Published in final edited form as:

Biol Res Nurs. 2015 May ; 17(3): 276–284. doi:10.1177/1099800414541961.

Fatigue and Physical Activity After Myocardial Infarction

Patricia B. Crane, PhD, RN, FAHA, FNAP¹, Willie M. Abel, PhD, RN, ACNS-BC², and Thomas P. McCoy, MS, PStat®³

¹Adult Health Department, The University of North Carolina at Greensboro, Greensboro, NC, USA

²School of Nursing, The University of North Carolina at Charlotte, Greensboro, NC, USA

³Community Practice Department, The University of North Carolina at Greensboro, Greensboro, NC, USA

Abstract

Background—Fatigue is prevalent after myocardial infarction (MI) and is a barrier to physical activity (PA). Because PA is an important health behavior in preventing or delaying recurrent MIs, examining the influence of biophysical markers and fatigue on PA is important as a prerequisite to developing effective interventions.

Objective—This study compared PA in 34 men and 38 women, aged 65 and older, 6–8 months post MI, and examined the influence of biophysiological measures and fatigue on PA in this sample.

Methods—Using a cross-sectional descriptive correlational design, adults completed a demographic form that included documentation of blood pressure, heart rate, height and weight; the Revised Piper Fatigue Scale (RPFS), and the Community Healthy Activities Model Program for Seniors Physical Activity Questionnaire for Older Adults, and blood collection for measurement of hemoglobin (Hgb), interleukin-6, and B-natriuretic peptide.

Results—There were no differences in frequency of PA between older men and older women; however, men reported a higher intensity of PA ($p = .011$). When controlling for sex, age, and biophysiological measures, the RPFS significantly explained 16% of the variance in the frequency of PA ($p = .03$), with no individual subscale serving as a significant predictor. The RPFS behavior/severity subscale explained 31% of the variance in energy expended on all PA ($p < .001$) and 40% of the variance in energy expended on moderate-intensity PA ($p < .001$).

Conclusion—The older adults participating in this study did not participate in the recommended levels of PA, and fatigue significantly influenced PA post MI.

Keywords

myocardial infarction; physical activity; biophysical

Reprints and permissions: sagepub.com/journalsPermissions.nav

Corresponding Author: Patricia B. Crane, PhD, RN, FAHA, FNAP, Adult Health Department, The University of North Carolina at Greensboro, PO Box 26170, Greensboro, NC 27402, USA. pbcrcane@uncg.edu

Declaration of Conflicting Interests: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Participation in physical activity (PA) to improve cardiovascular fitness is an important behavior for controlling or reducing cardiovascular risk factors, such as obesity and hypertension, and preventing or delaying recurrent myocardial infarctions (MIs; Chomistek, Chiueve, Jensen, Cook, & Rimm, 2011; Fleg et al., 2013). An estimated 27% ($n = 190,000$) of the 715,000 MIs that occur annually in the United States are recurrent (American Heart Association [AHA], 2013), and the average hospital cost for an MI is US\$18,200 (Pfuntner, Wier, & Steiner, 2013). If a recurrent MI could have been delayed or prevented in 10% of those who had an MI last year, then approximately 71,500 persons would have benefited, resulting in US\$1.3 billion savings in hospital costs alone.

Research indicates that even small increases in PA yield health benefits, including reduction in the risk of MI (Fleg et al., 2013; D. Lee et al., 2011; J. L. Smith et al., 2013) and an increase in survival rate similar to that of pharmacological interventions post MI (Boden, Franklin, & Wenger, 2013). The incidence of MI increases with age (AHA, 2013), yet only 35% of older adults meet the Center for Disease Control and Prevention's (CDC's) recommended PA goals (National Center for Health Statistics, 2013). Further, there are differences in levels of participation in PA by sex, with women reporting more inactivity and sedentary time than that of men (AHA, 2013; Healy, Matthews, Dunstan, Winkler, & Owen, 2011). Despite this difference, Dai, Wang, and Morrison (2014) noted that as the health of both men and women declined, their PA level decreased. Therefore, encouraging adequate PA after an MI in both men and women is an efficacious way of promoting health and wellness in older adults and decreasing health care costs.

The recent guidelines for secondary prevention of atherosclerotic cardiovascular disease in older adults (Fleg et al., 2013) note that lack of PA in older adults compounds age-related changes associated with cardiovascular disease. PA is defined as any bodily movement that increases energy expenditure above the basal metabolic rate, and it should be performed at an intensity level that offers health benefits. Cardiovascular fitness, an indicator of effective PA, is a measure of the ability of the heart and other organs to deliver oxygen (O_2) to working muscles during PA and may be expressed in peak metabolic equivalents (METs). One MET = 3.5 ml O_2 /kg/min or 1 kcal/kg/hr, which is the energy required to sit quietly (Ainsworth et al., 2000). Recommendations from the American Association of Sports Medicine and the AHA on PA and cardiovascular disease support the performance of moderate-intensity PA (3.0–4.0 METs), such as brisk walking, for at least 30 min most days of the week in addition to daily activities for adults of all ages (S. C. Smith et al., 2011). However, less than a third of those with known coronary heart disease meet this recommendation (Zhao, Ford, Li, & Mokdad, 2008).

One of the reasons people cite most frequently for not participating in PA is fatigue (Brownson, Baker, Housemann, Brennan, & Bacak, 2001; King et al., 2000; Reichert, Barros, Domingues, & Hallal, 2007). Persons reporting fatigue are almost 4 times more likely to report an insufficient amount of PA compared to those without fatigue (Resnick, Carter, Aloia, & Phillips, 2006). When examining personal and environmental factors associated with PA in middle-aged and older women from diverse racial groups, researchers found that fatigue was the third most frequently reported barrier and the first symptom associated with barriers reported (King et al., 2000).

Fatigue is the most common symptom reported 5 months after MI (Brink, Karlson, & Hallberg, 2002), and older adults' participation in PA post MI is negatively influenced by fatigue (Crane, 2005; Crane & McSweeney, 2003). Patients have described the impact of post-MI fatigue on their ability to carry out even daily activities as “paralyzing,” “restricting,” and “incomprehensible” (Alsen, Brink, & Persson, 2008). However, in many studies examining fatigue in heart disease, researchers have either used unidimensional measures of fatigue (Brink & Grankvist, 2006; Fitzpatrick, Reed, Goldberg, & Buchwald, 2004) or have not clearly reported how the multi-dimensions of fatigue affect outcomes such as PA.

Biophysiological factors, such as aging, anemia, inflammation, and cardiac function, are associated with subjective fatigue, especially in older adults after MI, and may indirectly influence participation in PA. Fatigue has been associated with aging (Liao & Ferrell, 2000); thus, aging may be a covariate of persistent fatigue post MI. Because the incidence (Beghe, Wilson, & Ershler, 2004) and prevalence (Guralnik, Eisenstaedt, Ferrucci, Klein, & Woodman, 2004) of anemia increase with age and fatigue is a symptom of anemia, it is important to consider hemoglobin (Hgb) levels as a measure of anemia when exploring the causes of fatigue in older adults. The cytokines interleukin (IL)-1 β , IL-6, and tumor necrosis factor (TNF)- α decrease red blood cell production (Ershler, 2003), and increased levels of IL-6 are also associated with fatigue and aging (Michaud et al., 2013). Thus, measuring a selected pro-inflammatory marker (IL-6) to examine its effect on fatigue and PA post MI in older adults is also important. Cardiac function post MI may also affect fatigue and PA. Given that β -blockers are a Class I therapeutic recommendation post MI and that a side effect of β -blockers is a decreased heart rate, it also makes sense to measure blood pressure and heart rate when exploring the associations between fatigue and PA (S. C. Smith et al., 2011). Finally, a damaged myocardium after an MI, coupled with decreased heart rate and blood pressure, may significantly decrease cardiac function and contribute to persistent fatigue. B-natriuretic peptide (BNP), a serum biomarker for cardiac function, serves as an indicator of increased pressure or fluid overload in the cardiac ventricles and, thus, of heart failure (Maisel, 2002). This marker is also important to monitor when examining fatigue and PA in older adults post MI.

PA is an important secondary preventive behavior after an MI. Because fatigue is a prevalent symptom post MI and may significantly influence both the frequency and the intensity of PA, the purposes of this study were to compare PA in older men and women 6–8 months post MI and to examine the influence of selected biophysiological measures and fatigue on participation in PA in this study population.

Method

In this cross-sectional, descriptive study, we recruited a convenience sample of 49 men and 49 women from a tertiary care medical center in a central mid-Atlantic state. Only those who reported fatigue after their MI (i.e., scored > 0 on the Revised Piper Fatigue Scale [RPFS]) and had complete biophysiological data were included in this analysis ($N = 72$).

Eligibility criteria included age 65 or older and a diagnosis of acute MI (new or recurrent) validated by International Classification of Diseases-9 code and verbally confirmed by each participant. Exclusion criteria included (1) a memory deficit, operationalized as a score of 6 or higher on the Abbreviated Mental Test, a 10-item test measuring orientation, attention, and recent and remote memory (Jitapunkul, Pillay, & Ebrahim, 1991); (2) antidepressant medication (for treatment of depression only); (3) major surgery affecting inflammation (surgery within 6 months prior to recruitment and requiring a minimum of 24-hr hospitalization); and (4) chemotherapy (within the 12 months prior to recruitment). Participants were recruited by a study coordinator from the participating medical center via telephone contact 5 months after a patient's MI. The principal investigator or research assistant contacted patients who provided verbal consent to screen for eligibility and provided additional information about the study. Research staff visited those who were eligible and who verbally consented in their preferred location (their home or other site) to obtain written study consent and collect data. Data collection lasted approximately 60–90 min. The appropriate institutional review boards approved the study protocol.

Measures

Data collection included completion of the Demographic Health Status questionnaire, which, along with demographic information, comprised documentation of the following measurements: blood pressure, heart rate, height and weight for the calculation of body mass index (BMI), and venous blood collection (for measurement of Hgb, IL-6, and BNP levels). Participants also completed the RPFS (Piper et al., 1998) and the Community Healthy Activities Model Program for Seniors (CHAMPS) Physical Activity Questionnaire for Older Adults (Stewart et al., 2001).

Height and weight were measured using a portable sta-diometer and standardized scales. BMI was calculated by dividing the weight in kilograms by height in meters squared. A sample of venous blood was obtained, prepared according to standardized procedures, and analyzed by a certified laboratory for each individual. Mean arterial blood pressure (MAP) was calculated by summing the systolic blood pressure and 2 times the diastolic blood pressure and dividing this sum by 3. The heart rate was obtained by counting the radial pulse for 1 min.

The RPFS is a 22-item instrument designed to capture four dimensions of subjective fatigue: (1) the behavioral/severity subscale explores the extent to which fatigue causes distress or interferes with enjoyable activities such as socialization with friends; (2) the affective meaning subscale relates to the emotional meaning of fatigue and includes items such as the choice to describe the fatigue as protective or destructive or as positive or negative; (3) the sensory subscale comprises descriptors of physical sensations associated with fatigue such as strong or weak, awake or sleepy, and lively or listless; and (4) the cognitive/mood subscale describes how fatigue affects thinking processes and mood state with terms such as *exhilarated* or *depressed*. The 22 items of the RPFS are self-rated on a 0–10 Likert-type scale with anchors at each end. All of the 22 items are used to calculate the total fatigue score that ranges from 0 to 220. To place the total RPFS score on a 10-point scale, the total score is divided by 22. Each of the subscales is individually totaled and divided by the

number of items in the subscale to also place these scores on a 10-point scale. Higher scores indicate increased fatigue.

Prior to administering the RPFS, we presented participants with a single item that asked whether they had experienced fatigue, tiredness, and/or exhaustion (all synonyms of fatigue) after their MI that they would report as different from fatigue they were experiencing prior to their MI. If the participant responded yes, then they completed the scale according to the fatigue they had experienced in the last 4 weeks. Participants who indicated that they had experienced no difference in fatigue before and after their MI did not complete the scale and were given a score of 0.

The RPFS has acceptable reliability and validity (Piper, 1997; Piper et al., 1998) and has been used in older adults with cardiovascular disease (Crane, 2005; Liao & Ferrell, 2000; Varvaro, Sereika, Zullo, & Robertson, 1996). We chose this tool over other measures of fatigue because of the multidimensionality of the instrument, validation in older populations, and the biopsychosocial assessment of fatigue (behavioral, affective, sensory, and cognitive). The RPFS took approximately 10–15 min to complete, and the Cronbach's α for the RPFS subscales in this study ranged from .87 to .94.

PA was measured using the CHAMPS Physical Activity Questionnaire for Older Adults, a self-report questionnaire consisting of 41 items that address PAs relevant to older adults, which are categorized as light activity (walking leisurely or light gardening), moderate-intensity activity (brisk walking or heavy gardening), or vigorous activity (running or tennis; Stewart et al., 2001). Respondents report frequency and duration of PA for a typical week in the past month for all items. Scoring yields measures for (1) frequency of PA in number of times respondent participated in the activity per week, (2) kilocalories expended per week in all types of PA, and (3) kilo-calories expended in only those activities classified as meeting or exceeding moderate-intensity standards (Harada, Chiu, King, & Stewart, 2001). The final question on the instrument asks whether the respondent participates in other types of PA not previously mentioned on the tool. The tool was developed to be valid, reliable, and sensitive to changes in older adults and designed to maximize recall of PA while minimizing social-desirability responses. The instrument took approximately 10–15 min to complete.

Data Analyses

An a priori power analysis revealed that a sample of 54 would provide 80% power to detect a .20 R^2 at a .05 significance level with four normally distributed independent variables (four subscales of the RPFS). Demographic variables were analyzed using descriptive and univariate statistics. Discrete variables were summarized with percentages, and continuous variables were summarized with means and standard deviations (SDs). Bivariate relationships among the variables between men and women were examined using t -tests and Pearson's correlations.

Multiple linear regression was used to examine whether fatigue, operationalized as the four subscales of the RPFS, was associated with participation in PA, while controlling for sex, age, and biophysiological measures of BNP, IL-6, MAP, Hgb, heart rate, and BMI. To meet the assumptions for multiple regression analysis, all the dependent variables (frequency of

PA, sum of kilocalories expended on all PA, and sum of kilocalories expended on moderate-intensity PA) were checked for normality as well as regression residuals, and appropriate transformations were made using square root (Tabachnick & Fidell, 1996). Additionally, log transformations for BNP and IL-6 were performed prior to regression analysis. Graphical assessments of box plots and scatter plots were used to visually examine the data, and one significant outlier was identified. Regression models were conducted with and without this case. Because the regression coefficients did not significantly change, the case was retained for final analyses. All collinearity statistics, including the variance inflation factor and tolerance, were assessed and deemed acceptable. A two-sided p value $< .05$ was considered to be statistically significant. All analyses were performed using Statistical Package for the Social Sciences for Windows, version 19 (SPSS Inc., Chicago, IL).

Results

A total of 34 men and 38 women ($N = 72$) reported fatigue after their MI that they perceived as different from fatigue prior to their MI. Table 1 presents participant characteristics by sex. The mean age of the entire sample was 76.3 years ($SD = 6.49$). The sample was primarily Caucasian (83%). The only significant difference between men and women was in marital status. The majority of men were married ($\chi^2 = 13.05$; $p < .01$), whereas the majority of women were single (divorced, separated, or widowed). Most participants had at least a ninth-grade education, but more men than women had 8 years or less of education, and more women had postsecondary education. The majority of participants reported an annual income of less than \$30,000. The mean BMI for the sample as a whole was 27.9 ($SD = 5.06$), and 29% of men and 36% of women were classified as obese, with a BMI greater or equal to 30 (see Table 1).

The mean frequency of PA was 12.4 ($SD = 9.33$) times per week (range = 0–44). Frequency of PA did not differ significantly between men and women ($t = .325$; $p = .746$). Most (97%) men and women reported participating in some type of PA, and 74% reported participating in some moderate-intensity PA. Total kilocalories expenditures were higher in men ($M = 2,993.93$ kcal; $SD = 2,888.18$) compared to women ($M = 1,528.68$ kcal; $SD = 1,541.40$), and this difference was significant ($t = 2.654$; $p = .011$). Men also reported significantly more moderate-intensity PA than women reported ($t = -3.519$; $p = .002$). Only eight men, as compared to 19 women, reported no moderate-intensity PA, and 35% of men and 60% of women did not meet the lowest recommended level of moderate-intensity PA, which is 525 kcal per week.

Women had a lower mean total RPFS score compared to men (81 [$SD = 50$] and 94 [$SD = 44$], respectively), but this difference was not significant ($t = 1.16$; $p = .25$). When standardizing the fatigue scores on a 10-point scale, women had a mean total fatigue score of 3.7 ($SD = 2.28$) compared to 4.28 ($SD = 1.99$) for men. Scores for all of the subscales of the RPFS, except for the cognitive/mood subscale, correlated negatively with PA energy expenditure and frequency of PA. Significant correlations ranged from $-.448$ ($p < .001$) to $-.240$ ($p < .05$).

Influence of Fatigue on Frequency of PA

Performing multiple linear regression modeling with blockwise steps, we entered sex and age into the first block (Model 1) and the biophysiological measures (BNP, IL-6, MAP, Hgb, heart rate, and BMI) into the second block (Model 2). Neither model significantly explained frequency of participation in PA. When we added the four subscales of the RPFS into the regression, the final model significantly explained 16% of the variance in the frequency of PA ($F = 2.111$ [12, 59]; $p = .030$); however, none of the fatigue subscales were significant on their own (see Table 2).

Influence of Fatigue on Energy Expenditure for All PA

Using multiple linear regression analysis, we entered sex and age into the first block, biophysiological measures (BNP, IL-6, MAP, Hgb, heart rate, and BMI) into the second block, and the four subscales of the RPFS into the third block. Sex and age explained 12% of the variance in energy expenditure on all PA ($F = 5.845$ [2, 69]; $p = .005$). Sex, age, and biophysiological measures explained 18% of the variance in energy expenditure on all PA ($F = 2.952$ [8, 63]; $p = .007$). When adding the four subscales, the final model explained 31% (adjusted R^2) of the variance in energy expenditure on all PA ($F = 3.696$ [12, 59]; $p < .001$). Sex and Hgb significantly explained energy expenditure on all PA in the first and second blocks. When controlling for sex, age, and the biophysiological measures, only sex ($p = .001$) and the behavior/severity subscale ($p = .002$) were significant variables contributing to the final model (see Table 2), with fatigue behavior/severity having the largest standardized β , indicating that it is the strongest predictor of energy expenditure on all PA.

Influence of Fatigue on Energy Expenditure on Moderate-Intensity PA

Using the multiple linear regression analysis, we again entered sex and age into the first block and biophysiological measures into the second block (Models 1 and 2). The four RPFS sub-scales were added into the third block (Model 3). The dependent variable was transformed energy expenditure on moderate-intensity PA. Model 1 explained 16% of the variance ($F = 7.974$ [2, 69]; $p = .001$), Model 2 explained 21% (adjusted R^2) ($F = 3.312$ [8, 63]; $p = .003$), and Model 3 explained 40% of the variance in energy expenditure on moderate-intensity PA ($F = 4.967$ [12, 59]; $p < .001$). Sex and heart rate were the only significant variables in Model 2, and sex ($p < .001$) and the behavior/severity subscale ($p = .001$) were the only significant variables in the final model (see Table 2).

Correlations Between the Behavioral/Severity RPFS Subscale Items and PA

Because the behavioral/severity subscale of the RPFS was the only subscale to significantly predict energy expenditure on all and moderate-intensity PA, we explored the 6 individual items of this subscale using Pearson's correlations. Fatigue that interfered with completing work or activities, the ability to socialize, sexual activity, and the ability to participate in enjoyable activities were negatively correlated with the number of kilocalories expended on all PA and moderate-intensity PA and with the frequency of PA (Table 3). Intensity or severity of the fatigue was also negatively correlated with energy expended on all and moderate-intensity PA and with frequency of PA. The degree of distress associated with fatigue, however, did not significantly correlate with any of the PA variables.

Discussion

The majority of older adults in this study reported participating in some type of PA. More than twice the number of women compared to men reported participating in no moderate-intensity PA. The recommended amount of PA for older adults is 2.5 hr of moderate-intensity PA weekly in addition to their normal daily activities, and the moderate PA should use 3.5 to 7 kcal each minute (Centers for Disease Control and Prevention [CDC], 2011). Based on the lowest recommendation of using 3.5 kcal per min for 2.5 hr, a person should expend at least 525 kcal on PA per week. Almost twice the proportion of women compared to men, 60% versus 35%, did not meet this lowest recommended level of kilocalories per week. This finding is even more concerning in light of other research indicating that utilization of 1,000–1,500 kcal is required to achieve greater health benefits (CDC, 2011; Schairer, Keteyian, Ehrman, Brawner, & Berkebile, 2003).

Our findings are consistent with those of Barnes, Yaffe, Satariano, and Tager (2003) indicating that women are less likely than men (28.5% vs. 35.4%) to engage in regular leisure-time PA or a high level of overall PA (16.9% vs. 21.3%). Furthermore, women are more likely than men (11.6% vs. 7.3%) to never engage in any PA. In this study, it appears that women were either not participating in activities at a level that would qualify the activity as moderate intensity or they did not participate in the types of activity that are categorized as moderate intensity on the CHAMPS. Although research has identified psychosocial and cultural factors that influence lifestyle behavior choices among women, there is little evidence that adequately explains differences in PA patterns between men and women (Zoeller, 2008). Additional investigation is thus needed to understand how older adults, especially women, choose the type and intensity of PA in which they will participate post MI. Such an understanding would assist researchers and caregivers in designing interventions that are sustainable and effective in improving health post MI.

We found a negative relationship between age and energy expenditure on PA in participants reporting fatigue after their MI in this study, indicating that those who were the oldest had the least amount of PA. However, the majority of participants in this sample had both low frequency of and low energy expenditure on PA levels regardless of age or sex. This finding is concerning because PA plays an important role in preventing recurrent MIs and other cardiovascular events such as heart failure and stroke (Schocken et al., 2008, S. C. Smith et al., 2011). In fact, there is evidence that regular low- or moderate-intensity exercise is associated with improvement in cardiovascular risk factors and development of physiological functional capacity, even in previously sedentary older adults (Mazzeo & Tanaka, 2001).

Even small increases in PA levels can have an effect. In a study of the long-term effects of cardiorespiratory fitness, D. Lee et al. (2011) found that a one-MET increase in activity was associated with a decrease of up to 19% in the risk of mortality due to cardiovascular disease independent of any change in BMI (D. Lee et al., 2011). In a recent viewpoint published in the *Journal of the American Medical Association*, the authors noted that “exercise is medicine,” is underutilized in secondary prevention, and should be considered a first-line therapy in patients with stable ischemic heart disease (Boden et al., 2013). Thus, while

increases in PA should be encouraged in all populations, it is of utmost importance in those who have had an MI.

When examining the biological measures influencing PA, we were surprised to find that BNP, our biomarker for cardiac function, was not significantly related to fatigue. Up to 31% of adults aged 65 and over are expected to develop heart failure within 5 years after their first MI (AHA, 2013), and fatigue is a common symptom associated with heart failure. While further studies are needed to understand fatigue post MI, this finding suggests that clinicians should consider the possibility that post-MI fatigue may be related to something other than cardiac function.

Heart rate was the only biophysical measure to significantly contribute to PA in our models in this study, specifically to energy expended on moderate-intensity PA. In healthy populations, a low resting heart rate is correlated with physical fitness. However, a large majority of our participants (81%) were taking β blockers that lower the heart rate and are reported to contribute to exercise intolerance (Jorde et al., 2007). Further investigations of heart rate, the effect of β blockers, and participation in PA are needed.

Our study population comprised older adults who reported experiencing some level of fatigue post MI that felt different than any fatigue they may have experienced prior to MI. Within the first-year post MI, more than 25% of individuals experience functional decline, regardless of their age, and those who report this decline are almost twice as likely to also report fatigue (Arnold et al., 2009). In a previous study, Liao and Ferrell (2000) used the RPFS to examine fatigue in a community sample of older adults ($N = 199$), primarily women (82%). The authors used scores on the RPFS to categorize the fatigue as mild, moderate, or severe. The vast majority of their participants reported experiencing fatigue; however, only 33% reported fatigue lasting 1–12 months. If we apply Liao and Ferrell's fatigue categories to the older, post-MI participants in this study and then compare the two populations, we find that 39% of our participants had mild fatigue compared to 51% of the community sample, 51% of our participants had moderate fatigue compared to 40% of the community sample, and 10% of our participants had severe fatigue compared to 7% of the community sample. In another study, H. Lee, Kohlman, Lee, and Schiller (2000), utilizing a visual analogue fatigue scale, also noted a high level of moderate fatigue with wide variability among patients in the first few weeks post MI ($N = 22$; mean age = 54 years; range 31–77 years). Fatigue lasting 6–8 months post MI, as it did with the participants in this study, is concerning as it affects, not only participation in PA but also quality of life.

Standardized measures to identify clinically significant levels of fatigue in older adults with cardiovascular disease are lacking. In fact, we found no other studies that used the RPFS to measure fatigue post MI, so that we could compare the variability in fatigue scores. The high *SDs* for the fatigue scores in this study may be attributed to the heterogeneity of a geriatric population, the subjective perception of fatigue, and the impact fatigue may have had on participants' behavior, senses, affect, cognition, and mood.

We also found no prior studies in which the subscales of the RPFS were correlated to participation in PA. In this study, only one of the RPFS subscales, cognitive/mood, did not

correlate with PA. Items in this subscale focus on concentration, memory, and mood states such as patience or relaxation and exhilaration or depression. This result was surprising because depressed mood states are associated with decreased PA (Strawbridge, Deleger, Roberts, & Kaplan, 2002). Our results may be sample-specific or may be associated with PA at a certain frequency and level of intensity. Conversely, the behavioral/severity subscale of the RPFS was the only subscale that significantly influenced PA in the multivariate model. When we examined the 6 items of this subscale, we found that fatigue that interfered with the respondents' ability to socialize had the strongest correlation to energy expenditure for all and moderate-intensity PA. We found it surprising that severity or intensity of fatigue did not have the strongest correlation with PA. Further investigation into why fatigue that interferes with socializing may influence participation in PA more than the severity or intensity of fatigue is warranted.

Older men and women reported similarly high levels of fatigue after MI, yet men engaged in significantly more moderate-intensity PA than women. These findings suggest that factors other than fatigue are contributing to the difference in PA between older men and women post MI. The relative contribution of fatigue to participation in PA in comparison to other biopsychological variables is not well understood and warrants further research.

Limitations

Because of the cross-sectional design of this study, we cannot make inferences regarding causal direction between biophysiological variables and fatigue and PA. Also, the lack of comparison of pre-MI data necessitates the use of caution when interpreting fatigue scores. Participants may have developed multiple adaptive behaviors to fatigue over time. The perception of fatigue 6–8 months post MI may also have undergone a response shift (Visser, Smets, Sprangers, & deHaes, 2000), resulting in a change in internal standards for appraising fatigue, which can lead to reframing and minimizing the negative aspects or intensity. Likewise, expectations for participation in PA may have been adjusted after MI, leading to decline in the type, frequency, intensity, and duration of PA or substitution of activities that are less fatiguing or require less exertion. Future prospective studies examining fatigue and PA both prior to and post MI at multiple time points are needed to explore the trajectory of fatigue and its consequences on the frequency and intensity of PA of older adults post MI.

Most of the participants in this study were taking antiplatelet agents and having their lipids managed. These medications may have influenced the level of the inflammatory marker (IL-6; Pahan, 2006). Also, though a previous systematic review noted a consistent pattern between self-report and direct measures of PA (Prince et al., 2008), it is possible that self-reported type, intensity, and frequency of PA may not have accurately reflected actual energy expenditure in this study. Studies utilizing a combination of self-report and direct measures of PA, such as pedometers and accelerometers, may provide more accurate estimates. Finally, while this small sample provided preliminary evidence about the relationship of fatigue and PA participation in older adults after MI, larger, more ethnically and culturally diverse samples are needed for future research.

Conclusion

In this study, we examined the relationships between biophysiological factors and fatigue with the frequency and intensity of PA in older adults after MI. Women and men reported similar frequency of participation in PA post MI, but men reported significantly more moderate-intensity PA. However, neither men nor women participated in the minimum recommended amount of moderate-intensity PA. We found, further, that fatigue significantly influenced the intensity of PA in these participants. Because PA is an important and modifiable health behavior that moderates risks of recurrent MI, these findings suggest that further research into the effects of fatigue on the intensity and sustainability of PA after an MI could provide valuable insights for the design of interventions to improve cardiovascular health in post-MI patients.

We further found that the items in the behavior/severity sub-scale of the RPFS that had the highest association with decreased PA were those relating to fatigue that interferes with activities, such as work or socializing, even more so than the severity or intensity of the fatigue. This finding suggests that assessment of fatigue in among older adults post MI in the clinical setting should focus on how fatigue affects activities rather than on how the fatigue feels or ratings of intensity. It may be that a simple question related to the effect of fatigue on activities will provide a good indication of older adults who are at the highest risk of decreased PA. Further research on effective strategies for sustaining PA post MI are needed, as small doses of PA yield positive health benefits but discontinuation of PA programs is common (Vallance, Courneya, Plotnikoff, Dinu, & Mackey, 2008).

Acknowledgments

Funding: The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: NINR (1R15NR009033-01A1).

References

- Ainsworth BE, Haskill WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Leon AS. Compendium of physical activities: An update of activity codes and MET intensities. *Medicine & Science in Sports & Exercise*. 2000; 32:S498–S516. doi:0194-9131/00/3209-0498/0. [PubMed: 10993420]
- Alsen P, Brink E, Persson L. Living with incomprehensible fatigue after recent myocardial infarction. *Journal of Advanced Nursing*. 2008; 64:459–468. [PubMed: 19146515]
- American Heart Association. Heart disease and stroke statistics—2013 update: A report from the American Heart Association. *Circulation*. 2013; 127:e1–e240. DOI: 10.1161/CIR.0b013e31828124ad [PubMed: 23283860]
- Arnold SV, Alexander KP, Masoudi FA, Ho PM, Xiao L, Spertus JA. The effect of age on functional and mortality outcomes after acute myocardial infarction. *Journal of the American Geriatrics Society*. 2009; 57:209–217. [PubMed: 19170779]
- Barnes DE, Yaffe K, Satariano WA, Tager IB. A longitudinal study of cardiorespiratory fitness and cognitive function in healthy older adults. *Journal of the American Geriatrics Society*. 2003; 51:459–465. [PubMed: 12657064]
- Beghe C, Wilson A, Ershler WB. Prevalence and outcomes of anemia in geriatrics: A systematic review of the literature. *American Journal of Medicine*. 2004; 116:3S–10S.

- Boden WE, Franklin BA, Wenger NK. Physical activity and structured exercise for patients with stable ischemic heart disease. *Journal of the American Medical Association*. 2013; 309:143–142. [PubMed: 23299603]
- Brink E, Grankvist G. Associations between depression, fatigue, and life orientation in myocardial infarction patients. *Journal of Cardiovascular Nursing*. 2006; 21:407–411.
- Brink E, Karlson BW, Hallberg LRM. Health experiences of first-time myocardial infarction: Factors influencing women's and men's health-related quality of life after five months. *Psychology, Health, & Medicine*. 2002; 7:5–16.
- Brownson RC, Baker EA, Housemann RA, Brennan LK, Bacak SJ. Environmental and policy determinants of physical activity in the United States. *American Journal of Public Health*. 2001; 91:1995–2003. [PubMed: 11726382]
- Centers for Disease Control and Prevention. How much physical activity do older adults need? 4-29-0011. 2011. Retrieved from <http://www.cdc.gov/physicalactivity/everyone/guidelines/olderadults.html>
- Chomistek AK, Chiuve SE, Jensen MK, Cook NR, Rimm EB. Vigorous physical activity, mediating biomarkers, and risk of myocardial infarction. *Medicine & Science in Sports & Exercise*. 2011; 43:1884–1890. [PubMed: 21448079]
- Crane PB. Fatigue and physical activity in older women after myocardial infarction. *Heart & Lung*. 2005; 34:30–38. [PubMed: 15647732]
- Crane PB, McSweeney JC. Exploring older women's lifestyle changes after myocardial infarction. *Medsurg Nursing*. 2003; 12:170–176. [PubMed: 12861754]
- Dai S, Wang F, Morrison H. Predictors of decreased physical activity level over time among adults: A longitudinal study. *American Journal of Preventive Medicine*. 2014; doi: 10.1016/j.amepre.2014.04.003
- Ershler WB. Biological interactions of aging and anemia: A focus on cytokines. *Journal of the American Geriatrics Society*. 2003; 51:S18–S21. [PubMed: 12588568]
- Fitzpatrick A, Reed T, Goldberg J, Buchwald D. The association between prolonged fatigue and cardiovascular disease in World War II veteran twins. *Twin Research*. 2004; 7:571–577. [PubMed: 15607007]
- Fleg JL, Forman DE, Berra K, Bittner V, Blumenthal JA, Chen MA, et al. Ziemann SJ. Secondary prevention of atherosclerotic cardiovascular disease in older adults: A scientific statement from the American Heart Association. *Circulation*. 2013; 128:2422–2446. [PubMed: 24166575]
- Guralnik JM, Eisenstaedt RS, Ferrucci L, Klein HG, Woodman RC. The prevalence of anemia in persons age 65 and older in the United States: Evidence for a high rate of unexplained anemia. *Blood*. 2004; 104:2263–2268. [PubMed: 15238427]
- Harada ND, Chiu V, King AC, Stewart AL. An evaluation of three self-report physical activity instruments for older adults. *Medicine & Science in Sports & Exercise*. 2001; 33:962–970. [PubMed: 11404662]
- Healy GN, Matthews CE, Dunstan DW, Winkler EA, Owen N. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. *European Heart Journal*. 2011; 32:590–597. [PubMed: 21224291]
- Jitapunkul S, Pillay I, Ebrahim S. The abbreviated mental test: Its use and validity. *Age and Ageing*. 1991; 20:332–336. [PubMed: 1755388]
- Jorde UP, Vittorio TJ, Kasper ME, Arezzi E, Colombo PC, Goldsmith RL, et al. Hirsh DS. Chronotropic incompetence, beta-blockers, and functional capacity in advanced congestive heart failure: Time to pace? *European Journal of Heart Failure*. 2007; 10:96–101. DOI: 10.1016/j.ejheart.2007.11.006 [PubMed: 18096432]
- King AC, Castro C, Wilcox S, Eyler AA, Sallis JF, Brownson RC. Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U.S. middle-aged and older-aged women. *Health Psychology*. 2000; 19:354–364. [PubMed: 10907654]
- Lee D, Sui X, Artero EG, Lee I, Church TS, McAuley PA, et al. Blair SN. Long-term effects of changes in cardiorespiratory fitness and body mass index on all-cause and cardiovascular disease mortality in men: The aerobics center longitudinal study. *Circulation*. 2011; 124:2483–2490. [PubMed: 22144631]

- Lee H, Kohlman GCV, Lee K, Schiller NB. Fatigue, mood, and hemodynamic patterns after myocardial infarction. *Applied Nursing Research*. 2000; 13:60–69. [PubMed: 10842901]
- Liao S, Ferrell BA. Fatigue in an older population. *Journal of the American Geriatrics Society*. 2000; 48:426–430. [PubMed: 10798471]
- Maisel A. B-type natriuretic peptide levels: Diagnostic and prognostic in congestive heart failure: What's next? *Circulation*. 2002; 105:2328–2331. DOI: 10.1161/01.CIR.0000019121.91548.C2 [PubMed: 12021215]
- Mazzeo RS, Tanaka H. Exercise prescription for the elderly: Current recommendations. *Sports Medicine*. 2001; 31:809–818. [PubMed: 11583105]
- Michaud M, Balardy L, Moulis G, Gaudin C, Peyrot C, Vellas B, et al. Nourhashemi F. Proinflammatory cytokines, aging, and age-related disease. *Journal of the American Medical Directors Association*. 2013; 14:877–882. [PubMed: 23792036]
- National Center for Health Statistics. Health, United States, 2012: With special feature on emergency care. Hyattsville, MD: Author; 2013. Retrieved from <http://www.cdc.gov/nchs/data/healthstats/us12.pdf>
- Pahan K. Lipid-lowering drugs. *Cellular and Molecular Life Sciences*. 2006; 63:1165–1178. [PubMed: 16568248]
- Piper, BF. Measuring fatigue. In: Frank-Stromberg, M., Olsen, SJ., editors. *Instruments for clinical research in health care*. Boston, MA: Jones & Bartlett; 1997. p. 482–496.
- Piper BF, Dibble SL, Dodd MJ, Weiss MC, Slaughter RE, Paul SM. The revised Piper Fatigue Scale: Psychometric evaluation in women with breast cancer. *Oncology Nursing Forum*. 1998; 25:677–684. [PubMed: 9599351]
- Pfuntner, A., Wier, LM., Steiner, C. Costs for hospital stays in the United States, 2010. Agency for Healthcare Research and Quality: Statistical brief #146: Healthcare Cost and Utilization Project; 2013. Retrieved from <http://www.hcup-us.ahrq.gov/reports/statbriefs/sb146.pdf>
- Prince SA, Adamo KB, Hamel MH, Hardt J, Gorger SC, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*. 2008; 5:56.doi: 10.1186/1479-5868-5-56 [PubMed: 18990237]
- Reichert FF, Barros AJD, Domingues MR, Hallal PC. The role of perceived personal barriers to engagement in leisure-time physical activity. *American Journal of Public Health*. 2007; 97:515–519. [PubMed: 17267731]
- Resnick HI, Carter EA, Aloia M, Phillips B. Cross-sectional relationship of reported fatigue to obesity, diet, and physical activity: Results from the third national health and nutrition examination survey. *Journal of Clinical Sleep Medicine*. 2006; 2:163–169. [PubMed: 17557490]
- Schairer JR, Keteyian SJ, Ehrman JK, Brawner CA, Berkebile ND. Leisure time physical activity of patients in maintenance cardiac rehabilitation. *Journal of Cardiopulmonary Rehabilitation*. 2003; 23:260–265. [PubMed: 12893999]
- Schocken DD, Benjamin EJ, Fonarow GC, Krumholz HM, Levy D, Mensah GA, et al. Functional Genomics and Translational Biology Interdisciplinary Working Group. Prevention of heart failure: A scientific statement from the American Heart Association Councils on Epidemiology and Prevention, Clinical Cardiology, Cardiovascular Nursing, and High Blood Pressure Research; Quality of Care and Outcomes Research Interdisciplinary Working Group; and functional Genomics and Translational Biology Interdisciplinary Working Group. *Circulation*. 2008; 117:2544–2565. [PubMed: 18391114]
- Smith JL, Verrill TA, Boura JA, Sakwa MP, Shannon FL, Franklin BA. Effect of cardiorespiratory fitness on short-term morbidity and mortality after coronary artery bypass grafting. *American Journal of Cardiology*. 2013; 112:1104–1109. [PubMed: 23849973]
- Smith SC, Benjamin EJ, Bonow RO, Braun LT, Creager MA, Franklin BA, et al. Taubert KA. AHA/ACC secondary prevention and risk reduction therapy for patients with coronary and other atherosclerotic vascular disease: 2011 update: A guideline from the American Heart Association and American College of Cardiology. *Circulation*. 2011; 124:2458–2473. [PubMed: 22052934]
- Stewart AL, Mills KM, King AC, Haskell WL, Gillis D, Ritter PL. CHAMPS physical activity questionnaire for older adults: Outcomes for interventions. *Medicine & Science in Sports & Exercise*. 2001; 33:1126–1141. [PubMed: 11445760]

- Strawbridge WJ, Deleger S, Roberts RE, Kaplan GA. Physical activity reduces the risk of subsequent depression for older adults. *American Journal of Epidemiology*. 2002; 156:328–334. [PubMed: 12181102]
- Tabachnick, BG., Fidell, LS. Using multivariate statistics. 3rd. New York, NY: HarperCollins; 1996.
- Vallance JK, Courneya KS, Plotnikoff RC, Dinu I, Mackey JR. Maintenance of physical activity in breast cancer survivors after a randomized trial. *Medicine & Science in Sports & Exercise*. 2008; 40:173–180. [PubMed: 18091007]
- Varvaro FF, Sereika SM, Zullo TG, Robertson RJ. Fatigue in women with myocardial infarction. *Health Care for Women International*. 1996; 17:593–602. [PubMed: 9119777]
- Visser MRM, Smets EMA, Sprangers MAG, deHaes HJCJM. How response shift may affect the measurement of change in fatigue. *Journal of Pain and Symptom Management*. 2000; 20:12–18. [PubMed: 10946164]
- Zhao G, Ford ES, Li C, Mokdad AH. Are United States adults with coronary heart disease meeting physical activity recommendations? *American Journal of Cardiology*. 2008; 101:557–561. [PubMed: 18307998]
- Zoeller RF Jr. Lifestyle and the risk of cardiovascular disease in women: Is physical activity an equal opportunity benefactor? *American Journal of Lifestyle Medicine*. 2008; 2:219–226.

Table 1

Characteristics of Participating Older Men and Women, 6–8 Months Post MI, With Fatigue.

Characteristic	Men (<i>n</i> = 34)	Women (<i>n</i> = 38)
Age (years), <i>M</i> (<i>SD</i>)	76.12 (6.37)	76.95 (6.54)
Ethnicity/race, <i>n</i> (%)		
Caucasian	29 (85.3)	31 (81.6)
African American	4 (11.8)	6 (15.8)
American Indian	1 (2.9)	1 (2.6)
Marital status, <i>n</i> (%)		
Married	24 (70.6)	13 (34.2)
Divorced, separated	5 (14.7)	4 (10.5)
Widowed	5 (14.7)	21 (55.3)
Education, <i>n</i> (%)		
8 years or less	6 (17.6)	4 (10.5)
Ninth grade–HS graduate	17 (50.0)	20 (52.6)
College	11 (32.4)	14 (36.8)
Income, <i>n</i> (%)		
<US\$10,000	2 (5.9)	6 (15.8)
US\$10,000–29,999	15 (44.1)	15 (39.5)
US\$30,000–49,999	6 (17.6)	4 (10.5)
US\$50,000	5 (14.7)	6 (15.8)
Not reported	6 (17.6)	7 (18.4)
BMI ^a (kg/m ²), <i>M</i> (<i>SD</i>)	28.11 (4.18)	27.57 (5.88)
Weight classification by BMI, <i>n</i> (%)		
Underweight	1 (2.9)	1 (2.6)
Normal	7 (20.6)	14 (36.8)
Overweight	16 (47.1)	9 (23.7)
Obese	10 (29.4)	14 (36.8)

Note. *N* = 72. BMI = body mass index; HS = high school. All participants had Revised Piper Fatigue Scale total scores > 0.

^aUnderweight: BMI < 18.5 kg/m²; Normal: BMI 18.5–24.9 kg/m²; Overweight: BMI 25–29.9 kg/m²; Obese: BMI ≥ 30 kg/m².

Table 2

Revised Piper Fatigue Scale (RPFS) Subscale Scores Regressed on Physical Activity, ^a Controlling for Sex, Age, and Biophysical Measures.

Independent variable	Dependent variable					
	Frequency of PA ^a			Energy expenditure for all PA ^a		
	B	SE B	β	B	SE B	β
Sex	-.192	.339	-.066	-17.136	5.03	-.381**
Age	-.024	.028	-.106	-.713	.409	-.191
BNP ^b	-.557	.438	-.169	-.567	6.49	-.011
IL-6 ^b	-.203	.798	-.031	8.560	11.8	.080
MAP	.003	.016	.023	.045	.236	.024
Hemoglobin	.206	.124	.213	2.530	.253	.160
HR (radial, 1 min)	-.009	.017	-.064	-.361	.576	-.156
BMI (kg/m ²)	-.017	.039	-.058	.031	.576	.007
RPFS subscales						
Behavior/severity	-.022	.016	-.238	-.773	.241	-.510**
Affective	-.013	.018	-.133	.079	.274	.051
Sensory	-.003	.027	-.024	.116	.405	.060
Cognitive/mood	.002	.018	.021	-.031	.262	-.017

Note. $N = 72$. PA = physical activity; B = beta; β = standardized β ; SE B = standard error of β ; BNP = B-natriuretic peptide; IL = interleukin; MAP = mean arterial blood pressure; HR = heart rate; BMI = body mass index. Frequency of PA: $R^2 = .16$, $F = 2.111$ (12, 59), $p = .03$; Energy expenditure for all PA: $R^2 = .31$, $F = 3.696$ (12, 59), $p < .001$; Energy expenditure for moderate-intensity PA: $R^2 = .40$; $F = 4.967$ (12, 59); $p < .001$.

^aTransformed using square root.

^bTransformed using log.

* $p < .05$;

** $p < .01$.

Table 3

Correlations of Items From the Behavioral/Severity Subscale of the Revised Piper Fatigue Scale and Physical Activity.^a

Item	Energy expended on all activity	Energy expended on moderate-intensity activity	Frequency of physical activity
Fatigue is causing distress	-.148	-.197	-.133
Fatigue is interfering with work or other activities	-.413 ***	-.411 ***	-.362 **
Fatigue is interfering with ability to socialize	-.429 ***	-.431 ***	-.445 ***
Fatigue is interfering with sexual activity	-.272 *	-.294 *	-.346 **
Fatigue is interfering with activities enjoyed	-.285 *	-.370 **	-.240 *
Fatigue is intense or severe	-.334 **	-.364 **	-.386 **

Note. $N = 72$.

^a Pearson's correlations with transformed physical activity measures using square root.

* $p < .05$;

** $p < .01$;

*** $p < .001$.