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Feasibility of using the Fitbit Charge HR in validating self-reported exercise diaries in a community setting in patients with heart failure

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Introduction

In the community setting, measurement of physical activity (PA) is done using heart rate (HR) monitors, accelerometers and pedometers. Though very useful, these instruments do have limitations related to the amount and type of information they provide and in the complexity of use. A HR monitor such as a Polar watch is effective in measuring HR and energy expenditure during exercise but is not convenient in monitoring daily PA as it generally requires the participant to wear a chest strap at all times and is limited in the information it provides[1]. Accelerometers provide good objective measures of PA but have several limitations including no real-time feedback to user on type of exercise or HR, an important element in regulating and monitoring intensity of exercise [1]. Hip-worn pedometers are effective but limited in providing information only on step-count [1]. Finally, hip-worn activity monitors are limited by capturing only lower extremity movements[1], and may have limited storage capability.

Newer wrist-worn activity monitors, with multiple built-in sensors, have become popular as they can provide real-time information and monitoring of PA (i.e. steps, calories, type of activity such as walking or biking) and use of HR to guide exercise intensity. These devices allow the user to sync the device to the manufacturer's server to transfer the data in real-time and negates the need for manual data download [2, 3]. Among the many wrist-worn activity monitors, the Fitbit® brand has become widely popular. A review found high inter-device reliability for steps, energy expenditure, and sleep for certain Fitbit models, including the Fitbit® Charge HR (FCHR), as compared to other wrist-worn activity monitors [4] and it has been recommended for use in adherence studies [5].

Exercise is beneficial to patients with HF [6], however, adherence to exercise in this population has been reported to be low [7, 8]. Most reports of exercise adherence have been from

lab-based exercise studies with subjective information obtained from self-reported exercise diaries [9]. Self-reported data can have inaccuracies [10], as such, objective validation of self-reported data is important for documentation of actual exercise adherence. The potentiality and power of the internet combined with newer technologies to monitor exercise and PA, such as the FCHR, provides an opportunity to test newer methods of validating self-reported exercise data, especially in the community setting. The purpose of this study was to determine the feasibility, practicality and acceptability of using the FCHR in a home-based exercise study of patients with heart failure. The study aims were to:

A) test ***feasibility*** of using the FCHR in validating self-reported exercise data; B) test ***practicality*** by: i) reporting on the devices used for syncing the FCHR and issues with set-up and installation of software**,** ii) providing a description of difficulty and issues in use of FCHR by participants**,** iii) describing ability to track PA (steps) and exercise (logs and HR) on a weekly basis by participants and research PI; and C) test ***acceptability*** by i) describing the cost of using the FCHR and ii) obtaining participant perception of using the FCHR.

Method

Design This study is part of a pilot study called **Move on Virtual Engagement- Heart Failure (MOVE-HF)**, a randomized controlled trial to improve adherence to home-based exercise in patients with HF, results of which will be reported separately. This article focuses on a descriptive analysis of the feasibility, practicality and acceptability of using the Fitbit® Charge HR (Fitbit Inc., San Francisco, CA) to track PA and exercise in a community setting and its use as a means of validating self-reported exercise diaries in the HF population.

Subjects Thirty individuals with HF were recruited from two mid-western cardiology clinics in the US. Based on the recommendation for feasibility studies[11], a sample size of 30 was considered adequate to meet the aims of this study.

Inclusion criteria Participants were screened for: a) age >19 years and diagnosis of HF (New York Heart Association class I to III) with no changes in medical history in the past 30 days; b) receiving standard pharmacologic treatment for HF and on a stable dose of beta-blockers for minimum of 30 days to elicit a stable HR response during exercise; c) able to hear, speak and read English; d) have access to a telephone; e) have an electronic device (desktop/laptop/iPad/tablet/smartphone) with internet connectivity and f) cardiologist clearance to participate in moderate intensity exercise at home.

Exclusion criteria: Exclusion criteria included: a) orthopedic or neuromuscular disorders preventing participation in aerobic exercise; b) participation in a formal exercise program (3 times a week for 30 min or more) within the past 30 days; c) clinical evidence of decompensated HF and any condition that required hospitalization in the prior 6 weeks. Similar inclusion and exclusion criteria have been used in exercise studies involving HF patients[12].

Exercise routine. An exercise routine (walking program) was provided to all participants to meet the recommended 150 min of moderate-intensity exercise a week (e.g., 30 min/day x 5 days/week) [13, 14]. Flexibility was provided to complete the 30 minutes per day in 3 bouts of 10 minutes if necessary or less than 10 minutes if difficulty was faced in walking a10 minute bout. Exercise intensity was regulated using the Borg 6-20 Rating of Perceived Exertion (RPE) Scale with a perceived exertion of 10-14 indicating moderate intensity exercise, as is recommended for individuals with HF [13]. Additionally, for safety purposes and to limit exertion to moderate-intensity, participants were provided with their average HR from the six-minute-walk-test (6

MWT) performed at baseline and were asked to maintain their HR at or below this HR using the HR function of the FCHR.

Devices and Instruments

Fitbit Charge HR (FCHR). The FCHR is a wrist-worn activity monitor that tracks and records PA (step-count, HR, type of exercise such as walking, running etc., energy expenditure, distance travelled, number of flights of steps climbed and sleep data) in real-time. Exercise logs, with details of date, time, HR, step-count and energy expenditure, can be manually created by starting and stopping the stopwatch function that is built into the FCHR. This information is stored in the physical memory of the FCHR for 4 weeks. Using a Fitbit account (e-mail and password created for participants) data can be synced and transferred from the FCHR's physical memory to the Fitbit's server by installing the Fitbit® application/connect software (app) to an electronic device. Syncing clears the stored data from the physical memory in the FCHR unit, thereby allowing for new information to be stored. Once synced, this information on PA and exercise can be tracked on Fitbit's website using the participants account information. Participants were asked to record their exercise sessions using the FCHR and sync to download the information on a daily basis. The FCHR automatically tracks "active minutes" for brisk paced walking bouts lasting more than 10 min. Participants were directed to wear the FCHR from awakening until going to bed at night, not to expose it to water and recharge the FCHR battery every 3 days or whenever the battery indicator indicated low charge. Written instructions on operating the Fitbit® software were provided to each participant.

Exercise diaries. All participants were provided with paper exercise diaries to record their exercise sessions and RPE on a daily basis for 8 weeks.

Methods for validation of exercise diaries with the FCHR. One or more of the following four methods were used to validate data from the self-reported exercise diaries with the FCHR:

i) From recorded exercise session logs in the FCHR. Consistency in step-count and elevation in HR from baseline resting was monitored across the sessions to substantiate that an exercise session occurred.

ii) If participants forgot to manually record their exercise session using the stopwatch function, the active minutes from the FCHR was compared with the duration of exercise mentioned in the exercise diaries.

iii) If validation of a particular session was not possible with the first two methods then the participant's overall step-count for that day was compared with validated data from a day when the participant recorded their walking session. Validation was determined if the overall steps for those two days were comparable (within 10%).

iv) Fitbit ® software allows for HR to be graphed across time in 24 hour periods. If self-reported diaries could not be validated with any of the above three methods, an elevation in HR, for the period of time noted in the exercise diaries, was tracked. Validation was determined if the elevation in HR was comparable (within 10%) to the average HR from the 6MWT. This method for validation was useful for participants using a walker or a cane for whom step-count from the FCHR was not reliable, for participants who walked at a pace slower than the FCHR would pick up active minutes and for participants who forgot to record their exercise session.

Questionnaire survey. An investigator-developed survey was completed at the end of the study with three "Yes/No" questions and a fourth open-ended question to capture participants' perception and experience of using the FCHR. These questions were: 1) Did you

find it easy to use the Fitbit?; 2) Was it difficult to sync the Fitbit with the Fitbit app?; 3) Did the Fitbit Charge HR help you become more active? and 4) What was your experience of using the FCHR (functions of the Fitbit that you liked, issues that you encountered and would you continue to use an activity monitor in the future)?

Measures

(INSERT Table 1)

Procedure

Recruitment Approval for the study was obtained from the University's Institutional Review Board prior to subject recruitment and "the investigation conforms with the principles outlined in the Declaration of Helsinki" (Br Med J 1964;ii:177). Recruitment was done via: (a) survey at the clinics for interest in study participation, (b) flyer displayed at the clinics and (c) by word of mouth. Participants signed the informed consent and cardiologist approval was obtained prior to enrollment.

Baseline. Participants brought their choice of electronic device (laptop/iPad/tablet/smartphone) with them for the baseline visit. During this visit, the FCHR was provided to the participants and the PI downloaded the Fitbit app and trained the participants on using the FCHR to record their exercise sessions. Thereafter, participants wore the FCHR and performed the 6MWT in a 30-meter long hallway. The average HR during the walk was recorded and provided to the participants. Participants, along with the PI, participated in a walking session lasting 10-12 min during which they demonstrated recording their walking session using the FCHR and regulated their walking speed to correspond to a RPE of 10-14 and average HR from the 6MWT. Participants then demonstrated their ability to sync the FCHR with the Fitbit® app.

Post-Intervention. At 8-weeks all participants returned the exercise diaries and completed the survey on their experience of using the FCHR. The PI inspected the diaries for completeness and asked the participants to fill out any missing information such as date, exercise duration and RPE.

Results

(INSERT Table 2)

Aim A: Validation of self-reported exercise sessions with objective data from FCHR: A total of 845 exercise session were reported in the exercise diaries across the 8-weeks. Using the strategies outlined earlier, it was possible to validate all but 6 self-reported exercise sessions with objective data from the FCHR. Participants did not wear the FCHR during those 6 exercise sessions and no information was available. Nearly 75% of the self-reported sessions mentioned in the diaries were validated using the first method, 15% using the second method and about 7% of exercise sessions were validated using the third method. Two participants in the study used a cane/walker while walking and on the days when they forgot to record their sessions, their self-reported diaries for those sessions (3%) were validated using the fourth method.

Aim B (i): Devices used for syncing FCHR and issue with set-up and installation of software:

(INSERT Table 3)

Apart from two participants who used a desktop computer, the PI was able to set up the Fitbit app to the participants' electronic device during the baseline visit. While one participant was able to set up the desktop app himself, the PI had to visit with the other participant at his home to help with set-up. This one-time visit to the participant's home lasted about 45 minutes with the PI

downloading the Fitbit software, setting up the bluetooth connection and training the participant to sync the FCHR using the desktop application. Three participants needed two sessions of training on using the FCHR.

Aim B (ii): Difficulty and issues in use of FCHR: Participants, in general, did not find using the FCHR difficult but forgetting to sync it with the app to download the data on a daily basis was reported by 80% of participants. Three participants visited the PI at the data collection site with difficulty in syncing the FCHR after an upgrade to the Fitbit app software. Two participants, 84-year-old male (using desktop computer) and 87-year-old male (using smartphone) respectively, reported using their spouse's help to sync the FCHR.

The most commonly reported complaint was forgetting to turn the stopwatch function "on" or "off" to record exercise session leading to discrepancies in the paper exercise log diaries and the exercise logs in the FCHR. Exercise logs, for those sessions in the FCHR, were missing or were shorter/longer than reported. Approximately 70% of participants also reported occasionally forgetting to wear the FCHR when they woke up in the morning but wore it when they remembered later on in the day.

All participants liked the HR feature of the FCHR. However, approximately 40% of participants complained of having difficulty in regulating their exercise intensity using the HR from the FCHR. They reported that, sometimes, although their RPE was in the 10-14 range, their HR would move above the average HR provided to them.

Three participants did not wear the FCHR for portion of the 8 weeks of the intervention. After week 3, two participants stopped wearing the FCHR for the remaining 5 weeks as that they did not like to wear anything on their wrist (they did not even wear wrist-watches); one

participant reported that the FCHR irritated her skin and did not wear it after week 7. In general, the relatively younger participants in the study found it easier to use the FCHR than the older participants. Issues reported in the use of the FCHR by the participants living in the rural areas was no different from issues reported by participants living in the urban areas.

Aim B (iii): Ability to track exercise on a weekly basis by participants and PI: All participants were able to use the Fitbit® app on their smartphone or log on to Fitbit's® website using the username and password provided to them to track their exercise over time. Nine participants forgot to sync the FCHR for more than a week which made it difficult for the PI to track their exercise sessions. In such cases, text message or phone calls were made as a reminder. Over the 8 weeks, the PI sent out 15 text messages to 9 participants and made 2 phone calls to 2 participants. Participants were generally responsive to the text message and would sync their FCHR after receiving the text/call. Two participants, in spite of reminders, did not sync the FCHR for 3 weeks. As the FCHR stored data for up to 4 weeks, there was no loss of data as the PI synced their FCHRs during the 8th week visit. Overall, by using the exercise logs, active minutes, step-count and HR data provided by the FCHR, the PI was able to track the participants' PA in general and specifically their exercise information on a weekly basis.

Aim C (i): Cost estimates of using the Fitbit® Charge HR: The initial cost of the FCHR was $149 each which included the price of the Fitbit® application and the Fitbit® Connect software. There was no cost associated with maintaining the FCHR or retrieving the data from Fitbit's server.

Aim C (ii): Participants perception of using the FCHR: All participants mentioned that the real-time feedback from the FCHR made them more conscious of their activity levels. Information on step-count and HR was identified as the most valuable information from the

FCHR. Participants mentioned that the ability to track HR provided them with reassurance and helped them regulate their intensity of workout.

At the end of the study, 11 participants reported that they had already purchased a FCHR, 6 participants mentioned that they were going to buy one, 8 participants reported that they would buy one if finances permitted and 5 participants were not interested in buying a FCHR. Nearly, 83% of participants reported already having bought or were planning to buy a FCHR for themselves by the end of the study, which indicates the wide acceptability of the FCHR among participants in this study.

Discussion and Conclusion

The use of a wrist-worn activity monitor to objectively validate self-reported exercise data in a community setting is feasible. In a laboratory setting, the FCHR is reported to be valid and reliable with walking and running activities [15], with moderate and high intensity exercise [16] and its results were in agreement with the most widely used PA monitor Actigraph GT3X tri-axial accelerometer for measuring energy expenditure and community based activity behavior [17, 18]. However, the FCHR, has been reported to overestimate step-count [19] and be inaccurate in measuring HR [20]. Currently, the literature is lacking on the validity and reliability of different measurements of the FCHR in the community setting. Nevertheless, in this study, it was effective and useful in validating self-reported exercise diaries.

The FCHR was easy to install and manage and apart from three participants who did not like to wear it, the vast majority of the participants found it easy to use. Most participants used their smartphones to install the Fitbit® app and to sync the FCHR to download the data. The one commonly reported problem was that participants would forget to “start or stop” the stopwatch

function in the FCHR to record their exercise sessions. In general, the participants found it easy to operate the FCHR and sync the data which allowed the PI to track the exercise logs remotely. In community-based longitudinal studies, it is particularly helpful if participants are able to sync the instrument themselves and that data can be then accessed by the research staff. This is a distinct advantage of the FCHR over traditional heart rate monitors and accelerometers as it reduces the participant's burden of having to meet with research staff every month or every other month to download data from the devices. By providing a variety of data such as activity logs, step-count, HR and active minutes, the FCHR also provided flexibility with validating the self-reported exercise sessions even when participants forgot to record their exercise session.

Participants in the study mentioned having HF has increased their concerns about safety with exercise. Although, the capability of the FCHR to provide accurate HR data has been questioned [20], the ability to track HR during exercise provided participants with a sense of comfort by knowing that they were exercising at an intensity level determined safe for them. Regulation of HR during exercise to maintain exercise intensity, in this population, may be difficult due to some patients having atrial fibrillation or the varying effect of beta-blockers on HR throughout the day. Providing participants with a target HR range may be an effective way to regulate intensity of exercise by using the HR feature of the FCHR. However, a maximal exercise test would be required to determine an accurate target HR range, which was not performed for this study. Intensity of exercise was primarily guided by RPE and as such validation was limited to self-report of exercise sessions only. Participants mentioned that the feedback they received on step-count made them conscious of their activity levels and motivated them to become more active. The fact that 25 participants had already bought a FCHR or were planning to buy one by the end of the study indicated its acceptability in this population.

The 6MWT was performed at baseline to provide the participants with a reference HR number for safety with performing the home-based walking program. A limitation of the study was that the 6MWT was performed only once and the average HR from one walk may not represent an accurate average HR. However, since peak HR was not a concerning factor in this study, it can be argued that an average HR from a second walk may not be very different from the first walk. Heart rate was mainly used for safety purpose in the home-based study rather than to specifically determine intensity of exercise. Missing information on the exercise diaries were filled out during the 8-week visit and there may be some error associated in recall. However, with less than 5% of the data missing and the FCHR providing the ability to validate those exercise sessions, the recall data were mostly accurate. Although the study had a small sample size, it is comparable to other studies that have validated the FCHR [5, 16, 17, 20].

The use of the internet and smartphone technology has grown over time. According to a recent report by Pew research, internet adoption among seniors has risen steadily over the last decade and a half with adoption going up from 14% in early 2000, to 67% of adults ages 65 and older saying they go online this year [21]. We found that with guidance and training, participants were able to navigate their way in using the FCHR and the Fitbit app that were previously unfamiliar to them. Participants found information of step-count and HR to be most valuable. Also, the sample consisted of 7 participants who lived in rural areas and the acceptance, practicality and feasibility of using the FCHR in this study provides the opportunity to deliver PA interventions and collect objective data in populations living in rural areas. Wrist-worn activity monitors such as the FCHR can be a useful addition to exercise adherence studies.

The study concludes that the use of a wrist-worn activity monitor to validate self-reported exercise diaries in patients with HF in a community setting is feasible and was acceptable to participants.

Implication for Practice

The newer generation wrist-worn activity monitors can serve as an effective resource for clinicians and researchers to study exercise and physical activity behavior in patients with HF living in a community setting. With the increasing use of internet among the U.S. population and adoption of newer technology among all age groups, further investigations into using these mediums to positively impact health promotion behaviors is needed. The newer generation wrist-worn activity monitors seem to have acceptance in the HF population and may have a positive impact on exercise adherence in this population and potentially other populations. How to best develop and use this technology to enhance patient care needs to be further investigated in future studies.

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Tables

Table 1: Specific Aims and Corresponding Measures

	Aim		Measure
Feasibility	A	Validation of self-reported exercise diaries with objective data from FCHR	Total number of self-reported exercise sessions validated with the FCHR and percentages verified using the four methods of validation.
Practicality	B (i)	Devices used for syncing FCHR and issue with set-up and installation of software	Detailed record of devices (e.g. smartphone, iPad, laptop, desktop, or tablet) used by participants.
	B (ii)	Difficulty and issues in use of FCHR	Detailed record of issues recorded by PI and those highlighted by participants in questionnaire.
	B (iii)	Ability to track exercise on a weekly basis by participants and PI	Detailed record of issues in tracking exercise highlighted by participants and by research PI.
Acceptability	C (i)	Cost of using the FCHR	Record of cost associated with use of FCHR and software
	C (ii)	Participants perception of using the FCHR	Perceptions obtained from investigator developed survey.

Table 2: Devices Used by the Participants for using FCHR

Device	Number of participants
Smartphone (iPhone/Android)	24
Laptop	2
Desktop	2
iPad	1
Android tablet	1