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Feature Article

A pilot study examining activity monitor use in older adults with heart failure during and after hospitalization

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ABSTRACT

Our study examined feasibility and acceptability of continuous objective activity monitoring during hospitalization and after discharge in older adults with heart failure. Recruitment rate was 49.2% of eligible patients with a 93.1% retention rate. Twenty-seven older patients admitted with heart failure (78 ± 9.8 years; 51.8% female) wore two inclinometric accelerometers to record posture in-hospital and an ankle accelerometer to record ambulatory activity in-hospital and 30-days after discharge. During hospitalization, participants had 96.2% recorded wear time for postural accelerometers, and 99% for the ankle accelerometer. During the post-discharge period, there was 92% recorded wear time of the ankle accelerometer. Themes identified by participants were ease of wear, compatibility with hospital technology, remembering device/device use, and need for feedback/curiosity. Our study demonstrates feasibility and acceptability of continuous objective monitoring during hospitalization and at home in this clinical population.

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Introduction

Older adults who engage in physical activity (PA) such as walking during and after hospitalization have better health outcomes and return of physical function.^{1–3} However, interventions to promote PA in older clinical populations are resource intensive. Emerging evidence into mobile health technologies in older adult populations offers significant promise for improving health and fitness while reducing burden of interventionist follow-up. Activity monitors have yielded reliable and valid results in healthy adults and older community-dwelling adults,^{4,5} and mixed results in disabled persons or in those with altered ambulatory patterns.⁶ There is a slow increase in studies utilizing wearable activity monitors to measure PA in older clinical populations. Brown et al.⁷ were among the first to use objective monitoring of posture and steps in a sample of hospitalized older male Veterans, and Pedersen et al.⁸ measured the same in a cohort of older hospitalized adults. Both studies reported similar lying and sitting times among participants. Activity monitors have been used to examine associations of hospital stepping activity and minutes active with survival after discharge in older hospitalized adults.⁹ Researchers have also used activity monitors to investigate ambulatory (steps)

level as a predictor of readmission¹⁰ and functional outcomes post-discharge.¹¹ While these studies are promising for new discovery, few studies have described in detail feasibility and acceptability of their use in older clinical populations.^{12,13} Furthermore, the adoption of mobile health technologies such as activity monitors in clinical care remains low. The very limited evidence regarding how older clinical populations view wearable activity monitors may be a barrier to initiation of monitor use and development of successful interventions incorporating these modalities in health settings.

There are many research-grade and commercial activity monitors from which to choose. Accuracy and cost are two major factors. The activPAL3c™ micro accelerometer (hereafter called activPAL™) (Pal Technologies Limited, Glasgow, UK), is one of the most accurate (with 97% precision) free-living postural classifiers of lying/sitting versus standing when the device is placed on the thigh.¹⁴ Further data suggests that an additional activPAL™ sensor placed on the rib/torso can accurately (with close to 100% precision) distinguish between sitting and lying positions when data are merged with the device on the thigh.¹⁵ The activPAL™ can be fully waterproofed and fixed discreetly to the thigh and torso using a transparent dressing and continuously record for 10 days. The Tractivity® accelerometer (Kineteks Corp., Vancouver, B. C., Canada) is a secure web-based activity monitor worn on the ankle. It utilizes tri-axial accelerometry and advanced signal-processing techniques to detect step count and time active and

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is designed to track ambulatory activities that involve taking steps. It uses a cloud-based data collection system. Tractivity® continually obtains activity data for up to one year on a battery and wirelessly transfers activity data via IOS Cloud systems or a Bluetooth® connection to a secure server for viewing by those with granted access. These monitors may provide accurate, objective information on patient activity to nurses and other medical team members during hospitalization and after discharge.

The purpose of this study was to examine feasibility and acceptability of continuous objective activity monitor use in an aging clinical population during and after hospitalization. In addition to evaluating usability of the specific devices to record patient activity in and out of the hospital setting, we wanted to evaluate recruitment (whether the clinical population would enroll in a study utilizing activity monitors), retention, level of burden of assessments, and acceptability ratings of participants. This is a first step to better understand how activity monitors may be utilized to promote PA for recovery of physical function in older clinical populations.

Methods

Design and setting

We conducted a prospective observational study of older adults with heart failure, including a qualitative component of thematic analysis. Data were collected at two community hospitals from February to July 2015. As part of a larger study,¹¹ we wanted to evaluate feasibility and acceptability of activity monitor wear in older adults with heart failure. The study was approved by affiliated hospital and university institutional review boards. All participants provided written, informed consent prior to participation.

Recruiting and sample

Nurse investigators reviewed medical records of older adults admitted to a general medical unit with a diagnosis of heart failure. Major inclusion criteria were: ≥ 62 years, heart failure primary

diagnosis, living independently prior to hospitalization with self-reported ability to walk without assistance of another person (assistive device such as walker permitted) across a small room during the month prior to admission, and expected hospital stay at least two days. Exclusion criteria included: medical contraindications to wearing activity monitors, cognitive impairment delineated in medical record, non-English speaking, and discharge to other than home. During the study period, 135 patient records were reviewed; 59 (43.7%) met eligibility to participate and 29 were enrolled (see Fig. 1). Primary reasons for declining participation were “not interested” ($n = 19$), and “felt too ill to participate” ($n = 8$). Two participants were discharged from the hospital to a skilled nursing facility and thus no longer met criteria. A sample of 27 older adults admitted with heart failure diagnosis was followed from consent, through hospitalization, and until the 30-day post-discharge or readmission end-points. Five participants were readmitted to the hospital during the study period.

Procedures

Investigators showed participants the monitors and provided an overview of activity data to be collected. Posture was assessed with activPAL™, and ambulatory activity was assessed with the Tractivity®. Investigators used a laptop computer with appropriate software and connected to hospital Wi-Fi to initialize the activPALs™. They were then waterproofed and affixed with medical grade tape—one on the right rib cage area under the nipple line and one midline on the right thigh midway between the hip and knee joint—and were worn during the hospital stay. At the same time, the Tractivity® monitor was initialized using an android tablet enabled with Wi-Fi, then was placed on the ankle with a nylon strap and was worn throughout the hospital stay and at home for 30-days post-discharge. For each participant, literature was provided at the bedside and to nursing staff to minimize confusion during nursing and clinical care and to provide instructions on contacting the investigator in the case of a dislodged monitor or other concern. Participants were visited daily in the hospital by an investigator, then at home the day after discharge, and biweekly for two visits. Investigators reviewed the ankle monitor

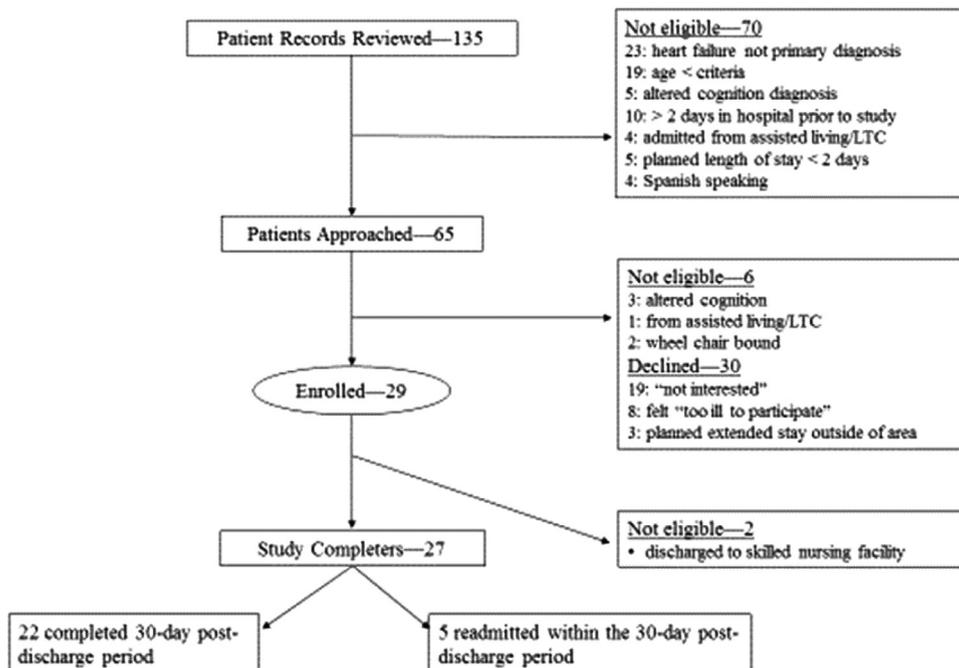


Fig. 1. Consort diagram.

when visiting the participant during the post-discharge period. We offered the Tractivity® ankle monitor to participants to keep for personal use at the end of the study.

Data collection and analysis

Demographic and clinical characteristics were collected through chart review and patient survey. Percent wear time, time in posture (lying, sitting, standing) and daily stepping were collected for hospital stay. Postural data were downloaded the day after discharge when the activPALs™ were collected from the participant. Hospital step data from Tractivity® were downloaded daily during investigator visits (with Wi-Fi enabled android tablet) and post-discharge step data were downloaded with the same device during scheduled participant home visits.

Documentation of monitor wear was by the investigator visually confirming daily monitor placement with participant and nursing staff and noting of reasons for non-wear (e.g. dislodged, removal for procedure). Investigators assessed the participant's skin daily around each of the monitors. The day after hospital discharge and bi-weekly, investigators visited participants at home to download recorded step data and document any self-report of non-wear time and issues identified by the participant. Estimation of non-wear time during hospitalization was performed by analyzing data near reported non-wear times for periods of 60+ minutes of non-movement with an interruption allowance of two minutes or less for activPAL™.¹⁴ Tractivity® data were analyzed for periods near reported non-wear times for two or more hours during waking hours of non-ambulatory time. The total time of that incident of no step count was considered non-wear (KineteKs, unpublished data, 2014). Percentage monitor wear time was then calculated.

Acceptability was assessed during the last study visit via semi-structured interview questions (e.g. "Tell me about your experience

wearing the monitors in and out of the hospital", and "Please share any issues you had with the monitors"). We also offered to assist participants to set up the ankle monitor with mobile app for personal use and asked if they would like to continue using it for personal use.

Analysis

Demographic and clinical data are reported descriptively (mean, median, percentages), stratified by age group. Percent time in posture, steps per day, and total wear/non-wear time were calculated for hospitalization; steps per day and total wear/non-wear time were calculated for the 30-day post-discharge period. Non-wear time was also categorized according to cause. Feasibility was analyzed by calculating overall and monthly recruitment rates and retention rate and are reported as percentages.

Thematic content analysis was used to understand participant perceptions regarding wear of the monitors. First, one independent investigator summarized each participant's answers, then grouped and coded similar statements. Next, the first and another investigator reviewed codes and combined them into themes. Last, each theme was agreed upon by all authors and described using representative quotations. Recurring themes were identified.

Results

Investigators screened an average of 27 patient records each month over the five-month study period. We had a 49.2% response rate for recruitment of eligible patients to the study and 93.1% retention rate. Other than losing two participants who no longer met eligibility (not discharged home), there was no dropout in our study. Table 1 shows demographic and clinical characteristics of the sample. Participants were 78.0 ± 9.8 years, 51.8% female, 92.6% White, and 66.7% lived with a spouse or family member. The median hospital

Table 1
Participant characteristics and activity measurements (N = 27).

Characteristic	Age 62–79 years n = 15 N (%)	Age 80+ years n = 12 N (%)	Total N (%)
Age, M ± SD	70.6 ± 5.6	87.3 ± 4.2	78.0 ± 9.8
Sex, female	7(46.7)	10(83.3)	14(51.8)
Race			
White	13 (86.7)	12 (100)	25 (92.6)
Hispanic	2 (13.3)	0 (0)	2 (7.4)
Marital Status			
Married	5 (33.3)	5 (41.7)	10 (37.0)
Widowed	5 (33.3)	7 (58.3)	18 (44.4)
Single/Divorced	5 (33.3)	0 (0)	5 (18.5)
BMI, M ± SD	27 ± 6.5	25.6 ± 3.3	26.4 ± 5.2
Comorbidities, M ± SD	5.1 ± 2.3	4.7 ± 2.0	4.9 ± 2.2
Hypertension	12 (80.0)	10 (83.3)	22 (81.5)
Atrial Fibrillation	3 (20.0)	7 (58.3)	10 (37.0)
History of MI	3 (20.0)	0 (0.0)	3 (11.1)
Diabetes	6 (40.0)	2 (16.7)	8 (29.6)
Arthritis	0 (0.0)	4 (33.3)	4 (14.8)
Renal Insufficiency	3 (20.0)	2 (16.7)	5 (18.5)
COPD	4 (26.7)	3 (25.0)	7 (25.9)
Depression	1 (6.7)	3 (25.0)	4 (14.8)
Ejection Fraction ^a , %, M ± SD	35.3 ± 14.3	50.8 ± 12.2	42.2 ± 15.3
Hospital Length of Stay, M ± SD	5.8 ± 4.1	4.2 ± 2.5	5 ± 3.9
Median	4.2	3.5	3.9
Activity Measurements			
Hospital Posture (% per 24 h), M ± SD			
Time lying	56.8 ± 20.5	70.1 ± 14.8	63.01 ± 19.2
Time sitting	34.6 ± 20.3	24.9 ± 15.8	30.27 ± 18.7
Time standing	6.2 ± 5.1	4.2 ± 2.4	5.30 ± 4.2
Time ambulating	3.5 ± 11.5	0.3 ± 0.2	1.97 ± 8.6
Hospital steps per 24 h, M ± SD	1801 ± 1460	1005 ± 465	1447 ± 1184
Steps during 30d post-discharge period ^b , M ± SD	5083 ± 2401	4099 ± 2206	4851 ± 2253

^a EF reported in percentage of volume.

^b Average steps for 30-day post-discharge period or period prior to readmission if at least five days of post-discharge data; does not include 1 participant readmitted within 2 days.

stay was 3.9 days. During hospitalization, participants had 96.2% recorded wear time for the activPAL™ postural monitors, and 99% for the Tractivity® ankle monitor. Two activPALs™ were lost during routine patient care. One participant was diaphoretic that led to loosening of the tape over the device on the rib area and the device was dislodged approximately 18 h after placement. An activPAL™ affixed to the thigh of a second participant was lost due to frequent toileting care approximately 24 h after placement. A subsequent activPAL™ was placed back on each participant within 6 h, but all prior data was lost. Six participants had an invasive procedure performed (e. g. cardiac catheterization) while the monitors remained in place. Nursing staff stated no monitors required removal for any procedure or care activity. When investigators made daily visits to the hospital, most participants (92%) were available in their room for monitor assessment and Tractivity® data download.

Participants ($n=22$) completing the full 30-day post-discharge period had 92% recorded wear time for the ankle monitor. The most common non-wear time at home was time-lapse after hygiene activities before remembering to replace the monitor on the ankle. One participant removed the monitor for five days due to general anxiety. Another participant attended a formal event for several hours and did not want to wear the activity monitor.

For both devices, participant themes during their hospital stay were ease of wear and compatibility with hospital technology. During the post-discharge period, participant themes were ease of wear, remembering device, and need for feedback/curiosity. Table 2 highlights participant quotes supporting each identified theme. At study conclusion, just four of 22 participants (18%) stated they would like to continue wearing the ankle monitor for personal use. Only one of these was in the 80+ age group. The majority stated they did not have interest in tracking their steps for the long term (8 participants), did not have a Smartphone/android device for the monitor app (7 participants), or were not comfortable with Smartphone/android technology or computer software (3 participants). Of the seven participants without a Smartphone, six of them were in the 80+ age group.

There was some burden on hospital staff during this study. Investigators reviewed patient charts independently and only confirmed patient eligibility information with the primary nurse. A few participants' study literature was misplaced/lost during their stay, requiring nurses without knowledge of the study to follow-up with a supervisor or co-worker. Investigators replaced any missing literature in the room during their daily visits and were available for education/instruction if requested by staff.

Discussion

Our study is among the first to evaluate feasibility and acceptability of objective activity monitor wear by older adults during and after an acute hospital stay. There was an adequate pool of eligible patients for recruitment and our high recruitment rate over 49% was a welcome finding. The use of nurse investigators to recruit face-to-face likely supported enrollment. It is feasible to use monitors on various body locations and track activity of patients during a general medical hospitalization period. Participants had very high wear time of all activity monitors in and out of the hospital. It is likely that wearing the monitors while hospitalized was viewed by participants as just "one more thing in the hospital". The use of small, non-intrusive monitors such as activPAL™ and Tractivity® may minimize the burden of wearing such devices; they did not interfere with any medical or nursing procedures. A few postural monitors were lost during hospitalization. A limitation of this specific device is the inability to download data until the device is removed from the participant, resulting in loss of data from lost devices. Technology advances may support current commercial monitors to collect this information daily.

Table 2

Participant themes regarding monitor wear.

Monitor wear in hospital: Ease of wear	
What's one more thing in the hospital? I am so tied up anyway, as long as I don't have to get stuck for it.	Participant 106, Female, 75 years
I didn't remember they were there until each time [investigator] came in	Participant 119, Male, 71 years
Compatibility with technology they were not in the way-even for my procedures	Participant 128, Male, 84 years
Not even a problem when I had my catheterization [cardiac]	Participant 117, Male, 62 years
They could get all my vitals [signs] with no interference from it...	Participant 118, Female, 64 years
Monitor wear at home: Ease of wear	
It was around my sock and I didn't remember it was there most of the time	Participant 109, Male, 89 years
It was very easy to keep on in the ankle strap and comfortable	Participant 123, Male, 75 years
Remembering device	
I would take it off for my shower... didn't want to wear it in there...I forgot a couple times to put it back on until later	Participant 111, Male, 69 years
I had no problems wearing it...took it off one time and went out and forgot it	Participant 125, Female, 70 years
Need for feedback	
I liked seeing my activity when you came to visit...I'm glad you told me	Participant 101, Female, 75 years
it was a bother sometimes because it didn't tell me anything, but I remembered you need the information for your study	Participant 119, Male, 71 years

The very high wear time for the ankle monitor at home may support ankle placement to improve wear compliance as this location does not interfere with clothing at the waist or become a distraction on the hip or wrist. However, ankle placement may be a disadvantage for those who wish to interact with the device, such as review data on the device face. Incorporating daily syncing of devices with Smartphones or computers may provide support for ankle location. The long-term data collection capability of devices such as Tractivity® and usability of personal Smartphones/tablets for data download supports the use of these devices in the community without the requirement for frequent investigator contact. The high wear time at home also may have been supported by the bi-weekly nurse visits. It may be possible for community participants to have nurse support directly through the activity monitor app without face-to-face follow-up, as many of these devices have programs enabling sharing of data and allow comment postings from another user with granted access.

Findings from our study show that older adults with heart failure are accepting of activity monitor wear during and after hospitalization. Comments regarding acceptability of device wear in our sample were similar to responses in other studies of clinical populations.^{12,13,16} Some of the participant themes from our study are supported by Rosenberg et al.,¹³ highlighting ease of wear and need for feedback as two key areas for activity monitor acceptance and uptake. There were similar acceptability feelings across ages in the sample regarding monitor wear during the study, however fewer participants in the 80+ age group were interested in learning their step activity during the investigator home visits. Additionally, a majority of the 80+ age group did not have access to a Smartphone/tablet or were not comfortable operating one. This may be especially important when addressing technology adoption in persons 80 years and older as they are the adult group with the lowest Smartphone use.¹⁷ This group

may be more accepting of standard pedometers that use basic displays on the monitor and recording in a daily step log that could be shared with a provider or other health support person. We suggest further research with this age group.

Limitations

The devices did not provide personal feedback to participants thus we cannot evaluate acceptability of technology adoption in this sample. We were not able to obtain feedback from physicians/health care providers regarding usefulness of the monitors to provide mobility metrics. This limits our ability to fully evaluate feasibility and is an area we suggest for research on adoption of mobility metrics into patient electronic health records. Furthermore, no participant data/feedback were provided to nursing staff, thus we were not able to ascertain their views on incorporating patient mobility metrics into their plans of care.

Implications

Wearable objective monitors may be used to aid nursing and other healthcare personnel to capture real-time data on time-in-posture or ambulatory status for their patients. This objective information could inform staff about appropriate times for repositioning, assisting out of bed or ambulation in the hallway. Additionally, future research should focus on identifying key time points of ambulatory change in the transition to home that may indicate a decline in health status of the older adult. Persons with heart failure experiencing an exacerbation may have notable changes in stepping activity due to fatigue, and it may be possible to detect this trajectory if daily step review is available to a health professional. The ability to identify a decline prior to a critical emergency and intervene may reduce the need for hospital admission or promote faster recovery. These are highly relevant uses for activity monitor wear, however, patients need to be open to wearing them if we hope to harness this information.

Conflict of interest

The authors have no conflicts of interest to declare.

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