Fall 12-16-2016

MOVE-HF: An Internet-Based Pilot Study to Improve Adherence to Exercise in Patients with Heart Failure

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MOVE-HF: An Internet-Based Pilot Study to Improve Adherence to Exercise in Patients with Heart Failure

By

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A DISSERTATION

Presented to the Faculty of the Graduate College in the

University of Nebraska Medical Center

In Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy
Nursing

Under the Supervision of Dr. Bunny Pozehl

University of Nebraska Medical Center
Omaha, NE

December, 2016

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Acknowledgements

Thank you to my PhD advisor, Dr. Bunny Pozehl, for her consistent support, words of encouragement and wisdom, and for being a role model.

I would also like to thank my supervisory committee: Dr. Bernice Yates, Dr. Joe Norman, Dr. Mark Williams and Dr. Deepak Khazanchi for their insightful wisdom, guidance and ongoing support.

I would like to thank Dr Kevin Kupzyk and Ms Dola Pathak for their help with statistical analysis.

I would like to thank the Mid-West Nursing Research Society/Center for Advancement of Nursing Research for funding this research project. Also, thanks to the College of Nursing, UNMC for the Nellie House Craven Scholarship that helped to supplement some of the fund needed for the project.

Many thanks to the faculty, staff and administration at the UNMC College of Nursing for their support and help throughout the program.

Thank you to all my friends and nurse colleagues at Nebraska Medicine, who embody the best that nurses have to offer and from whom I have learnt so much.

Thank you to Ratul Dev Sarma. I would not have come to the US to pursue higher education without his encouragement.

Thank you to Samar Gogoi and Archana Chatterjee for standing by our side whenever my family has needed them. I would have gone back to India in 2010 if it was not for their help and support.

Thank you to my parents, Nripen and Kamala Deka, and my father-in-law Kulendu Pathak for encouraging me to pursue my dreams and for supporting my family.

I could never have accomplished this goal without the loving support of my wife, Dola and two wonderful daughters, Srutee and Shreya. Thank you for your patience, enduring love and encouragement as I traveled on this journey. Your presence has made this achievement even more meaningful. To the three of you, I dedicate this dissertation work.

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University of Nebraska Medical Center, 2016

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Abstract

Background Although the use of internet-based exercise interventions to improve physical activity has become popular and useful, such approaches to improve exercise adherence in patients with heart failure (HF) are lacking. It is also unknown whether the delivery of objective feedback on physical activity can impact exercise adherence.

Purpose The purpose of the Move on Virtual Engagement (MOVE-HF) study was to i) test the feasibility of delivering an internet-based face-to-face group discussion/education intervention using a software called "Vidyo" and monitoring of physical activity using the Fitbit Charge HR (FCHR) in community dwelling patients with heart failure; ii) compare the MOVE-HF intervention group and the control group on adherence to recommended exercise guidelines (150 minutes of moderate intensity exercise) from baseline to 8 weeks; iii) compare intention to adhere to exercise, functional status, self-efficacy for exercise and perceived social isolation between the groups at baseline and 8 weeks.

Methods Thirty HF patients, aged 64.7±11.5 years, were randomly assigned to an experimental or comparison group. Participants were stable HF patients belonging to NYHA Class I-III and were required to have an iPad/cell phone/laptop/desktop with internet connectivity. Participants in both groups were provided with a Fitbit Charge HR, assistance in set-up and training, and were asked to wear the Fitbit all day from awakening until going to bed at night. All participants were provided with a handout on self-care in HF, an exercise routine and asked to record their exercise sessions using the Fitbit and exercise diaries.

The 15 participants in the experimental group were subdivided into 3 cohorts of 5 participants each. These subjects were provided with Vidyo software, assistance in set-up and training. Each cohort met once a week, for 8 weeks, for a 45 min face-to-face online group discussion/education session.

Data Analysis: Repeated measure ANOVA was done to compare group differences in adherence, intention to adhere and functional status across time. A non-parametric Mann-Whitney U test with change score was done to compare changes in group scores for self-efficacy for exercise and perceived social isolation at baseline and at 8 weeks.

Results Overall Vidyo session attendance was 68% with 73% of participants attending 5 or more group meeting sessions. Adherence to exercise was 58.8% in the experimental group and 57.3% in the comparison group (NS). Intention to adhere, functional status,

self-efficacy and perceived social isolation were not significantly different between the groups. The experimental group participants anecdotally reported perceptions of receiving social support through the face-to-face group meetings but due to a small sample size and lack of adequate power, no significant impact on exercise adherence was observed.

Conclusion An internet based group face-to-face intervention is feasible and feedback on exercise and physical activity can play an important role in adherence to exercise in patients with HF. HF patients may have unique barriers to overcome and interventions using the internet are feasible to use in patients with heart failure.

Keywords: heart failure, exercise, adherence, internet, activity monitors

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Chapter 1: Introduction

Background & Significance

The American College of Sports Medicine (ACSM) and the American Heart Association (AHA) recommends moderate intensity exercise training of at least 150 min/week for the general population (Nelson et al., 2007). Similar exercise recommendations have also been echoed by the Heart Failure Society of America (HFSA), the Heart Failure Association and the European Association for Cardiovascular Prevention and Rehabilitation (EACPR) (Heart Failure Society of America et al., 2010; Piepoli et al., 2011) for patients with heart failure (HF). Exercise has been described as a subset of physical activity that is planned, structured and repetitive with an objective of improving physical fitness (Caspersen, Powell, & Christenson, 1985).

Aerobic exercise training has been found to be safe (O'Connor et al., 2009) and studies using interventions of resistance (Meyer, 2006; Savage et al., 2011; Selig et al., 2004), interval and discontinuous (Chrysohoou et al., 2015; Mader, Roth, Furrer, Brechet, & Boutellier, 2001) training have reported no adverse effects of these interventions on patients with HF. Exercise training in HF has been shown to improve *functional capacity* (Belardinelli, Georgiou, Scocco, Barstow, & Purcaro, 1995; Belardinelli, Georgiou, Cianci, & Purcaro, 1999; Collins et al., 2004; Dracup et al., 2007; R. A. Gary et al., 2004; Jakovljevic et al., 2010; Kitzman et al., 2013; Klempfner et al., 2013; Maiorana et al., 2000; Moholdt, Bekken Vold, Grimsmo, Slordahl, & Wisloff, 2012; O'Connor et al., 2009; Oka, DeMarco, & Haskell, 2005; Selig et al., 2004; Smart, Haluska, Jeffriess, & Marwick, 2005; Wisloff et al., 2007), *cardiac output* (Fu et al., 2013), left ventricular function (Chrysohoou et al., 2015), *heart rate variability* (Murad et al., 2012; Selig et al., 2004), *flow mediated dilation* (Anagnostakou et al., 2011; Wisloff et al., 2007), *muscle strength* (Beckers et al., 2008; Maiorana et al., 2000; Mandic, Myers, Selig, & Levinger, 2012;

Selig et al., 2004), *functional status* (Dracup et al., 2007; R. A. Gary, Cress, Higgins, Smith, & Dunbar, 2011; R. A. Gary, Cress, Higgins, Smith, & Dunbar, 2012; O'Connor et al., 2009; Savage et al., 2011; Witham et al., 2005), *fatigue/dyspnea* (Beckers et al., 2008; Pozehl, Duncan, & Hertzog, 2008), *anxiety* (Chien, Lee, Wu, & Wu, 2011; Freyssin et al., 2012), *depression* (Blumenthal et al., 2012; Chien et al., 2011; Freyssin et al., 2012; R. A. Gary et al., 2004; R. A. Gary et al., 2012), *self-efficacy for exercise* (Collins et al., 2004; Duncan, Pozehl, Norman, & Hertzog, 2011; Oka et al., 2005; Pozehl, Duncan, Hertzog, & Norman, 2010), *mortality and hospitalization rate* (Dracup et al., 2007; O'Connor et al., 2009) and *health related quality of life (HRQoL)* (Belardinelli et al., 1999; Chien et al., 2011; Collins et al., 2004; Dracup et al., 2007; R. A. Gary et al., 2004; R. A. Gary, Dunbar, Higgins, Musselman, & Smith, 2010; R. A. Gary et al., 2012; Nyquist-Battie et al., 2007; Pozehl et al., 2010; Wisloff et al., 2007).

In spite of the potential benefit of exercise, adherence to exercise in this population has been found to be low and the large multisite HF-ACTION study on patients with HF reported that adherence to recommended exercise guidelines in this trial was about 30% (O'Connor et al., 2009). In another study, patient reported adherence to exercise was 26% (Marti et al., 2013). Patients with HF exhibit physiological and psychosocial signs and symptoms such as decreased functional status (Pihl, Fridlund, & Martensson, 2011), dyspnea/fatigue (H. Falk, Ekman, Anderson, Fu, & Granger, 2013; K. Falk, Swedberg, Gaston-Johansson, & Ekman, 2007; Jones, McDermott, Nowels, Matlock, & Bekelman, 2012), anxiety and depression (Conraads et al., 2012; Dekker et al., 2014), social isolation (Aldred, Gott, & Gariballa, 2005; Jeon, Kraus, Jowsey, & Glasgow, 2010; Pihl et al., 2011) and experience of an overall lower quality of life (H. Falk et al., 2013). Many of these are considered factors that influence self-care activities including exercise (Conraads et al., 2012) and physical activity (Center for Disease Control,

2005). Other factors such as fear, lack of knowledge, skill and confidence to participate in physical activity, access to an exercise facility, problems with transportation and income have also been described as obstacles that can lead to decreased adherence to exercise in this population (Artinian, Magnan, Sloan, & Lange, 2002; Carlson, Riegel, & Moser, 2001; Conraads et al., 2012; R. Gary, 2006; Jaarsma et al., 1999; Pihl et al., 2011).

Improving adherence to exercise has not been a primary objective in the majority of studies involving exercise interventions in patients with HF. The main focus to date has been understanding the physiological or psychological effects of exercise on HF. In a review of the literature, only one facility-based exercise study was found where theory-based interventions were designed with the primary aim of improving exercise adherence in patients with HF (Duncan et al., 2011). Adherence to exercise requires making behavioral changes that are difficult and recommendations have been made to design interventions to target many of the factors that lead to lack of adherence to exercise in patients with HF (Keteyian, Squires, Ades, & Thomas, 2014). Home-based studies that have reported adherence to the specific exercise program, have used strategies such as supervision, follow-up, weekly or monthly meetings/telephone calls, providing feedback, group support or face-to-face contact (Belardinelli, Georgiou, Cianci, & Purcaro, 2012; Chien et al., 2011; Corvera-Tindel, Doering, Woo, Khan, & Dracup, 2004; Dracup et al., 2007; R. Gary, 2006; R. A. Gary et al., 2012; Oka et al., 2000; Oka et al., 2005).

The use of social support to improve health related outcomes, including physical activity, has been strongly advocated (Arestedt, Saveman, Johansson, & Blomqvist, 2013; Clark et al., 2012; Tsay & Chao, 2002). However, the use of the internet in a home-based setting to test the delivery of social support in the form of a face-to-face synchronous group discussion/education

to improve adherence to exercise in patients with HF has not been tested. Also, unknown is how objective feedback on physical activity impacts exercise adherence. In addition, there is a need to obtain objective data on exercise and daily physical activity measures when studying adherence to exercise as a primary outcome. Therefore, the purpose of this ***Move on Virtual Engagement-Heart Failure (MOVE-HF)*** pilot study was to test the feasibility of delivering an internet-based face-to-face group intervention and providing objective feedback on physical activity with the primary intention of improving adherence to recommended exercise guidelines (150 min of moderate intensity exercise per week) for patients with heart failure. The study also evaluated if intention to adhere to recommended guidelines, functional status, self-efficacy for exercise and perceived social isolation was improved because of the intervention. Specific aims for the study were to:

1) Test the feasibility of delivering an internet-based intervention in patients with HF.
    a) Track recruitment and attrition for the study
    b) Provide cost estimates for use of Vidyo and FCHR to deliver intervention
    c) Feasibility of the face-to-face group discussion/education was determined by records of: i) Internet connectivity; ii) Vidyo software use; iii) Required technical support; iv) Scheduling of intervention; v) Attendance report; vi) Unanticipated issues/problems; vii) acceptability among participants in intervention group
    d) Feasibility of monitoring physical activity, specifically exercise, using the FCHR was determined by records of: i) Devices used for syncing FCHR and issues with set-up and installation of software; ii) Difficulty and issues in use of FCHR; iv)

Ability to track exercise on a weekly basis by PI and participants; v) acceptability of the FCHR among the participants

2) Compare the MOVE-HF intervention group and the control group on: a) adherence to recommended exercise guidelines (150 minutes of moderate intensity exercise per week), and b) intention to adhere to these guidelines from baseline to 8 weeks.

3) Compare the MOVE-HF intervention group and the control group on the secondary outcomes of: a) functional status, b) self-efficacy for exercise, and c) perceived social isolation at baseline and post-8 weeks.

Key Concepts and Theoretical Framework

The key concepts in this study included the following:

Adherence. The World Health Organization (WHO) has defined adherence as "the extent to which a person's behavior – taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider" (World Health Organization, 2003). Adherence has also been defined as "the extent to which a patient acts in accordance with the prescribed interval and dose of a dosing regimen", measured over a period of time and reported as a percentage (Cramer et al., 2008). This study focuses on adherence to recommended exercise guidelines in patients with HF.

Intention. As defined by the Theory of Planned Behavior (TPB), intention is an internal control factor that influences the performances of the behavior and strong perceived internal control for the behavior can itself lead to direct performance of the behavior (Ajzen, 1991). This study focuses on intention to adhere to the recommended exercise guidelines in patients with HF.

Self-Efficacy. Self-efficacy is an integral part of Bandura's Social Cognitive Theory (SCT) (Bandura, 1977) and has been defined as the perceived belief one has in their capability to produce effect (Bandura, 1994). The concept of self-efficacy does not concern with a person's thoughts about oneself but rather in the perception or judgment of being able to accomplish a specific goal (Zulkosky, 2009). Internal control factors such as intention can be improved using the self-efficacy determinant of the SCT (Bandura, 1977; Dzewaltowski, Noble, & Shaw, 1990; Hagger, Chatzisarantis, & Biddle, 2002). The components of self-efficacy that will be operationalized in the study are performance accomplishment, vicarious experience, verbal persuasion/feedback and physiological/emotional arousal (Appendix A). Self-efficacy for exercise as recommended for patients with HF is the focus in this study.

Functional Status. The National Committee on Vital and Health Statistics has defined functional status broadly in two different areas namely: (i) basic physical and cognitive activities and ii) activities involving life situations (National Committee on Vital and Health Statistics, 2001). In this report, walking has been considered a basic physical functioning and is the focus of the exercise in this study.

Perceived Social Isolation. Perceived social isolation has been defined as "the subjective experience of a shortfall in one's social resources such as companionship and support" (Cornwell & Waite, 2009) [(p 3)]. Perceived social isolation can impact ones health-related behavior including participation in physical activity (Hawkley, Thisted, & Cacioppo, 2009; Hawkley & Cacioppo, 2010) and being socially connected vs socially isolated can impact behavior by ways of information source and normative pressure to perform the behavior (Cacioppo & Hawkley, 2003).

Theoretical Framework: Internet interventions that are theory based and offer multiple behavior change techniques tend to have a larger effect than interventions that do not incorporate such strategies (Webb, Joseph, Yardley, & Michie, 2010). The interventions in this study (Figure 1) was based on Bandura's Social Cognitive Theory (SCT) and Ajzen's Theory of Planned Behavior (TPB), the most widely used theories in internet-based studies for behavioral change (Webb et al., 2010). The TPB states that internal factors such as intention, which can be improved using the self-efficacy determinant of SCT (Bandura, 1977; Dzewaltowski et al., 1990; Hagger et al., 2002), can influence performance of the behavior (Ajzen, 1991). The theoretical framework used in this study integrates the TPB and the SCT to improve self-efficacy for exercise and intention to adhere to recommended exercise. The components of self-efficacy that were operationalized in the study are performance accomplishment, verbal persuasion/feedback and physiological/emotional arousal (Appendix A). Decline in perceived social isolation can also positively influence exercise behavior.

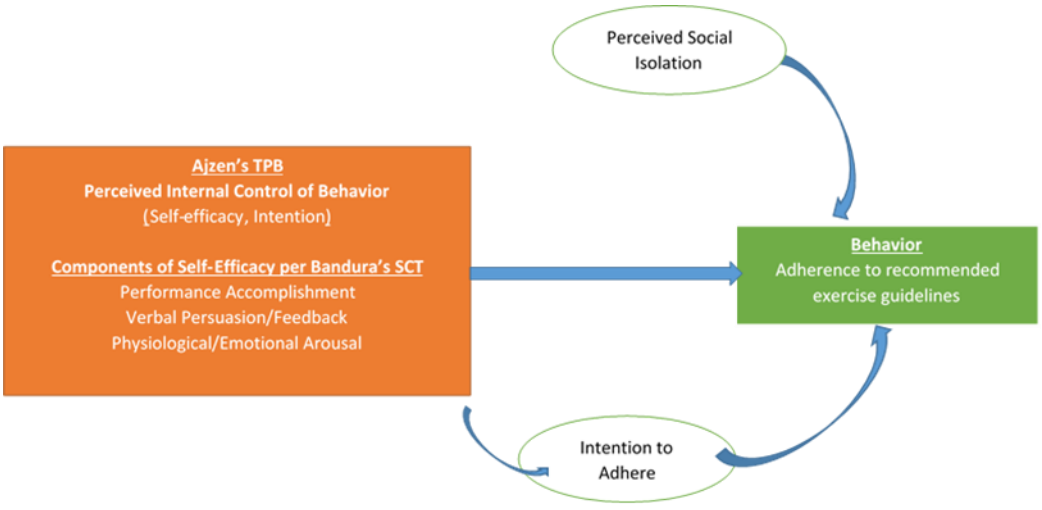

Figure 2: MOVE-HF theoretical framework

Overview of Manuscripts

Three manuscripts will be presented in the following sections. **Manuscript 1** is a comprehensive review of the literature on adherence to recommended exercise guidelines in patients with HF. **Manuscript 2** presents the feasibility results (Aim 1) of delivering an internet-based face-to-face group discussion/education intervention using a software called Vidyo and monitoring of physical activity and exercise using the FCHR in a sample of community dwelling patients with HF. **Manuscript 3** presents the results of the MOVE-HF intervention on adherence to exercise in patients with HF (Aim 2 and 3).

Adherence to Recommended Exercise Guidelines in Patients with Heart Failure

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The final publication is available at DOI: 10.1007/s10741-016-9584-1

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Abstract

Exercise training has been shown to be beneficial in patients with heart failure and its effectiveness is connected to adherence to the exercise program. Nonetheless, adherence to exercise in these patients remains a concern. Heart failure patients can be considered adherent to an exercise program if they meet 80% of the recommended dose. We summarize exercise recommendations for patients with heart failure, identify exercise prescription methodologies used in studies that have reported exercise adherence, identify strategies and tools used to improve adherence and examine whether these strategies were developed using a theoretical platform with the primary aim to change behavior and improve adherence to exercise. Factors which may also impact adherence such as exercise setting, intensity and length of participation, gender, race, New York Heart Association functional class, and heart failure with preserved and reduced ejection fraction were also investigated. Finally, recommendations for future studies for improving adherence to exercise in patients with heart failure are provided.

Keywords: heart failure; exercise adherence; exercise compliance; exercise training.

Adherence to Recommended Exercise Guidelines in Patients with Heart Failure

Introduction

Numerous studies have established the safety and benefits of exercise participation in patients with heart failure (HF). Nonetheless, it is well understood that to avail the desired benefits of exercise, adherence to recommended exercise training guidelines including the exercise prescription as well as the program itself, is paramount. Recognizing the issues surrounding these components is essential to developing future exercise programming for these patients.

This review is divided into four parts. Part I defines adherence and reviews the literature to examine recommendations for exercise frequency, duration and intensity of exercise in the HF population. Part II provides a narrative review of randomized controlled exercise trials that have evaluated exercise adherence in patients with HF and includes: i) a summary of definitions of adherence to exercise used in these studies; ii) a summary of exercise protocol highlighting recommendations for frequency, duration and intensity of exercise in these studies; iii) an examination of whether adherence to exercise is an aim of the study or merely reported as a parameter within the exercise intervention; iv) an examination of instruments used to record exercise performance; v) an examination of strategies used to optimize exercise program adherence; vi) an examination of whether strategies for exercise program adherence have been based on any theoretical framework; and vii) a summary of the reports on exercise program adherence in these studies. Part III addresses the effect of various other factors which may impact adherence such as exercise setting, age, gender, race, New York Heart Association (NYHA) functional class, heart failure with preserved and reduced ejection fraction (HFpEF and

HFrEF), exercise intensity, and length of study duration. Finally, part IV summarizes key points of the review and provides suggestions for future studies.

Part I: Adherence to Exercise and Recommendations

Definition of Adherence to Exercise: The World Health Organization (WHO) has defined adherence as "the extent to which a person's behavior – taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider"[1]. Adherence has also been defined as "the extent to which a patient acts in accordance with the prescribed interval and dose of a dosing regimen", measured over a period of time and reported as a percentage [2]. Adherence to an exercise program has been classified as meeting at least 80% of the recommended exercise dose [3, 4]. The designation of 80% is consistent with the medication adherence literature where patients are considered adherent if they are taking their medications 80% of the time [2, 5]. Additionally, participants who have less than 20% adherence to exercise are classified as "non-adherent" and "partially adherent" if their adherence is between 20 to <80% [3]. Adherence is often used interchangeably with the term "compliance". In the health care setting compliance often denotes "the extent to which a person's behavior coincides with medical or health advice" [6] and includes the characteristic of sub-ordination where one person directs and the other has the disposition to yield [7]. The definition of compliance comes with an undertone of blame on the part of the patient when the patient's behavior did not meet the medical or health advice. The WHO definition of adherence makes an attempt to move away from blaming the patient to the development of patient understanding and agreement to actively pursue the recommendations rather than passively following them [1, 8]. Decisional conflict, predictability, personal experience, power, agreement and pervasiveness are common attributes that have been identified with adherence [8].

Recommended Exercise Guidelines: Exercise-specific guidelines for patients with HF were not clearly defined prior to 2010. In 2010, the Heart Failure Society of America (HFSA) for the first time provided specific information on recommended frequency, duration and intensity for exercise in the HF population. The HFSA recommendations for exercise included 30 minutes of moderate intensity activity/exercise performed 5 days of the week, with warm up and cool down exercises [9]. In 2011, the Heart Failure Association (HFA) and the European Association for Cardiovascular Prevention and Rehabilitation (EACPR) provided more detailed and comprehensive exercise training guidelines on intensity, type, method, application, control and setting-based recommendations specific for HF patients [10]. This consensus document indicated that the aim of endurance aerobic exercise training in HF is to be able to perform moderate to high intensity exercise for up to 30 minutes on all days of the week [10]. The document also specifically stated that endurance exercise remains the mainstay in HF patients and that resistance training can complement, but not act as substitute for, aerobic exercise; and that a maintenance exercise stage should begin after 3-6 months of the initial training period [10]. However, the authors noted that a universally accepted statement on exercise prescription in HF does not exist and training should be individualized to meet patient-specific goals. In general, the HFSA, HFA, EACPR, American Heart Association (AHA) and the American College of Sports Medicine (ACSM) [11] have agreed that exercise training in these patients should consist of the performance of ***moderate intensity aerobic exercise for 30 min/day for 5 days a week (150 min/week)***. The HFA/EACPR statement also recommends that aerobic training be complemented with resistance training for 2-3 days a week in this population. Importantly, these recommended aerobic and resistance exercise guidelines are the same as those from the ACSM and AHA for the general population [12-14].

Part II: Results from Randomized Controlled Trials

A literature review was conducted to examine the current state of the science regarding adherence to exercise training in patients with HF. PubMed, Medline, CINAHL and Google Scholar were accessed using the search terms “exercise adherence”, “exercise compliance”, “exercise training” and “heart failure”. Reference was also made to a 2008 study identifying articles addressing the concept of exercise adherence in patients with HF prior to that year [15]. Articles were excluded if they were not randomized controlled trials or were published before 1995. From the search, 21 randomized controlled trials (Table 1) met these criteria and reported exercise adherence in patients with HF [16-36]. Three studies were published before the year 2000, 13 studies between year 2000 and 2010 and 5 studies after 2010. Nine of the 21 studies included in this review had also been included in the review published in 2008 [15].

Definitions of Adherence to Exercise: Studies selected for the present review utilized a variety of parameters in defining adherence including the specific components of the exercise prescription, that is frequency, duration, intensity etc. as well as achievement of a specific number of minutes of exercise per week, i.e. 120, [16, 26], average compliance to minutes of prescribed weekly walking time [29] or percentage change in pedometer scores [20, 27]. Others defined adherence in terms of exercise program attendance [17, 18, 21-23, 28, 30-33, 35, 36].

Recommendations for Frequency, Duration and Intensity of Exercise: A great deal of variability in frequency, duration and intensity was observed across studies. Frequency of exercise varied between 2 and 7 days per week with the most commonly prescribed frequency being 3 days per week [16-20, 23, 25, 26, 32, 34-36]. Similarly, duration of exercise ranged between 10 min to 60 min per session, most commonly 30 minutes [16, 17, 19, 25, 26, 34, 35]. Recommendations for participants to start with a lower duration and slowly build up to the

prescribed duration of exercise were also provided in some studies [16, 26, 28, 29, 33]. Some studies also recommended resistance training along with aerobic exercise, to be performed 2 days/week [17, 18, 22, 23] or 3 days/week [20, 36].

Recommended exercise intensity in patients with HF was based on a percentage (%) of peak oxygen consumption (peak VO_2) or maximal oxygen consumption (VO_2 max) [22-24, 30, 36], heart rate at a % of peak VO_2 [30, 33], a % peak heart rate reserve (HHR) [16, 18, 26, 29, 32, 35], a % maximal heart rate [20, 27, 34] or Rating of Perceived Exertion (RPE) [17, 21, 35]. RPE as measured by the Borg (6-20) or modified Borg (0-10) scale was used along with VO_2 or HR [18, 21, 36] to monitor intensity. Moderate intensity has been defined as intensities ranging between 50-85% of VO_2max or HRR. Low intensity exercise was also prescribed in some studies where intensity was set between 40-65% of peak HR [19, 20, 29]. In recent times, the physiological effects of high-intensity interval training (HIIT) at 90-95% of HRR has been studied on HF patients. Due to insufficient evidence and lack of adherence reports they have not been included in this review [37]. Studies utilizing RPE to determine intensity of exercise recommended RPE ranging between 11-14 on the Borg scale and 3-5 on the modified Borg scale. Exercise intensity, in general, can also be categorized using metabolic equivalents (MET) where one 1MET, which is roughly the energy expenditure at rest, is defined as oxygen uptake of 3.5 ml/kg/min. MET-min is used as an index of energy expenditure to quantify the total amount of physical activity performed in a standardized manner across individuals for the number of minutes the activity is performed [38]. Generally, activities that require a MET<3 are classified as low intensity, MET 3-5.9 as moderate and MET>6 as high intensity activity [14].

Clearly, the present review demonstrates that there is no consistency in the recommended exercise training parameters of frequency, duration and intensity in patients with HF. Frequency

of exercise ranged between 2 to 7 days per week with varied duration of exercise per session. The intensities described in a majority of the studies are consistent with the current recommendations for patients with HF [10]. Notably, many of the studies in this review were completed prior to the 2011 publication of the specific guidelines for exercise recommendations in patients with HF [10], which may explain the variation observed in exercise prescription from these studies.

Adherence as a Primary Outcome of a Specified Aim: A research aim is generally a statement of desired outcome or a statement that highlights the intention of the research. Adherence as a primary outcome of a specified aim was investigated in only one study where the authors' *a-priori* stated that the interventions were targeted toward improving exercise adherence [17]. Other studies describing adherence to exercise in patients with HF reported adherence to the specific exercise program used in the study although the primary aim was not to improve adherence to exercise. In these studies, primary outcomes were functional status (performance of activities of daily living) [18, 21, 24, 25, 29], depression [16, 25], anxiety [25], symptoms/clinical status [24, 34, 36], exercise self-efficacy [19, 22, 24], functional capacity (aerobic capacity) [23, 24, 32-34], oxidative capacity and structural morphology [31], left ventricular function and hemodynamic response [30], quality of life [23-25, 34], clinical outcomes [20, 26], exercise safety [26], and validity of pedometers as a measure of exercise adherence [27].

In summary, the primary objective in the majority of reviewed studies focused on examining the physiological and psychological effects of exercise performance in HF. Adherence was most commonly reported in relation to the prescribed exercise protocol for the intervention which as mentioned previously, was quite variable across studies. Adherence to an

exercise program has not been the primary objective or goal of exercise intervention studies; therefore, if measured at all, findings were inconsistent.

Instruments Used to Record Exercise Performance: Several different instruments have been used to record performance to the exercise program. Weekly exercise diaries or activity logs [16-27], heart rate monitors (e.g. polar watches) [16-18, 26], pedometers [18, 20, 27, 29] and tele-monitoring [18] have been used to record exercise performance and adherence was calculated from data from these instruments. There were also studies that did not report on how adherence was measured or recorded [31-33].

The most widely used instrument to record exercise adherence has been exercise diaries or activity logs and adherence reports have been based on participants' self-report within the diaries. Given the limitations of accuracy and overestimation of physical activity with self-reported exercise data [39], it is important to examine strategies used to objectively validate self-reported data. In one study, self-reported exercise diaries were compared with pedometer step count and the data were found to be correlated ($r=.594$; $p=.001$) [27] providing validity evidence for self-report diaries. Another study, however, simply stated that the data from the self-reported dairies were valid [18] without providing any evidence for it.

Studies that have combined heart rate monitors with exercise diaries, primarily utilized them to provide participants with heart rate data to guide them with exercise intensity during exercise performance [16-18, 26]. However, none of these studies have reported the use of heart rate monitors to validate self-reported data in exercise diaries. Similarly, tele-monitoring has been primarily used to track and monitor heart rate, blood pressure, daily weight and symptoms and flag the participant for a follow up appointment rather than validation of diaries. Finally, an

accelerometer was used to measure overall improvement in physical activity at 6 months' [21] but not to measure adherence to the exercise intervention protocol.

Most of the studies included in this review only used exercise diaries as the primary source of information for frequency, duration and intensity of exercise. Consequently, there is need for these data to be compared and validated with objectively collected data from instruments such as heart rate monitors and accelerometers.

Strategies to Aid Exercise Program Adherence: Strategies to aid exercise program adherence have been varied as described in Table 2.

Table 2: Interventions used to aid exercise performance and adherence to exercise

Strategy	Reference
Telephonic conversation with the principal investigator	[25]
Contact with research staff or exercise trainer	[21, 23]
Video and audio cassettes	[21]
Group support sessions	[17]
Group exercise sessions	[30, 31]
Visiting web sites for exercise information and posting on online discussion board	[17]
Weekly or monthly face-to-face contact	[19, 20, 29]
Feedback on exercise performance	[17, 25, 36]
Supervision of exercise performance	[16, 17, 26, 28, 29, 33, 34, 36]
Education on benefits of exercise	[17, 28]
Providing participants with exercise equipment such as treadmill or exercise bicycle to exercise at home	[26, 31]

The majority of studies do not mention using strategies for improving adherence to the prescribed exercise program. Strategies such as feedback, group support sessions and supervision of exercise have been used in multiple studies although only one study [17] defined the strategy employed for the specific purpose of improving exercise adherence. Furthermore, even the use of multiple strategies, such as supervision of exercise and providing participants with exercise equipment to aid with exercise performance/adherence, did not demonstrate significant long term

adherence [26]. Unfortunately, the actual effects of the strategies listed in table 2 are difficult to determine as most studies did not report or test their effects on adherence.

Use of Theoretical Framework to Improve Adherence: Adherence to exercise requires an individual to make long term behavioral changes. It appears that studies incorporating interventions that are theory-based and offer multiple behavior change techniques tend to have a greater impact than interventions that do not incorporate such strategies [40]. Only two studies based the intervention and strategies to improve exercise adherence on a theoretical foundation [17, 36]. Bandura's Social Cognitive Theory was used to develop the framework and identify strategies to enhance adherence in both the studies. The Social Cognitive Theory states that humans learn from observation and that improving self-efficacy, which is influenced by performance accomplishments, vicarious experience, verbal persuasion and emotional arousal, is key to behavioral change [41]. Goal setting, feedback and problem solving guidance were used in one study [36] while guided strategies for improvement in self-efficacy and adherence were employed in the second study [17]. However, as both of these studies had relatively short intervention periods, 12 weeks [17] and 24 weeks [36], the long term effects of theory-based interventions on adherence to exercise in patients with HF are not known.

In summary, the use of a theoretical framework to guide the interventions was rare and many of the strategies mentioned in the previous section were not theory based. This is primarily because improving adherence was not the primary outcome or a specific aim in the majority of studies in this review.

Reported Adherence to the Exercise Protocol: Most studies did not indicate program adherence as a primary outcome measure. The purpose or primary aim of these studies was not to see a change in behavior that led to improvement in adherence to exercise. Instead, most

reports of adherence merely described attendance of participants to the exercise program. As noted previously, exercise programs varied widely in terms of the components of exercise protocol, namely frequency, duration and intensity of exercise, with reported adherence levels ranging from 30-110% [16-19, 21-24, 26, 28-31, 33, 36] where 110% indicated that the mean adherence score was more than the prescribed exercise. In one study, patient exercise participation was reported to be 1.7 sessions of the recommended 3 sessions per week [34]. Studies that calculated adherence or compliance in terms of the number of individuals who adhered to the prescribed exercise program reported 20 of 38 to be adherent [27], 20 of 42 to have greater than 80% compliance [35] and 14 out of 15 to have 100% adherence [32]. Studies of exercise programs that included resistance exercise along with aerobic exercise reported adherence of 75-99% to the resistance exercises [18, 22, 23].

The present review demonstrates that reports of protocol adherence among the studies varied widely from levels as low as 30% to levels as high as 110%. The limitations in interpreting such findings are further complicated by the large variation in the exercise prescription methodologies employed within studies, particularly the prescribed frequency, duration and intensity of exercise as well as the basic definition of "adherence".

Other important factors to consider when determining adherence to an exercise program are the length of the intervention itself as well as how adherence may have changed over time, particularly in determining the effectiveness of the intervention on long term adherence. By comparison, when these factors are considered, it may be that reports of high adherence in one study would be considered low adherence in another study or when compared to the currently recommended exercise guidelines of 150 min/week of moderate intensity exercise. In the HF-ACTION study [26], the number of minutes of moderate intensity aerobic exercise performed

per week was calculated and participants were categorized as "adherent" if they performed 120 min of exercise per week. This categorization is consistent with the generally accepted definition of adherence of meeting 80% of the recommended dosing.

Part III: Impact of Various Factors on Exercise Program Adherence

The examination of other factors that may affect exercise program adherence in patients with HF is also important to consider [3]. These potential factors include exercise setting, age, gender, race, NYHA class, HFrEF/HFpEF and length of exercise duration in patients with HF.

Effect of Exercise Setting: Settings for exercise performance have been varied as described in Table 3.

Table 3: Exercise Program settings

Setting	References
Facility-based	[24, 32, 33, 35, 36]
Facility-based with transitioning to home-based	[16, 17, 21, 26, 34]
Primarily facility-based with provision for home-based exercise once a week	[28]
Primarily home-based with provision for facility-based exercise once or twice a week	[30, 31]
Purely home-based	[18-20, 22, 23, 25, 27, 29]

In summary, facility-based programs reported adherence of 50-91.8% [24, 33, 35, 36] and programs transitioning from a facility-based to a home-based setting reported declines in adherence with the transition and overall adherences of 30-82.7%, [16, 17, 21, 26]. One program, which was primarily facility-based but provided for home-based exercise, reported an 88% adherence rate [28]. Programs which were primarily home-based but incorporated facility-based group exercise once or twice a week reported adherences between 60-62% [30, 31] and purely home-based programs reported adherences rates of 77.3%-110% [18, 19, 22, 23]. Two studies reported on the number of participants who adhered to the exercise protocol but did not provide a

mean adherence score, making it difficult to estimate the overall adherence to the home-based protocol [27, 35].

It is interesting to note that, overall, home-based exercise interventions have shown better adherence than not only facility-based interventions but also interventions that transitioned from a facility to a home-based setting. Some of the home-based interventions that have shown better adherence have also included for provisions of social support, supervision and feedback [18-20, 23, 25, 29]. One important point to note is that the reports of high adherence in these home-based studies have been based on subjective self-report by participants using exercise diaries or logs. The facility-based studies, especially those with provision for supervision, offer ways to validate attendance and exercise performance. The home-based studies with reports of high levels of adherence did not provide such validation reports. Thus, interpretation of these data must be done with some caution.

Effect of Age: Mean age of participants reported in reviewed studies was greater than 50 years [16, 20, 26-28, 30, 31], greater than 60 years [16, 18, 22, 24, 29, 33-36, 42] and 81 years of age [21], which reflects the general age of the HF population. These studies did not report whether age influenced exercise adherence. One study that included participants with age ranging between 30-76 years did not compare adherence between the younger and older participants [23]. Unfortunately, results provide no clear understanding of how age may affect adherence to exercise, primarily because this information was not provided in the majority of these studies.

Effect of Gender: Data indicate that studies of exercise adherence in patients with HF have been primarily performed in samples that were predominantly male and Caucasian. Males comprised at least 75% [16, 17, 20, 23, 25-28, 34-36] or 100% of subjects [22, 24] with only one study consisting of 100% female participants [19]. Females were adequately represented (i.e., 50% of

the sample) in only two studies [17, 18]. However, a comparison of adherence to exercise programming between males and females was not reported in these studies. With the majority of studies reporting program adherence in male samples and those studies with a similar proportion of males and females not providing a comparison of program adherence between males and females, our understanding of how gender may affect exercise adherence in patients with HF is limited.

Effect of Race: Several studies did not describe race or ethnicity of their participants [21, 25, 28, 34-36], while other studies only indicated that study-samples consisted of 50-100% Caucasians [17-20, 22, 23, 26, 27]. Thus, reports of the impact of race on adherence to exercise in patients with HF are lacking.

Relationship of NYHA Functional Class to Adherence: Functional capacity as impacted by severity of symptoms in HF has been identified as a potential barrier to exercise [3]. Often classified by NYHA functional class, functional limitations are classified as NYHA class I to IV, where Class I indicates least limitation and IV indicates greatest limitation. Studies including various exercise interventions have included participants within NYHA class I-III [24, 25, 33-35] and NYHA class II and III [19, 20, 28, 31, 32, 36] with a few studies including participants belonging to NYHA class IV [16, 20, 26, 27, 36]. Unfortunately, although HF patients belonging to different NYHA functional classes have been included in many studies, a breakdown of how adherence to the intervention protocol may have been impacted participants belonging to different NYHA classes has not been provided. Hence, our understanding of exercise adherence among participants belonging to different NYHA classes is limited.

Effect of HFrEF and HFpEF: In studies that have evaluated the relationship of ejection fraction and exercise adherence, the majority reported on adherence in patients with HF with

HFrEF versus those with HFpEF. The ejection fraction of participants in the majority of the studies ranged from 25% to 40% [17, 18, 20, 22, 23, 29-31, 33, 34]. Of the studies examining exercise in patients with HFpEF only two were found that included reports of exercise adherence. Participants with HFpEF were included in only one study with all participants having an EF>45% [19]. In another study, participants belonging to both HFpEF (>40%) and HFrEF were included but a comparative report of exercise adherence based on EF was not provided [24]. With only two studies reporting on exercise adherence in patients with HFpEF, it is unclear how adherence to exercise in patients with HFpEF differs from HFrEF. It is also inconclusive how severity of HFrEF affects adherence as well.

Effect of Exercise Intensity: Adherence to the specific components of the exercise prescription have only addressed exercise intensity and results have been mixed with high, moderate and low adherence levels. The majority of studies have utilized moderate intensity aerobic exercise interventions. Only one study prescribed low intensity exercise but did not report on adherence [20], while two studies where exercise intensities ranged between low to moderate intensity [19, 29] reported higher levels of adherence. However, no study compared adherence based on intensity of exercise. Hence, it is unclear how intensity of exercise affects adherence in patients in HF.

Effect of Length of Study Duration: Exercise adherence has been reported in exercise interventions lasting 8 weeks -10 years [16-36]. In many of these studies, especially those with interventions lasting 12 weeks or more, adherence to the intervention protocol declined over time [16, 17, 19, 22, 23, 26, 29].

It is important that exercise adherence interventions focus not only on adherence during the intervention phase but also during the maintenance phase. Typically, the maintenance phase

begins 3-6 months after the intervention phase [10]. Studies of interventions that lasted more than 6 months report adherence rates of 30% (30 months) [26], 38% (30 months) [16]and 88% (10 years) [28]. In another study lasting 12 months, 20 participants were classified as adherers [27]. The report of high levels of adherence to the exercise protocol for a period of 10 years in one study may be attributed to continued exercise supervision provided in a "coronary club" setting throughout the length of the study [28, 43]. However, this report should not be considered in isolation as the recommendations for exercise frequency and duration (40 min, 2-3 days/week) in this study varied widely with the other studies and with the current recommended exercise guidelines. In summary, adherence to exercise appears to decline over time, especially in interventions lasting more than 6 months.

Part IV: Summary and Recommendations

Key findings from the review indicate:

- That study protocols vary widely as to the definitions of adherence, exercise intervention protocols and study length.
- Most studies investigated the effects of moderate intensity exercise but varied as to duration and frequency of the exercise recommendations. As such, comparison of findings regarding adherence are difficult at best.
- Exercise adherence was a primary outcome in only one study and the majority of the studies which reported adherence did so in relation to the exercise intervention prescribed in the study.

- The primary objective in the vast majority of these studies was to examine the physiological or psychological outcome of exercise participation in patients with HF rather than to investigate theory-based strategies to improve adherence to exercise.
- Self-reported exercise diaries have been the most widely used tool to measure exercise adherence.
- Although a few studies have used tools to objectively collect data, reports of validation of subjectively reported data with objectively collected data have not been provided.
- There is a lack of understanding of how age, gender, race or variability in ejection fraction may impact exercise adherence in patients with HF.
- Exercise adherence appears to decline over time even with the use of multiple strategies. This implies that long term behavioral change to impact exercise adherence is not easily achievable for patients with HF.

It is recommended that:

- More studies need to be undertaken with the primary aim to improve adherence to exercise in patients with HF.
- The definition of adherence needs to be consistent and reported in terms of the recommended guidelines of 150 min/week of exercise. We advocate that meeting 80% of this recommendation be broadly adopted as a threshold for exercise adherence in the heart failure literature.
- Exercise diaries, because of their ease of use, remain one of the most widely used instrument to record exercise data. However, validation of these self-reported subjective data are lacking. Knowing that self-reported data can be overestimated, it

is recommended that activity monitors be used to collect objective data regarding exercise performance to validate self-reported exercise data.

- To minimize error in subjective data participants may be instructed to fill out their exercise diaries on a daily basis rather than at the end of a week. Also, participants should be encouraged to record specific information from heart rate monitors such as average heart rate and length of time for exercise from the exercise sessions.
- The use of technology, not only to objectively validate adherence data, but to provide education, support and feedback on exercise performance, should be investigated as a potential strategy to improve adherence.
- Barriers to exercise in patients with HF are multifactorial and few studies have incorporated specific strategies to address those barriers and to improve long term exercise behavior.
- Adherence to exercise in patients at different levels of HFrEF as well as in patients with HFpEF should be investigated. Also, adherence to exercise in patients with HFrEF vs HFpEF should be further explored.
- Effects of demographic factors such as age, race, gender, income levels, educational level and occupation on adherence to exercise in patients with heart failure should be investigated.
- Clinicians need to appreciate the fact that long term adherence to exercise requires one to make behavioral changes and that interventions should be built on behavioral theories that have been successful in bringing about positive behavioral change. Combining multiple theories to create unique interventions to address the multiple known barriers to adherence may be helpful.

The benefits of exercise in the HF population can only be realized if adherence to the recommended exercise guidelines is met. Future research is needed to test innovative models to improve exercise adherence in this population.

Table 1: Summary of Randomized Controlled Trials Reviewed in this Study

Author, Year, Purpose	Sample size	Age (y) (M±SD)	NYHA/ EF	Adherence instrument	Adherence strategy	Duration	Modality	Setting	Adherence definition and Reporting of adherence
Blumenthal et al. (2012)	N= 2322. F=29% AA=33% About 51% ischemic CM	60±10	II-IV	Polar watch and self- report	Cycle or TM was provided Supervision of exercise before transition	30 months	Aerobic exercise Facility: 3 days/week. Home exercise: 40 min, 5days/week	Full transition from facility to home	Full adherence (defined as >120-min/week) during the home-based phase (*a-priori* defined) **Adherence:** 38%. Declined with time
Gary et al. (2012)	N=24 M=50% White =50% Did not report etiology	60±10	II-III 25±10%	HR monitor+ exercise diaries+ pedometer recording of steps during exercise + Tele-monitoring Validated diary step count with pedometer		12 weeks	Aerobic and resistance exercise. Eight supervised resistance exercise sessions using color coded Thera-cords 30 to 60 min	Home-based (community walking)	(Number of exercise sessions recorded / number of sessions prescribed) x100 **Adherence:** 83% for aerobic exercise 99% for resistance exercise
Belardinelli et al. (2012)	N=123 M=96 (78%) F=27 M (ET): 49/14 (78%) Did not report race Ischemic CM 80%	59±14	II-III	Written report of each session	Supervised exercise. Education on benefits of physical activity	10 years	Aerobic exercise 40 min, 2-3 days/week	Facility based (2 days/week). Encouraged home exercise (1day/week)	Definition not provided **Adherence:** 88% 137±18 sessions performed per year ET group 39±13 sessions performed at home
Chien et al. (2011) (Taiwan)	N=51. M=38 (75%) F=13 Did not report race	58±16	I-III	Daily activity log	Telephone, feedback, discussion with PI about adherence and barriers	8 weeks	Aerobic + resistance 30 min, 3 days/week	Home	Definition not provided **Adherence**: not reported

	51% ischemic CM								
Duncan et al. (2011)	N=20. M=11(55%) F=9 (45%) 95% white Did not report etiology	59.3±3.8	EF<40%	exercise logs+ HR monitor watch+	group support sessions+ Internet web site+ graphic Feedback + first 3 weeks of supervised exercise	12 weeks	Aerobic (30 min, 3 days/week) + resistance	Facility + home	Continued participation at the levels prescribed. **Adherence**: 73%. Declined with time
O'Connor et al. (2009)	N=2331 F=28% 61% white 51% ischemic CM	Median age 59 (51.2-67.8)	II-IV	HR monitor and self- report on activity logs	Cycle or TM was provided Supervision of exercise before transition	30 months	Aerobic exercise Facility: 3 days/week. Home exercise: 40 min, 5days/week	Full transition from facility to home	Adherence was evaluated by measuring attendance at the supervised training sessions and by activity logs, telephone and clinic follow-up, and heart rate monitoring data during the home exercise training phase (Goal of 120 min/week) **Adherence**: 30%. Declined with time
Mandic et al. (2009)	N=42 M=32 (76%) F=10 Did not report gender or race. 45% ischemic CM	62±12	I-III			12 weeks	Aerobic vs aerobic + resistance vs usual care. Aerobic exercise 3 days/week for 30 min. Resistance group performed 3 days of resistance training as well	Facility	Adherence defined as attending ≥80% of sessions. **Adherence**: 20 out of 42
Pozehl et al. (2008)	N=21 M=19 (90%) F=2 100% white Did not report etiology	66.2±10.2	II-IV 28.4±7.4%	Exercise session attendance	Social cognitive theory (goal setting, feedback, problem solving guidance)	24 weeks	Both aerobic and resistance 60 min, 3 days/week	Facility	Number of exercise sessions attended vs goal (3x/week) **Adherence**: 91.8%

					Supervised exercise for 12 weeks				
Dracup et al. (2007)	N=173. M=72% 60% white 38% ischemic CM	54±12.5	II-IV 26.4±6.8 %	Activity log + pedometer (during walking)	Weekly visit by nurse x 2weeks; then monthly visit	12 months	Aerobic + resistance 45 min, 3 days of aerobic	Home	Daily distance travelled in miles. Percent change in pedometer scores. >10% change termed adherers. Only 44% in the intervention group reported exercise diaries and pedometer. **Adherence:** not reported
Gary et al. (2006)	N=32 F=100% AA=38% Did not report etiology	50-85	II-III >45% HFpEF (diastolic HF)	Walking logs + HR monitor (target HR)	Weekly face to face contact	12 weeks	Aerobic 30 min, 3 days/week	Home	Adherence scores were determined as either 100% (all walking sessions), 67% (two walking sessions), 33% (one walking session), or 0% (no walking). scores for each week women walked were summed and divided by the total number of weeks women walked for the adherence score **Adherence**: 85%. Declined over time
Evangelista et al. (2005)	N=38 M=74% 68% white 42% ischemic	54.1 ± 11.7	II-IV	Exercise diaries Pedometer Pedometer and step count data was correlated (r=.594; p=.001)		12 months	walking program of 45 minutes' duration, designed to achieve 60% of maximal heart rate	Home	10% increase in baseline numbers in pedometer scores were called adherers **Adherence:** 20 participants were classified as adherers.
Witham et al. (2005)	. N=82 M=45 (55%) Did not report race 66% ischemic CM	81±6	II-III	Weekly exercise logs + accelerometer	Video/audio cassette + telephone liaison for encouragement and new target setting with physiotherapist	6 months	Chair based exercises (not described) 20 min (2-3days /week)	Supervised + Home	Mean attendance to the program (number of sessions offered vs attended) **Adherence:** 82.7%

Oka et al. (2005)	N=24 M=100% 100% Caucasian Did not report etiology	60 (30-76)	II EF<40%	Daily exercise logs		3 months	Aerobic + strength 40-60 min, 2-3 days/week	Home	Number of exercise sessions reported as a percent of exercise sessions prescribed per week. **Adherence:** Aerobic exercise (110%); Upper body resistance (87%); Lower body resistance (75%). Declined over time
Collins et al. (2004)	N=31 M=100% Did not report race. Do not report etiology	64±10	I-III EF= 29±7%. 12 participants had EF>40%	Activity diary	Supervision of exercise	24 weeks	Interval training. Supervision tapered from twice in the first 12 weeks to once in week 13 to 24	Facility	Did not provide definition but stated adherence to study exercise program. **Adherence:** 57%
Corvera-Tindel et al. (2004)	N=42 M=90% 41% white Ischemic (53%) and non-ischemic CM	62.6±10.6	II-III EF=27± 8.8%	Pedometer, Nurse home visit on a weekly (weeks) and biweekly (6 weeks)	Supervision of exercise	12 weeks	Aerobic (walking) progressed up to 60 min, 5 days/week	Home based	Overall compliance: Sum of average weekly compliance rates/ 12. Weekly compliance= (actual walking time/prescribed walking time)x100 **Adherence**: 74.3±37%. Compliance progressively declined after the first 4 weeks.
McKelvie et al. (2002)	N=181 M=162 (89%) F= 19 Did not report race 84% ischemic CM	64.8±1.1 (ET group)	I-III EF<40%	Monthly report	Supervision for 3 months	12 months	Aerobic (30 min, 3 days/week) + Resistance (2 days/week)	3 months of supervised training, then 9 months of home-based training	Did not provide definition but stated adherence to study exercise program. (attendance) **Adherence**: 14% did not attend initial sessions. Compliance at home was 1.7±0.4 sessions.
Oka et al. (2000)	N=40,	30-76	II-III EF<40%	Exercise logs	Telephone + meeting with	12 weeks	Aerobic + resistance	Home based	Average weekly adherence rates were calculated as the

	M=31(77.8%) F=9 70% white 35% ischemic				project staff once a month with concerns with exercise performance		45-60 min, 3 days/ week		number of exercise sessions reported as a percent of exercise sessions prescribed for the week. **Adherence**: Aerobic exercise (110%); Upper body resistance (87%); Lower body resistance (75%). At 12 weeks adherence decreased for all 3 components.
Hembrecht et al. (2000)	N=73 Male 100% Did not report race Dilated (84%) or ischemic CM	54±9 (ET group)	EF=27%	Do not report	Bicycle ergometer; one group meeting of 60 min/week	6 months	20 min, 7 days/week	Facility (2 weeks) to home (6 months). Not complete transition with one meeting during the week at facility	**Adherence**: 60%
Willenheimer et al. (1998)	N=49 M=72% Did not report race 76% ischemic CM	64±5 (ET group)	I-III EF≤45%	Do not report	Supervised group exercise	16 weeks	Interval training 90s exercise with 30 s rest. 15 min, 2 days/week till week 8; 45 min, 3 days/ week from 9 weeks	Facility	Defined as % of sessions attended **Compliance**: 74.5% (range: 54.5% to 97.7%)
Keteyian et al. (1996)	N=40 M=100% 63% white 40% ischemic CM. Higher rate of drop out in ischemic (44%) than	56±11	II-III EF≤35%	Do not report		24 weeks	Aerobic: 33min, 3 days/week	Facility	**Adherence**: 14 out of the 15 participants in the training group had 100 percent adherence.

	non-ischemic CM.								
Hembreht et al. (1995)	N=22 M=100% Did not report on race Dilated (86%) or Ischemic CM	51±9	II-III EF=26± 9%	Do not report	Bicycles ergometers were loaned; two group training sessions /week	6 months	Aerobic 2x daily for 40 min/day	Facility (3 weeks) to home Not complete transition with one meeting during the week at facility	Do definition was provided. **Adherence**: 62±24% (facility); 70% (home)

N: number; CM: cardiomyopathy; AA: African American; NYHA: New York Heart Association Functional Class; EF: ejection fraction; HR: heart rate; BP: blood pressure; M: Male; F: Female; ET: exercise training; TM: treadmill; ET: exercise training; HFpEF: heart failure with preserved ejection fraction

Conflict of Interest: All authors have made significant contributions to the study and endorse the data and conclusions. The authors have no potential conflict of interest.

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Feasibility of Delivering an Internet-Based Intervention in Patients with Heart Failure

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Abstract

Use of the internet in delivering group face-to-face video interventions for behavioral change has not been studied. The purpose of the study was to assess the feasibility and acceptability of implementing the Move on Virtual Engagement-Heart Failure (MOVE-HF) intervention and utilizing a wrist worn activity monitor (Fitbit Charge HR, FCHR) to monitor exercise in community dwelling patients with HF. Thirty heart failure patients (12 females and 18 males) aged 64.7±11.5 years were randomly assigned to an experimental (n=15) or comparison (n=15) group. Once a week for 8 weeks, the experimental group participants attended internet-based face-to-face group meetings using a software called Vidyo and all participants used the FCHR to record exercise and physical activity data. Participants' perception and acceptance for use of the Vidyo software and the FCHR was positive. Such an intervention appears feasible for testing in a larger study with potential for recruiting patients living in rural areas.

Keywords: internet-based; face-to-face video; heart failure; exercise; activity monitors

Introduction

Use of the internet has grown over time (PewResearchCenter, 2014). Internet-based interventions for behavioral change including physical activity are increasing in use due to factors such as low cost, convenience, increased control of delivery of the intervention, overcoming isolation and stigma reduction (Griffiths, Lindenmeyer, Powell, Lowe, & Thorogood, 2006; McCully, Don, & Updegraff, 2013). The internet is efficacious in delivering interventions to participants with chronic conditions especially for those needing to learn self-management skills and having limitations in accessing healthcare (Kirsch & Lewis, 2004). Research on the use of the internet to improve physical activity is however limited and a systematic review of the literature shows that many internet interventions to improve PA were limited to visiting websites, watching online videos and engaging in online chats with peers or healthcare providers (Carr et al., 2013).

The use of synchronous face-to-face individual video coaching sessions over the internet is a new strategy that has been tested for improving physical activity in inactive participants (Alley, Jennings, Plotnikoff, & Vandelanotte, 2016), effect change in parenting behavior (Wade, Oberjohn, Burkhardt, & Greenberg, 2009), delivering smoking cessation interventions (Whittaker et al., 2011) and providing in-home rehabilitation programs (Taylor et al., 2015). Advantages in use of video conferencing include: better engagement of participants, more accountability for participants, increased perception of social support, and opportunity to clarify misunderstandings as compared to email and instant messaging (Abbott, Klein, & Ciechomski, 2008; Fantus & Mishna, 2013). However, to the best of our knowledge, the delivery of an internet-based face-to-face discussion/education in a group setting in patients with heart failure (HF) has not been tested.

In the community setting, measurement of physical activity including exercise, which is defined as a subset of physical activity (Caspersen, Powell, & Christenson, 1985), has been done using heart rate (HR) monitors, pedometers and accelerometers. These instruments, however, can have limitations on the amount and type of information they provide to the user and in the complexity of use by older adults. A HR monitor such as a polar watch is effective in measuring HR during exercise but is not convenient in monitoring daily physical activity as they generally require the participant to wear a chest strap at all times and is limited in the information it provides. Older generation of pedometers and accelerometers are effective in measuring PA but do not provide heart rate information which is important in regulating and monitoring intensity of exercise. Accelerometers, though very effective in objective measurement of physical activity in the community setting, are limited in providing real time feedback to users. Newer activity monitors such as the Fitbit Charge HR (FCHR) have recently become popular as they can be worn on the wrist and provide information related to amount of physical activity (i.e. steps) but also allow for use of heart rate to guide intensity of exercise. An older generation of the Fitbit that did not have the heart rate monitoring capability was used in the community setting and was found to be useful in improving physical activity in inactive women (Cadmus-Bertram, Marcus, Patterson, Parker, & Morey, 2015).

Although exercise has been found to be beneficial in patients with heart failure (HF), adherence to exercise in this population has been reported to be low (Marti et al., 2013; O'Connor et al., 2009). The potentiality and power of the internet combined with newer technologies to monitor exercise make it an opportune time to test newer approaches to deliver interventions over the internet. Therefore, the study tests the implementation of the Move on

Virtual Engagement- Heart Failure (MOVE-HF) intervention in community dwelling patients with HF with the use of a software called Vidyo and FCHR. The study aims to:

Aim I: Track recruitment and attrition and provide cost estimates for the study.

Aim II: Test the feasibility of delivering an internet-based face-to-face group discussion/education intervention to patients with HF using the "Vidyo" software for participants in the experimental group.

Aim III: Examine the feasibility and acceptability of monitoring physical activity, specifically exercise, among patients with HF in a community setting using the FCHR in participants in both the experimental and comparison group.

Method

Design This study used a two group randomized controlled design to investigate the feasibility and acceptability of delivering an internet-based face-to-face group based intervention over the internet and to examine if the FCHR could be used to track exercise over time in HF patients. 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 exercise in patients with HF. Primary results addressing the effects of this intervention on exercise adherence are reported separately. This article focuses on a descriptive analysis of the feasibility of the intervention in this population and highlights experiences of the participants in the experimental and comparison groups.

Subjects Thirty HF patients were recruited from two mid-western heart clinics in Nebraska, USA. With the aim to calculate effect size for a larger study, a sample size in the range of 15-20

per group has been considered adequate for feasibility testing (Hertzog, 2008). Based on these recommendations, a sample size of 30 was considered adequate to meet the aims of this study.

Recruitment Multiple approaches were utilized to recruit participants: (a) survey at the clinics where participants indicated if they were interested and willing to be contacted about an internet-based intervention, (b) flyer displayed at the clinics and (c) by word of mouth. The clinic staff helped to identify potential participants and sought consent from them to be contacted by the PI to provide more information and likely recruitment. The PI then contacted the participant over telephone, provided them with more information about the study and if interested, set up an appointment to meet with them to sign informed consent and baseline testing. Approval for the study was obtained from the Institutional Review Board.

Randomization A block randomization strategy, using sealed envelopes created by a statistician, was used and participants were randomized to an experimental or a comparison group. Randomization was done in blocks of 10 participants which allowed for 5 participants, from that block of 10, to be randomized to the experimental group. If a participant, in the experimental group, dropped out before the first group meeting was held then that participant was replaced with the first participant that came in for their baseline visit.

The 15 participants in the experimental group were further sub-divided into 3 cohort groups with 5 members each. Participants in each cohort were asked to indicate the times they would be available to meet and the PI set up a group meeting time that was agreeable.

Inclusion criteria Participants were screened to meet the following criteria for inclusion in the study: a) medical diagnosis of HF (New York Heart Association class I to III) with preserved or reduced ejection fraction and no changes in medical history in the past 30 days; b) receiving

standard pharmacologic treatment for heart failure (beta-blockers, ACE inhibitor, and diuretics) and on a stable dose of beta-blockers for minimum of 30 days to elicit a stable heart rate response on the 6 min-walk-test; c) able to hear, speak and read English; d) have access to a telephone and a valid e-mail address (PI provided help to set up email account if participant did not have one but was willing to open an account); e) have an electronic device (desktop/laptop/iPad/tablet/smartphone) with internet connectivity at home (participants who do not have a web-camera with microphone were provided with one); f) cardiologist clearance to participate in moderate intensity exercise; and g) intact cognitive functioning (determined during informed consent with the participant being able to describe what participation in the study would involve).

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 heart failure and any of the following medical conditions: unstable angina pectoris, end stage renal disease, myocardial infarction, coronary artery bypass surgery, or biventricular pacemaker less than 6 weeks prior. Similar inclusion and exclusion criteria have been used in exercise studies involving HF patients (Pozehl et al., 2014).

MOVE-HF Intervention Provided to both experimental and comparison groups

Exercise routine. An exercise routine (walking program) was provided to all participants to meet the recommended 150 min of moderate intensity exercise a week (30 min/day x 5 days/week). Participants regulated their exercise intensity using the Borg 6-20 Rating of Perceived Exertion Scale. They were also provided with a heart rate number from the six-min-

walk-test at baseline to regulate their intensity of exercise using heart rate information from the FCHR.

Fitbit Charge HR (FCHR). All participants were provided with a FCHR, a wrist worn activity monitor that tracks and records physical activity (step count, heart rate, energy expenditure, distance travelled and flight of steps climbed) in real time. The FCHR can also be used to manually create exercise logs, with details of date, time, HR, step count and energy expenditure, by starting and stopping a stopwatch 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 to an electronic device. Syncing the FCHR to the application/connect software transfers the information to the Fitbit's server and deletes it from the physical memory of the FCHR thereby allowing for new information to be stored. This information on exercise logs can be then tracked on Fitbit's website using the participants account information. The PI tracked this information on a weekly basis. Participants were asked to record their exercise sessions using the FCHR and sync to download the information on a daily basis. The FCHR also by default automatically tracks active minutes for walking bouts of brisk pace lasting more than 10 min.

Handout on education on HF self-care. All participants were provided with a hard copy containing information on 8 topics on self-care from Heart Failure Society of America (HFSA). A link to the website was also provided and participants were encouraged to visit the website for more information on these topics *(http://www.hfsa.org/patient/education-modules/).*

MOVE-HF provided only to the experimental group:

Vidyo. Participants in the experimental group connected with other members in their cohort group weekly for a 45 min long face-to-face discussion/education session that was moderated by the primary investigator (PI). Vidyo is a software-based video conferencing application that is used to connect participants in distant locations for a face-to-face group audio/video conference. The user is required to download the VidyoDesktop or VidyoMobile application to their electronic device. This software was managed by the information technology (IT) services at the University and a link to the virtual conference room was provided to the PI. This link could be then used by participants in distant locations to log in for a face-to-face group video conversation. Delivery of video services using this software has been found to be effective even with mobile data services (Taylor et al., 2015).

Group sessions commenced for each group after the 5 members were assigned to each group. The literature did not provide any suggestions on the number of participants for effective face-to-face video group interventions over the internet. The group size of 5 participants was based on live video streaming limitations as indicated by the IT staff at the University.

The first group meeting for each cohort started with the participants introducing each other and describing their HF experience. The weekly meetings focused on the participants reflecting on their exercise over the week and on the assigned weekly HFSA patient specific information on HF self-care from the handout provided to them. Each week covered a topic from the handout and participants were asked to comment on those topics. Participants were encouraged to share their experiences with HF, the barriers they experienced with exercise adherence during the week and strategies that they used to overcome those barriers. Participants were also encouraged to exchange emotional and informational support with one another by providing assurance, advice and suggestions for exercise adherence during the discussion sessions. The PI provided

clarification on any questions that the participants had and motivated and encouraged them to find ways to overcome their barriers to exercise.

Instruments used

Questionnaire survey. An investigator-developed survey was completed at the end of the study to capture participants' perception of participating in the MOVE-HF study. The questionnaire had 11 questions: 4 were in "Likert scale" format; 3 were in "Yes/No" format; 2 were in "Yes/No/Maybe"; 1 in "Yes/No/Not sure" format and one open-ended question. Three aspects (Vidyo, FCHR and intervention) of the study were evaluated. Seven questions targeted use of the Vidyo software for participants in the experimental group only; one question targeted use of the FCHR and two questions targeted participation in MOVE-HF study. One open-ended question asked the participants to provide comments on their perception and experience of participating in the MOVE-HF study and provide specific comments on the FCHR and Vidyo and if they visited the HFSA website for more information on HF self-care. Participants in the comparison group did not respond to the questions related to the Vidyo software.

Exercise diaries. All participants were provided with paper exercise diaries to record their exercise sessions on a daily basis for 8 weeks. Data from the diaries were used to calculate the min/week of exercise that the subjects performed. This information was used to compare with the information that was recorded on the FCHR.

Measures

Table 1: Specific Aims and Corresponding Measures

	Aims	Measure
Aim I	A) Recruitment and attrition for the study B) Cost estimates for use of Vidyo and FCHR to deliver intervention	Detailed records of recruitment and attrition and cost incurred for the project: 1) number of patients contacted, recruited and drop outs; 2) cost of using Vidyo software and FCHR for delivery of intervention.
Aim II	A) Feasibility of using Vidyo B) Acceptability of use of Vidyo	Determined by records of: 1) Internet connectivity; 2) Vidyo software use; 3) Required technical support; d) Scheduling of intervention; 4) Attendance to program; 5) Unanticipated issues/problems Investigator developed survey responses
Aim III	A) Feasibility of using FCHR B) Acceptability of the FCHR	Determined by: 1) Devices used for syncing FCHR and issues with set-up and installation of software; 2) Difficulty and issues in use of FCHR; 3) Ability to track exercise on a weekly basis by PI and participants Investigator developed survey responses

Procedure Approval from the institutional IRB was obtained. Participants signed the informed consents and cardiologist approval was obtained before enrollment in the study.

Baseline. Participants were asked to bring their electronic device with them during the baseline visit. The PI downloaded the Fitbit application/connect software to the devices and trained participants in both the experimental and comparison group on using the FCHR to record their exercise sessions and to sync and transfer their exercise and physical activity information using the Fitbit app/connect software. Participants performed the 6 min-walk-test (6MWT) and their average HR during the walk was recorded to guide exercise intensity. Participants, along with the PI, then participated in a walking session lasting 10-12 min during which they demonstrated recording their walking session, monitoring their HR and after completion of the

walk to sync the FCHR with the Fitbit app/connect software to transfer the data to the internet account. Participants were asked to wear the FCHR from awakening till they went to bed at night and to not expose the FCHR to water. Participants were provided with written instruction on operating the Fitbit software.

Experimental Group. During the baseline visit, the PI downloaded and installed the VidyoDesktop or VidyoMobile application to the participants' devices. A 45min demonstration and return demonstration was completed on use of the Vidyo software. An email and hard copy containing the web-link to the conference room and detailed step-by-step instructions on set-up and operation of the software was provided to the participants. Within the next 3 days the PI connected with the participants through the Vidyo software from their home for a 5-10 min video session to assess if participants were able to successfully navigate through the connection process on their own and offered help over the phone if needed. On average, it took about 2.5 hours to complete assessment and enroll participants in the experimental group.

Post-Intervention. At 8 weeks all participants completed the survey on their experience of participating in the MOVE-HF study.

Results

The sample consisted of 12 females and 18 males of Caucasian race; the mean age of the participants was 64.7±11.5 years. Twenty-two participants were married and 8 were single or divorced. Twelve participants, 7 in the experimental group and 5 in the comparison group, reported working full time or part-time. Other participants reported being retired or did not work outside their home. Most participants lived within 15 miles of the data collection site. However,

7 participants lived in rural areas that were an average of 37 miles from the data collection site. Of these 7 participants, 6 participants had been assigned to the experimental group.

Aim 1.A: Recruitment and Attrition: A total of 82 HF patients were contacted for recruitment to the study. Figure 1 provides a CONSORT diagram of recruitment, randomization and attrition and Table 2 provides a breakdown of the reasons for not participating in study. Only 5 of the 82 (6%) potential participants could not be recruited due to lack of internet connectivity.

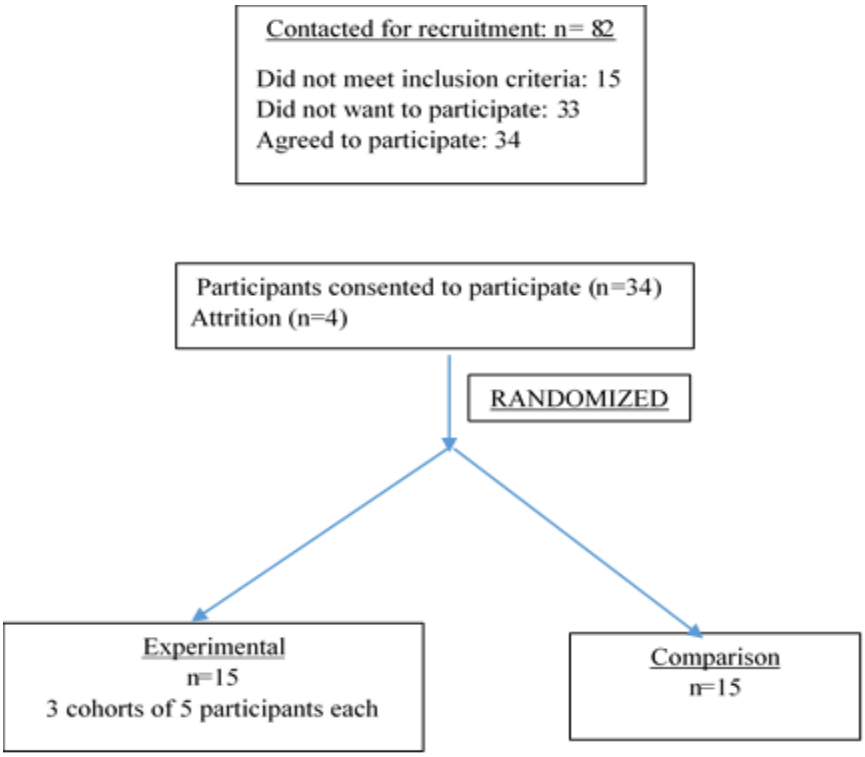

Fig 1: Recruitment, randomization and attrition flow chart

Table 2: Reasons for not Participating in Study

Reason	Number of Participants
Not feeling well to participate in exercise	3
Cardiologist said it was not mandatory to exercise	1
Changed mind after initially wanting to participate	7
Busy with work	2
Moving or moved out of State	2
Not interested	18
	n=33

Aim 1.B: Cost estimates for use of Vidyo and FCHR to deliver intervention: The Vidyo software was supported by the IT department at the University and no cost was incurred in using the software for the project. There was no additional cost to the participants beyond their regular payment to the internet service provider for internet services.

The initial cost of the FCHR was $149 each but prices of the FCHR and similar activity monitors have reduced since the intervention started. Two participants who had already bought the FCHR reported buying it at the end of the study for a discounted price of $99. There was no cost associated with maintaining the FCHR or to retrieve the data from Fitbit's server.

Aim II.A.1 Internet connectivity: Of the 30 participants, 26 participants used broadband internet connection, 3 used DSL internet connection and 3 participants used 4G wireless connection from their cell phone provider. The PI who moderated the group meeting used a combination of broadband, DSL and 4G wireless connection to connect with other participants over Vidyo. A primary concern with recruitment was access to internet connectivity.

II.A.2 Vidyo software use: Setting up of the Vidyo software was easily done as most participants in the experimental group brought their iPad (n=2) or laptop (n=10) with them during the baseline visit. One of these participants was loaned an iPad when his device broke.

Three participants used a desktop computer to connect to the group meetings using Vidyo. Two participants were able to set up the software themselves by following the instructions provided to them but one participant required a visit to the home, by the PI, to set-up the VidyoDesktop application. Two of the three participants that used desktop computers did not have a web-camera with a microphone and they were provided with one. The PI connected to the group meetings using a desktop, laptop, iPad and iPhone and did not encounter any issues with audio and video.

II.A.3 Required Technical Support: During the recruitment phase, IT services at the University provided the PI with 24 hour 7 days a week access to the Vidyo conference room. This was helpful as it provided the PI with flexibility in recruitment and training especially with participants that were employed and only found time to connect after work or during weekends. Once the participants in the 3 cohorts of the experimental group were recruited and group meeting times determined, access to the conference room was provided for those specific meeting times only. The PI contacted the IT staff via email (4 times) or over phone (3 times).

II.A.4 Scheduling of intervention: Group meeting times were easy to set up as a majority of participants were retirees and were flexible with their meeting times. In one cohort group, initially meetings were held during the noon hour to allow for the participants that worked to connect during lunch hour. This meeting time had to be later changed to in the evening after 5 weeks. In the two other cohort groups meeting time was set for later in the evening after work.

II.A.5 Attendance: A total of 120 instances (15 per week x 8 weeks) of attendance for the 3 cohorts in the experimental group over the 8 weeks was possible. Seventy three percent of participants attended 5 or more group meetings and the overall attendance for the 3 cohort groups was 68%. Table 3 outlines the reasons for participants not attending the group meetings.

Table 3: Reasons for Experimental Group Participants not attending the Weekly Internet-Based Face-to-Face Group Meetings

Reason	Number of participants	Total instances
Busy with work or other commitments	3	7
Depressed and did not want to connect with others	2	8
Forgot about meeting time	2	2
Audio problem (able to hear others but others could not hear the participant)	2	2
Video (not able to connect to Vidyo conference room)	6	8
Had internet issues at home and got disconnected during meeting	2	2
Vacation	2	4
Sick	1	1
Not interested in attending group meetings	1	5

II.A.6 Unanticipated issues/problems: Only 1 of the 24 scheduled sessions was not delivered over Vidyo as University IT services with the University had changed the address link to the Vidyo conference room as part of their routine practice at the beginning of the semester and did not inform the PI. Participants in one cohort could not gain access that day.

Four participants had difficulty with connecting to the Vidyo conference room (audio or video problems) after they upgraded their computer to Windows 10. Participants were provided instructions over the phone to navigate the problem or they visited with the PI at the data collection site to resolve the problem. The PI had to visit one participants in his home as the upgrade created audio problems and the problem could not be resolved over the phone. Participants sometimes experienced a slight lag time in audio delivery but it was not significant to disrupt conversation.

Aim II.B Acceptability of using Vidyo: The survey done at the end of the study indicated that the group meetings were well received by the participants in the experimental group. The

questionnaire asked participants about difficulty with connecting to the meeting with Vidyo, difficulty in interacting with others, if they liked interacting in their group, if they liked being able to connect from their home and not have to travel to a site and if they would participate in a similar program again. All participants agreed that connecting for group meeting using Vidyo was not difficult as it was already set up for them. One participant, an 87 year old male, reported to using his spouse's help to connect to Vidyo during group meetings. Fourteen of the fifteen participants reported enjoying their interactions with other group members also admitted that their participation would have been lower if they had to travel to a specific location to attend these meetings. Apart from one participant who found the intervention interesting but did not want to connect with others, fourteen of the fifteen participants in the experimental group reported that they would participate in a similar program again.

Aim III.A.1 Devices used for syncing FCHR and issue with set-up and installation of software:

Table 4: Devices Used by the Participants for using FCHR

Device	Number of participants
Smartphone (Iphone/Android)	24
Laptop	2
Desktop	2
Ipad	1
Andriod tablet	1

Apart from one participant who used a desktop computer, the PI was able to set up the Fitbit application to the participants' smartphone/laptop/iPad/tablet during the baseline visit. Three participants needed 2 sessions of training to sync the FCHR with the app to download the data.

III.A.1 Difficulty and issues in use of FCHR: The majority of the participants did not find the use of the FCHR difficult but sometimes forgot to sync it with the application to download the data. Three participants visited the PI at the data collection site as they had troubles with syncing the FCHR after an upgrade to the Fitbit app software. The PI helped to reset the FCHR and the problem resolved after the reset.

The most common complaint that participants reported was that they would forget to turn their stopwatch "on" or "off" to record their exercise session. This meant that sometimes their exercise log in the paper exercise diaries would not match the exercise logs in the FCHR. Exercise logs, for those sessions in the FCHR, were missing or an exercise session was shorter/longer than the actual duration of exercise. The FCHR records physical activity information in general and for the sessions that participants forgot to manually log their exercise session, the PI was able to validate these exercise sessions mentioned in the diaries by tracking the overall number of steps taken during the day or by tracking an elevation in HR and comparing those numbers with exercise sessions from other days.

III.A.3 Ability to track exercise on a weekly basis by participants and PI: The majority of participants were able to use the Fitbit application 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 reminder to sync their FCHR. Over the course of 8 weeks, the PI send out about 15 text messages and made 2 phone calls. Participants were generally responsive to the text message and would sync their FCHR after receiving the text. Two participants, in spite of a couple of reminders, did not sync the FCHR for about 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 post intervention visit. Overall, by using the exercise logs, active minutes, step count and heart rate data the PI was able to track the participants' physical activity in general and specifically their exercise information over time on a weekly basis with the FCHR.

Aim III.B Acceptability of using the Fitbit Charge HR: Two participants did not wear the FCHR after about 3 weeks as they did not like wearing anything on their wrist. Both of these participants did not even wear wrist watches. One participant reported that the FCHR irritated her skin around week 7 and she did not wear it for the last week. One participant forgot to wear the FCHR for a week but started wearing it again after receiving the reminder text message.

Two participants, males aged 84 and 87 years respectively, reported using their spouses help to sync the FCHR. One participant used a desktop computer and the other used a smartphone.

The majority of the participants reported that along with the step count, the ability of the FCHR to provide them with HR data was an important part of the feedback they received. The ability to track their HR during exercise and other activities of daily living provided them with reassurance and helped them to regulate their intensity of workout.

At the end of the study, 11 participants reported that they had already bought a FCHR, 6 participants mentioned that they were going to buy, 8 participants reported that they would buy one if finances permitted and 5 participants were not interested in buying a FCHR. Eighty three percent of participants reported already having bought or planning to buy a FCHR for themselves by the end of the study.

Discussion and Conclusion

The delivery of an internet-based face-to-face group discussion/education intervention along with using a wrist worn activity monitor to track exercise and physical activity over time in patients with HF is feasible. In this study, a software-based video conferencing application called Vidyo to connect participants from their homes for a group discussion/education session was used. The software did not cost the participants any money to use as it was provided free of charge by the University's IT department. Free web-based video calling programs such as Skype have been used to deliver video-based web interventions (Alley et al., 2016). Other services such as Skype for business ($5.00/month) and Adobe Connect ($50.00/month) can also be used to deliver such an intervention. The overall attendance over Vidyo was 68%. As such an intervention has not been tested before, a comparative report of attendance to such an intervention could not be made.

Participants in the experimental group used both wireless and Wi-Fi connection to connect to the group meetings using Vidyo. Participants were provided help with setting up the Vidyo software during their baseline visit and six participants that lived in rural areas were able to connect from their homes to engage in these weekly group meetings. Minimal technical support was required from the IT staff. Access to the Vidyo conference room at all times during the recruitment phase was critical for training and recruitment. Most participants were retirees and scheduling group meeting times was easily done. The overall attendance to these meetings over the 8 weeks was 68% with 73.3% of participants attending 5 or more sessions. Personal issues such as being on vacation or busy at work, being sick or depressed and some unforeseen issues with connection to Vidyo with a Windows 10 upgrade were major reasons why participants did not attend the group meetings. The majority of the participants in the

experimental group mentioned that their attendance would have been lower if they had to drive to a particular location to attend the weekly group meetings. In general, the participants felt that the Vidyo software was easy to use after it was set up and that they would participate in such group meetings again.

The FCHR was easy to install and manage and apart from three participants that 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 application 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 in the FCHR to record their exercise sessions. In general, the participants found it easy to operate the FCHR and sync the data and this allowed the PI to track the exercise logs remotely. The FCHR also provided flexibility with validating the exercise sessions with step count and HR data when participants forgot to record their exercise session. The majority of the participants mentioned that being HF patients they always have concerns with their ability to exercise and the ability to track their HR during exercise relieved them of fears concerning exercise at an intensity level that was determined safe for them. 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.

This intervention used a novel technology that had not been tested in a population of community dwelling patients with heart failure. However, we found that with guidance and training these participants were able to navigate their way in using an instrument and a software that were previously unfamiliar to them. Also, the sample consisted of 7 participants who lived in rural areas and the acceptance and success of such an intervention provides the opportunity to

deliver interventions to populations living in rural areas who have more barriers in access to health care.

From this study, it is concluded that the use of the internet to provide a web-based face-to-face discussion/education program in a group setting to patients with heart failure and the use of a wrist worn activity monitor to track exercise in the community setting is acceptable and feasible.

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MOVE-HF: An Internet-Based Pilot Study to Improve Adherence to Exercise in Patients with Heart Failure

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(to be submitted to the Journal of Cardiovascular Nursing)

Abstract

Background Although the use of internet-based exercise interventions to improve physical activity has become popular and useful, such approaches to improve exercise adherence in patients with heart failure (HF) is lacking. It is also unknown whether the delivery of objective feedback on physical activity can impact exercise adherence.

Purpose The purpose of the Move on Virtual Engagement (MOVE-HF) study was to compare an experimental group and comparison group on change in i) adherence to recommended exercise guidelines from baseline to 8 weeks; ii) intention to adhere to those guidelines; and iii) functional status, self-efficacy for exercise, and perceived social isolation at baseline and 8 weeks.

Methods Thirty HF patients, aged 64.7±11.5 years, were randomly assigned to an experimental or comparison group. Participants were stable HF patients belonging to NYHA Class I-III and were required to have an iPad/cell phone/laptop/desktop with internet connectivity. Participants in both groups were provided with a Fitbit Charge HR, assistance in set-up and training, and were asked to wear the Fitbit all day from awakening until going to bed at night. All participants were provided with a handout on self-care in HF, an exercise routine and asked to record their exercise sessions using the Fitbit and exercise diaries.

The 15 participants in the experimental group were subdivided into 3 cohorts of 5 participants each. These subjects were provided with Vidyo software, assistance in set-up and training. Each cohort met once a week, for 8 weeks, for a 45 min face-to-face online group discussion/education session.

Data Analysis: Repeated measure ANOVA was done to compare group differences in adherence, intention to adhere and functional status across time. A non-parametric Mann-Whitney U test with change score was done to compare changes in group scores for self-efficacy for exercise and perceived social isolation at baseline and at 8 weeks.

Results Overall Vidyo session attendance was 68% with 73% of participants attending 5 or more group meeting sessions. Adherence to exercise was 58.8% in the experimental group and 57.3% in the comparison group (NS). Intention to adhere, functional status, self-efficacy and perceived social isolation were not significantly different between the groups. The experimental group participants anecdotally reported perceptions of receiving social support through the face-to-face group meetings but due to a small sample size and lack of adequate power, no significant impact on exercise adherence was observed.

Conclusion Feedback on exercise and physical activity can play an important role in adherence to exercise in patients with HF. HF patients may have unique barriers to exercise adherence. Interventions using the internet appear feasible to use in this patient group.

Introduction

Congestive Heart Failure (HF) has the highest re-hospitalization rates among all chronic diseases (Elixhauser & Steiner, 2013). There are many physiological benefits of exercise and its impact on reducing mortality and hospitalization rates in patients with heart failure has also been established (O'Connor et al., 2009). However, adherence to exercise in this population has been found to be low (Marti et al., 2013; O'Connor et al., 2009). A review of the literature shows that the primary aim, in many of the studies that have reported on adherence to exercise in patients with HF, was to test the physiological and psychological effects of exercise, with adherence being reported as participation or attendance to the exercise program (Deka, Pozehl, Williams, & Yates, 2016). Strategies and interventions to improve adherence to exercise have not been studied (Deka et al., 2016). Additionally, reports of exercise adherence in HF patients have been primarily based on subjective data from exercise diaries, but methods to validate these exercise diaries with objective exercise data especially in the community setting have been lacking (Deka et al., 2016).

Adhering to an exercise program is often difficult to achieve as it requires one to make both behavioral and lifestyle changes. It has been suggested that theory-based interventions and strategies may be effective in making such changes (Deka et al., 2016). Studies focused on provision of social support have demonstrated improvements in adherence to exercise (Deka et al., 2016); however, the use of the internet to provide face-to-face peer support, as a method to improve adherence to exercise in this population is lacking (Deka et al., 2016). Perceived social isolation can impact health-related behavior including participation in physical activity (Hawkley, Thisted, & Cacioppo, 2009; Hawkley & Cacioppo, 2010). Being socially connected vs socially isolated can impact behavior in ways of information sharing and applied pressure

from others to perform the behavior (Cacioppo & Hawkley, 2003). Although it has been reported that patients with HF experience social isolation (Jeon, Kraus, Jowsey, & Glasgow, 2010), the use and effectiveness of the internet to socially connect HF patients and to test its impact on exercise adherence have not been investigated.

Exercise is a subset of physical activity (Caspersen, Powell, & Christenson, 1985). The impact of providing regular objective feedback on physical activity (including exercise performance) with the use of modern wrist worn activity monitors such as the Fitbit Charge HR (FCHR, Fitbit, San Francisco, USA) on adherence in HF patients has not been investigated. Internet-based interventions that are theory based and offer multiple behavior change techniques tend to have a larger effect than interventions that do not incorporate such strategies (Webb, Joseph, Yardley, & Michie, 2010). The **Move on Virtual Engagement (MOVE-HF)** is a theory-based intervention to improve adherence to exercise in patients with HF. The study incorporates the use of the internet as a strategy to provide group peer support and feedback on physical activity to improve exercise adherence. For this study, the internet-based synchronous face-to-face group discussion/education was provided using Vidyo software. Feedback on daily activity was provided through use of the FCHR. The feasibility of providing such an intervention in this population has been described previously (Deka, Pozehl, Yates, & Khazanchi, 2016).

The purpose of this randomized controlled pilot study was to investigate if adherence to exercise can be improved through an internet-based face-to-face group support intervention in patients with HF. The study compared the experimental and comparison groups on:

1) Adherence to recommended exercise guidelines (150 minutes/week of moderate intensity exercise) with changes compared weekly across 8 weeks.

2) Intention to adhere to recommended exercise guidelines with changes compared weekly across 8 weeks.
3) Secondary outcomes, namely: a) functional status, b) self-efficacy for exercise, and c) perceived social isolation across time (at baseline and post-8 weeks).

Methods

Design

The MOVE-HF study (Figure 1) is an 8 week experimental, randomized controlled two group (experimental and comparison) repeated measures design to pilot test the impact of the MOVE-HF intervention on improving adherence to the recommended exercise guidelines of 150 min of moderate intensity exercise per week.

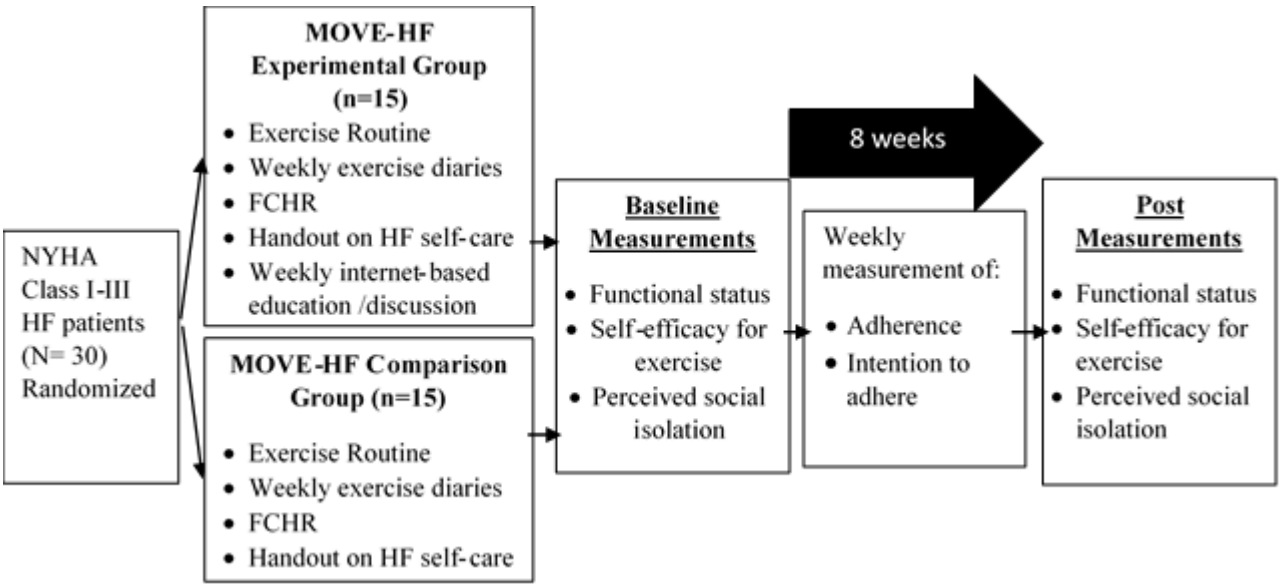

Fig. 1: MOVE-HF study design. NYHA: New York Heart Association Functional Class; MOVE-HF: Move on Virtual Engagement-Heart Failure; FCHR: Fitbit Charge HR; HF: Heart Failure

Setting

Patients were recruited from two cardiology practices in the Midwest. The following consort diagram shows recruitment and drop out for the study.

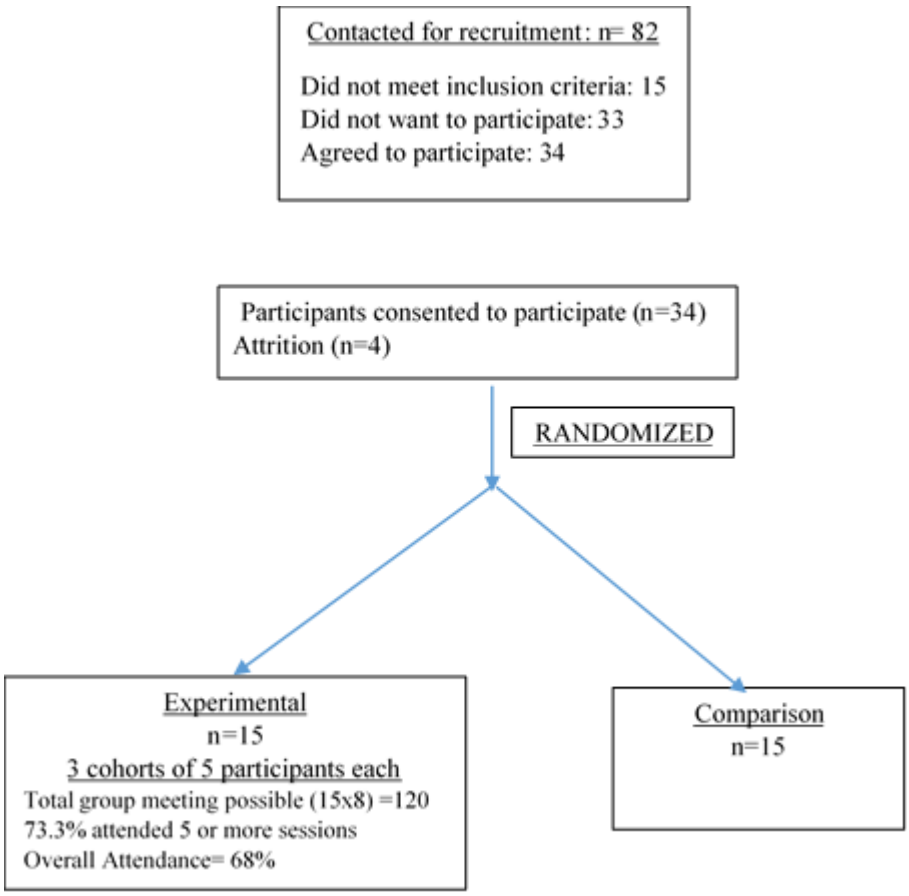

Fig 2: Consort diagram showing details of recruitment, attrition and randomization

Participants

Inclusion criteria. Participants were screened to meet the following criteria for inclusion in the study: a) medical diagnosis of HF (New York Heart Association class I to III) with preserved or reduced ejection fraction with no changes in medical history in the past 30 days; b) taking standard pharmacologic treatment for heart failure (beta-blockers, ACE inhibitor, and diuretics).

Participants were required to be on stable dose of beta-blockers for minimum of 30 days so that the heart rate response on the 6 min-walk-test would reflect current state of beta blockade; c) able to hear, speak and read English; d) have access to a telephone and a valid e-mail address (PI provided help to set up email account if participant did not have one but was willing to open an account); e) have an electronic device (desktop/laptop/iPad/tablet/smartphone) with internet connectivity at home (participants who did not have a web-camera with microphone were provided with one); f) cardiologist clearance to participate in moderate intensity exercise; and g) intact cognitive functioning (determined during informed consent with the participant being able to describe what participation in the study would involve).

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 heart failure and any of the following medical conditions: unstable angina pectoris, end stage renal disease, myocardial infarction, coronary artery bypass surgery, or biventricular pacemaker less than 6 weeks prior. Similar inclusion and exclusion criteria have been used in exercise studies involving HF patients (Pozehl et al., 2014).

Intervention

The MOVE-HF intervention was based on Bandura's Social Cognitive Theory (SCT) and Ajzen's Theory of Planned Behavior (TPB), the most widely used theories in internet-based studies for behavioral change (Webb et al., 2010). The TPB states that internal factors such as intention, which can be improved using the self-efficacy determinant of SCT (Bandura, 1977; Dzewaltowski, Noble, & Shaw, 1990; Hagger, Chatzisarantis, & Biddle, 2002), can influence performance of the behavior (Ajzen, 1991). The theory-based intervention used in this study

integrated the TPB and the SCT to improve self-efficacy for exercise and intention to adhere to exercise and reduce perceived social isolation through group interaction and thus lead to adherence to exercise (Cacioppo & Hawkley, 2003). The components of self-efficacy that were operationalized in the study are performance accomplishment, verbal persuasion/feedback and physiological/emotional arousal.

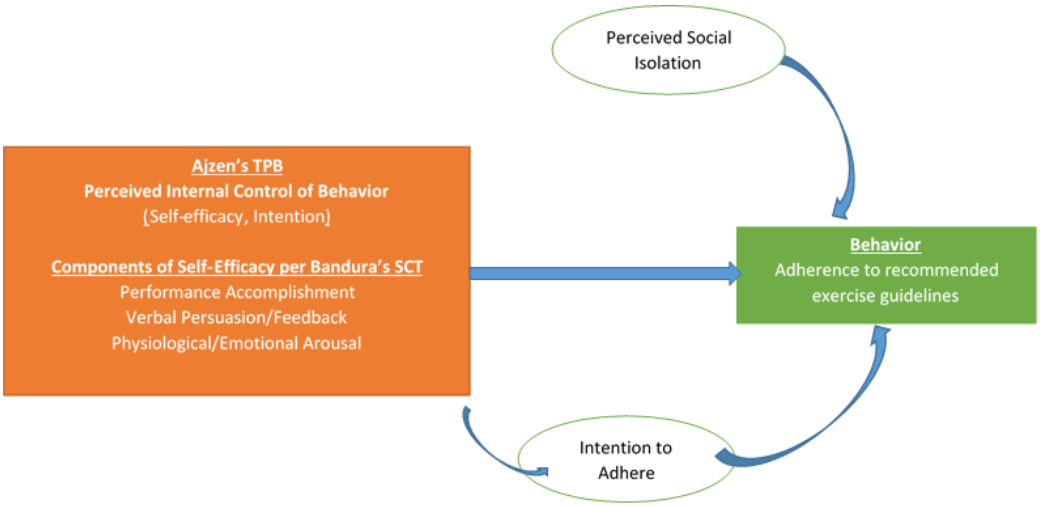

Figure 3: Move on Virtual Engagement-Heart Failure theoretical framework. TPB: Theory of Planned Behavior; SCT: Social Cognitive Theory

Move-HF intervention

The MOVE-HF intervention that was provided to both the experimental and comparison group included:

Exercise routine. Participants in both the experimental and comparison groups were encouraged to incorporate regular walking into their day-to-day life to meet the recommended guidelines of 150 minutes/week of moderate intensity aerobic exercise (American College of Sports Medicine, 2013; Heart Failure Society of America et al., 2010; Piepoli et al., 2011). They were instructed to self-limit their exercise according to their individual responses and break

down the 30 min/day in a combination of three 10 min sessions or less if needed. Moderate intensity exercise has been found to be safe in patients with HF (O'Connor et al., 2009) and in this study exercise intensity was guided by rating of perceived exertion (RPE) of 10-14 using the Borg (6-20) scale (Borg, 1970). Participants were taught how to use of the Borg scale and the appropriate RPE responses for moderate intensity exercise. Borg scale RPE of 10-14 for moderate intensity has been recommended in this population (Piepoli et al., 2011) and used in other studies in HF patients to quantify moderate intensity of exercise (Duncan, Pozehl, Norman, & Hertzog, 2011; R. A. Gary, Cress, Higgins, Smith, & Dunbar, 2012; Mandic et al., 2009; Moholdt, Bekken Vold, Grimsmo, Slordahl, & Wisloff, 2012). To avoid injuries associated with exercise, participants were encouraged to start at a lower end of the RPE scale and slowly increase the intensity and duration of their walk.

It has been recommended that HF patients should exercise under supervision for safety reasons (Piepoli et al., 2011). This being a community-based exercise program, direct supervision was not possible. However, specific methods to ensure safety were instituted. Average HR from the 6MWT was provided to the participants. Participants were cautioned to not exercise at an intensity that elevated their HR above this number. Keeping their HR at or below this number assured that participants exercised at an intensity which was determined to be safe for them. After completion of baseline assessment, all participants participated in a 10 min long walking session with the PI during which they practiced moderating intensity using the RPE scale and monitoring their HR with the FCHR.

Fitbit Charge HR (FCHR). All participants were provided with a FCHR, a wrist worn activity monitor that tracks and records step count, heart rate, energy expenditure, distance travelled, and flight of stairs climbed in real time. Exercise logs, with details of date, time, HR,

step count and energy expenditure, can also be manually created by the user by starting and stopping a stopwatch that is built into the FCHR. Participants were instructed to create these logs for each exercise session. Using a Fitbit account (e-mail and password created for participants), data were synced from the FCHR physical memory to the Fitbit's server by installing the Fitbit application/connect software to an electronic device. Information can be stored in the physical memory for 4 weeks and syncing frees up the memory to store new information. Once synced, information on exercise logs and physical activity can be tracked on Fitbit's website. This information was then tracked by the PI. Participants in both groups were asked to record their exercise sessions using the FCHR.

Exercise diaries. All participants were provided with paper exercise diaries to record their exercise sessions with duration and RPE, on a daily basis for 8 weeks. Participants were also asked to note the barriers they faced and the strategies they used to overcome those barriers.

Educational handout on HF self-care. All participants were provided with a hard copy of the educational handout containing information on 8 topics on self-care from Heart Failure Society of America (HFSA). These 8 modules were: understanding HF, exercise and activity with HF, how to follow a low sodium diet, heart failure medication, dealing with HF symptoms, depression and anxiety with HF, managing lifestyle changes along with other chronic conditions and heart rhythm problems. A link to the website was also provided and participants were encouraged to visit the website for more information on these topics *(http://www.hfsa.org/patient/education-modules/).*

The MOVE-HF intervention that was provided only to the experimental group included:

Social support through Vidyo. The 15 participants in the experimental group were further sub-divided into 3 cohort groups with 5 members each for purposes of the weekly face-

to-face education/discussion meeting over the internet. Participants in the experimental group connected with other members in their cohort group weekly for a 45 min long face-to-face discussion/education session that was moderated by the primary investigator (PI). Vidyo is a software-based video conferencing application that is used to connect participants in distant locations for a face-to-face group audio/video conference. In community based palliative care service, delivery of video services using this software has been found to be effective even with mobile data services (Taylor et al., 2015). Each week, education was provided on one topic of self-care from the handout provided to the participants. Participants were encouraged to interact with other group members and discussed their exercise performance during the week. The PI, who moderated these education/discussion sessions, provided encouragement to follow the exercise routine and suggestions on overcoming exercise barriers.

Measures

Adherence to exercise. Weekly adherence was calculated using the formula {exercise adherence = [(actual # of min/wk) / (150 min/wk target goal) x 100] (Dunbar-Jacob et al., 2000)}. Based on the mean adherence achieved over the 8 weeks, participants were categorized as adherent (>80%), partially adherent (20%-80%) and non-adherent (<20%) (Conraads et al., 2012). Primary adherence score was calculated from **s**ubjective reporting of exercise minutes on self-reported paper exercise diaries. It is understood that self-reported physical activity data can be either over or under estimated compared to measured levels of physical activity (Prince et al., 2008; Shephard, 2003). To account for such discrepancies, during the post-8 week visit, the PI examined the diaries for completeness and reviewed with the subject any data on diaries that were vaguely or not clearly reported. Additionally, self-reported data from the exercise diaries

was validated with data from the FCHR. Validation of data was done by one of the three methods:

i) From manually recorded exercise session logs in the FCHR.

ii) If participants forgot to manually record their exercise session, then the time mentioned in the exercise diaries was compared with the active minutes provided by the FCHR. The FCHR can track active minutes if the user is active for a minimum of 10 minutes and walked at a brisk pace.

iii) Participants were instructed that they could have exercise sessions of less than 10 min if they found it hard to walk for a10 min bout and to also use the RPE scale as a guide for intensity. An RPE of 10-11 may not represent a brisk walking pace and the FCHR may not detect active minutes. If validation of a particular session was not possible with the first two methods then the participants overall step count for that day was compared with validated data from a day when the participant recorded walking for the same duration. If the overall steps for those two days were comparable, then credit was given to the participant for the time mentioned in the exercise diary. Also, Fitbit allows for HR to be graphed across time in 24 hour periods. For participants who used a walker or a cane and for whom step count was not reliable, validity was established by observing an elevation in heart rate which was similar to average HR during the 6MWT.

Intention to adhere to exercise: Participants were asked to report their intention to adhere to the recommended exercise guidelines on a scale of 1 to 5 at the beginning of the week. This single item question was a part of the paper exercise diary and completed at the beginning of

each week. A score of 1 indicated weak intentions and 5 indicated very strong intentions to adhere.

Attendance to group meetings. Attendance records were maintained by the primary investigator who moderated the group meetings for the experimental group. Overall attendance in percentage was calculated out of the possible 120 group meetings over the 8 weeks.

Survey questionnaire. Participants completed an investigator-developed survey at the end of the study. The scale had 4 questions in a "Likert scale" and 6 questions "Yes/No" format and 1 open-ended question. The survey captured: i) participants perceptions of participating in the MOVE-HF study; ii) their experience of using the Vidyo software to connect with other participants; and iii) their experience on the use of the FCHR.

Six-min-walk test (6MWT). The 6MWT was used to measure functional status. The test has been found to be valid and reliable for measuring function in cardiac patients in general (Cronbach $\alpha = 0.97$; $r = 0.687$; $p<0.001$) (Hamilton & Haennel, 2000) and valid for patients with HF ($r=0.579$; $p=0.001$) (Guyatt et al., 1985). Participants were asked to walk laps in a 30m long hallway and cover as many laps as they could in 6 min. The total distance walked in meters in 6 minutes was recorded. Except for performing two tests at each time point, all other recommendations from the American Thoracic Society were followed (ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories, 2002)

Bandura's exercise self-efficacy scale (BESES). The BESES contains 18 potential barriers to exercise and participants are required to indicate their confidence level, on a scale of 0-100%, for exercising 30 min a day for 5 or more days a week when facing those barriers. The tool has documented reliability with a Cronbach $\alpha=0.95$ and validity with change in 6MWT distance

score (r=0.28; p=0.035) (Everett, Salamonson, & Davidson, 2009). Cronbach α for this study was 0.96. A higher score on the scale indicates a high level of confidence that one will be able to exercise 5 or more days a week even when faced with those barriers.

Friendship scale. The Friendship scale was used to measure perceived social isolation. The tool contains 6 questions in Likert scale format and has been found to be reliable (Cronbach α=0.83) and valid in measuring perceived social isolation when compared with the Word Health Organization Quality of Life social domain measure (validity: r=0.44, p<.001) (Hawthorne, 2006). Cronbach α for this study was 0.76. A score of 0-15 indicates "friendship low acuity"; 16-18 indicates "friendship moderate acuity" and 18-24 indicates "friendship high acuity". A lower score on the scale indicates a higher perceived level of social isolation.

Procedures

Approval from the institutional IRB at the University of Nebraska Medical Center was obtained. Informed consents were signed and cardiologist approval was obtained before enrollment in the study. At baseline, all participants were trained on using the FCHR, performed the 6MWT, and responded to two questionnaires (BESES and the Friendship scale). All participants were also provided the handout containing 8 educational modules on self-care in HF from HFSA. Participants were asked to follow the exercise routine for the next 8 weeks. Participants in the experimental group were trained on using the Vidyo software and met once a week for 8 weeks with their cohort for a face-to-face group discussion/education session. At the end of 8 weeks, all participants performed the 6MWT, responded to the two questionnaires, and completed the survey describing their experience of participating in the study. The procedure used to set-up the Vidyo software and the FCHR application on participants' electronic devices and training

participants to use these software has been described in details in a separate manuscript (Deka. Pozehl, Yates & Khazanchi, 2016).

Data Analysis

Aim 1. Adherence was measured across 8 weeks using repeated measures analysis of variance (ANOVA), with week as the measure of time. In total there were 8 repeated measures. Effect size was calculated from the between group differences. Self-reported data from the exercise diaries was validated by comparing with data from the FCHR for the adherence measure.

Aim 2. Intention to adhere was measured across 8 weeks using repeated measures ANOVA, with week as the measure of time.

Aim 3a. Repeated measures ANOVA with 2 repeated measures was done to measure differences in functional status (6MWT scores) across time (baseline and post-8 weeks).

Aim 3b&c. A non-parametric Mann-Whitney U test with change scores (post – baseline) was done to compare experimental and comparison groups for differences in self-efficacy for exercise and perceived social isolation across time (baseline and post-8 weeks). This test was selected for the two measures because of the small sample size and categorical nature of the data. Analysis was done using IBM SPSS 23. The level of significance has been set at $\alpha=0.05$.

Results

Subjects in both groups were predominantly Caucasian, married, retired and living in urban areas.

Table 1: Demographic and Clinical Characteristics of Participants by Group. Data are number of subjects unless otherwise indicated.

	Experimental (n=15)	Comparison (n=15)
Age	61.7±11.3 yrs	67.8±11.4
Gender (M/F)	10/5	9/6
Race (Caucasian)	100%	100%
Marital Status:		
Married	13	9
Single or Divorced	2	6
Working/Retired or Did not work	6/9	5/10
Place of dwelling		
Rural	6	1
Urban	9	11
NYHA		
Class I	0	3
Class II	10	7
Class III	5	5
Ejection Fraction	41±12.6%	44±10.8%
HFpEF	4	3
HFrEF	11	12
Etiology of HF		
Ischemic	1	3
Non-ischemic	14	12
Medical History		
Hypertension	9	11
Hypercholesterolemia	13	9
Diabetes Type II	7	3
COPD	3	2
Renal Disease	2	5
Arthritis	0	2

M=Male; F=Female; NYHA: New York Heart Association Functional Class; HFpEF: Heart failure with preserved ejection fraction; HFrEF: Heart failure with reduced ejection fraction; COPD: Chronic obstructive pulmonary disease

No significant difference ($p<0.05$) in demographic and clinical characteristics was found between the experimental and the comparison group at baseline.

Aim 1: From the data reported in exercise diaries which was validated by comparing with the FCHR, repeated measures ANOVA showed no significant difference [F (df =7, 196) = 0.361; p=0.625] in the interaction effect of time by group scores. No significant differences were observed for the main effects of group and time. A small effect size of 0.013 was found. Table 2 provides details of mean adherence scores across the 8 weeks between the two groups which was 58.8% for the experimental group and 57.2% for the comparison group.

Table 2: Mean Duration of Exercise in Min/Week across the 8 weeks

	Group	N	Mean	SD	Std. Error Mean	F value (df)	p-value	Effect Size (partial η^2)
Adherence	Experimental	15	88.2	81.9	21.2			
	Comparison	15	85.9	44.2	11.4			
	Group*Time					0.361(7, 196)	0.924	0.013
	Time					0.394(7, 196)	0.905	0.014
	Group					0.009(1, 28)	0.925	0.000

Figure 4 provides a schemetic diagram of how adherence changed over the 8 weeks in the two groups.

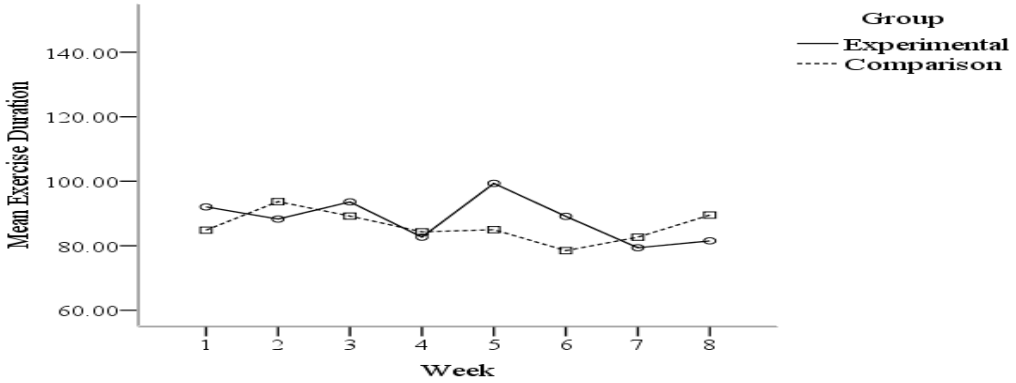

Figure 4: Mean duration of exercise (min/week) across the 8 weeks between the two groups

Aim 2: Repeated measures ANOVA showed no significant difference [F (df =7, 196) = 0.319; p=0.732] in the interaction effect of time by group scores. No significant differences were also observed for the main effects of group and time. Table 3 outlines the mean intention scores across the 8 weeks. Figure 4 provides a graphical representation of how intention scores between the two groups changed over the 8 weeks. A significant correlation (r= .488; p=.006) was found between intention to adhere to the recommended exercise guidelines and actual adherence scores for all participants. No significant differences were found for the main effects of group and time.

Table 3: Mean Intention Scores for the Two Groups

	Group	N	Mean	SD	Std. Error Mean	F value (df)	p-value	Effect size (partial η^2)
intention	Experimental	15	4.17	1.03	.27			
	Comparison	15	4.12	0.97	.25			
	Group*Time					0.319(7, 196)	0.732	0.007
	Time					0.210(7, 196)	0.823	0.11
	Group					0.019(1, 28)	0.892	0.001

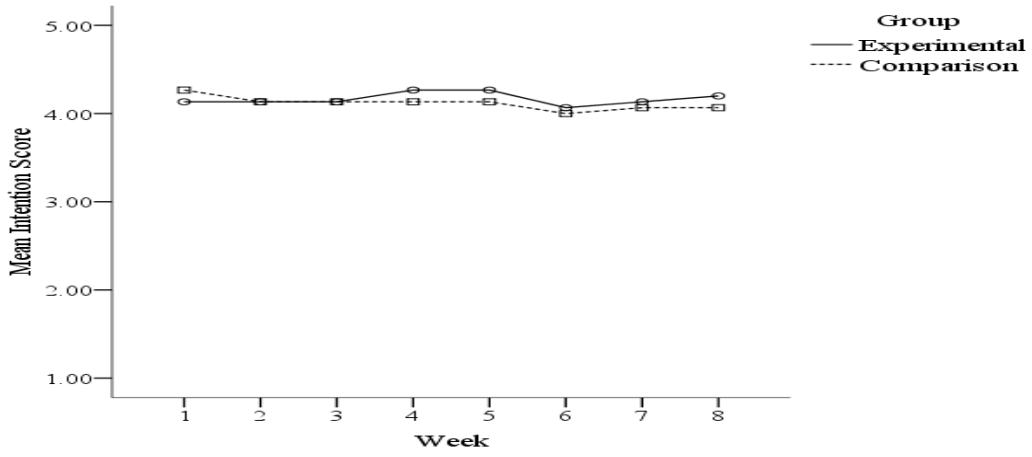

Figure 4: Intention to adhere to recommended exercise between the groups across the 8 weeks

Aim 3a: Two participants did not perform the 6MWT at post-8 week assessment as they were not feeling well and did not want to exert themselves. Their data were not included in the analysis leaving the comparison group with a sample size of 13 for the post-8 week analysis. Repeated measures ANOVA showed no significant difference [F (1, 28) = 0.908; p=0.349] in the interaction effect of time by group scores as indicated in table 4. No significant differences were found for the main effects of group and time.

Table 4: Results of the 6MWT Score (meters) and RPE scores at Baseline and Post-8 weeks

	Experimental			Comparison			
	N	Mean	RPE	N	Mean	RPE	F value (df)	p-value
Aim 3a: Functional status								
Baseline	15	399±102	16±2	15	356±142	16±2		
Post-8 weeks	15	399±96	13±2	13	368±131	13±2		
Group*Time							0.908 (1, 28)	0.349
Group							0.333 (1, 28)	0.569
Time							0.724 (1, 28)	0.403

Aim 3b and 3c: No significant difference between groups was observed in the Mann-Whitney U test with change scores was seen between the groups on their exercise self-efficacy ($Z = -0.332$; p=0.740) and social isolation ($Z = -0.481$; p=0.631) as outlined in Table 5.

Table 5: Comparison of Exercise Self-efficacy and Social Isolation Scores for the Two Groups

	N	Median		*Z*	p-value
Aim 3b: Exercise Self-Efficacy		Baseline	Post-8 weeks		
Experimental group	15	54%	50%		
Comparison group	15	62%	59%		
Mann-Whitney	30			-0.332	0.740
Aim 3c: Social Isolation					
Experimental group	15	20	22		
Comparison group	15	20	21		
Mann-Whitney	30			-0.481	0.631

Discussion

This study investigated the use of a theory based intervention to improve adherence to exercise in patients with HF by providing feedback on physical activity and an internet-based face-to-face group discussion/education meeting. In interpreting the results of the study based on the guideline recommendations of 150min/week of exercise (Piepoli et al., 2011), the study found that participants in both the experimental (58.8%) and comparison (57.2%) group to be partially adherent (Conraads et al., 2012). The average exercise time was 88 min (experimental group) and 86 min/week (comparison group), respectively, and no significant difference in adherence to recommended exercise was found between the groups. However, studies done before the guidelines were published, that prescribed exercise programs of 30 min/day, 3 days/week of low-moderate intensity exercise (total 90 min of moderate intensity exercise per week) have reported higher level of adherence than found in this study (Chien, Lee, Wu, & Wu, 2011; Duncan et al., 2011; R. Gary, 2006; Hambrecht et al., 1995; McKelvie et al., 2002; Witham et al., 2005). It may be that, for patients with HF, barriers to exercising 5 days/ weeks can be very different and from exercising 3 days/week making adherence harder to achieve.

Seventeen participants during enrollment indicated that they had been exposed to some form of exercise previously but currently were leading very sedentary lives. They reported that they were active in performing their activities of daily living but were not participating in any form of exercise. Two participants in the experimental group and one participant in the comparison group mentioned that they presently exercised about 1-2 days a week but were not consistent.

The experimental group participated in an internet-based face-to-face group discussion/education meeting once a week for 8 weeks and the overall attendance to these meetings was 68% with 73.3% of participants attending 5 or more sessions of the 8 possible sessions. Health, use of diuretics, personal and professional issues, and weather were identified as barriers to adherence to exercise by participants. It may be that the dose of once a week for the group meeting was not strong enough and the experimental group participants, most of whom were leading very sedentary lives prior to participation in the study, needed from more group meetings sessions to facilitate full adherence to the recommended exercise guidelines. Thirteen of the fifteen participants in this group mentioned that they had not previously interacted with anyone else with a diagnosis of HF and found it interesting to get to know other people with HF and being able to interact with them. Learning about the unique barriers to exercise that other participants in the group faced and being able to learn more about their own disease condition during the discussion/educational sessions over Vidyo are aspects of the MOVE-HF intervention that participants reported as enjoyable. Five of the fifteen participants also indicated that the weekly group meetings made them "accountable" towards the other members of the group. During the 6^{th} week of the intervention, two participants in the experimental group exchanged telephone numbers during group meeting sessions and connected with each other to walk together at a local mall. These anecdotal references indicate that participants did perceive

receiving some social support because of the intervention although the sample size was too small to detect any significant change in behavior.

Both groups were provided with a FCHR for objective feedback on physical activity and an educational handout on self-care in HF, which included a module on exercise in HF. The Transtheoretical model calls this aspect of providing feedback and education as "awareness raising," which leads to contemplation about making behavioral change (Prochaska & DiClemente, 1982). It may be that the feedback on activity levels and exercise performance that participants in the comparison group received was significant in changing their exercise behavior, which lead to exercise adherence levels comparable to the experimental group. The majority of participants indicated in the survey that the feedback on step count and heart rate received from the FCHR, made them more conscious of their activity levels and accountable to themselves, and was instrumental in helping them become more active. While some participants mentioned that the target of walking 30 min/day is what motivated them, others mentioned using the number of steps per day as motivation to exercise. Twenty seven of the 30 participants indicated that, even on days that they did not exercise, the FCHR provided them with a constant reminder of their activity levels and prompted them to follow the exercise routine. It is noteworthy that nearly 83% of participants had already bought a FCHR or a similar activity monitor or were planning to buy one by the time they completed the study.

Due to the small sample size and lack of adequate power, the internet-based group social support did not result in significantly different exercise adherence scores between the groups. Objective feedback on activity levels did help participants to become more active than at baseline and partially adherent to exercise. It may be that HF patients may require interventions

that are more personalized to overcome barriers that are unique to the participant to become fully adherent to the recommended exercise guidelines.

Aim 2 looked at change in intention to adhere to exercise scores and no significant difference in intention to adhere to exercise was found between the two groups. A significant positive correlation existed between strength of intention and exercise adherence validating the assertions made by the Theory of Planned Behavior. However, although the mean intention score was high, participants were not able to achieve the desired outcome behavior of meeting 150 min of exercise/week. It may be that the dose of social support and feedback that was provided was not adequate to help participants become fully adherent to the recommended guidelines exercise. It may also be that there are factors that prevent HF patients from adhering to exercise in spite of having strong intentions exercise. Interestingly, one participant reported that because of being acutely depressed, in spite of having very strong intentions, he was not able to exercise at all. A significant relationship with an odds ratio of 3.0 has been found between depression and lack of adherence to medical treatment in patients with angina, end stage renal disease, cancer, renal transplant and rheumatoid arthritis (DiMatteo, Lepper, & Croghan, 2000). The HF population may be similarly affected by depression as it is a prevalent co-morbidity in patients with HF (Havranek, Ware, & Lowes, 1999; Vaccarino, Kasl, Abramson, & Krumholz, 2001; Williams et al., 2002). Depression has been identified as a barrier to adherence to exercise in this population (Conraads et al., 2012). Functional decline in HF patients suffering from depression has been observed (Vaccarino et al., 2001) and HF patients suffering from depression may require additional support to become adherent to exercise. In this study, two participants in the experimental group indicated on their exercise diaries that they did not exercise because of being depressed.

Without adequate power, the effect of social support in the form of an internet-based face-to-face group discussion/education on intention to adhere to recommended exercise guidelines between the groups could not be determined. A longer intervention with strategies to help transform strong intentions into behavioral actions may be needed.

Functional status (Aim 3a) as determined by the 6MWT was not significantly different between the groups. The mean 6MWT score remained almost the same in both groups at the 8 weeks, end of study assessment. However, the 6MWT RPE scores post-completion decreased significantly (p=.0001), indicating that participants were able to walk a similar distance with less perceived exertion. A lower 6MWT RPE at post-completion at 8 weeks compared to baseline also indicates that the participants were less fatigued than they were at baseline, while walking almost the same distance. The exercise routine consisted of a moderate intensity workout with an RPE of 10-14. The majority of participants indicated that their RPE during the exercise was between 10 and 13. Although the purpose of this study was to improve adherence to the exercise program and was not focused on improvement in exercise capacity, since perceived exertion levels improved, it may be that a longer intervention with a larger sample size might have led to measurable functional improvement. Also, performing the 6MWT on two separate days at baseline and at 8 weeks may have also helped to negate any error that occurred in conducting the test.

Aim 3b looked at change in exercise self-efficacy scores due to the intervention. Friedman's test showed no significant difference in pre and post scores in self-efficacy for exercise within the groups at baseline and at 8 weeks. It is possible that the educational material and exercise monitoring devices that were provided to both groups were sufficient to maintain the confidence or self-efficacy for exercise. It may also be that participants overestimated their

confidence scores at baseline. However, these claims are made cautiously due to the small sample size and lack of adequate power.

Similarly, no difference was seen in the perceived social isolation scores between groups (Aim 3c). This lack of difference or effect on this measure may be related to the low levels of perceived social isolation that were found in the sample at baseline. This study included HF patients with NYHA class I-III and these participants may be experiencing less social isolation that patients with NYHA Class IV HF. From the anecdotal references from participants, as discussed earlier, it seems that participants did perceive some aspect of social support from the intervention. Due to lack of power with the small sample size, it is unclear from these study findings whether the intervention was actually not effective in improving social isolation or whether the measure of social isolation used, did not accurately measure social isolation in these HF patients.

Limitations

The small sample size is a definite limitation of the study. A sample size of 30 did not provide sufficient power to detect differences between the groups. Effect size calculated from these data shows that the intervention, using an internet-based face-to-face group discussion/education resulted in a small effect on adherence. It is noteworthy, that the comparison group was also provided with a FCHR and educational material. Had the comparison group not received this information the effect size may have been larger. Activity levels of participants in both groups were determined from subjective response to inclusion criteria during screening; objective measurement of physical activity levels at baseline was not done. As such, it is unknown whether there was any difference in activity levels between the two groups at baseline or if there may have been a significant change in minutes of moderate intensity exercise

from baseline. The length of the intervention was only 8 weeks; thus study findings may have been impacted with an extended period of intervention. No post-intervention follow up was performed in this study, so it is not known how the intervention may have affected long term adherence after completion of the intervention. The FCHR was not reliable in capturing active minutes for some participants that walked at a slower pace and exercised in bouts of less than 10 min. This resulted because the algorithms used to detect active minutes and exercise intensity using heart rate are applicable for healthier people and not for the HF populations, who may have significantly slower walking pace and are on medications that may affect HR response to exercise. However, for the purpose of this study, the FCHR provided other forms of data, such as daily step count, that were helpful in validating self-reported data on exercise diaries.

Conclusion

This pilot study was designed to improve exercise adherence in patients with HF and is the first to test whether social support provided through an internet-based synchronous face-to-face group discussion/education can help these patients to become adherent to recommended exercise guidelines.

The study found that both the comparison and experimental groups were partially adherent to recommended exercise in HF. The comparison group being as adherent to exercise as the experimental group could be due to the fact that participants in both groups benefitted from the use of the FCHR and educational materials that were provided to them. The feedback received from the FCHR may have been a motivating factor in itself for participants to become more active. Additionally, participant activity levels at baseline were gathered from subjective information and not objectively measured. Hence, it is unknown whether there was any difference in activity levels at baseline between the groups. The study duration was only 8 weeks

long and the sample size was small. The long term impact of such an internet-based face-to-face social support on exercise adherence using a larger sample should be investigated.

Considering that HF has the highest re-hospitalization rates among chronic diseases and that exercise can help to decrease these rates as well as the cost associated with hospitalization, it is important to investigate ways to help patients with HF become more adherent to exercise. Future research using a similar research model should be performed using a larger sample and an extended duration of study, with provision for post-intervention follow up to assess the long term impact of such an intervention on exercise adherence. The use of a tool that is sensitive to capturing social isolation in the HF population should be used. Providing objective feedback on exercise and physical activity programming may be an important factor for promoting adherence to exercise. Future research should also incorporate goal setting for min/week of exercise or step count over time to help progress participants towards meeting recommended exercise guidelines.

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Chapter 5: Discussion and Conclusion

Discussion

The aim of the study was to test the feasibility of delivering an internet-based face-to-face group discussion/education intervention and monitoring of exercise and physical activity using a wrist worn activity monitor in patients with HF. The study also aimed to study the effects of such an intervention on adherence to recommended exercise guidelines, intention to adhere, functional status, self-efficacy for exercise and perceived social isolation.

Results of the study showed that the delivery of an internet-based face-to-face group discussion/education intervention along with using a wrist worn activity monitor to track and provide feedback on exercise and physical activity over time in patients with HF is feasible.

Aim 1 in this study was to test the feasibility of providing an internet-based intervention in patients with HF. In an internet-based study, access to the internet is a concern for the targeted population to be able to participate in such a study (Aim 1a). It was found that the HF population did access the internet using various and multiple electronic devices. Out of the 82 participants that were screened, only 5 participants were found who did not have access to the internet. Seven participants who lived in rural areas were also able to participate in the study. Over the 8 weeks, only 4 participants dropped out of the study which was within the anticipated attrition rate.

In this study, we used a software-based video conferencing software called Vidyo to connect participants in the intervention group from their homes for a group discussion/education session. The software did not cost the participants any money to use as it was provided free of charge by the University's IT department (Aim 1b). Free web-based video calling programs such as Skype have been used to deliver video-based web interventions (Alley, Jennings, Plotnikoff,

& Vandelanotte, 2016). Other services such as Skype for business ($5.00/month) and Adobe Connect ($50.00/month) can also be used to deliver such an intervention.

In relation to Aim 1c, participants in the intervention group used both wireless and Wi-Fi connections for the group meetings using Vidyo. Participants were provided help with setting up the Vidyo software during their baseline visit and six participants that lived in rural areas were able to connect from their homes to engage in these weekly group meetings. The majority of the participants used a portable electronic device that they could bring with them during their baseline visit. Minimal technical support was required from the IT staff. Access to the Vidyo conference room at all times during the recruitment phase was critical for training and recruitment. Most participants were retirees and scheduling of group meeting times was easily done. The overall attendance to these meetings over the 8 weeks was 68% with 73.3% of participants attending 5 or more sessions. Personal issues such as being on vacation or busy at work, being sick or depressed and some unforeseen issues with connection to Vidyo with a Windows 10 upgrade were major reasons why participants did not attend the group meetings. The majority of the participants in the intervention group mentioned that their attendance would have been lower if they had to drive to a particular location to attend the weekly group meetings. In general, the participants felt that the Vidyo software was easy to use after it was set up and that they would participate in such group meetings again.

Aim 1d investigated the feasibility of using the FCHR to monitor exercise and physical activity. The FCHR was easy to install and manage and apart from three participants that 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 application 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 in the FCHR to record their exercise sessions. In general, the participants found it easy to operate the FCHR and sync the data and this allowed the PI to track exercise and physical activity remotely. The FCHR also provided flexibility with validating the exercise sessions with step count and HR data when participants forgot to record their exercise session. The majority of the participants mentioned that being HF patients they always have concerns with their ability to exercise and the ability to track their HR during exercise relieved them of fears concerning exercise at an intensity level that was determined safe for them. 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.

This intervention used a novel technology that had not been tested in a population of community dwelling patients with heart failure. However, we found that with guidance and training these participants were able to navigate their way in using an instrument and a software that were previously unfamiliar to them. Also, the sample consisted of 6 participants who lived in rural areas and the acceptance and success of such an intervention provides the opportunity to deliver interventions to populations living in rural areas who have more barriers in access to health care. As participants were able to sync and download the data on their own, activity monitors such as the FCHR can greatly decrease the time and resources needed to gathering data in community based longitudinal studies as the participants do not have to be scheduled to meet with research staff to download and collect data in periodic intervals.

In relation to aim 2a, the study found that participants in both the intervention (58.8%) and control (57.2%) group were partially adherent (Conraads et al., 2012) and no significant difference in adherence to recommended exercise was found between the groups. The average

minutes of exercise of 88 min (intervention group) and 86 min/week (control group) respectively can be however compared to high adherence reports of studies that had exercise programs of 30 min/day, 3days/week of low-moderate intensity exercise (total 90 min of moderate intensity exercise per week) (Chien et al., 2011; Duncan et al., 2011; R. Gary, 2006; Hambrecht et al., 1995; McKelvie et al., 2002; Witham et al., 2005). Seventeen participants, during enrollment, indicated that they had been exposed to some form of exercise previously but currently were leading very sedentary lives. They considered themselves to be actively performing the activities of daily living but not exercising. Two participants in the intervention group and one participant in the control group mentioned that they tried to exercise about 1-2 days a week but were not consistent with this exercise.

In this study, both groups were provided with a FCHR for feedback on exercise and physical activity and handouts on education on self-care in HF which included information on the importance of exercise in HF. The Transtheoretical model calls this aspect of providing feedback and education as “awareness raising” which leads to contemplation about making behavioral change (Prochaska & DiClemente, 1982). It may be that the feedback on activity levels and exercise performance that the participants in the control group received was significant to change their exercise behavior leading to exercise adherence levels comparable to the intervention group. A majority of participants indicated in the survey that the feedback on step count and heart rate they received from the FCHR was instrumental in helping them to become more active as it made them more conscious of their activity levels and made them accountable to themselves. While some participants mentioned that the target of walking 30 min/day is what motivated them, others mentioned they used number of steps per day as motivation. Twenty seven of the 30 participants indicated that, even on days that they did not

exercise, the FCHR provided them with a constant reminder of their activity levels which played on their consciousness to follow the exercise routine. It is noteworthy that nearly 83% of participants had already bought a FCHR or a similar activity monitor or were planning to buy one by the time they completed the study.

The intervention group participated in an internet-based face-to-face group discussion/education meeting once a week for 8 weeks. The overall attendance to these meetings was 68% with 73.3% of participants attending 5 or more sessions. It may be that the dose of once a week of group meeting was not strong enough to produce a group difference. Perhaps the intervention should be designed with more group meeting sessions initially to help them transition from a sedentary lifestyle to becoming fully adherent to the recommended exercise guidelines. Thirteen of the 15 participants in this group mentioned that they had not interacted with anyone else with a diagnosis of HF and found it interesting to get to know other people with HF and be able to interact with them. Five out of the 15 participants also indicated that the weekly group meetings made them accountable towards the other members of the group. During the 6^{th} week of intervention, two participants in the intervention group exchanged telephone numbers during group meeting sessions and connected with each other to walk together at the mall. These anecdotal comments from participants indicate some perceived social support related to exercise. The actual data related to perceived social support will be discussed in aim 3c.

Health, weather personal and professional issues are some of the main factors that the participants indicated as barriers to adherence. Some of the strategies that participants used to overcome these barriers were by walking: early in the morning, during lunch hour, in the mall and to the grocery store.

The internet-based group social support did not result in significantly different exercise adherence scores between the groups. Objective feedback on activity levels did help participants to become more active and partially adherent to exercise. It may be that HF patients require interventions that are more personalized to overcome barriers that are unique to the participant to become fully adherent to the recommended exercise guidelines.

Aim 2b looked at change in intention to adhere to exercise scores and no significant difference was found between the two groups and a significant positive correlation was found between strength of intention and exercise adherence validating the assertions made by the Theory of Planned Behavior. However, although the mean intention score was high, participants were not able to achieve the desired outcome behavior of meeting 150 min of exercise/week. It may be that the dose of social support and feedback that was provided was not adequate enough to help participants become fully adherent to the recommended guidelines exercise. It may also be that there are factors that keep HF patients from adhering to exercise in spite of having strong intentions for exercise.

Social support in the form of an internet-based face-to-face group discussion/education did not produce a significant difference in intention to adhere to recommended exercise guidelines between the groups in this study. A longer intervention with strategies to help transform strong intentions into behavioral actions may be needed.

Functional status (Aim 3a) as determined by the 6MWT was not significantly different between the groups. The post-8 week scores remained almost the same as baseline measurements in both the groups. RPE scores decreased significantly indicating that participants were able to walk almost the same distance but were less exhausted at 8 weeks than at baseline. Since

perceived exertion levels improved, it may be that a longer intervention would lead to functional improvement.

Aim 3b and 3c looked at change in exercise self-efficacy and perceived social isolation scores due to the intervention. No significant differences with and between the groups was observed for both measures. This lack of difference or effect on perceived social isolation may be related to the low levels of perceived social isolation that was found in the sample at baseline and the sample only including HF patients with NYHA class I-III and excluding NYHA Class IV HF patients. Anecdotal references from participants, as discussed earlier, does indicate that participants did perceive social support from the intervention. It is unclear from these study findings whether the intervention was actually not effective in improving social isolation or whether the measure of social isolation used did not accurately measure social isolation in these HF patients.

Limitations

The small sample size is a definite limitation of the study. A sample size of 30 did not provide sufficient power to detect differences between the groups. Effect size calculated from these data shows that the intervention, using an internet-based face-to-face group discussion/education resulted in a small effect on adherence. It is noteworthy, that the comparison group was also provided with a FCHR and educational material. Had the comparison group not received this information the effect size may have been larger. Activity levels of participants in both groups were determined from subjective response to inclusion criteria during screening; objective measurement of physical activity levels at baseline was not done. As such, it is unknown whether there was any difference in activity levels between the two groups at baseline or if there may have been a significant change in minutes of moderate intensity exercise

from baseline. The length of the intervention was only 8 weeks; thus study findings may have been impacted with an extended period of intervention. No post-intervention follow up was performed in this study, so it is not known how the intervention may have affected long term adherence after completion of the intervention. The FCHR was not reliable in capturing active minutes for some participants that walked at a slower pace and exercised in bouts of less than 10 min. This resulted because the algorithms used to detect active minutes and exercise intensity using heart rate are applicable for healthier people and not for the HF populations, who may have significantly slower walking pace and are on medications that may affect HR response to exercise. However, for the purpose of this study, the FCHR provided other forms of data, such as daily step count, that were helpful in validating self-reported data on exercise diaries.

Conclusion

From this study, it is concluded that the use of the internet to provide a web-based face-to-face group discussion/education program to patients with heart failure and the use of a wrist worn activity monitor to track exercise and physical activity in the community setting is acceptable and feasible.

This pilot study was designed to improve exercise adherence in patients with HF and is the first study to test the feasibility of connecting participants for an internet-based synchronous face-to-face group discussion/education and help them to become more adherent to the recommended exercise guidelines. Six participants who lived in rural areas were able to participate in the study and this is a positive indicator that this intervention is feasible for rural dwelling HF patients who have less access to such care.

The study found that both the control and intervention groups were partially adherent to recommended exercise in HF. The control group being as adherent to exercise as the intervention group could have been due to the fact that participants in both groups benefitted from the use of the FCHR and educational material that was provided to them. The feedback received from the FCHR may have been a motivating factor in itself for participants to become more active. Also, activity levels of participants at baseline was gathered from subjective information and not objectively measured. Hence, it is unknown if there was any difference in activity levels at baseline between the groups. The study duration was only 8 weeks and the sample size was small. The long term impact of this internet-based face-to-face social support on exercise adherence may result in significant differences in exercise adherence scores.

Considering that HF has the highest re-hospitalization rates among chronic diseases and that exercise can help to decrease these rates and the cost associated with hospitalization, it is important to investigate ways to help patients with HF become more adherent to exercise. Future research using a similar research model should be done using a larger sample and for a longer duration of time with provision for post-intervention follow up to assess the long term impact of such an intervention on exercise adherence. Also, use of a tool that is sensitive to capturing perceived social isolation in the HF population should be used. Providing objective feedback on exercise and physical activity may be an important factor on promoting adherence to exercise and future research should also incorporate goal setting for min/week of exercise or step count over time to help progress participants' towards meeting the recommended exercise guidelines.

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Appendix A

Operationalization of the Components of self-efficacy from Bandura's Social Cognitive Theory

Component	Provided by
Performance Accomplishment	Exposure to exercise Self-modelling Gradual desensitization to exercise over 8 weeks
Verbal Persuasion/Feedback	Objective feedback on heart rate, duration of exercise and step count on a daily basis from the Fitbit Charge HR activity monitor Discussion among participants on weekly exercise performance Suggestions by peers and PI during group meetings on overcoming barriers Encouragement for regular exercise
Physiological/Emotional Arousal	Education on the pathophysiology of HF Education on safety of exercise in HF population Education on appropriate frequency, duration and intensity of exercise Education on HR monitoring and using RPE scale Education on diet and medication for HF Education on exercising in a safe and known environment