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Abstract

Aim: Pneumonia is a common disease with a high mortality rate among the elderly that is associated with a decline in activities of daily living (ADL) are during hospitalization. The aims of this study were to investigate (i) early physical activity time among elderly patients hospitalized with community-acquired pneumonia (CAP), and (ii) the association of physical activity time with the recovery of ADL.

Methods: A prospective observational study was carried out in patients ≥ 65 years with hospitalized with community acquired pneumonia (CAP). We measured the time spent standing and walking as physical activity time using the activPAL^{TM} accelerometer from the third to the ninth day of admission. Patients underwent rehabilitation during their hospitalization, and rehabilitation effectiveness was calculated using the motor Functional Independent Measure on admission and at day 10. We used stepwise multiple regression to examine the relationship between physical activity time and rehabilitation effectiveness.

Results: Eighty-seven patients were included in the analysis. Median [interquartile range] physical activity time was 69 [43-103] mins/day. In the multiple regression model, a greater daily walking time, higher cognitive and physical function, and ADL at admission were independently associated with rehabilitation effectiveness (adjusted R2=0.32, p<.0001). For every increase of 10 mins/day of walking time, ADL improve by 7.8% (B=7.8, 95% CI: 1.3 to 14.2, p=0.02).

Conclusions: Elderly patients hospitalized with CAP have low levels of physical activity, and increasing early walking time may be an effective strategy to accelerate the recovery of ADL.

Key words: activities daily of living; community-acquired pneumonia; physical activity time; hospitalization; rehabilitation

Introduction

Pneumonia is a serious illness that occurs frequently among the elderly, and is a leading cause of hospitalization and mortality (1). However, pneumonia in elderly patients is often associated with non-respiratory symptoms (2), which may delay diagnosis and treatment. Moreover, in elderly people with acute illness, it has been reported that 30% demonstrated a decline in activities of daily living (ADL) after hospitalization (3). Among a cohort of 853 elderly patients hospitalized with pneumonia in Japan, 25% demonstrated a decrease in their ADL at discharge compared to preadmission, and 28% were unable to be discharged to the residence they occupied prior to hospitalization (4). Further, a decrease in ADL during hospitalization is an independent predictor of 30-day mortality in this patient population (5).

Low mobility, defined as being confined to a bed or chair, is a common event during hospitalization among elderly patients with acute illness. Up to a fifth of elderly patients experience low mobility during hospitalization, regardless of their preadmission level of independence (6). Immobility during hospitalization is associated with functional decline and the development of new impairments in ADL at discharge (6). These findings highlight the need for interventions aimed at preventing a decline in ADL in elderly patients hospitalized for pneumonia.

Early rehabilitation, that includes ambulation, is an effective intervention to prevent disability due to physical inactivity and improve the outcomes in elderly patients with pneumonia (7). The benefits of early rehabilitation include a decrease in hospital length of

stay (8), improved short-term survival (9), reduced readmission within 30 days (10) and improved ability to undertake ADL (11). These studies suggest that, for inpatients with pneumonia, medical staff should promote strategies to increase physical activity during hospitalization and set specific goals such as daily physical activity time and step counts. However, no study has objectively measured physical activity in elderly patients hospitalized for pneumonia. Also, it is unclear which factors are associated with the amount of physical activity undertaken by elderly patients with pneumonia during the early period of hospitalization, and whether levels of physical activity are related to improvement in ADL. This information may contribute to targeting and providing an efficient program to increase hospital-based activity in this patient population.

The aims of this study were to investigate time spent physical activity among elderly patients hospitalized with community-acquired pneumonia (CAP), and to investigate the association of early physical activity time (EPAT) with the recovery of ADL.

Material and Methods

Study design

This study was a prospective observational study at a single center in Japan.

Participants

The study was conducted from April 2017 until February 2019. The participants comprised patients aged 65 years and older who were admitted to the emergency unit at

Nagasaki Memorial Hospital, Japan (164 bed general hospital) with a diagnosis of pneumonia. Patients were eligible for inclusion if they had CAP (4, 12) and early rehabilitation commenced within 48 hours of admission. Patients were excluded if the pneumonia was categorized as nursing or healthcare-associated pneumonia (NHCAP) (4), which applied to a patient who was resident in an extended care facility or nursing home, had been discharged from a hospital within the preceding 90 days, was elderly or disabled and was receiving nursing care, or receiving regular endovascular treatment as an outpatient. Patients also were excluded if they required mechanical ventilation, were non-ambulant prior to admission, could not understand instructions and/or complete assessments or unable to wear the activity monitor.

The study was approved by the Human Ethics Review Committee of Nagasaki University Graduate School of Biomedical Sciences (approval number 17030952-2) and Nagasaki Memorial Hospital (approval number 2017-1). All patients gave written informed consent prior to participation.

Early rehabilitation protocol

All patients undertook physical and/or occupational therapy as their rehabilitation program within 48 hours following hospital admission. Time spent undertaking supervised rehabilitation was approximately 40 minutes a day, five days a week, and comprised early mobilization, passive and active limb exercise, muscle strengthening exercises and self-care. The early rehabilitation program varied depending on the patient’s condition, and

mobilization commenced with permission of the referring physician and according to specific clinical criteria (respiratory rate < 40/min, oxygen saturation ≥ 90%, heart rate < 120 bpm and blood pressure; systolic < 200 and diastolic < 120 mmHg). Transfer to a wheelchair, standing and walking training were gradually progressed in accordance with the patient's condition. When fever (≥ 38 ˚C), orthostatic hypotension, or vomiting was observed, mobilization was discontinued, and attempted on the following day. Patients who were able to independently mobilize safely were instructed to walk in the hospital as much as possible.

Measures

Patient characteristics

The patients' data collected at admission comprised age, sex, comorbidity, and physical status prior to admission. Comorbidity was assessed using the Charlson comorbidity index (CCI) (13) which consists of 19 disease groups; with higher scores indicating greater mortality risk. Physical status was assessed with the Japanese version of the Eastern Cooperative Oncology Group Performance Status (ECOG-PS) (14), with scores ranging from 0 to 4 and higher scores indicating worse physical status.

Early physical activity time

To measure EPAT, we used a three-axis accelerometer (activPAL^{TM} 3μ, PAL Technologies Ltd., Glasgow, UK). The monitor was worn on the midpoint of the anterior aspect of the thigh on the dominant leg and secured in place using waterproof tape. The

activPAL^{TM} is a valid method for quantifying physical activity in the elderly, including hospitalized patients (15). We measured EPAT and step count daily from the third day to the 9th day (7 consecutive days) of admission. Patients were asked to wear the monitor for the entire 24-hour period on all 7 days. We defined EPAT as total time spent standing or walking, including the time spent undergoing rehabilitation (16). For the analysis we used the daily average of EPAT and step count having first excluded data recorded on the first and final day of monitoring.

Activities of daily living

The ADL undertaken during hospitalization (at admission and 10th day after admission) were assessed using the Functional Independence Measure (FIM) (17). We assessed the ADL on the 10th day after admission because the average period of duration of intravenous antimicrobial agents for elderly patients with CAP was 10 days in our pilot study. The FIM consists of 18 tasks (13 motor and 5 cognitive tasks). We used only the motor Functional Independence Measure (mFIM) to assess ability to perform ADL. The scores for mFIM range from 13 to 91, and higher scores indicate a greater level of independence.

Relative functional gains of mFIM were calculated using the following formula from admission to the 10th day and used as a measure of rehabilitation effectiveness (REs).

$$\text{REs} = \frac{[\text{10th day mFIM} - \text{admission mFIM}]}{[\text{maximum mFIM} - \text{admission mFIM}]} \times 100$$

REs is expressed as a percentage that reflects the proportion of the potential improvement that is actually achieved in hospital (18).

Community-Acquired Pneumonia

The severity of CAP at admission was assessed using the ADROP system (12), which comprises five factors: age, dehydration, respiration, orientation and blood pressure. Scores range from 0 to 5 and are interpreted as follows; 0 mild, 1 or 2 moderate and 3 or more indicates severe pneumonia. In addition, body temperature at admission, duration of intravenous antimicrobial agents, supplemental oxygen use and length of hospital stay were recorded at discharge.

Nutritional status

Nutritional status at admission was assessed using the Geriatric Nutritional Risk Index (GNRI) (19), an established assessment tool and predictor of morbidity due to pneumonia in the elderly. The GNRI is based on height, bodyweight and serum albumin, and is calculated as follows: 14.89 × serum albumin (g/dL) + 41.7 × body mass index / 22. Higher scores indicate better nutritional status.

Cognitive and physical function, and symptoms

Cognitive function was assessed using the Japanese version of the Mini-Mental State Examination (MMSE) (20). Scores range from 0 to 30 with higher scores indicating better cognitive function. Lower extremity function was evaluated using the Short Physical Performance Battery (SPPB) (21) which assesses standing balance, 4 m gait speed, and ability to rise from a chair. Scores range from 0 to 12 with higher scores indicating better performance.

Symptoms of depression were evaluated using the Japanese short version of the Geriatric Depression Scale (GDS-15) (22). Scores range from 0 to 15 with higher scores indicating greater symptoms. Physical fatigue was evaluated using a numerical rating scale (NRS) with higher scores indicating greater fatigue. All of these measures were assessed within 3 days following admission by a physical or occupational therapist. In addition, the time spent physical and/or occupational therapy rehabilitation per day and discharge destination were recorded.

Statistical analysis

We performed single (unadjusted) and multiple (fully adjusted) stepwise regression analysis to explore the factors affecting EPAT and REs respectively. We performed multiple stepwise regression analysis forcibly adjusted with age, sex, CCI and ADROP. In addition, we carried out multiple stepwise regression analysis for REs with standing and walking time as independent variables, if a linear correlation > 0.7 between EPAT and walking time was found.

Data are presented as median and interquartile range (IQR). All statistical analyses were carried out using JMP® Pro version 14.0 software (SAS Institute Inc, Cary, NC, USA). A p-value of <0.05 was considered significant.

Results

Patients' characteristics

Three hundred and ninety-three patients were admitted with CAP or NHCAP during the study period. Two hundred and eighty-nine were excluded due to NHCAP, rehabilitation commenced > 48 h, required mechanical ventilation, declined to participate and skin irritation from waterproof tape. Of this sample, 104 (26%) had the activity monitor applied. Physical activity data were incomplete in 17 (16%) of the 104 patients due to missing assessments or because the person died. Thus data from 87 patients were included in the final analysis (Figure 1). Table 1 shows the characteristics of these 87 patients. Seventy-four (85%) patients had pneumonia of a moderate severity. The majority of patients (70%) had underlying lung disease. The duration of intravenous antibiotic therapy was 10 [7-13] days (median [IQR]) and 38 (44%) patients required supplemental oxygen during hospitalization. The daily average time spent undergoing rehabilitation was 34 [29-38] mins/day (Table 2).

Early physical activity time and step count

The median EPAT during the 7 days from the 3rd to 9th day after admission, which combined the time spent standing (52 [35-74] mins/day) and walking (14 [4-26] mins/day), was 69 [43-103] mins/day. Sitting or lying time was 1367 [1340-1397] mins/day. Step count was 1080 [301-2058] steps/day.

Activities of daily living

The mFIM was 59 [49-66] points at admission, and 72 [62-82] points on the 10th day of

hospitalization. The relative functional gain of mFIM (REs) was 40 [19-67] %.

Factors affecting early physical activity time and REs

In a single analysis model, mFIM at admission, requiring supplement oxygen, SPPB, PS and MMSE all showed a significant relationship with EPAT. Furthermore, walking time, MMSE, SPPB, mFIM at admission, PS, sex, standing time and EPAT showed a significant relationship with REs. In the multiple stepwise analysis model, mFIM at admission and requiring supplemental oxygen were independent factors affecting EPAT (adjusted R2=0.35, p<.0001). REs was influenced by daily walking time, MMSE, SPPB and mFIM at admission as independent factors (adjusted R2=0.32, p<.0001). For every increase of 10 mins a day in walking time, REs increased by approximately 8% (10 min, B=7.8, 95% CI: 1.3 to 14.2, p=0.02) (Table 3).

Discussion

We found that (i) elderly patients hospitalized with CAP had an average daily standing time of 52 [35-74] minutes and walking time of 14 [4-26] minutes during the 7 days from 3rd to 9th day after admission, and (ii) early walking time influenced recovery of ADL during hospitalization.

The duration of early physical activity being only 69 [43-103] mins/day represents just 5% of a 24-hour period. Data describing the time spent physical activity in patients with pneumonia are few. Rice et al. (23) reported a median walking time of 66 [41-121]

mins/day in hospitalized patients with CAP. This is almost four times longer than in our study (14 [4-26] mins/day), and may be explained by differences in age, severity of pneumonia and epochs of accelerometer data between the two samples. Participants in the study by Rice et al (23) were younger (66.8 ± 18.2) years and had less severe pneumonia (confusion, urea, respiratory rate, blood pressure and age ≥ 65 (CURB-65) 1 [1-2]) than our sample (82 [75-89] years, ADROP 2 [1-2]). Older age (24) and more severe illness (25) have been reported to be associated with lower hospital-based mobility. Furthermore, the sampling epoch of the accelerometer used in the earlier study (23) was longer (60 s) than in ours (15 s). Because the calculation of the time spent walking is dependent upon the sampling epoch, a longer sampling epoch would overestimate the time spent walking (26). In fact, the step count reported by Rice et al (23) is similar (926 [457-1706] steps/day) to our data (1080 [301-2058] steps/day). Even so, it clear that patients with pneumonia had high levels of immobility consistent with other medical inpatients (15, 16).

Our study found that EPAT was affected by the mFIM at admission and receiving supplemental oxygen during hospitalization. Evensen et al. (27) showed that an increasing Barthel Index score was associated with greater hospital-based physical activity time, supporting our findings. Moreover, the need for devices such as urinary catheters, intravenous lines and oxygen tubing contribute to the decline in mobility during hospitalization (28). None of our participants required a urinary catheter and unexpectedly there was no significant relationship between the presence of an intravenous line and EPAT in our study. However, mobility was restricted in those using supplemental oxygen. Hence,

when considering the benefits of EPAT during hospitalization, patients with low ADL at admission and those who require supplemental oxygen during hospitalization should be prioritized for receiving a walking-based program.

Furthermore, we identified that a greater daily walking time during the acute phase, and higher MMSE, SPPB and mFIM scores at admission contributed to higher REs. A previous study reported that immobility during hospitalization (6, 16), low cognitive function (29) and poor physical function (ie, lower extremity function (21) and ADL (6, 29)) in hospitalized elderly patients were predictors of functional decline, and this finding supports our study. Therefore, our study indicates that medical staff should give a greater consideration to patients with immobility, low cognition and poor physical function at admission and introduce an exercise program with the aim of preventing further decline and assisting recovery.

Our data also showed that for every increase in 10 mins/day of walking time from the acute phase, REs improved by 8%. Some studies describing the relationship between physical activity time in-hospital and ADL have been reported in various clinical populations (15, 16), however there are few objective data reporting the effects of increasing daily walking time or step count in hospitalized patients. Rice et al. (23) reported that for every increase of 500 in average daily step count, length of stay reduced by 11% for patients with CAP. Ostir et al. (30) showed that an extra 100 steps a day was associated with a 3% decrease in mortality at 2 years after discharge among elderly medical patients. Hence, our study highlights the importance of increasing daily walking time in patients

identified with immobility in the early period of hospitalization considering the potential to increase functional recovery and prognosis.

To the best of our knowledge this is the first prospective study to provide objective measurements of the EPAT in elderly patients hospitalized with CAP, and clarify the relationship between EPAT and REs, however, the study has several limitations. First, the study was conducted at a single center therefore may lack external validity. Second, there may be information bias, because the wearing of the accelerometer may have influenced the amount of physical activity undertaken. Finally, the severity of the pneumonia in our patients was predominantly mild to moderate thus further study is required in patient populations with severe disease.

In conclusion, this prospective study showed that increasing early walking time may be a feasible and effective strategy to accelerate the recovery of ADL in elderly patients with CAP. Our findings provide information for further research studies and the future rehabilitation interventions for hospitalized elderly patients with CAP.

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Disclosure statements

The authors declare no conflict of interest.

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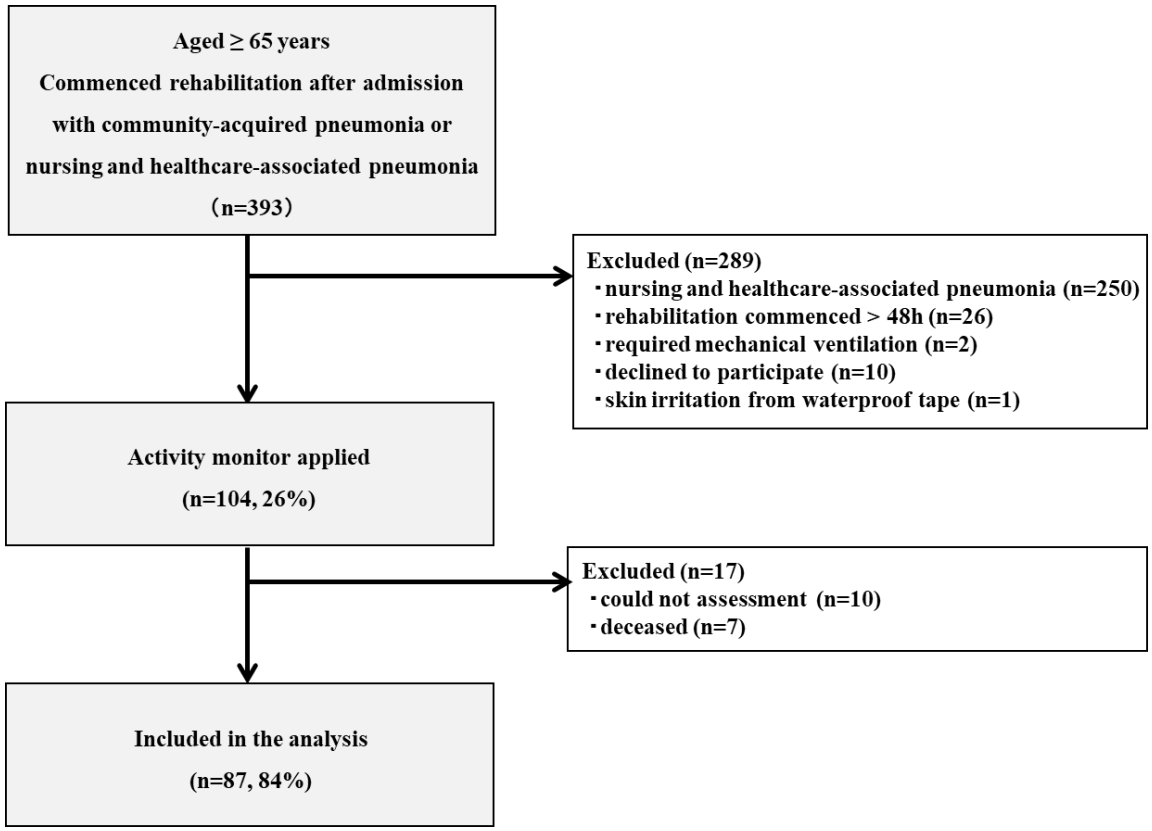

Figure 1. Flow diagram of participants

Table 1. Baseline Characteristics of the 87 patients

Variable	
Age (yrs)	82 [75-89]
Sex, female	41 (47)
CCI (score 0-37)	3 [2-5]
Comorbidities	
Cerebrovascular disease	39 (45)
Chronic heart failure	42 (48)
Chronic pulmonary disease	61 (70)
Dementia	12 (14)
Diabetes	33 (38)
ECOG-PS preadmission (score 0-4)	1 [0-1]
0	27 (31)
1	42 (48)
2	18 (21)
3-4	0 (0)
ADROP (score 0-5)	2 [1-2]
0	6 (7)
1	35 (40)
2	39 (45)
3	7 (8)
4-5	0 (0)
Body temperature (˚C)	37 [37-38]
GNRI	93 [86-101]
mFIM (score 13-91)	59 [49-66]
MMSE (score 0-30)	24 [22-27]
SPPB (score 0-12)	9 [5-11]
GDS-15 (score 0-15)	6 [3-8]
Physical fatigue (score 0-10)	4 [3-5]

ADROP: age, dehydration, respiration, orientation, blood pressure; CCI: Charlson co-morbidity index; GDS: geriatric depression scale; GNRI: geriatric nutritional risk index; IQR: Interquartile range; mFIM: motor-functional independence measure; MMSE: mini-mental state examination; PS: performance status; SPPB: short physical performance battery.

Data are presented as median [interquartile range] and number (%).

Table 2. Characteristics of the 87 patients at hospital discharge

Variable	
Duration of intravenous antimicrobial agents (days)	10 [7-13]
Received supplemental oxygen	38 (44)
Duration of physical and/or occupational therapy (days)	13 [10-20]
Time of rehabilitation per day (minutes)	34 [29-38]
Length of stay (days)	15 [13-21]
Discharge destination	
Discharged to home	84 (97)
Discharged to rehabilitation ward	3 (3)

Data are presented as median [interquartile range] and number (%)

Table 3. Factors associated with early physical activity time and rehabilitation effectiveness

Variable	Unadjusted Regression coefficient B			Fully adjusted Regression coefficient B		
	Estimate	95% CI	p-value	Estimate	95% CI	p-value
Dependent variable: EPAT				adjusted R2=0.35, p<.0001		
mFIM at admission (1 score)	1.88	1.30 to 2.46	<0.001	1.47	0.70 to 2.24	<0.001
Supplemental oxygen (none)	14.44	5.55 to 23.32	0.01	13.53	3.12 to 23.93	0.01
SPPB (1 score)	4.92	2.58 to 7.27	<0.001	2.53	-0.08 to 5.14	0.57
ADROP (1 score)	-12.07	-24.4 to 0.28	0.05	9.97	-5.96 to 25.90	0.22
Age (1 year)	-0.59	-1.69 to 0.52	0.29	-0.52	-1.60 to 0.57	0.34
PS (1 score)	-17.00	-29.60 to -4.40	0.01	4.23	-9.83 to 18.30	0.55
MMSE (1 score)	2.50	0.30 to 4.70	0.03	0.36	-1.72 to 2.44	0.73
CCI (1 score)	0.15	-4.48 to 4.79	0.95	-0.61	-4.53 to 3.32	0.76
Sex (female)	-9.35	-18.48 to -0.21	0.05	-1.04	-10.34 to 8.25	0.82
Dependent variable: REs				adjusted R2=0.32, p<.0001		
Walking time (10 min)	9.9	5.6 to 14.2	<0.001	7.8	1.3 to 14.2	0.02
MMSE (1 score)	2.48	0.99 to 3.97	0.01	2.42	0.91 to 3.92	0.01
SPPB (1 score)	3.58	2.00 to 5.16	<0.001	2.20	0.24 to 4.15	0.03
mFIM at admission (1 score)	0.66	0.20 to 1.12	0.01	-0.66	-1.27 to -0.04	0.04
PS (1 score)	-17.12	-25.31 to -8.93	<0.001	-6.02	-16.32 to 4.27	0.25
ADROP (1 score)	-0.33	-9.48 to 8.82	0.94	5.86	-2.81 to 14.53	0.18
Age (1 year)	-0.65	-1.39 to 1.10	0.09	-0.36	-1.11 to 0.38	0.34

CCI (1 score)	-0.56	-3.70 to 2.58	0.73	-1.52	-4.28 to 1.24	0.28
Sex (female)	-6.69	-12.94 to -0.45	0.04	-2.72	-9.11 to 3.67	0.40
Standing time (10 min)	2.3	0.5 to 4.1	0.01	0.2	-1.9 to 2.2	0.88
EPAT (10 min)	2.4	1.0 to 3.8	<0.01			

Single (Unadjusted) regression analysis was performed to explore associations between patients' characteristics and EPAT and REs. Multiple stepwise regression analysis with REs was performed with standing and walking time as independent variables to investigate the relationship between REs and EPAT. ADROP: age, dehydration, respiration, orientation, blood pressure; CCI: Charlson comorbidity index; CI: confidence interval; EPAT: early physical activity time; mFIM: motor-functional independence measure; MMSE: mini-mental state examination; PS: performance status; REs: rehabilitation effectiveness; SPPB: short physical performance battery.