Published in final edited form as:
*J Am Geriatr Soc*. 2011 January ; 59(1): 91–95. doi:10.1111/j.1532-5415.2010.03202.x.

# Ambulatory Activity of Older Adults Hospitalized with Acute Medical Illness

**Steve R. Fisher, PT, PhD**[*], **James S. Goodwin, MD**[†,‡], **Elizabeth J. Protas, PT, PhD**[§], **Yong-Fan Kuo, PhD**[‡], **James E. Graham, PhD, DC**[*], **Kenneth J. Ottenbacher, PhD, OTR**[*,†], and **Glenn V. Ostir, PhD**[*,†,‡]

[*] Division of Rehabilitation Sciences, University of Texas Medical Branch, Galveston, Texas

[†] Sealy Center on Aging, University of Texas Medical Branch, Galveston, Texas

[‡] Division of Geriatrics, Department of Internal Medicine, University of Texas Medical Branch, Galveston, Texas

[§] School of Health Professions, University of Texas Medical Branch, Galveston, Texas

## Abstract

**OBJECTIVES—**To describe the amount and patterns of ambulatory activity in hospitalized older adults over consecutive hospital days.

**DESIGN—**Observational cohort study.

**SETTING—**University teaching hospital Acute Care for Elderly (ACE) unit.

**PARTICIPANTS—**Adults aged 65 and older (N = 239) who wore a step activity monitor during their hospital stay.

**MEASUREMENTS—**Total number of steps per 24-hour day. Mean daily steps were calculated based on number of days the step activity monitor was worn.

**RESULTS—**Mean age was 76.6 ± 7.6; 55.1% of participants were female. Patients took a mean number of 739.7 (interquartile range 89–1,014) steps per day during their hospital stay. Patients with shorter stays tended to ambulate more on the first complete day of hospitalization and had a markedly greater increase in mobility on the second day than patients with longer lengths of stay. There were no significant differences in mean daily steps according to illness severity or reason for admission.

**CONCLUSION—**Objective information on patient mobility can be collected for hospitalized older persons. Findings may increase understanding of the level of ambulation required to maintain functional status and promote recovery from acute illness.

### Keywords

geriatrics; walking; hospitalization



Address correspondence to Steve Fisher, University of Texas Medical Branch, 301 University Blvd., Galveston, TX 77555. stfisher@utmb.edu.

**Conflict of Interest:** The editor in chief has reviewed the conflict of interest checklist provided by the authors and has determined that the authors have no financial or any other kind of personal conflicts with this paper.

**Author Contributions:** Dr. Fisher had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Acute hospitalization is often a life-changing event for older adults.[1,2] Up to 50% of patients aged 65 and older lose function in basic activities of daily living (ADLs) while hospitalized.[3] Declines are known to begin soon after admission and progress rapidly[4]—often in spite of successful treatment of the condition precipitating the admission.[5] Although the etiology is complex, prolonged periods of low mobility such as being confined to bed or chair[6] can initiate a downward spiral resulting in severe deconditioning and long-lasting functional deficits.[7]

A barrier to mobility assessment has been the inability to accurately and unobtrusively measure patient ambulation throughout the entire hospital stay.[8] Investigators have used a number of methods to estimate patient activity, including direct observation,[9] chart documentation,[10] and brief surveys,[6] but there is little objective information available on how much patients walk in a typical hospital day or how walking patterns change during the course of hospitalization. A better understanding of patient ambulatory activity would help advance the development of standards of care concerning their mobility.[6]

Accelerometers have been used recently to measure mobility, physical activity, and gait parameters in older adults.[11] Similar to ambulatory blood pressure monitoring, accelerometer technology has the advantage of synchronizing step count measurements to a 24-hour clock at frequent intervals.[12] The resulting temporal series of data can be analyzed to identify patterns of ambulatory activity that may not be apparent using other methods.[12] A cohort of patients aged 65 and older admitted for an acute medical illness who wore accelerometers from admission to discharge was studied. The objective was to describe the amount and patterns of ambulatory activity over consecutive complete hospital days.

## METHODS

### Study Population

Three hundred twenty-three patients aged 65 and older admitted to an Acute Care for Elders (ACE) unit at a university teaching hospital were studied. A step activity monitor (SAM) was placed on patients on the day of admission and worn until discharge; eligible patients included those aged 65 and older of either sex. Data were collected over 4 consecutive months beginning April 2009. Patients who had a contraindication to wearing the SAM, such as active bilateral lower leg infection, severe lower leg edema, bilateral lower extremity amputations, terminal illness, or severe agitation, were excluded. Also excluded were patients with a primary orthopedic surgical diagnosis.

Eighty-four of the 323 patients had incomplete SAM data—36 spent less than 1 complete 24-hour day (midnight to midnight) in the hospital, 28 removed the SAM, two wore the SAM home (and data were lost), and 18 had the SAM removed for medical reasons or tests. The final sample included 239 patients with complete in-hospital SAM data. The study received approval from the university's institutional review board.

### Assessment of Ambulation

The SAM is a waterproof dual-axis accelerometer attached at the ankle with a Velcro strap. The monitor measures 75 × 50 × 20 mm and weighs approximately 1.3 oz. It is not affected by off-axis accelerations (i.e., will not record leg movements while lying in bed) and has been shown to be 98% accurate in a variety of clinical populations, including individuals with slow or shuffling gait.[12–15] Stride counts (steps) were recorded in 1-minute intervals synchronized to a 24-hour clock (midnight to midnight), resulting in a temporal series of 1,440 observations per day. Data were uploaded to a host computer at the end of the recording period.

The primary parameter analyzed was total number of steps taken per day; steps were defined as stride counts recorded by the monitor times two. Mean daily steps were calculated based on the number of complete hospital days the SAM was worn. A complete hospital day was defined as a 24-hour, midnight to midnight interval. Activity monitoring began at midnight on the day of admission and ended at midnight of the day before discharge. Total minutes of ambulatory activity, defined as the number of 1-minute intervals recorded by the monitor with a stride count greater than 0, were also determined.

To provide perspective on the number of steps required to complete common hospital tasks, step values from the SAM were recorded and verified for a representative patient. The patient was asked to walk from the bed to the bathroom and from the bed to a chair and to walk once around the ACE unit. Whether the SAM would falsely record a step while lying in bed was also tested.

## Chart Review

Information on patient demographic and clinical characteristics was obtained from the electronic medical record. Demographic measures included age, sex, race, and body mass index (BMI; calculated according to weight in kilograms divided by height in meters squared). Clinical measures included patient or proxy report of ambulatory status in the 2 weeks before admission (independent, with assistance of a cane or walker, or requiring significant help from another), history of falls over the past year (yes vs no), whether tubing or monitoring equipment restricted the patient's mobility at the time of the admission assessment (yes vs no), presence of confusion or delirium (yes vs no), and whether the patient had any limitations in basic ADLs before admission (yes vs no). Other measures included physician's activity orders at hospital admission (as tolerated, ambulate with assist, or bed rest), whether physical therapy was consulted any time during the patients' stay (yes vs no), Charlson Comorbidity Index[16] (a measure of the burden of chronic illness; range 0–37; categorized as ≤3 vs >3[6]), discharge diagnosis category (cardiopulmonary, infectious, gastrointestinal, metabolic, and other), length of stay (defined as the number of calendar days in the hospital); and the All Patient Refined Diagnosis-Related Group (APR-DRG) severity of illness classification obtained for each patient from hospital databases. The APR-DRG is a modification of the traditional DRG but adds four classes of illness severity (1 = minor, 2 = moderate, 3 = major, 4 = extreme).[17,18]

## Statistical Analysis

Means (with standard deviations or interquartile ranges (IQRs)) were reported for continuous measures, and percentages were reported for categorical measures. The cumulative percentile distribution for all SAM recording days (complete 24-hour days as the unit of analysis) was calculated for total daily steps. Median total daily steps were stratified according to number of consecutive 24-hour days that patients wore the SAM and graphed for visual analysis. Nonparametric univariate statistics were used to examine the relationships between individual patient characteristics and mean daily step count. The Wilcoxon signed-rank test was used to determine change in step activity between the first and last hospital days for patients with at least two 24-hour days in hospital. Chi-square tests were used to determine whether distributions within patient characteristic categories differed significantly between patient groups. Testing was two-sided, using an alpha of 0.05. All analyses were performed using SAS statistical software, version 9.2 (SAS Institute, Inc., Cary, NC).

# RESULTS

## Characteristics

Table 1 shows the demographic and clinical characteristics of the sample. Mean age was 76 ± 6, range 65–100); 55.1% were female and 62.8% non-Hispanic white. Mean length of hospitalization was 4.9 ± 2.4 days. Forty-seven percent had a BMI in the normal to overweight range (22–29 kg/m$^2$). A majority (57.4%) reported being mobility independent 2 weeks before hospitalization. Cardiopulmonary conditions (34.5%) were the most common diagnostic category. “Moderate” (44.4%) was the most common rating from the 4-level APR-DRG illness severity index, followed by “major” (34.2%), “minor” (14.5%), and “extreme” (6.8%).

There were a total of 708 days of observation for the 239 patients. On 50% of observation days, patients took fewer than 300 steps, on 12.9% of observation days, patients took no steps, and on only 1% of days patients took more than 4,100 steps.

Mean daily steps were 739.7 (IQR 89–1,014; median 468). Mean daily minutes of ambulatory activity were 57.6 (IQR 12–86; median 42.6). For each 24-hour day, 57.6 minutes corresponds to 4.1% of the time being active (walking) and 95.9% of time being inactive (not engaged in any ambulatory activity).

Table 1 also provides means and IQRs for daily steps according to each patient characteristic. Age ($P$ = .05), mobility status before hospital admission ($P$<.001), history of falls ($P$ = .002), prior ADLs limitations ($P$<.001), confusion or delirium during the admission assessment ($P$ = .02), physician’s admitting activity orders ($P$ = .05), and length of stay ($P$ = .03) showed statistically significant differences in mean steps per day. Patients who had a physical therapy consultation during their stay walked significantly less than those who did not ($P$<.001). In general, aged 75 and older, mobility impairment before admission, a history of falls, delirium, a physician’s order for bed rest at admission, and prolonged length of stay were all associated with fewer mean daily steps during hospitalization.

Figure 1 shows the median daily steps taken per day stratified according to the number of complete 24-hour days the patient was in the hospital. Patients with shorter lengths of stay tended to have higher total steps on the first complete hospital day and an increase in step activity from the first to second hospital day. Patients with longer lengths of stay had low step activity on Day 1 and increased their walking activity slowly, or not at all, over subsequent hospital days. For these patients, the number of steps taken on the last hospital day was not significantly different from that on the first hospital day ($P$ = .58).

Number of steps taken on the last hospital day was significantly higher from the first hospital day for patients who spent only 2 ($P$ = .01) or 4 ($P$ = .01) 24-hour days in the hospital; the difference was not significantly different for patients who spent 3 ($P$ = .08) 24-hour days.

A subsample of patients with low levels of activity was examined over a multiday period. Patients who took fewer than 500 steps (approximately the median value for daily steps) per day for at least 5 consecutive 24-hour days (n = 27) were compared with all other patients. No significant differences were found according to age, sex, race, physician’s activity orders, reason for admission, presence of confusion, presence of tubing or monitoring equipment, or number of comorbid conditions. Patients who took fewer than 500 steps over 5 consecutive days were significantly more likely to have a prior history of falls (41.6.0% vs 18.5%; $P$ = .02) and preadmission limitations in basic ADLs (58.3% vs 32.6%; $P$ = .03).

These patients were significantly less likely to be classified as independent ambulators before admission (20.8% vs 61.9%; $P<.001$) or have a "minor" APR-DRG illness severity rating (4.2% vs 15.7%; $P = .04$).

The number of steps required to perform common hospital walking activities were 8 steps to transfer from bed to chair and back, 44 steps to walk from bed to bathroom and back, and 152 steps to walk once around the hospital unit. Values recorded by the SAM were 99.0% accurate. In addition, whether the SAM would falsely record a step while the patient was in bed was tested. Only two steps were recorded during 10 consecutive minutes of vigorous leg movements while lying down.

## DISCUSSION

To the knowledge of the authors, this is the first investigation to provide objective quantitative information on the walking behavior of older adults hospitalized for acute illness. Ambulation overall was remarkably low. On average, patients spent 4.1% of their time walking. Ambulation appeared to correspond well to the presumed recovery process and improvements in physiological health. Patients with shorter lengths of stay tended to ambulate more on the first complete day of hospitalization and to have a markedly greater increase in mobility on the second day than patients with longer lengths of stay. There were no significant differences in mean daily steps according to illness severity or reason for admission. Factors associated with the lowest ambulatory activity were primarily related to prior functional status, a bed rest order at hospital admission, delirium, and prolonged length of stay.

Published research on the ambulatory activity of community-living older adults provides some perspective on the levels of ambulation observed. A recent systematic review of number of pedometer-assessed steps taken per day by adults reported that persons aged 65 and older average 6,566 (95% confidence interval = 4,897–8,233) steps per day.[19] Other pedometer-based studies generally report estimates in the range of 6,000 to 8,500 steps for this age group.[20] In a small sample of older adults with functional limitations, a mean of 7,681.5 steps per day was reported using the same type of accelerometer as in the current study.[12]

The assessment of patient activity has historically been challenging. Methods have typically relied on nurse reports, chart reviews of physician orders, or direct observation in hallways.[9,21] These approaches have inherent limitations. For example, transferring or walking in the hospital is often a brief activity, mostly done within the patient's room.[9] Hospital staff or surveys of location would easily miss these activities, especially if the patient was mobility independent.[11]

The SAM used in the current study was able to unobtrusively and continuously measure patient ambulation during an acute stay. These findings should encourage continued development of patient care applications for motion sensor technology. It has previously been demonstrated that this kind of information can be transmitted, in the hospital, wirelessly to a central hub.[8] Although additional research is needed on the feasibility of incorporating these data into the patient's electronic medical record, mobility-related information would then be viewable in real time, with past history.

It is likely that easy access to patient activity data is essential to increasing awareness of healthcare providers regarding the potential consequences of low mobility during an acute stay. One study showed that the amount of time older patients with acute medical illnesses were limited to a bed or chair was an independent predictor of decline in ADLs, even after controlling for preadmission ADL impairment and illness severity.[6] Although some

inactivity during acute illness may not be avoidable or inappropriate, data from the current study also suggest that low mobility may be an underlying common pathway to functional decline in many geriatric patients.

This study has some limitations. First, data were collected on an ACE unit and therefore may not be representative of the hospital experience of older patients admitted to a traditional hospital ward. The physical environment of an ACE unit is designed to promote ambulation and provide incentive for patients to increase mobility and participate in activities during their hospital stay. ACE units employ a pre-habilitation model of acute care by using large congregate rooms and a prepared environment[8] (e.g., hallways have reduced-glare lighting and grab bars and are carpeted). In this context, the findings regarding low ambulatory activity may be conservative because traditional hospital units may be less conducive to walking. Second, wearing the SAM could have influenced how much patients in the study walked, although the SAM provides no direct knowledge of results, and patients were instructed not to walk any more or less than they otherwise would while they were wearing the SAM.

In conclusion, ambulatory activity was low in the geriatric patients studied. How this walking behavior compares with that of younger patient populations during an acute stay with similar clinical profiles will require further study. Accelerometer technology shows potential for quantifying ambulation and patterns of activity of older hospitalized adults. Objective information on patient mobility may increase understanding of the level of ambulation required to maintain function while allowing patients to recover from their acute illness, develop appropriate standards of care for mobility in hospital, and influence policy decisions regarding hospital processes that affect mobility.

## Acknowledgments

We would like to thank the ACE unit nursing staff for their cooperation and support during this study.

This work was funded in part by National Institutes of Health Grants R01 AG031178 (Ostir, PI), P30 AG017231-03 (Goodwin, PI), and K12 HD055929 (Fisher, Scholar).

**Sponsor's Role:** The funding organizations had no role in the design or conduct of the study; collection, management, analysis, or interpretation of the data; or preparation, review, or approval of the manuscript.

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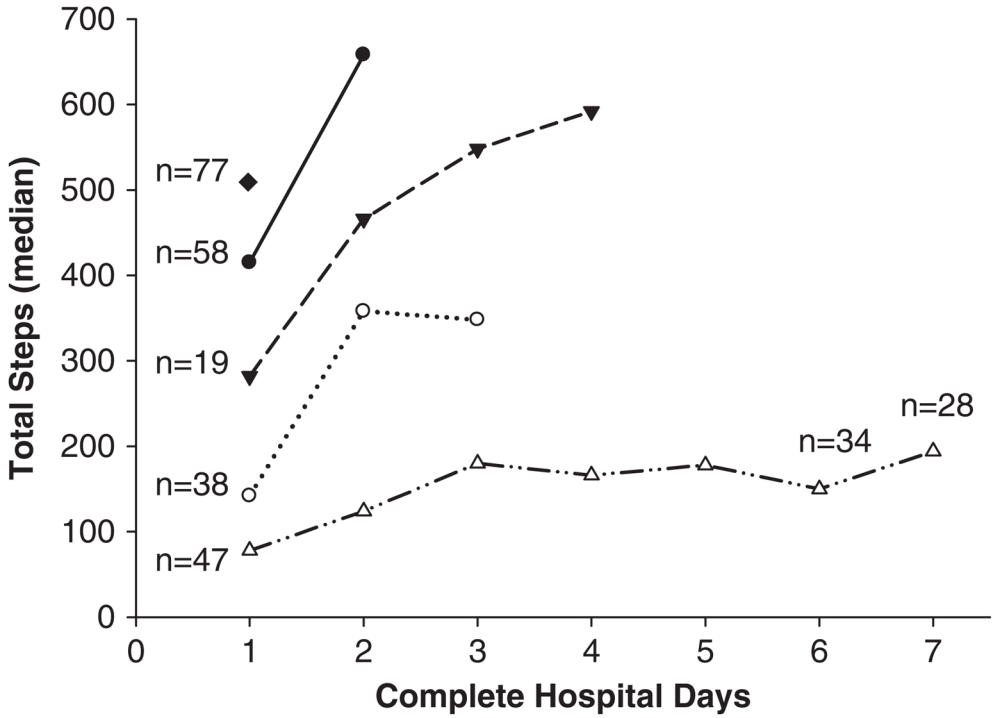


**Figure 1.**

Total daily steps as a function of length of stay. Patients were stratified according to number of complete 24-hour (midnight to midnight) days spent in the hospital, including 1, 2, 3, 4, and 5 or more days. 47 patients spent at least five 24-hour days, 34 at least six 24-hour days, and 28 at least seven 24-hour days. Activity monitoring began at midnight on the day of admission and ended at midnight of the day before discharge. Total length of stay therefore is always 2 days longer than the number of 24-hour days accumulated (e.g., 3 complete 24-hour days corresponds to a 5-calendar-day length of stay; 1 complete 24-hour day corresponds to a 3-day length of stay.

## Table 1

Patient Characteristics and Mean Daily Steps According to Characteristic (N = 239)

| Characteristic | % | Daily Steps, Mean (Interquartile Range) | *P*-Value |
|---|---|---|---|
| Age | | | .05 |
| <75 | 44.8 | 926.3 (106–1,124) | |
| ≥75 | 55.2 | 589.8 (56–954) | |
| Sex | | | .81 |
| Female | 55.1 | 771.9 (99–954) | |
| Male | 44.9 | 714.3 (74–1,057) | |
| Race | | | .73 |
| White | 62.8 | 786.0 (89–1,074) | |
| Nonwhite | 37.2 | 665.5 (89–970) | |
| Body mass index, kg/m$^2$ | | | .39 |
| ≤29 | 72.6 | 698.5 (80–1,007) | |
| ≥30 | 27.4 | 848.4 (98–1,306) | |
| Mobility before admission | | | <.01 |
| Independent | 57.4 | 1,023.1 (235–1,356) | |
| Cane or walker | 32.5 | 417.0 (56–508) | |
| Dependent* | 10.1 | 305.9 (10–469) | |
| History of falls | | | <.01 |
| Yes | 20.9 | 525.4 (16–660) | |
| No | 79.1 | 798.4 (133–1,059) | |
| Restricted by tubing† | | | .99 |
| Yes | 28.6 | 771.8 (81–1,019) | |
| No | 71.4 | 726.3 (94–1,007) | |
| Physician activity orders‡ | | | .05 |
| As tolerated | 61.4 | 881.5 (99–1,085) | |
| Ambulate with assistance | 10.4 | 655.2 (160–1,101) | |
| Bed rest | 28.2 | 466.0 (44–813) | |
| Physical therapy consultation§ | | | <.01 |
| Yes | 43.8 | 503.6 (49–676) | |
| No | 56.2 | 924.3 (137–1,269) | |
| Confusion or delirium | | | .02 |
| Yes | 15.4 | 469.9 (14–698) | |
| No | 84.6 | 791.7 (98–1,049) | |
| Prior limitations in activities of daily living | | | <.01 |
| Yes | 35.3 | 434.4 (21–674) | |
| No | 64.7 | 886.2 (140–1,124) | |
| Reason for admission | | | .24 |

| Characteristic | % | Daily Steps, Mean (Interquartile Range) | *P*-Value |
|---|---|---|---|
| Cardiopulmonary | 34.5 | 836.3 (98–1,078) | |
| Infectious | 23.7 | 603.8 (56–977) | |
| Gastrointestinal | 15.5 | 830.9 (150–1,162) | |
| Neurological | 5.6 | 516.7 (2–839) | |
| Other | 20.7 | 722.6 (97–958) | |
| Charlson Comorbidity Index | | | .65 |
| ≤3 | 75.5 | 650.2 (23–1,020) | |
| ≥4 | 24.5 | 628.0 (18–976) | |
| Illness severity[||] | | | .16 |
| 1 or 2 | 58.9 | 857.1 (89–1,092) | |
| 3 or 4 | 41.1 | 571.2 (80–918) | |
| Length of stay, days | | | .03 |
| 3–4 | 56.5 | 882.9 (98–1,110) | |
| 5–6 | 23.8 | 689.6 (66–1,011) | |
| ≥7 | 19.7 | 359.8 (73–614) | |

[*] Requiring significant help from another.

[†] Mobility restricted by tubing or monitoring equipment during the nurse's admission assessment.

[‡] Activity orders at hospital admission only.

[§] Physical therapy consulted any time during patient's stay.

[||] Center for Medicare and Medicaid Services All Patient Refined Diagnosis-Related Group (DRG) severity of illness classification: a modification of the traditional DRG that adds four classes of illness severity: 1 = minor, 2 = moderate, 3 = major, and 4 = extreme.