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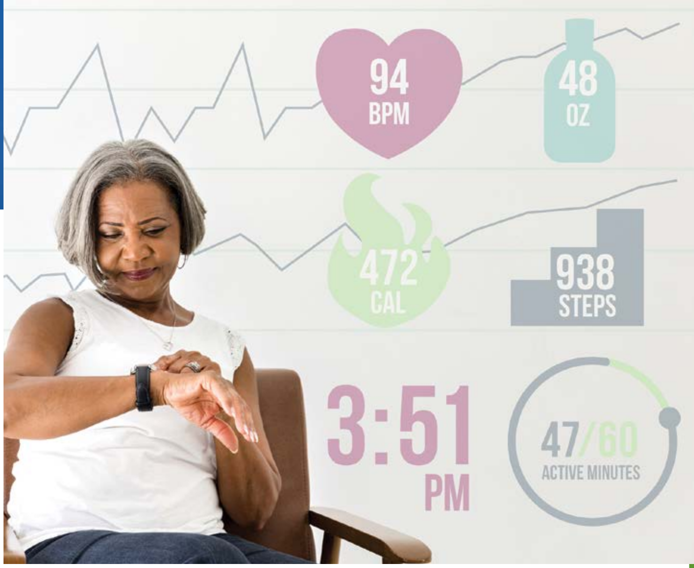

Sustaining Physical Activity Following Cardiac Rehabilitation Discharge

Kelly R. Evenson, Ty A. Ridenour, Jacqueline Bagwell, and Robert D. Furberg

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Abstract

Because many patients reduce exercise following outpatient cardiac rehabilitation (CR), we developed an intervention to assist with the transition and evaluated its feasibility and preliminary efficacy using a one-group pretest–posttest design. Five CR patients were enrolled ~1 month prior to CR discharge and provided an activity tracker. Each week during CR they received a summary of their physical activity and steps. Following CR discharge, participants received an individualized report that included their physical activity and step history, information on specific features of the activity tracker, and encouraging messages from former CR patients for each of the next 6 weeks. Mixed model trajectory analyses were used to test the intervention effect separately for active minutes and steps modeling three study phases: pre-intervention (day activity tracking began to CR discharge), intervention (day following CR discharge to day when final report sent), and maintenance (day following the final report to ~1 month later). Activity tracking was successfully deployed and, with weekly reports following CR, may offset the usual decline in physical activity. When weekly reports ceased, a decline in steps/day occurred. A scaled-up intervention with a more rigorous study design with sufficient sample size can evaluate this approach further.

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Introduction

Lack of physical activity is a major risk factor for cardiovascular disease[1] and physical activity is recommended for both primary and secondary cardiovascular disease prevention.[2] Despite these recommendations, physical activity is often suboptimal among those with cardiovascular disease. National data indicate that those with cardiovascular disease have lower accelerometer-assessed physical activity and higher sedentary behavior than a matched comparison group without cardiovascular disease.[3] Cardiac rehabilitation is a medically supervised, comprehensive, secondary prevention program with the overarching goal to stabilize, slow, or reverse the progression of underlying atherosclerotic processes, thereby reducing disability and death.[4] In the United States, eligibility for cardiac rehabilitation includes conditions such as myocardial infarction, stable angina, and congestive heart failure, and receipt of treatments such as coronary artery bypass graft surgery, percutaneous coronary intervention including angioplasty or stenting, heart valve repair or replacement, and heart or heart-lung transplant.

Although the value of physical activity and exercise (a component of physical activity) is well established as a component of cardiac rehabilitation, it must be maintained beyond the structured cardiac rehabilitation program for optimum benefit.[5,6] This period of transition from cardiac rehabilitation to self-monitoring is often not adequately addressed by professionals, particularly because there is not usually a reimbursement mechanism for insurance coverage, and by researchers, because there is a lack evidence-based interventions developed to facilitate this important milestone. The importance of this transition cannot be understated: it is a time of concern for the patient because their condition is no longer being monitored (i.e., electrocardiogram, heart rate, blood pressure, signs, and symptoms); they are not being supervised by professionals while exercising; and they miss the social support of peers in their group with similar conditions.

Most patients are unable to maintain the exercise routine they acquire during supervised cardiac rehabilitation and discontinue exercise. As a result, the patients begin to lose the benefits they achieved during the period of supervised cardiac rehabilitation. Studies document that fewer than half of patients continue to exercise after cardiac rehabilitation completion,[7] and some studies report fewer than 15 percent continue to exercise one year later.[8] Even with regular follow-up telephone calls, fewer than 40 percent fully adhered to prescribed exercise protocols.[6,9] This may be caused by patients' transition back to work, loss of social support, and lack of continuity with tailored monitoring and staff contact.

Mobile and wireless technologies, including smartphones and wearables, could transform delivery of some health services. Specifically, emerging mobile health technologies may provide a lower cost and a more engaging opportunity to assist cardiac rehabilitation patients through that transition. There is early evidence that interventions using these technologies may help maintain physical activity during maintenance cardiac rehabilitation programs[10] or following cardiac rehabilitation discharge.[11–13] However, cardiac rehabilitation recommendations and context differ across countries,[14] and few studies explore use of an activity tracker post cardiac rehabilitation in the US context.[15] Our study developed a theory-based digital health intervention to assist cardiac rehabilitation patients in transitioning from outpatient cardiac rehabilitation to exercising on their own. Using a one-group pretest-posttest design, the intervention was pilot tested for feasibility and preliminary efficacy.

Methods

The procedures for all components involving human subjects were approved by the Institutional Review Board at the University of North Carolina at Chapel Hill.

Participants

Staff recruited patients for the intervention who were attending a single cardiac rehabilitation program in North Carolina and had at least 4 weeks left before completion. Eligible participants were at least 18 years old, had a diagnosis of coronary heart disease, were

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of adequate clinical stability to allow participation, owned a smart phone, and were able to read and write in English. The following exclusion criteria were used:

- Currently using a digital or nondigital physical activity tracker (e.g., Fitbit, Jawbone, pedometer)
- Past use of a digital activity tracker (e.g., Fitbit, Jawbone)
- Planned re-location within 12 weeks
- Medical procedure scheduled within next 12 weeks
- Acute symptoms of coronary artery disease
- Decompensated heart failure
- Severe valvular heart disease
- Severe pulmonary hypertension
- End stage renal disease
- Heart failure, New York Heart Association class IV
- Cardiac transplantation
- Impairment from stroke, injury, or other medical disorder that would preclude participation in the intervention
- Dementia that would preclude ability to participate in and follow study protocols
- Inability or unwillingness to comply with the study requirements

In total, seven cardiac rehabilitation patients were approached, and five agreed to participate.

Assessments and Points of Contact

Table 1 provides a summary of the intervention and measurement periods. Participants began cardiac rehabilitation from August 2017 through September 2017. All five participants enrolled in the study in November 2017 and the final participant completed the intervention in March 2018. At enrollment, participants signed the informed consent and completed a written questionnaire, which included questions on age, employment, phone ownership, general health, diagnosis, and general social support during this time. Specific to cardiac rehabilitation, the form asked about attendance, physical activity during a typical session, physical activity outside of cardiac rehabilitation, confidence and any concerns about continuing to exercise, typical weekday and weekend

Table 1. Summary of intervention and measurement periods

Intervention Periods	Time Periods	Description	Self-Report Measurement	Activity Tracker Wear
Pre-intervention: during CR, starting on the day the activity tracker was given and ending on the last day of CR	At least 4 weeks of CR; weekly summary of steps and physical activity minutes sent	Enrolled in study	Questionnaire #1	Activity tracker starts[a]
		Discharge meeting with CR staff and with research staff	Questionnaire #2	
Intervention: starting the day following cardiac rehabilitation discharge and ending on the day the last (sixth) report was sent	Week 1	Topic: weight tracking[b]		
	Week 2	Topic: sedentary behavior[b]		
	Week 3	Topic: heart rate[b]		
	Week 4	Topic: sleep tracking[b]		
	Week 5	Topic: connecting the activity tracker to other apps[b]		
	Week 6	Topic: resetting goals[b]		
Maintenance: starting the day following the last report and ending the last day of tracking by study staff	• Day after last report • Approximately 4 weeks following the last report	Contacted with instructions to change activity tracker password	Questionnaire #3	Activity tracker ends[a]

Abbreviations: CR = cardiac rehabilitation

[a] Participants were asked to wear the activity tracker daily from enrollment to the study to 4 weeks following the last report.

[b] Intervention materials always included (1) their weekly step and physical activity results and comparisons to their results during CR, (2) supportive messages from focus groups and follow-up in-depth interviews with past CR participants, and (3) special topics on the activity tracker as described in the table.

day physical activity, and experience tracking health behaviors.

Also at this meeting, the Fitbit app was loaded on their phone and instruction was provided on how to use the Fitbit Alta HR activity tracker with the app. Specifically, instruction included how to view their steps and minutes of physical activity, as well as how to enter activities (such as using a stationary bicycle or an elliptical trainer) manually using the diary function. Participants were advised to wear the activity tracker on their nondominant wrist and remove it during bathing and swimming because it was not waterproof. They were also advised to charge the device daily. Staff also gave participants a summary sheet on this information with staff contact information for any questions. Staff set up Fitbit accounts for each device according to the protocol detailed elsewhere.[16]

On the day of cardiac rehabilitation discharge, participants had a final meeting with program staff. With permission from the participant, one study staff member observed each of these meetings to record information regarding exercise prescription and other risk factor instructions. Following this, study staff briefly met with the participant to address any intervention questions and to describe the weekly emailed reports they would receive. At this time, a second questionnaire was completed, which included questions on general health, changes in health status, confidence in continuing to exercise, and whether the activity tracker and weekly emails were useful.

For the 6 weeks following cardiac rehabilitation discharge, participants received tailored emailed reports on a weekly basis. Following the sixth tailored report, participants were notified that staff were available for questions but that weekly notifications would cease. At that time, participants were sent the third questionnaire, which included the same questions asked at cardiac rehabilitation discharge, along with items on whether the individualized reports were useful, whether activity tracker features highlighted in the weekly reports were used, and any other feedback on the intervention they wanted to provide. Approximately one month later, a final email was sent that instructed participants to change their Fitbit password to disallow account access by study staff. Participants retained the tracker at the end of the study (~$150 US dollars).

Intervention

The social cognitive theory[17] guided our approach and the intervention focused on incorporating behavioral change techniques to address the potential for decline in physical activity following cardiac rehabilitation.[18,19] The techniques specifically from the Fitbit activity tracker and app[20] included goal setting, reviewing goals, identifying discrepancy between current behaviors and goals, receiving feedback on behavior, self-monitoring, biofeedback (e.g., heart rate), reward, and focus on past success. The options for social comparison and social support using the app were not used, based on feedback we received from focus groups of cardiac rehabilitation participants before the intervention launch.[21] In addition to the activity tracker, we reinforced most of the techniques and incorporated social support through the weekly tailored messages.

After enrollment and during cardiac rehabilitation, a summary of daily steps and minutes of physical activity recorded from the activity tracker were emailed to each participant at the end of each week. The same graphics could be viewed within their Fitbit app dashboard. No other feedback was given. This was sent to allow the participant to become used to wearing the tracker and to understand their own daily physical activity and steps through self-monitoring. This also allowed time for questions and technical challenges to be addressed.

Following cardiac rehabilitation discharge, weekly for 6 weeks, individualized reports were sent to participants as both an email and an email attachment (Adobe Acrobat Portable Document Format). The messages included a summary of their physical activity and steps data along with comparisons with their data during cardiac rehabilitation, supportive messages from other cardiac rehabilitation participants, and highlights of various Fitbit features. The comparison of current data with steps and physical activity during cardiac rehabilitation attempted to make the participant more aware of whether they were reaching their goals and of any drop-off in physical activity that might be occurring. The supportive messages consisted of quotes from focus groups and follow-up in-depth interviews of cardiac rehabilitation participants, with examples provided in Table 2.[21] The Fitbit features highlighted on a weekly basis included (in order of the week delivered) weight tracking, setting reminders to move more each hour to reduce sedentary behavior, heart rate usage, sleep tracking, connecting the Fitbit to other apps, and resetting goals within the app. The report concluded with encouragement based on whether goals were being met and whether they had a successful week, both based on physical activity and steps. The final pages of the message contained charts of their daily physical activity minutes and steps over time, similar to what was available from the dashboard.

Data Analysis

All five participants used the activity tracker during and after cardiac rehabilitation as indicated by the intervention. To determine an adherent wearing day, we defined it to be a day where at least 500 steps were taken, although we also explored a 1,000 steps/day criterion. Days with steps lower than these values were considered to be missing.

Data for the participant's first day in cardiac rehabilitation was collected and for each day in attendance following study enrollment. The following dates were specified for analysis, corresponding to three time periods:

- Pre-intervention: during cardiac rehabilitation starting on the day the activity tracker was given to the last day of cardiac rehabilitation (e.g., discharge);
- Intervention: day following cardiac rehabilitation discharge to the day the last (sixth) report was sent; and
- Maintenance: day following the last report to the last day of tracking by study staff.

The within-subject study design and analyses are based on previous small sample clinical trials.[22–25] The outcomes tested for the intervention included

Table 2. Examples of messages from prior cardiac rehabilitation participants

Topic	Message Excerpt
Benefits of exercise	As we mentioned last week, we spoke with other cardiac rehabilitation participants. Here is what one person had to say about the benefits of exercise for her. "I just have a lot more energy. I didn't have much energy before. But I do have energy now. It was just gone and I couldn't do anything really. But after being here [in cardiac rehabilitation], you know … now I can walk without huffing and puffing. And I can clean the house. I like to think that's a good thing."
Transition from a structured cardiac rehabilitation program	Can you believe it has been about a month since you finished cardiac rehabilitation? Have you stuck with your transition plan so far upon finishing or have you had to modify the plan to make it work for you? One cardiac rehabilitation participant we spoke with had this to say about the topic as she was preparing to finish. "I think perhaps, making sure that somebody has a transition plan, like, what are you going to do, how are you going to do it, where are you going to do it. Some people just say, "Oh I'll walk." I'm trying to come up with a plan, but it's unpredictable. I'm planning to join a gym, but if something in the house needs repairs, there goes the gym membership."
Encouragement to continue comprehensive changes	When we interviewed cardiac rehabilitation participants who had finished the program, we asked them what encouragement they might have for others. Here is what one gentleman wanted to say to you. "Try to instill to them that the most important thing is them. Don't try to do this because of my girlfriend, because of my wife… it needs to be pounded in their head that it is about them. It starts with you first. That's made a mentally way of try to instill to them that, than trying to say it's for your grandkids, for your wife. Just let them know that if your heart ain't kicking, then you ain't going to be around to do that. You ain't going to around to be with your grandkids or with your wife. So, that's why it's so important for you to know that this is for you. In order for you to do the things that you want to do, you've got to do the right things for yourself."
Usefulness of activity tracker	Here is what one person had to say who started using the Fitbit activity tracker during cardiac rehabilitation and continued afterwards. "Because of the functionality of the Fitbit, you're able to . . . do workouts and you could tell by the timing of the day, the intensity, duration, the heart rate, and it was very easy do distinguish between the [exercise sessions] that were done in rehab versus the ones in addition to rehab, and mostly after rehab."

physical activity (defined by the activity tracker as very active minutes/day) and steps/day, both of which had evidence for validity and reliability from earlier Fitbit devices.[26]

The activity tracker data were analyzed using SAS (2018) version 9.4 (Cary, NC). Since results were similar with both adherence definitions, models only included days with at least 500 steps. Mixed model trajectory analysis using PROC MIXED was used to test the effect of the intervention. To prevent potential biases in estimates that can occur with small samples, statistical comparisons between competing models in terms of their fit to observed data used the full maximum likelihood estimation. Derivation of the variable coefficients within the best fitting model used restricted maximum likelihood estimation. Fit to observed data among competing models was based on Akakie's Information Criterion, Bayesian Information Criterion, and the likelihood ratio χ^2 test.

Dependent variables consisted of either number of very active minutes/day or steps/day. Independent variables consisted of differences between study periods in terms of intercepts and slopes (i.e., as interaction terms). Differences among study periods were tested for improving fit to the observed data compared with a more parsimonious model. The first model was a standard comparison model, consisting of study-aggregate fixed and random intercepts and slopes, autocorrelation, and the time trend observed in the dependent variable. Several error covariance structures were compared to determine which best fit the average autocorrelation pattern in the observed data (autoregressive lag 1, compound symmetry, Toeplitz, and variance components). The second model tested the difference between days on which a cardiac rehabilitation session occurred versus other days to control for the effect of supervised exercise. The third and fourth models, respectively, tested for differences in intercepts and slopes of participants' active minutes (or steps) on days during maintenance versus intervention periods and then during pre-intervention period versus the rest of the study time.

Results

Description of Sample

Participants were referred to cardiac rehabilitation because of recent coronary artery bypass grafting surgery ($n = 2$), coronary artery stenting ($n = 2$), and myocardial infarction ($n = 1$). They ranged in age from 51 to 79 years, including four men and one woman, and attended cardiac rehabilitation two to three times/week with 80 percent reporting excellent ($n = 2$) or very good ($n = 2$) general health (Table 3). Most ($n = 4$) reported their physical activity to be about half sitting/standing and half walking on both weekdays and weekend days. During cardiac rehabilitation, participants engaged in walking, stationary bicycling, using an elliptical (recumbent or upright), and strength training. Activities outside of cardiac rehabilitation included interval running, Zumba classes, walking, elliptical, bicycling, rowing, strengthening, and chopping wood. All participants responded that they had social support during this time.

All participants owned a cell phone. Four participants indicated that they tracked health behaviors, including weight, blood pressure, and salt and sugar intake. One participant indicated tracking bicycling using MapMyRide, but none of the participants had tracked other types of physical activities, including steps. Three participants were very confident and two were somewhat confident that they would continue to exercise following cardiac rehabilitation discharge. For the two participants who were somewhat confident, concerns were around work and life conflicts ($n = 1$) and not enjoying exercise ($n = 1$).

Self-Reported Assessment

Total time participants attended cardiac rehabilitation ranged from 80 to 138 days (mean 113, standard deviation 26, median 127 days). For the pre-intervention period (study enrollment to cardiac rehabilitation discharge), four participants attended 6 to 12 (6, 7, 7, 12) cardiac rehabilitation sessions, with a time period ranging from 16 to 64 days. One participant did not return to cardiac rehabilitation after the enrollment visit as planned because of work schedule changes. Therefore, the second assessment

Table 3. Description of participants at study entry (*n* = 5)

Characteristics	n	%
General health		
Excellent	2	40
Very good	2	40
Good	1	20
Fair		
Poor		
Employment[a]		
Employed for wages full time	2	40
Employed for wages part time	1	20
Out of work	1	20
Retired	1	20
Typical weekday		
Mostly sitting or standing	1	20
About half sitting/standing and half walking	4	80
Mostly walking	0	
About half heavy work and half sitting/standing	0	
About half heavy work and half walking	0	
Mostly heavy work or physically demanding work	0	
Typical weekend day		
Mostly sitting or standing	0	
About half sitting/standing and half walking	4	80
Mostly walking	0	
About half heavy work and half sitting/standing	1	20
About half heavy work and half walking	0	
Mostly heavy work or physically demanding work	0	
Phone ownership		
Landline		
Yes	1	20
No	4	80
Cellular phone		
Yes	5	100
No	0	
Use of activity tracker (i.e., Fitbit, Jawbone, smartwatches)		
Yes	0	
No, I do not track my fitness, steps, or other physical activity	4	80
Other, tracks bicycling only	1	20
Confidence in continuing exercise		
Very confident	3	60
Somewhat confident	2	40
Not at all confident	0	

[a] Other employment responses were not chosen, including self-employed, homemaker, student, or disabled and unable to work.

was completed approximately 7 weeks after the initial assessment, corresponding to when the intervention messages began.

The distribution of general health did not change from baseline to cardiac rehabilitation discharge and intervention completion. Four participants received the intervention without interruption; one participant did not receive the sixth report because of reoccurring angina. Three of the five participants had activity tracker failure at some point during the study, including trouble syncing (*n* = 2) and heart rate device failure requiring a replacement (*n* = 1). At cardiac rehabilitation discharge, four participants reported that the activity tracker was useful, with one participant explaining that it confirmed what they knew and was reassured to know it was capturing their information. At study completion, all five participants reported that the activity tracker was useful, and four planned to continue using it. The one participant not planning to continue cited challenges with synching and discomfort with the wrist band. Confidence in continuing to exercise following cardiac rehabilitation was high at discharge (*n* = 4 very confident, *n* = 1 somewhat confident) and at intervention completion (*n* = 3 very confident, *n* = 2 somewhat confident).

The weekly individualized reports were favorably received by participants, with all of them emailing back to study staff one to three times during the intervention period to provide unprompted feedback and updates. They reported that they were a useful centralized record, encouraging, and offered a perspective on how they were doing. Regarding the additional features highlighted in the weekly reports, four used the sedentary behavior reminders, three used weight tracking, and three used sleep tracking. Overall, three reported meeting their physical activity goals since cardiac rehabilitation discharge whereas two did not because of a busy schedule (*n* = 1) and weather/travel (*n* = 1).

Activity Tracker Assessment

Activity tracker adherence was high for four of the four participants, ranging from 89 percent to 100 percent using two different definitions of an adherent day (Table 4). Assessment of the intervention results included four participants,

Table 4. Number and percent of days with activity tracker wear adherence by participant (in order of days monitored in the study) using two different criteria

Participant	Total Study Days	No. (%) of Days ≥ 500 steps	No. (%) of Days ≥ 1,000 steps
1	95	53 (55.5%)	53 (55.2%)
2	98	99 (100%)	99 (100%)
3	105	105 (92.9%)	100 (88.5%)
4	113	113 (100%)	113 (100%)
5[a]	98	98 (90.7%)	96 (88.9%)

[a] This participant was not included in the modeling because no cardiac rehabilitation sessions following enrollment occurred during the pre-intervention phase.

with one participant excluded because no cardiac rehabilitation sessions following enrollment occurred during the pre-intervention phase. The crude mean number of very active minutes/day declined with time: 14 pre-intervention, 11 intervention, and seven maintenance. The crude mean number of steps/day also declined with time: 6,507 pre-intervention, 5,960 intervention, and 5,158 maintenance.

Because results were similar with both adherence definitions (e.g., ≥500 and ≥1,000 steps/day), models were conducted to include only days with at least 500 steps. Because of the decline over time, rather than statistically controlling for the effect of time as an unexplained latent trend, the statistical models were based on the more conservative assumption that decline in physical activity may be attributable to study periods (i.e., pre-intervention, intervention, maintenance). According to the model for very active minutes/day that included differences among the three study periods, participants averaged 9.3 very active minutes/day during the pre-intervention period on days that did not include a cardiac rehabilitation session, with 21.4 more minutes occurring on days when they attended cardiac rehabilitation, 0.01 more minutes/day during the intervention period, and 0.04 minutes/day fewer during maintenance (Table 5). When the maintenance period was dropped from the model, the results were similar with participants averaging 8.6 very active minutes/day during the pre-intervention period with 24.4 more minutes occurring on days when participants attended cardiac rehabilitation, and 0.02 minutes/day higher during the intervention period. Individual models for each participant demonstrated variation in the average very active minutes/day (range 1.2 to 22.7) and the impact of cardiac rehabilitation on that measure (0.7 to 42.2) but more consistency during the intervention (−0.01 to 0.07) and maintenance period (−0.08 to 0.005).

According to the model for number of steps/day that included differences among the three study periods, participants averaged 5,918 steps/day during the rehabilitation phase on days that did not include

Table 5. Model fit statistics testing if the intervention sustained very active minutes/day

Model Number and Description	AIC	BIC	−2LL	df	LR χ^2	p
1. Base Model	3180.5	3178.6	3174.5	4	—	—
2. Model 1 + Cardiac Rehabilitation versus Other Days	3122.2	3119.7	3114.2	5(1)	60.3	< 0.001*
3. Model 2 + Maintenance Period	3120.5*	3117.4*	3110.5	6(1)	3.7	< 0.10
4. Model 3 + Intervention versus Pre-intervention	3122.3	3118.7	3110.3	7(1)	0.2	ns

Abbreviations: AIC = Akaike information criterion; BIC = Bayesian information criterion; df = degrees of freedom (parenthetical value indicates the df for likelihood ratio χ^2 test); LL = log likelihood; LR = likelihood ratio; ns = not significant. * indicates the best fitting model per criterion.

Notes: *N* = 4; Observations = 370 days. Error covariance structure = variance components.

Base model consisted of fixed and random intercepts, autocorrelation, and linear effect of time.

Cardiac rehabilitation versus other days tested whether very active minutes/day were greater on days with cardiac rehabilitation compared with other study days.

Maintenance period tested for a difference in very active trends between follow-up study days compared with other study days, controlling for cardiac rehabilitation attendance.

Intervention versus pre-intervention tested for a difference in very active minutes/day between the intervention period and pre-intervention period, controlling for cardiac rehabilitation attendance and the study follow-up period.

The final models are detailed in Appendix Table A1.

a cardiac rehabilitation session, with 2,278 more steps occurring on days when they attended cardiac rehabilitation, a 0.4 steps/day decline during the intervention period, and a 7 steps/day decline during maintenance (Table 6). When the maintenance period was removed from the model, the results were similar with participants averaging 5,878 steps/day, with 2,287 more steps occurring on days when they attended cardiac rehabilitation and a 0.7 steps/day decline during the intervention period. Models for each participant demonstrated variation in the average steps/day (range 2,576 to 8,347) and the impact of cardiac rehabilitation on that measure (1,284 to 3,134) but demonstrated more consistency during the intervention (−7 to 7) and maintenance period (−23 to 6).

Discussion

In the United States, most outpatient cardiac rehabilitation programs include up to 36 sessions of supervised exercise, after which patients are prescribed exercise on their own. Because many patients reduce or discontinue exercise following cardiac rehabilitation completion, we developed an intervention to assist with the transition and evaluated its feasibility and preliminary efficacy. We found that activity tracking was successfully used throughout the monitoring period. We also found that the tailored reports were well received and provided added accountability by ensuring that someone was tracking participant physical activity following discharge.

Based on lessons learned from the pilot, there were four major areas of discovery. First, the reports would be more useful if delivered to the participant by cardiac rehabilitation program staff rather than research staff. For piloting purposes, so as not to burden the program staff, we provided the reports to participants each week. However, program staff knew the patient's medical history and exercise needs from the prior months spent during sessions and could provide feedback with a greater depth of understanding. In addition, one participant suggested that reports generated during cardiac rehabilitation be reviewed while at the facility, rather than only being emailed at the end of the week.

Second, although the weekly frequency of report generation worked sufficiently during and following discharge, tapering the reports might be better than simply removing them after the intervention period. The reports provided before discharge were given to reinforce the use of the activity tracker and understanding of how much physical activity was being performed while in cardiac rehabilitation. These reports mimicked what the participant could view on the Fitbit dashboard, and the frequency seemed reasonable. Detailed individualized reports were given for each of 6 weeks following discharge

Table 6. Model fit statistics testing if the intervention sustained steps/day

Model Number and Description	AIC	BIC	−2LL	df	LR χ^2	p
1. Base Model	6,914.8	6,912.9	6,908.8	4	—	—
2. Model 1 + Cardiac Rehabilitation versus Other Days	6,893.3	6,890.9	6,885.3	5(1)	23.5	<0.001*
3. Model 2 + Maintenance Period	6,891.6*	6,888.6*	6,881.6	6(1)	3.7	<0.10
4. Model 3 + Intervention versus Pre-intervention	6,893.6	6,890.0	6,881.6	7(1)	0.0	ns

Abbreviations: AIC = Akaike information criterion; BIC = Bayesian information criterion; df = degrees of freedom (parenthetical value indicates the df for likelihood ratio χ^2 test); LL = log likelihood; LR = likelihood ratio; ns = not significant. * indicates the best fitting model per criterion.

Notes: *N* = 4; Observations = 370 days. Error covariance structure = Toeplitz.

Base model consisted of fixed and random intercepts, autocorrelation, and linear effect of time.

Cardiac rehabilitation versus other days tested whether number of steps/day were greater on days with cardiac rehabilitation compared with other study days.

Maintenance period tested for a difference in trend of steps/day between follow-up study days compared with other study days, controlling for cardiac rehabilitation attendance.

Intervention versus pre-intervention tested for a difference between the intervention and pre-intervention period, controlling for cardiac rehabilitation attendance and the study follow-up period.

The final models are detailed in Appendix Table A2.

and then the reports were removed. The results indicated that daily steps declined during the maintenance period. To offset this, reporting could shift to every other week and then monthly to transition participants more gradually from staff-based monitoring.

Third, a better integration of step-based goals is needed during cardiac rehabilitation, if steps are used in setting goals in follow-up. The Fitbit application integrates goals based on steps. However, the participants were not given step goals during or at discharge, making these recommendations harder to follow. Moreover, if step goals are used, then stride length should be entered at set-up if the activity tracker allows for this.

Fourth, there was disconnect between the triangulation of intensity categories that counted physical activity minutes used by Fitbit (lightly active, fairly active, very active), the heart rate zones used by Fitbit (peak, ≥85 percent maximal heart rate; cardio, 70–84 percent; fat burn, 50–69 percent; and out of zone, <50 percent), and those perceived by the participant. This could be because of a variety of reasons, including a mismatch of heart rate prescription and the difficulty the tracker had with capturing non-locomotor activities. Although we encouraged the use of the diary function, some participants reported the activity tracker under-counted active minutes. This inaccuracy made it more difficult to provide feedback on the intervention reports because changes could have been caused by participation in differing physical activity modes rather than a true change in physical activity duration. Ways to address this mismatch include programming the activity tracker, if allowed, to a heart rate prescription tailored to the participant, several of whom were on medications that lowered typical age-predicted exercise heart rates.

Strengths and Limitations

The strengths of this study were the use of qualitative inquiry with both cardiac rehabilitation participants and program directors to inform the intervention development,[21] use of the social cognitive theory[17] to guide the intervention, and the adherence to the study protocol from participants. Limitations include the small sample size and enrollment from only one cardiac rehabilitation program. Despite the limited scope, valuable lessons were learned that can inform translation of the current study to larger-scale deployment. These findings can also assist cardiac rehabilitation program staff who wish to use activity tracking and tailored reporting for their patients.

Although use of activity trackers during and following cardiac rehabilitation is promising, the issue of how to pay for the service will need to be addressed. Patients could borrow a device during cardiac rehabilitation, with the option to purchase it. Following cardiac rehabilitation, participants who would like to continue receiving personalized reports on their progress (ideally from cardiac rehabilitation staff) could pay a fee for this service. A cost model for this service would need to be developed. One encouraging example of system changes necessary to support new cost models can be found in the Physician Fee Schedule, which details the payment policies for the Centers for Medicare and Medicaid Services.[27] Effective January 1, 2018, the Centers for Medicare and Medicaid Services enabled new policies to reimburse time spent by physicians on the collection and interpretation of patient generated health data. These changes eliminate a previously required in-person visit for remote patient monitoring and introduced a mechanism to seek reimbursement for time healthcare providers spend documenting results and communicating with patients.

Conclusions

To our knowledge, systematic efforts to facilitate transition from supervised cardiac rehabilitation to home-based exercise are lacking in the United States. Based on this study, a structured intervention using an activity tracker and weekly reports to facilitate this process is a promising strategy to help offset declines in physical activity. This intervention could be scaled up and assessed further using a more rigorous study design with a sufficient sample size and cost-effectiveness evaluation to assist cardiac rehabilitation patients in sustaining the benefits obtained during rehabilitation.

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Appendix. Supplemental Tables

Table A1. Final models from Table 5 that tested whether the intervention sustained very active minutes/day

Model	Definition
Final model 3	Very Active Minutes/day = 9.3418 + 21.3947 (cardiac rehabilitation day) + 0.0140 (per intervention day) – 0.0353 (per maintenance day)
Model for each participant	Participant #1 Very Active Minutes/day = 1.2306 + 7.6265 (cardiac rehabilitation day) + 0.0514 (per intervention day) – 0.0185 (per maintenance day)
	Participant #2 Very Active Minutes/day = 22.7215 + 36.7071 (cardiac rehabilitation day) + 0.0698 (per intervention day) – 0.0282 (per maintenance day)
	Participant #3 Very Active Minutes/day = 2.0926 + 0.7407 (cardiac rehabilitation day) – 0.0139 (per intervention day) + 0.0045 (per maintenance day)
	Participant #4 Very Active Minutes/day = 8.9454 + 42.1546 (cardiac rehabilitation day) + 0.0016 (per intervention day) – 0.0823 (per maintenance day)
Model 2 without maintenance data	Very Active Minutes/day = 8.6111 + 24.4192 (cardiac rehabilitation day) + 0.0216 (per intervention day)

Table A2. Final models from Table 6 that tested whether the intervention sustained steps/day

Model	Definition
Final model 3	Steps = 5,918.21 + 2,278.49 (cardiac rehabilitation day) – 0.3626 (per intervention day) – 6.8195 (per maintenance day)
Model for each participant	Participant #1: Steps/day = 6,056.06 + 3,133.94 (cardiac rehabilitation day) – 6.7703 (per intervention day) - 22.5874 (per maintenance day)
	Participant #2: Steps/day = 8,347.18 + 2,334.54 (cardiac rehabilitation day) + 6.6253 (per intervention day) + 6.0868 (per maintenance day)
	Participant #3: Steps/day = 2,575.69 + 2,992.31 (cardiac rehabilitation day) + 5.0700 (per intervention day) + 1.6004 (per maintenance day)
	Participant #4: Steps/day = 6,356.80 + 1,284.20 (cardiac rehabilitation day) – 1.2437 (per intervention day) – 19.4548 (per maintenance day)
Model 2 without maintenance data	Steps = 5,877.57 + 2,287.24 (cardiac rehabilitation day) – 0.6897(per intervention day)

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