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Depression is Associated with Reduced Physical Activity in Persons with Heart Failure

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Abstract

Objective—Reduced physical activity is common in persons with heart failure (HF). However, studies of correlates and modifiers of physical activity in this population rarely employ objective measures. Motivational and mood related factors that may exacerbate inactivity in HF patients are also rarely investigated. In this study, we examined the relationship between physical activity as assessed by accelerometry, and depression in older adults with HF.

Methods—At baseline, older adults with HF ($N = 96$; 69.81 ± 8.79) wore an accelerometer for seven days, and completed a brief fitness assessment, neuropsychological testing, and psychosocial measures including the Beck Depression Inventory-II (BDI-II). Medical and demographic history was obtained through record review and self-report.

Results—Accelerometer measures showed that HF patients averaged 587 minutes of sedentary time and just 0.31 minutes of vigorous activity per day. Lower daily step count was associated with poorer quality of life and reduced cognitive function. A multiple linear regression adjusting for important demographic and medical variables found that greater number of depressive symptoms on the BDI-II independently predicted lower physical activity levels.

Conclusion—Consistent with past work, the current study found that low physical activity is common in older adults with HF. Depression is an independent predictor of physical activity in older adults with HF and reduced physical activity is associated with numerous adverse psychosocial outcomes. Future studies need to determine whether treatment of depression can boost physical activity and thus improve health outcomes in this population.

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Keywords

Physical Activity; heart failure; depression; psychosocial outcomes; step count

1. Introduction

Heart failure (HF) affects more than 5.7 million Americans (Lloyd-Jones et al., 2009), and constitutes a major public health risk exacerbated by recent increases in obesity, hypertension, and type-2 diabetes mellitus (Lloyd-Jones et al., 2009). HF is the most frequent cause of hospital re-admissions in the United States, with estimated annual direct and indirect costs of approximately $37.2 billion (American Heart Association, 2010).

Reduced physical activity is common in persons with HF. Previous work has shown that nearly half of persons with HF do not engage in regular exercise (van der Wal, Jaarsma, Moser & van Veldhuisen, 2005), and limited physical activity is the most common failure in self-care in this population (Schnell-Hoehnet, Naimark, & Tate, 2009). This pattern is unfortunate, as increased physical activity provide many benefits in patients with HF. Findings from the Heart Failure and A Controlled Trial Investigating Outcomes of Exercise Training (HF-ACTION) trial demonstrate that increased physical activity is associated with reduced mortality and hospitalization, enhanced maximal oxygen consumption, and improved health status (O'Connor et al., 2009; Keteyian et al., 2009; Flynn, Pina, & Whellan, 2009). Other studies reveal that physical activity provides additional benefits to persons with HF, including better quality of life (Davies et al., 2010), improved cardiac, musculoskeletal and endothelial functions (Hambrecht et al., 2000; Pina & Fitzpatrick, 1996; Haykowsky et al., 2007), and enhanced coronary perfusion (Corvera-Tindel, Doering, Woo, Khan & Dracup, 2004).

Despite these benefits, few studies have examined physical activity in persons with HF. The main drawback of most of the extant studies is their reliance on patient self-report of physical activity (Steele et al., 2000). Self-reported physical activity questionnaires tend to focus on activities of moderate to heavy intensity, and neglect everyday activities such as household chores, gardening, walking or standing (Bassett, Cureton, & Ainsoworth, 2000; Pereira et al., 1997; Lee & Buchner, 2008; Jacobs, Ainsworth, Hartman, & Leon, 1993). Despite its use in other patient populations (Araiza, Hewes, Gashetewa, Vella, & Burge, 2006; Ferrari, Friedenreich, & Matthews, 2007; Nikander et al., 2007; Pitta et al., 2005; Steele et al., 2003; Tudor-Locke, & Bassett, 2004), few studies have objectively assessed physical activity in persons with HF. Most relevant to the current study, Jehn et al. (2009; 2011) found associations between accelerometer-measured physical activity and both exercise capacity and disease severity in HF. However, these accelerometer studies, and other studies using pedometers in this population (Evangelista, Hamilton, Fonarow, & Dracup, 2010; Houghton, Harrison, Cowley, & Hampton, 2002) only investigated walking intensity and/or daily step count, and did not examine activities at other intensity levels (i.e., sedentary, and vigorous activity).

Although reduction of physical activity in HF patients has been demonstrated, little is known about the factors that promote and prevent physical activity in that population. Diverse factors have been proposed as influential modifiers of physical activity in HF. Among them include: the perceived cost/benefit of physical activity (Tierney et al., 2011a; Tagney, James, Albarran, 2003), self-efficacy (Oka, Gortner, Stotts, & Haskell, 1996), social support (Clark, Whelan, Barbour, MacIntyre, 2005), past experience of physical activity (Petter, Blanchard, Kemp, Mazoff, & Ferrier, 2009), and various psychoeducation variables (Riegel & Carlson, 2002). A recent qualitative study identified negative affect as an important contributor to sedentary lifestyles in persons with HF (Tierney et al., 2011b). This finding is particularly noteworthy, as past work links depression to limited physical activity in registered heart transplant candidates (Spaderna et al., 2010) and other samples of chronically ill persons (e.g. type 2 diabetes) (Lysy, Da Costa, Dasgupta, 2008). Given that 13%- 42% of persons with HF have clinically meaningful levels of depression (Havranek, Ware, & Lowes, 1999; Skotzko et al., 2000; Murberg & Bru, 2001), depression is a potentially important contributor to objective measures of physical activity in this population.

In this study, we examined the role of depressive symptoms as modifiers of physical activity in HF patients, as determined by objective accelerometric measurements. In addition, we examined whether low physical activity was associated with adverse outcomes. Based on the above, we expected that depression would be an important predictor of physical activity and that persons with low levels of physical activity would have poorer outcomes on measures of cognitive function and quality of life.

2. Methods

2.1 Participants

The original sample consisted of 123 consecutively enrolled persons with HF selected from a database of a National Institute of Health (NIH) funded study titled "Cognition and Heart Failure in Cardiac Rehabilitation". As a result of invalid accelerometer wear (see *2.2.1 Physical Activity)* 27 participants were excluded from the analyses yielding a final sample size of 96. The excluded participants did not differ in age (t (121) = .15, p = .881), gender (χ^2 (1, N = 123) = .17, p = .685), or on medical variables including history of CABG (χ^2 (1, N = 123) = .04, p = .836), history of hypertension (χ^2 (1, N = 123) = 3.09, p = .079), history of myocardial infarction (χ^2 (1, N = 123) = .13, p = .722), and the BDI-II (t(121) = −1.74, p = .084). However, differences emerged on 2MST performance (t(116) = 3.97, p = .000; 63.96±20.91 in the current sample vs. 43.68±24.65 for those excluded) and history of diabetes (χ^2 (1, N = 123) = 7.05, p = .008; 28.1% in the current sample vs. 55.6% for those excluded).

Participants were recruited from the large number of HF patients approached regarding cardiac rehabilitation at Summa Health system in Akron, Ohio. Throughout the study, HF participants complete a comprehensive neuropsychological battery at three different time points (i.e., baseline, 3-months and 12-months follow-up), among many other assessments including physical activity. Only baseline assessments were examined for the present study, thus no participants were participating in cardiac rehabilitation at the time of the analyses.

Strict inclusion/exclusion criteria were chosen for entry into the NIH funded study to maximize generalizability to other samples and to capture the independent contribution of HF on cognitive function. Thus, participants of the current study met all criteria for parent study entry. Specifically, all participants were between the ages of 50-85 years of age, English-speaking, and had an established diagnosis of HF at New York Heart Association (NYHA) class II or III at the time of enrollment. Exclusion criteria included history of significant neurological disorder (e.g. dementia, stroke), head injury with more than 10 minutes loss of consciousness, severe psychiatric disorder, substance use, renal failure, and sleep apnea. Participants averaged 69.81±8.79 years of age, were 36.5% female, 8.3% African-American, and 2.1% Native American/Alaskan Eskimo. See Table 1 for sample medical, demographic and clinical characteristics.

2.2 Measures

2.2.1 Physical Activity—A GT1M accelerometer (Actigraph, Pensacola, FL) was used to assess physical activity over a 7-day period. GTIM accelerometer is a valid measure of physical activity and has been shown to provide reliable estimates of step counts and activity energy expenditure across various treadmill walking and running speeds (Abel et al., 2008). Participants were instructed in how to wear the accelerometer (over the right hip, affixed to an elastic belt, preferably worn under their waistbands) and provided with a set of instructions for wear over the 7 days. Daily step count was calculated by the accelerometer, and for the current population a daily step count between 0 and 2,499 represented sedentary, 2,500 to 4,999 as limited physical activity, and a 5,000 to 12,000 daily step count was considered to be physically active (Tudor-Locke, Johnson, & Katzmarzyk, in press). These cut-off values were based on values from healthy adults and adapted to be consistent with disabled older adults living with heart and vascular disease (Tudor-Locke, Johnson, & Katzmarzyk, in press). Step count was analyzed in conjunction with a diary entry of daily routine.

To more thoroughly characterize physical activity in the sample, an Excel macro was used to determine the number of minutes the participants engaged in each of the five activity levels. The levels of activity were as follows: sedentary (<100 counts per minute), light intensity (100-760 counts per minute), Matthews moderate intensity (760 -5,724 counts per minute), Freedson moderate (1952-5724) and vigorous intensity (> 5,724 counts per minute) (McLoughlin, Colbert, Stegner, & Cook, 2011). Cut points for moderate and vigorous activities were based on their correspondence to energy expenditures of 3-6 metabolic equivalents (METs) for moderate and greater than 6 METs for vigorous activity (Freedson, Melanson, & Sirard, 1998). An additional cut point of 760 counts per minute was used to more accurately capture free-living moderate intensity activities, as opposed to Freedson's moderate exercise intensity (Matthews, 2005). A valid day of wear was considered greater than or equal to 10 hours of wear per day, and the activity data was restricted to participants with at least 3 valid days of accelerometer wear. Average number of minutes per waking hours of the day spent in each activity level was calculated for each participant, as well as average minutes per day of accelerometer wear.

2.2.2 Quality of Life—The Short Form-12 Quality of Life Measure (SF-12) (Ware, Kosinski, & Keller, 1996) measured health-related quality of life. The two primary composite scores, Physical Composite Score (PCS; physical functioning, role-physical, bodily pain, and general health) and Mental Composite Scale (MCS; vitality, social functioning, role-emotional, and mental health) were examined.

2.2.3 Depressive Symptoms—Depression was assessed through the administration of the Beck Depression Inventory-II (BDI-II). The BDI-II is a commonly used measured of depressive symptoms with good psychometric properties in persons with medical conditions (i.e., test-re-test reliability of $r = .93$ to $r = .96$, and an internal consistency of $r = .54$ to $r = .74$) (Amau, Meagher, Norris, & Bramson, 2001; Beck, Steer, & Brown, 1996). BDI-II scores range from 0-63 with increased score indicative of increased symptomatology. Based on BDI-II scores, severity of depressive symptoms was categorized into the following groups: Minimal (0-13), mild (14-19), moderate (20-28), and severe (29-63) (Beck, Steer, Brow, 1996).

2.2.4 Cognitive Function—Cognitive status was assessed by the Mini-Mental State Examination (MMSE) and Trail Making Test A and B. The MMSE is a brief (5-10 minute) screening measure commonly used to provide an estimate of global cognitive function, tapping aspects of attention, orientation, memory, language, and calculation (Folstein,

Folstein, & McHugh, 1975). The MMSE has very good test-retest reliability (r = .80 to .95) and excellent internal consistency (r = .96) (Folstein, Folstein, & McHugh, 1975; Foreman, 1987). Trail Making Test A is a reliable and valid measure of attention, complex visual scanning and psychomotor speed (Spreen & Strauss, 1991). Test-retest reliability is estimated at r = 0.79 (Dikmen, Heaton, Grant & Temkin, 1999). Trail Making Test B is a widely used measure of executive function, Trail Making Test B has good psychometric properties (e.g., test-retest reliability up to r = 0.89) (Spreen, & Strauss, 1991; Dikmen et al., 1999). For both Trail Making Test A and Trail Making Test B longer time of completion is indicative of worse performance (Spreen & Strauss, 1991; Dikmen et al., 1999).

2.2.5 HF Severity—The 2-minute step test (2MST) is an assessment of cardiovascular endurance and was used to serve as an estimate of heart failure severity (Rikli & Jones, 2002). The 2MST requires the patient to march in place for 2 minutes. Increased step count was reflective of greater cardiovascular fitness.

2.3 Procedures

The local Institutional Review Board (IRB) approved the study procedures and all participants provided written informed consent prior to study enrollment. During a single assessment, participants completed medical and psychosocial self-report measures and a brief neuropsychological test battery. Participants then received an accelerometer and were instructed to wear the device each day for seven days from the moment they wake until they go to sleep.

2.4 Statistical Analyses

Descriptive analyses were conducted to characterize physical activity in the current sample including average accelerometer count, daily steps per day, and time per day spent sedentary, in light intensity activity, Matthew’s free-living moderate intensity activity, Freedson’s moderate exercise intensity activity, and in vigorous intensity activity. A multiple linear regression was performed to examine predictors of daily step count. Daily step count is an ecologically valid measure of physical activity. Assessment of daily step count is inexpensive, readily accessible to clinicians, and researchers, and has shown to be a valid indicator of exercise adherence in persons with HF (Evangelista et al., 2005). Participant age, gender, and education were entered in the first block of the model. Medical variables including the 2MST, and history of myocardial infarction, diabetes, hypertension, and history of CABG were entered into the second block of the model. To determine its incremental predictive validity, the BDI-II was entered into the final block of the model. The t-scores, and betas of the individual predictors were examined to determine their association with daily step count. Finally, ANOVA examined consequences of limited physical activity in the sample.

3. Results

Physical Activity in Older Adults with HF: Accelerometer

On average, the participants wore the accelerometer for 820 ± 79 minutes per day, and exhibited low levels of physical activity, averaging just 3677 ± 2121.16 steps per day. See Table 2. According to daily step counts, 32.3% participants were categorized as sedentary, 45.8% as showing limited physical activity, and just 21.9% as physically active. Consistent with this pattern, patients spent a large portion of time being sedentary (587.43 minutes per day±74.36). In addition, patients spent minimal time in Freedson’s moderate intensity activity (7.50 minutes per day±11.13), Matthew’s moderate intensity activity (48.24 minutes per day±37.22), and in vigorous activity (0.31 minutes per day±1.55).

Predictors of Daily Step Count in Older Adults with HF

A multiple linear regression was conducted to identify predictors of daily step count in older adults with HF. Education was a significant predictor of daily step count, with increased years of education associated with greater daily step counts (b = .21, $p = .039$). An initial trend emerged for age, however, this trend became significant after accounting for the variance of medical comorbidities (b = −.21, $p = .045$). Older participants had lower daily step counts. Gender did not emerge as a significant individual predictor. While males had lower total daily step counts (M = 3625.54, SD = 2108.22) than females (M = 3767.90, SD =2171.41) this difference was not statistically significant ($t(94) = -.32$, $p = .753$). Common medical comorbidities also did not emerge as significant individual predictors of daily step count after adjusting for age, gender and education ($p > .05$ for all). Finally, after adjusting for important demographic and medical characteristics the BDI-II demonstrated incremental predictive validity as it significantly predicted daily step count (b= −.24; $p = .023$); increased scores on the BDI-II were associated with decreased daily step count. See Table 3 for a full model summary.

Based on established BDI-II cut off scores, 20.8% of participants reported clinically meaningful levels of depression: 11.4% reported mild symptoms, 6.3% reported moderate symptoms, and 3.1% reported severe symptoms. Of note, partial correlations adjusting for demographic and medical characteristics found no significant association between the 2-minute step test and BDI-II scores ($r = -.08$, $p = .435$).

Daily Step Count and Adverse Outcomes in Older Adults with HF

Based on daily step count, an ANOVA was conducted to compare HF patients categorized as being sedentary, having limited physical activity, and physically active on a variety of psychosocial outcomes. Between group differences emerged for the SF-12 PCS ($F(2, 93) = 15.37$, $p < .001$), and the MMSE ($F(2,93) = 3.09$, $p = .05$). Post-hoc comparisons revealed the following group differences: the sedentary group was significantly different from both the limited physical activity and physical activity group on the SF-12 PCS ($p < .05$), and sedentary HF persons were significantly different from the limited physical activity HF persons on the MMSE ($p < .05$). HF persons with decreased step count had lower SF-12 PCS and MMSE scores.

Further, Welche's F, due to violation of Levene's test of homogeneity of variances, showed a trend for between group differences for Trail Making Test B ($F(2, 57.61) = 2.84$, $p = .067$). No differences emerged for SF-12 MCS ($F(2, 93) = .73$, $p > .05$), or Trail Making Test A ($F(2, 93) = 1.41$, $p > .05$). See Table 4.

4. Discussion

The current study shows that limited physical activity is common in persons with HF. It replicates and extends previous findings by demonstrating these effects with objective accelerometer measures rather than self-reports. Depressive symptoms independently contribute to reduced physical activity in this population and low levels of physical activity are associated with poor psychosocial outcomes.

Consistent with past work, the present study demonstrates similar rates of depression in older adults with HF (Havranek et al., 1999; Skotzko et al., 2000; Murberg & Bru, 2001). The observed association between depressed mood and reduced physical activity is consistent with the many other adverse effects of depression in this population, including cognitive impairment (Pullicino et al., 2008), reduced independence in daily living (Friedman, Lyness, Delavan, Li, & Barker, 2008), and increased risk of morbidity and mortality (Yu, Lee, Woo, & Thompson, 2004). However, the exact mechanisms linking depression to low physical activity are unknown.

Previous work has shown depressive illness to impair cognitive and motivational capacities, regulation of affect, social perception, and to amplify physical symptoms such as fatigue (Ormel et al., 1994; VonKorff, 1999). Interestingly, when compared to non-depressed persons with HF, one study found that depressed HF persons have decreased perceptions of their functional ability, as opposed to poor functional ability causing depression, as was evident by the absence of physiological differences between the two groups (Skotzo et al., 2000). Interventions targeting underlying cognitive thoughts in patients with HF, such as cognitive behavioral therapy, may help change patient perceptions of their physical ability, and thus increase physical activity behaviors. Even further, reduced self-efficacy is a known contributor to limited physical activity in this population (Oka et al., 1996), and prior work has shown self-efficacy to moderate the relationship between subjective physical health and depressive symptoms in an older adult population (Paukert et al., 2010). Future work examining psychotherapy interventions in this population is encouraged, as cognitive behavioral therapy, counseling, and supportive psychotherapy have all been shown to be effective treatments for depression in other medically ill populations (i.e., diabetes) (Huang, Song, & Li, 2001; Lustman, Griffith, Freedland, Kissel, & Clous, 1998; Simson et al., 2008).

Another possible approach to address depression in persons with HF might be enrollment in cardiac rehabilitation. Cardiac rehabilitation has been shown to be an effective intervention for decreasing depressive symptoms in persons with HF (Milani, Lavie, Mehra, & Ventura, 2011). However, consistent with the current findings, depression has also been shown to predict lower rates of completion of cardiac rehabilitation (Casey, Hughes, Waechter, Josephson & Rosneck, 2008). Future work is much needed to clarify whether treatment for depression may improve physical activity levels.

The current sample of HF persons exhibited high rates of sedentary time (i.e. >500 waking minutes per day) and extremely low rates of vigorous intensity activity (i.e. less than one minute per day). When compared to accelerometer data among healthy older adults between the ages of 60-75 from the National Health and Nutrition Examination Survey (NHANES), the current sample of HF patients spent more time sedentary and less time in all other physical activity levels (i.e., light intensity, moderate, and vigorous) (Hagstromer, Troiano, Sjostrom, & Berrigan, 2010; Troiano et al., 2207). However, such differences were minimal, regards to time spent sedentary as the healthy older adults were also found to spend >500 waking minutes per day of sedentary time (Hagstromer, Troiano, Sjostrom, & Berrigan, 2010). This inverse relationship between sedentary behaviors and age may be a contributing factor to the rising prevalence of cardiovascular disease in the United States (Lloyd-Jones et al., 2009). For example, increase in physical activity has been shown to provide many benefits for persons with HF (Hambrecht et al., 2000; Pina & Fitzpatrick, 1996; Davies et al., 2010), though a better understanding of its role in HF management is much needed (Jehn et al., 2009). An ongoing prospective trial, Multi-Sensor Monitoring in Congestive Heart Failure (MUSIC) is remotely monitoring HF patients using a multisensory system that will transmit accelerometer data, in addition to numerous other data values (Anand et al., 2011). Closely monitoring physical activity and disease outcomes will provide key insight into this relationship.

The current findings suggest a possible role for education in physical activity levels in older adults with HF. Previous work has shown HF patients to be generally “confused” about the effects of exercise and how much activity they should be engaging in (Horowitz et al., 2004; Riegel & Carlson, 2002). Moreover, recent work has shown low health literacy in patients with HF to be significantly associated with higher mortality (Peterson et al., 2011) and reduced compliance in self-care behaviors such as exercise (Chen, Yehle, Plake, Murawkski, & Mason, 2011). Prospective studies examining health literacy interventions targeting physical activity in a group of HF patients are encouraged, as it seems probable that such interventions would increase exercise adherence in this population.

Decreased physical activity was associated with adverse psychosocial outcomes, including poor quality of life and cognitive dysfunction in persons with HF. According to the 2008 European Society of Cardiology HF guidelines, physical activity and structured exercise training is strongly recommended in persons with HF as a means to improve exercise capacity, quality of life, and to reduce mortality and hospitalization (Dickstein et al., 2008). Consistent with these recommendations, the current findings suggest that increased physical activity may provide many additional benefits for patients with HF. For example, prior work has shown physical activity to be associated with better cardiorespiratory fitness and cognitive function, which are both important predictors of functional independence in older adults with HF (Galper, Trivedi, Barlow, Dunn, & Kampert, 2006; Corra, Mezzani, Bosimini, & Giannuzzi, 2004; Mancini et al., 1991; Stanek et al., 2011; Angevaren, Aufdemkampe, Verhaar, Aleman, & Vanhees, 2008; Alosco et al., in press). Disability is common in persons with HF (Seo, Roberts, Pina, & Dolansky, 2008; Bennett et al., 2003), and future work is needed to determine the potential benefits of physical activity on maintaining functional independence.

The current findings are limited in several ways. Prospective studies examining the pattern of physical activity in persons with HF are needed to clarify whether the predictors, particularly depression, change over time. Similarly, the mechanisms by which depression is associated with poor physical activity are unclear, as is the possibility of treatment for depression leading to improved physical activity. Additionally, the current study did not examine direct measures of HF severity (i.e., left ventricular ejection fraction) and future studies should examine how these measures might relate to depression and physical activity. Specifically, studies should investigate whether depression is associated with reduced physical activity independent of HF severity or whether depression is secondary to HF and thus indirectly influences physical activity levels. A further limitation of the current study is the limited literature on the duration and/or intensity of physical activity necessary to promote better outcomes. In addition, research examining physical activity in other forms of heart disease is warranted, as it is unclear the degree to which findings are specific to HF. Finally, a substantial number of participants ($N = 27$) were excluded from the current analyses due to invalid accelerometer wear. While depression was not associated with increased likelihood of inability to adhere to accelerometer instructions, increased HF severity (as assessed by the 2MST) and history of diabetes may impair such ability and future studies that objectively assess physical activity in medical populations should account for these factors.

In summary, the current findings indicate depression is an independent predictor of physical activity in older adults with HF and reduced physical activity is associated with numerous adverse psychosocial outcomes. Future studies are needed to determine whether treatment for depression can improve physical activity, prevent re-hospitalizations, and improve overall quality of life in this population.

References

Abel MG, Hannon JC, Sell K, Lillie T, Conlin G, Anderson D. Validation of the Kenz Lifecorder EX and ActiGraph GT1M accelerometers for walking and running in adults. Applied Physiology, Nutrition, and Metabolism. 2008; 33:1155–1164.

Alosco ML, Spitznagel MB, Cohen R, Lawrence S, Colbert LH, Josephson R, Gunstad J. Cognitive impairment is independently associated with reduced instrumental ADLs in persons with heart failure. Journal of Cardiovascular Nursing. (in press).

Arnau R, Meagher M, Norris M, Bramson R. Psychometric evaluation of the Beck Depression Inventory-II with primary care medical patients. Health Psychology. 2001; 20:112–119. [PubMed: 11315728]

American Heart Association. Heart Disease and Stroke Statistics – 2010 Update. American Heart Association; Dallas, Texas: 2010. ©2010, American Heart Association

Anand IS, Greenberg BH, Fogoros RN, Libbus I, Katra RP, Music Investigators. Design of the Multi-Sensor Monitoring in Congestive Heart Failure (MUSIC) study: prospective trial to assess the utility of continuous wireless physiologic monitoring in heart failure. Journal of Cardiac Failure. 2011; 17:11–16. [PubMed: 21187259]

Angevaren M, Aufdemkampe G, Verhaar HJ, Aleman A, Vanhees L. Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment. Cochrane Database of Systematic Reviews. 2008; 3:CD005381.

Araiza P, Hewes H, Gashetewa C, Vella CA, Burge MR. Efficacy of a pedometer- based physical activity program on parameters of diabetes control in type 2 diabetes mellitus. Metabolism. 2006; 55:1382–7. [PubMed: 16979410]

Bassett DR Jr. Cureton AL, Ainsworth BE. Measurement of daily walking distance-Questionnaire versus pedometer. Medicine and Science in Sports and Exercise. 2000; 32:1018–1023. [PubMed: 10795795]

Beck, AT.; Steer, RA.; Brown, GK. Beck Depression Inventory. 2nd ed. The Psychological Corporation; San Antonio, TX: 1996.

Bennett SJ, Oldridge NB, Eckert G, Embree JL, Browning S, Hou N, Murray MD. Comparison of quality of life measures in heart failure. Nursing Research. 2003; 52:207–216. [PubMed: 12867777]

Casey E, Hughes JW, Waechter D, Josephson R, Rosneck J. Depression predicts failure to complete phase-II cardiac rehabilitation. Journal of Behavioral Medicine. 2008; 31:421–431. [PubMed: 18719990]

Chen AMH, Yehle KS, Plake KS, Murawkski MM, Mason HL. Health literacy and self-care of patients with heart failure. Journal of Cardiovascular Nursing. 2011 [Epub ahead of print].

Clark AM, Whelan HK, Barbour R, MacIntyre PD. A realist study of the mechanisms of cardiac rehabilitation. Journal of Advanced Nursing. 2005; 54:362–371. [PubMed: 16268840]

Corra U, Mezzani A, Bosimini E, Giannuzzi P. Cardiopulmonary exercise testing and prognosis in chronic heart failure. Chest. 2004; 126:942–950. [PubMed: 15364777]

Corvera-Tindel T, Doering L, Woo MA, Khan S, Dracup K. Effects of a home-walking exercise program on functional status and symptoms in heart failure. American Heart Journal. 2004; 147:339–346. [PubMed: 14760334]

Davies EJ, Moxham T, Rees K, Singh S, Coats AJS, Ebrahim S, Lough F, Taylor RS. Exercise based rehabilitation for heart failure. Cochrane Database of Systematic Reviews. 2010; 4:CD003331.

Dickstein K, Cohen-Solal A, Filippatos G, McMurray JJ, Ponikowski P, Poole-Wilson PA, Swedberg K. European Society of Cardiology; Heart Failure Association of the ESC (HFA); European Society of Intensive Care Medicine (ESICM) ESC guidelines for the diagnosis and treatment of acute and chronic heart failure 2008: the task force for the diagnosis and treatment of acute and chronic heart failure 2008 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association of the ESC (HFA) and endorsed by the European Society of Intensive Care Medicine (ESICM). European Journal of Heart Failure. 2008; 10:933–989. [PubMed: 18826876]

Dikmen S, Heaton R, Grant I, Temkin N. Test-retest reliability of the Expanded Halstead-Reitan Neuropsychological Test Battery. Journal of the International Neuropsychological Society. 1999; 5:346–356. [PubMed: 10349297]

Evangelista LS, Dracup K, Erickson V, McCarthy WJ, Hamilton MA, Fonarow GC. Validity of pedometers for measuring exercise adherence in heart failure patients. Journal of Cardiac Failure. 2005; 11:366–371. [PubMed: 15948087]

Evangelista LS, Hamilton MA, Fonarow GC, Dracup K. Is exercise adherence associated with clinical outcomes in patients with advanced heart failure? The Physician and Sports Medicine. 2010; 38:28–36.

Ferrari P, Friedenreich C, Matthews CE. The role of measurement error in estimating levels of physical activity. American Journal of Epidemiology. 2007; 166:832–40. [PubMed: 17670910]

Flynn KE, Pina IL, Whellan DJ. Effects of exercise training on health status in patients with chronic heart failure. HF-ACTION randomized controlled trial. The Journal of the American Medical Association. 2009; 301:1451–1459.

Folstein MF, Folstein SE, McHugh PR. "Mini-Mental State." A practical method for grading the cognitive state of patients for the clinician. Journal of Psychiatric Research. 1975; 12:189–198. [PubMed: 1202204]

Foreman MD. Reliability and validity of mental status questionnaires in elderly hospitalized patients. Nursing Research. 1987; 36:216–220. [PubMed: 3299279]

Freedson P, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc., accelerometer. Medicine and Science in Sports and Exercise. 1998; 30:777–781. [PubMed: 9588623]

Friedman B, Lyness JM, Delavan RL, Li C, Barker WH. Major depression and disability in older primary care patients with heart failure. Journal of Geriatric Psychiatry and Neurology. 2008; 21:111–122. [PubMed: 18474720]

Galper DI, Trivedi MH, Barlow CE, Dunn AL, Kampert JB. Inverse association between physical inactivity and mental health in men and women. Medical Science Sports Exercise. 2006; 38:173–178.

Hagstomer M, Troiano RP, Sjostrom M, Berrigan D. Levels and patterns of objectively assessed physical activity—A comparison between Sweden and the United States. American Journal of Epidemiology. 2010; 171:1055–1064. [PubMed: 20406758]

Hambrecht R, Wolf A, Gielen S, Linke A, Hofer J, Erbs S, Schoene N, Schuler G. Effect of exercise on coronary endothelial function in patients with coronary artery disease. New England Journal of Medicine. 2000; 342:454–460. [PubMed: 10675425]

Havranek EP, Ware MG, Lowes BP. Prevalence of depression in congestive heart failure. American Journal of Cardiology. 1999; 84:348–50. [PubMed: 10496452]

Haykowsky MJ, Liang Y, Pechter D, Jones L, McAlister FA, Clark AM. A meta-analysis of the effect of exercise training on left ventricular remodeling in heart failure patients: the benefit depends on the type of training performed. Journal of the American College of Cardiology. 2007; 49:2329–36. [PubMed: 17572248]

Horowitz CR, Rein SB, Leventhal H. A story of maladies, misconceptions and mishaps: effective management of heart failure. Social Science and Medicine. 2004; 58:631–643. [PubMed: 14652059]

Houghton AR, Harrison M, Cowley AJ, Hampton JR. Assessing exercise capacity, quality of life and haemodynamics in heart failure: do the tests tell us the same thing? European Journal of Heart Failure. 2002; 4:289–295. [PubMed: 12034154]

Huang X, Song L, Li T. The effect of social support on type II diabetes with depression. Chinese Journal of Clinical Psychology. 2001; 9:187–189.

Jacobs DR Jr. Ainsworth BE, Hartman TJ, Leon AS. A simultaneous evaluation of 10 commonly used physical activity questionnaires. Medicine and Science in Sports and Exercise. 1993; 25:81–91. [PubMed: 8423759]

Jehn M, Schmidt-Trucksass A, Hanssen H, Schuster T, Halle M, Koehler F. Association of physical activity and prognostic parameters in elderly patients with heart failure. Journal of Aging and Physical Activity. 2011; 19:1–15. [PubMed: 21285472]

Jehn M, Schmidt-Trucksass A, Schuster T, Weis M, Hanssen H, Halle M, Koehler F. Daily walking performance as an independent predictor of advanced heart failure: Prediction of exercise capacity in chronic heart failure. American Heart Journal. 2009; 157:292–298. [PubMed: 19185636]

Keteyian SJ, Miller NH, Ellis SJ, O'Connor CM, Whellan DJ, Cooper LS, Pina IL, for the HF-ACTION Steering Group and Coordinators. A dose–response analysis of patients with heart failure enrolled in A Controlled Trial Investigating Outcomes of Exercise Training (HF-ACTION). Presented at the American College of Cardiology. 2009

Lee IM, Buchner DM. The importance of walking to public health. Medicine and Science in Sports and Exercise. 2008; 40:S512–S518. [PubMed: 18562968]

Lloyd-Jones D, Adams R, Carnethon M, De Simone G, Ferguson TB, Flegal K, Hong Y. Heart disease and stroke statistics—2009 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Circulation. 2009; 119:e21–e181. [PubMed: 19075105]

Lustman PJ, Griffith LS, Freedland KE, Kissel SS, Clouse RE. Cognitive behavior therapy for depression in type 2 diabetes mellitus. A randomized, controlled trial. Annals of Internal Medicine. 1998; 129:613–621. [PubMed: 9786808]

Lysy Z, Da Costa D, Dasgupta K. The association of physical activity and depression in type 2 diabetes. Diabetic Medicine. 2008; 25:1133–1141. [PubMed: 19046190]

Mancini DM, Eisen H, Kussmaul W, Mull R, Edmunds LH, Wilson JR. Value of peak exercise oxygen consumption for optimal timing of cardiac transplantation in ambulatory patients with heart failure. Circulation. 1991; 83:778–786. [PubMed: 1999029]

Matthews CE. Calibration of accelerometer output for adults. Medicine and Science in Sports and Exercise. 2005; 37:S512–S522. [PubMed: 16294114]

McLoughlin MJ, Colbert LH, Stegner AJ, Cook DB. Are women with fibromyalgia less physically active than health women? Medicine and Science in Sports and Exercise. 2011; 43:905–912. [PubMed: 20881881]

Milani RV, Lavie CJ, Mehra MR, Ventura HO. Impact of exercise training and depression on survival in heart failure due to coronary heart disease. American Journal of Cardiology. 2011; 107:64–68. [PubMed: 21146688]

Murberg TA, Bru E. Social relationships and mortality in patients with congestive heart failure. Journal of Psychosomatic Research. 2001; 5:521–627. [PubMed: 11602222]

Nikander R, Sievanen H, Ojala K, Oivanen T, Kellokump-Lehtinen PL, Saarto T. Effect of a vigorous aerobic regimen on physical performance in breast cancer patients—a randomized controlled pilot trial. Acta Oncologica. 2007; 46:181–186. [PubMed: 17453366]

O'Connor CM, Whellan DJ, Lee KL, Keteyian SJ, Cooper LS, Ellis SJ, Pina IL. Efficacy and safety of exercise training in patients with chronic heart failure. HF- ACTION randomized controlled trial. The Journal of the American Medical Association. 2009; 301:1439–1450.

Oka RK, Gortner SR, Stotts NA, Haskell WL. Predictors of physical activity in patients with chronic heart failure secondary to either ischemic or idiopathic dilated cardiomyopathy. American Journal of Cardiology. 1996; 77:159–163. [PubMed: 8546084]

Ormel J, VonKorff M, Üstün TB, Pini S, Korten A, Oldehinkel AJ. Common mental disorders and disability across cultures: Results from the WHO collaborative primary care study. Journal of American Medical Association. 1994; 272:1741–1748.

Paukert AL, Pettit JW, Kunik ME, Wilson N, Novy DM, Rhoades HM, Stanley MA. The roles of social support and self-efficacy in physical health's impact on depressive and anxiety symptoms in older adults. Journal of Clinical Psychology in Medical Settings. 2010; 17:387–400. [PubMed: 21110074]

Pereira MA, Fitzgerald SJ, Gregg EW, Joswiak ML, Ryan WJ, Suminski RR, Smuda JM. A collection of physical activity questionnaires for health related research. Medicine and Science in Sports and Exercise. 1997; 29:S1–S205. [PubMed: 9243481]

Peterson PN, Shetterly SM, Clarke C, Bekelman DB, Chan PS, Allen LA, Matlock DD, Magid DJ, Masoudi FA. Health literacy and outcomes among patients with heart failure. The Journal of the American Medical Association. 2011; 305:1695–1701.

Petter M, Blanchard C, Kemp KAR, Mazoff AS, Ferrier SN. Correlates of exercise among coronary heart disease patients: review, implications and future directions. Journal of Cardiovascular Prevention and Rehabilitation. 2009; 16:515–526.

Piña IL, Fitzpatrick JT. Exercise and heart failure. A Review. Chest. 1996; 110:1317–1327.

Pitta F, Troosters T, Spruit MA, Probst VS, Decramer M, Gosselink R. Characteristics of physical activities in daily life in chronic obstructive pulmonary disease. American Journal of Respiratory and Critical Care Medicine. 2005; 171:972–977. [PubMed: 15665324]

Pullicino PM, Wadley YG, McClure LY, Safford MM, Lazar RM, Klapholz M, Howard G. Factors contributing to global cognitive impairment in heart failure: Results from a population-based cohort. Journal of Cardiac Failure. 2008; 14:290–295. [PubMed: 18474341]

Riegel B, Carlson B. Facilitators and barriers to heart failure self-care. Patient Education and Counseling. 2002; 46:287–295. [PubMed: 11932128]

Rikli, RE.; Jones, CJ. Senior Fitness Test Manual. Human Kinetics; Champaign, IL: 2001.

Schnell-Hoehn KN, Naimark BJ, Tate RB. Determinants of self- care behaviors in community-dwelling patients with heart failure. Journal of Cardiovascular Nursing. 2009; 24:40–47. [PubMed: 19114800]

Seo Y, Roberts BL, Pina I, Dolansky M. Predictors of motor tasks essential for daily activities among persons with heart failure. Journal of Cardiac Failure. 2008; 14:296–302. [PubMed: 18474342]

Simson U, Nawarotzky U, Friese G, Porck W, Schottenfeld-Naor Y, Hahn S, Scherbaum WA, Kruse J. Psychotherapy intervention to reduce depressive symptoms in patients with diabetic foot syndrome. Diabetic Medicine. 2008; 25:206–212. [PubMed: 18290863]

Skotzko CE, Krichten C, Zietowski G, Alves L, Freudenberger R, Robinson S, Gottlieg SS. Depression is common and precludes accurate assessment of functional status in elderly patients with congestive heart failure. Journal of Cardiac Failure. 2000; 6:300–305. [PubMed: 11145754]

Spaderna H, Zahn D, Schleithoff SS, Stadlbauer T, Rupprecht L, Smits JMA, Weidner G. Depression and disease severity as correlates of everyday physical activity in heart transplant candidates. Transplant International. 2010; 23:813–822. [PubMed: 20158693]

Spreen, O.; Strauss, E. A Compendium of Neuropsychological Tests. Oxford University Press; New York: 1991.

Stanek KM, Gunstad J, Spitznagel MB, Waechter D, Hughes JW, Luyster F, Rosneck J. Improvements in cognitive function following cardiac rehabilitation for older adults with cardiovascular disease. International Journal of Neuroscience. 2011; 121:86–93. [PubMed: 21062215]

Steele BG, Belza B, Cain K, Warms C, Coppersmith J, Howard J. Bodies in motion: monitoring daily activity and exercise with motion sensors in people with chronic pulmonary disease. Journal of Rehabilitation Research and Development. 2003; 40:45–58. [PubMed: 15074453]

Steele BG, Holt L, Belza B, Ferris S, Lakshminaryan S, Buchner DM. Quantitating physical activity in COPD using a triaxial accelerometer. Chest. 2000; 117:1359–1367. [PubMed: 10807823]

Tagney J, James JE, Albarran JW. Exploring the patient's experi- ences of learning to live with an implantable cardioverter defibrillator (ICD) from one UK centre: a qualitative study. European Journal of Cardiovascular Nursing. 2003; 2:195–203. [PubMed: 14622627]

Tierney S, Elwers H, Sange C, Mamas M, Rutter MK, Gibson M, Deaton C. What influences physical activity in people with heart failure? A qualitative study. International Journal of Nursing Studies. 2011a doi:10.1016/j.ijnurstu.2011.03.003.

Tierney S, Mamas M, Skelton D, Woods S, Rutter MK, Gibson M, Deaton C. What can we learn from patients with heart failure about exercise adherence? A systematic review of qualitative papers. Health Psychology. 2011b Advance online publication. doi: 10.1037/a0022848.

Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. Medicine and Science in Sports and Exercise. 2007; 40:181–188. [PubMed: 18091006]

Tudor-Locke C, Bassett DR Jr. How many steps/day are enough? Preliminary pedometer indices for public health. Sports Medicine. 2004; 34:1–8. [PubMed: 14715035]

Tudor-Locke C, Johnson WD, Katzmarzyk PT. Accelerometer-determined steps/day in U.S. adults. Medicine and Science in Sports and Exercise. (in press).

van der Wal MH, Jaarsma T, Moser DK, van Veldhuisen DJ. Development and testing of the Dutch Heart Failure Knowledge Scale. European Journal of Cardiovascular Nursing. 2005; 4:273–277. [PubMed: 16126459]

VonKorff, M. Disability and psychological illness in primary care. In: Tansella, M.; Thornicroft, G., editors. Common mental disorders in primary care. Routledge; London: 1999. p. 52-65.

Ware JE, Kosinski M, Keller SD. A 12-item short-form health survey: Construction of scales and preliminary tests of reliability and validity. Medical Care. 1996; 34:220–233. [PubMed: 8628042]

Yu DSF, Lee DTF, Woo J, Thompson DR. Correlates of psychological distress in elderly patients with congestive heart failure. Journal of Psychosomatic Research. 2004; 57:573–581. [PubMed: 15596164]

Table 1

Demographic, Medical, and Clinical Characteristics of 96 Older Adults with Heart Failure

Demographic Characteristics	
Age, mean (SD)	69.81(8.79)
Sex (% Women)	36.5
Race (% Caucasian)	86.5
Education, mean years (SD)	13.54(2.62)
Medical Characteristics	
CABG/Bypass Surgery (%)	38.5
Diabetes (%)	28.1
Hypertension (%)	63.5
Myocardial Infarction (%)	59.4
2-minute step test, mean (SD)	63.96(20.91)
Test Performance, mean (SD)	
Beck Depression Inventory-II	8.34(7.79)
SF-12 Physical Component Scale	40.62(10.86)
SF-12 Mental Component Scale	51.62(10.99)
Mini Mental State Examination	28.01(1.68)
Trail Making Test A (seconds)	39.73(13.57)
Trail Making Test B (seconds)	109.83(49.96)

Table 2

Objectively Measured Physical Activity in Older Adults with HF ($N = 96$)

Activity Level	
Wear Time, mean (SD)	820.00(79.36)
Daily Step Count, mean (SD)	3,677.44(2121.16)
Light Intensity, median (IQR)	212.42(99.15)
Matthew's Moderate Intensity, median (IQR)	41.07(40.86)
Freedson Moderate Intensity, median (IQR)	3.24(9.00)
Vigorous Intensity, median (IQR)	0.00(0.00)
Sedentary Time, median (IQR)	584.33(96.23)

Note. Wear Time = Average minutes per day of accelerometer wear; Daily Step Count = Average daily steps per day; Light Intensity = Average minutes per day of light intensity activity; Matthew's Moderate Intensity = Average minutes per day of free-living moderate intensity activity; Freedson Moderate Intensity = Average minutes per day of moderate exercise intensity activity; Vigorous Intensity = Average minutes per day of vigorous intensity activity; Sedentary Time = Average minutes per day of sedentary time

Table 3

Predictors of Daily Step Count in Older Adults with Heart Failure (*N* = 96)

	Daily Step Count		
Variable	*B*	*SE B*	*t*
Model 1 (R^2 = .09)			
Age	−45.62	24.30	−1.88 †
Gender (1 = Males, 0 = Females)	−235.09	446.05	−.53
Education (years)	173.13	82.65	2.10 *
Model 2 (R^2 = .13)			
2MST	.45	10.51	0.04
Hypertension	−382.91	457.19	−0.84
MI	−2.16	468.89	−0.01
CABG	−789.67	472.89	−1.67
Diabetes	−221.33	488.06	−0.45
Model 3 (R^2 = .19)			
BDI-II	−64.35	27.79	−2.32 *

* *Notes*. denotes $p < 0.05$

† denotes $p = .064$

Abbreviations: b – unstandardized –coefficients; SE – standard error; 2MST = 2-minute step test; MI = Myocardial infarction; CABG = Coronary Artery Bypass Graft Surgery; BDI-II = Beck Depression Inventory-II

Table 4

Means and Standard Deviations (Means(SD)) of Psychosocial Outcomes for levels of Physical Activity

Physical Activity	***N***	**MMSE**	**TMT-A (seconds)**	**TMT-B (seconds)**	**SF-12 PCS**	**SF-12 MCS**
Sedentary	31	27.48(1.63)	42.35(15.44)	115.16(53.44)	34.64(9.36)	51.62(11.76)
Limited	44	28.43(1.44)	37.27(11.90)	114.57(53.03)	40.56(10.06)	50.48(11.36)
Active	21	27.90(2.02)	41.00(13.65)	92.05(33.20)	49.56(8.52)	54.02(8.99)

Note. MMSE: Sedentary is significantly different from limited ($p < .05$); SF-12 PCS: Sedentary is significantly different from limited and active, and limited is significantly different from active ($p < .05$)

Abbreviations: MMSE = Mini Mental State Examination; TMT-A = Trail Making Test A; TMT-B = Trail Making Test B; SF-12 PCS = SF-12 Physical Component Score; SF-12 MCS = SF-12 Mental Component Score