Prospective Study of Associations Among Positive Emotion and Functional Status in Older Patients With Coronary Artery Disease

Beverly H. Brummett, Miriam C. Morey, Stephen H. Boyle, and Daniel B. Mark

We examined associations between positive emotion (PE) and functional status (Duke Activity Status Inventory) in 948 coronary artery disease (CAD) patients (35.1% women; age \( M = 70.1 \text{ years}, SD = 6.3 \)). Emotion and function measures were gathered during hospitalization and annually for 3 years. We used random coefficient models to examine PE during hospitalization and follow-up, as a predictor of change in function. Analyses adjusted for baseline functional status, negative emotion, social support, marital status, and disease severity. Sex was examined as a moderator of effects. PE assessed during hospitalization was a significant predictor of change in function such that lower levels of PE were associated with accelerated decline in function. Lower levels of PE during follow-up were also related to increasing decline in function but only in men. Thus, our findings indicate that PE is associated with less decline in functional status following hospitalization for CAD.

Key Words: CAD patients—DASI—Functional status—Positive emotion.

Coronary artery disease (CAD) is the leading cause of disability among older individuals worldwide (Murray & Lopez, 1996). Although considerable advances have been made with respect to the management of CAD, this disease is typically accompanied by emotional distress that may continue for some time (Hance, Carney, Freedland, & Skala, 1996; Sullivan, LaCroix, Spertus, & Hecht, 2000). Emotional distress has been shown to adversely affect the health and well-being of CAD patients (Jiang et al., 1996; Sullivan et al., 2000; Thomas, Friedmann, Wimbush, & Schron, 1997; Verrier & Mittelman, 1997) and has been associated with decline in functioning (Forthofer, Janz, Dodge, & Clark, 2001), more days of disability in patients with CAD (Hlatky et al., 1986), and decreased longevity (Hemingway & Marmot, 1999; Rozanski, Blumenthal, & Kaplan, 1999). By comparison, relatively few studies have examined the effects of positive emotional experiences in CAD patients. However, evidence from related research suggests that positive emotions (PEs) are beneficial in older patient samples. Findings from the Hispanic Established Population for the Epidemiological Study of the Elderly indicate that PE is related to lower risk of frailty over a 7-year follow-up period (Ostir, Ottenbacher, & Markides, 2004). PEs have also been associated with lower incidence of arthritis-associated disability (Fisher, Snih, Ostir, & Goodwin, 2004), as well as gains in functional status following stroke (Ostir, Berges, Ottenbacher, Clow, & Ottenbacher, 2008). Thus, it is reasonable to expect that positive emotional experiences may play a role in recovery from a coronary event.

Motivational theories of emotion provide a framework for understanding how the experience of emotion, both positive and negative, may affect the recovery process following a coronary event. Briefly, basic models of emotion begin with the underlying premise that emotions exist in the service of motivating behavior (e.g., Frijda, 1986; Lazarus, 1991). Because emotions direct behavior, they have the ability to influence health habits that are important for recovering heart patients. The experience of emotion also stimulates the central nervous system, resulting in a cascade of physiological responses that can affect cardiovascular health. It has also been hypothesized that a beneficial effect of PE is to provide a respite from the stress often associated with negative emotion (Fredrickson, Mancuso, Branigan, & Tugade, 2000; Lazarus, Kanner, & Folkman, 1980). This functional aspect of PE may be of particular relevance with regard to the negative emotional stress experienced following hospitalization for CAD. In addition to providing a respite from negative affect, positive affect may serve other important functions. Fredrickson’s (1998) “broaden-and-build” model of PEs suggests that one of the principle functions of PEs is to broaden cognition and serve to motivate a wide variety of action tendencies that may facilitate personal growth and promote survival. Fredrickson’s theory suggests that PEs expand behaviors beyond the narrow focus directed by the negative emotions, and as a consequence, this redirection of behavior and cognition may help “undo” the consequences of negative affect. A key implication of Fredrickson’s model, therefore, is that PEs represent more than the absence of negative emotions.

A related issue of importance, however, concerns the independence of positive and negative affect. Although this debate is complex and may never be completely resolved,
the majority of researchers in this area agree that it is wise to treat positive and negative affect as separate constructs, particularly given evidence for their independence and the fact that they frequently correlate differentially with many constructs (Diener, Scollon, & Lucas, 2004; Huppert & Whittington, 2003; Lazarus, 1991; Lucas, Diener, & Suh, 1996). It is also worth noting that findings from the rapidly growing area of affective neuroscience strongly suggest that certain structures within the human brain are differentially related to the processing of positive and negative affect (Davidson, 2003, 2004; Lane, Reiman, Ahern, Schwartz, & Davidson, 1997; Urry et al., 2004).

In addition to the experience of PEs, factors such as social ties, comorbidity, and the severity of CAD, among others, are likely to influence functional recovery in CAD patients (Berkman, Leo-Summers, & Horwitz, 1992; Na, Kim, Song, Chin, Chea, 2009; Pelegrino et al., 2009). Thus, the ability to quantify the association between PE and functional status following a coronary event relies on the inclusion of such potentially relevant confounders. Likewise, it is critical to adjust for the effect of negative emotion in order to evaluate the independent effect of PE.

The present study examines associations among PE and functional status in patients following their hospitalization for significant CAD. We will assess PE during hospitalization (baseline) as a predictor of change in functional status during follow-up. In addition, we will model the change in emotion across time as it relates to the change in functional status. These subsequent follow-up assessments of PE have certain advantages over baseline assessment. First, assessment of emotion at baseline may be influenced by the stressors that present during hospitalization and therefore may vary from the emotional experience following return home. Second, follow-up emotion assessments have the advantage of being temporally contiguous with other events that occur during follow-up. Finally, repeated assessment over an extended period provides the ability to examine the temporal stability of such relations. To our knowledge, assessment of the dynamic relation between positive emotional experience and functional status during recovery in coronary patients has not previously been examined. Assessment of negative emotion will be controlled in all analyses in order to assess the unique contribution of PE. In addition, analyses will also adjust for perceptions of social support, marital status, presence and/or severity of congestive heart failure, left ventricular ejection fraction, rehospitalization, age, and co-morbidity. It is hypothesized that PE will be a significant predictor of functional status, independent of the effects of negative emotion, social support, and covariates related to disease severity. Finally, many aspects of emotional experience vary by sex. As compared with men, women experience significantly more depression following a diagnosis of CAD (Brummett et al., 1998), and recovery from a coronary event has been shown to be significantly different with regard to physical and psychosocial experiences (Badger, 1992; Czajkowski, 1998; Hawthorne, 1994). The nature of emotion may develop differently for men and women as they age (Mroczek & Kolarz, 1998). For example, age seems to be nonlinearly related to positive affect in women, whereas, in men, other constructs interact with age in predicting positive affect. Therefore, in an older sample, it may be particularly important to consider sex as a moderator of potential associations among affect and health outcomes. At present, however, we prefer to consider the examination of sex as a moderator of the association between PE and functional status as exploratory; thus, we do not make specific hypotheses regarding this potential association.

**Methods**

**Participants**

The present data were gathered as part of a prospective cohort study, Mediators of Social Support (MOSS; Bosworth et al., 1999). The study was designed to explore the effect of social support on mortality and other outcomes in coronary patients and to examine potential mediators of those relationships. CAD patients without history of prior revascularization who were referred to the Duke University Cardiac Catheterization Laboratory between July of 1992 and January of 1996 were approached regarding potential participation in the MOSS study. Eligible patients were those who were referred to the Duke University Medical Center for diagnostic cardiac catheterization and found to have significant CAD (≥75% stenosis of at least one coronary artery). Patients were excluded from the study if they had any of the following: prior angioplasty, congenital heart disease, primary valvular heart disease, substance dependence, history of impairing psychological disorder, or an inability to give informed consent.

A member of the MOSS research group obtained informed consent from all qualified patients who agreed to participate. At baseline, the full cohorts of 3,275 patients enrolled in the MOSS were given a psychosocial battery. Follow-up interviews were administered by phone annually for 3 years. By design, certain measures were administered to a random half of the sample (i.e., 1,637 patients) in order to limit patient burden and afford the opportunity to assess a different psychosocial construct in the remaining half of the sample. The age range in the full cohort was 30–94 years, and 36.9% of the sample were aged 60 years and older. The present study examined 948 patients who met the following criteria: (a) completed the Duke Activity Status Inventory (DASI; Hlatky et al., 1989) and the measure of emotion at baseline, (b) were aged 60 years and older, and (c) were randomized to the follow-up arm that contained pertinent measures relevant to the current study (i.e., the DASI and the assessment of emotion). The numbers of patients available for follow-up analyses were: Year 1, N=757; Year 2, N=623; and Year 3, N=421. As is typical in longitudinal
Studies in patient samples, a number of participants failed to complete the 3-year follow-up for a variety of reasons (e.g., death, relocation, refusal to participate). In regression analyses, patients who completed Year 3 of the study were significantly more likely ($p < .05$) to have higher ratings of PE and functional status scores at baseline compared with those who dropped out during the course of follow-up, whereas sex was unrelated to drop out.

**Measures**

**Demographic measures.**—Age was recorded in years. Sex was coded as $0 = \text{men}$ and $1 = \text{women}$. Marital status was coded as $0 = \text{married or living as married}$ and $1 = \text{neither married nor living as married}$.

**Functional status.**—The DASI (Hlatky et al., 1989) is a 12-item self-report measure of activities of daily living that asks patients about any physical limitations they may have at the present time. Items represent personal care, ambulation, household tasks, sexual function, and recreation. Each of the 12 items is assigned a weight based on the established metabolic cost of that activity in metabolic task units (METs; Fox, Naughton, & Gorman, 1972; Passmore & Durnin, 1955). The final score represents the sum of the weights for each activity positively endorsed and provides an estimate of maximal oxygen consumption. DASI scores can be divided by 3.5 to provide an estimate of METs (Wessel et al., 2004). Using this scoring method, the items assessed in the DASI have been validated against the criterion of peak oxygen uptake during a stress test. The DASI has been validated against the criterion of peak oxygen uptake during a stress test. The DASI has desirable internal consistency ($\alpha = 0.86$) and has been shown to correlate significantly with clinical and angiographic endpoints (Hlatky et al.; Nelson et al., 1991). Internal consistency for the DASI in the present sample is $\alpha = 0.88$.

**Clinical measures.**—The following clinical measures were included in all analyses. Congestive heart failure scored 0–5 based on physician ratings of presence and/or severity (i.e., $0 = \text{not present}; 5 = \text{severe disease}$). Left ventricular ejection fraction was assessed as a continuous measure (range 8.1–93.0) during baseline hospitalization. Rehospitalization for reoccurring CAD was coded from self-report data collected at each follow-up. To gather the required comorbidity information, each patient’s medical records were reviewed for details indicating the presence of a disease process in any of the major organ systems (i.e., gastrointestinal, renal, muscular, metabolic, vascular, and pulmonary). A comorbidity index was assigned to each patient defined by the total number of organ systems with significant disease at baseline.

**PE and negative emotion.**—The Center for Epidemiologic Studies Depression Scale (CES-D) is a 20-item measure of the frequency of various depressive symptoms experienced during the previous week (Radloff, 1977). Following results of prior studies (Miller, Markides, & Black, 1997; Nguyen, Kittner-Triolo, Evans, & Zonderman, 2004; Ostir, Markides, Black, & Goodwin, 2000; Ostir et al., 2004, 2008; Sheehan, Fitielf, Reisine, & Tennen, 1995), a PE summary score was created using four items from the CES-D. The four positive items ask whether patients have experienced the following specific emotional feelings in the past week: “I felt that I was just as good as other people,” “I felt hopeful about the future,” “I was happy,” and “I enjoyed life.” Responses were scored on a 4-point scale ranging from 1 (rarely or none of the time) to 4 (most of the time). Responses to these items were summed, creating a PE summary score ranging from 4 to 16. The reliability and validity of the PE summary scale has been established (Miller et al., 1997; Ostir et al., 2000; Sheehan et al., 1995). In the present study, the PE summary score demonstrated adequate internal consistency ($\alpha = 0.62$). Similarly, the seven-item subscale from the CES-D that represents depressive affect (Radloff) was used as the present measure of negative emotion. A recent meta-analysis conducted on 28 studies, representing 22,340 participants, also supports the use of this original seven-item subscale for negative affect (Shafer, 2006). These items are “I felt that I could not shake off the blues even with help from my family or friends,” “I felt depressed,” “I thought my life had been a failure,” “I felt fearful,” “I felt lonely,” “I had crying spells,” and “I felt sad.” Internal consistency for the negative emotion summary score in the present sample is $\alpha = 0.89$.

**Social support.**—The Interpersonal Support Evaluation List (ISEL; Cohen, Merelsteln, Kamarck, & Hoberman, 1985) was used to assess perceptions of social support. The ISEL consists of 40 items that assess the following dimensions of support: appraisal, self-esteem, belonging, and tangible. Internal reliability has been reported to range between $0.88$ and $0.90$ (Cohen, Merelsteln, Kamarck, & Hoberman). A shortened 16-item version of the ISEL was used in the MOSS protocol to limit patient burden (Brunnett et al., 1998). In order to select the 16 appropriate items, an item consistency analysis was performed for each subscale in an independent sample from a previous study, and the four items having the highest correlation with the subscale total were selected. However, if the response to an item was potentially affected by an experience with CAD, that item was discarded and the item with the next highest item-remainder correlation coefficient was chosen. The following is the percent of the full scale’s variance accounted for by use of the short scale, the subscales, and the total scale: appraisal 87.2%, belonging 84.9%, tangible 88.4%, self-esteem 75.7%, and total ISEL 90.9%. The correlations between the shortened subscales and the original version subscales ranged between .87 and .94. Items were rated on a 4-point scale, with a potential range of 0–48 for total ISEL scores. Higher scores reflect greater perceived support.
Table 1. Patient Characteristics at Baseline

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total, N=948</th>
<th>Men, N=615</th>
<th>Women, N=333</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnicity, % (N)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>81.2 (770)</td>
<td>75.1 (250)</td>
<td>84.6 (520)</td>
</tr>
<tr>
<td>African American</td>
<td>11.0 (104)</td>
<td>15.9 (53)</td>
<td>8.3 (51)</td>
</tr>
<tr>
<td>Unknown</td>
<td>7.8 (74)</td>
<td>9.0 (30)</td>
<td>7.1 (44)</td>
</tr>
<tr>
<td>Marital status, % (N) married</td>
<td>71.4 (677)</td>
<td>85.2 (524)</td>
<td>46.0 (153)</td>
</tr>
<tr>
<td>Age, M (SD) years</td>
<td>60.1 – 94.1</td>
<td>60.1 – 94.1</td>
<td>60.1 – 87.0</td>
</tr>
<tr>
<td>Range years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of comorbidities, % (N)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>18.4 (174)</td>
<td>21.4 (131)</td>
<td>12.1 (40)</td>
</tr>
<tr>
<td>1</td>
<td>36.1 (342)</td>
<td>34.3 (210)</td>
<td>39.8 (132)</td>
</tr>
<tr>
<td>2</td>
<td>28.9 (274)</td>
<td>28.7 (176)</td>
<td>29.5 (98)</td>
</tr>
<tr>
<td>3</td>
<td>12.0 (114)</td>
<td>12.2 (75)</td>
<td>11.8 (39)</td>
</tr>
<tr>
<td>≥4</td>
<td>4.6 (44)</td>
<td>3.4 (21)</td>
<td>6.8 (23)</td>
</tr>
<tr>
<td>Interpersonal support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>evaluation list, M (SD)</td>
<td>38.5 (7.0)</td>
<td>39.0 (6.7)</td>
<td>37.6 (7.3)</td>
</tr>
</tbody>
</table>

Analytic Strategy

We used random coefficient models (Singer, 1998) to examine PE as a predictor of change in functional status over time. Random coefficient models are a type of multilevel model (also referred to as random effects or hierarchical linear modeling) that allowed us to examine predictors of individual differences in functional status trajectories. In the mixed model longitudinal framework, annual interviews are nested within individuals. Estimates of intercepts and slopes (changes across time) are calculated for each individual from the available data that he or she contributed over the course of the study. One particular advantage of mixed models in the present study is their ability to compute estimates in the presence of randomly missing data in a time series. In a mixed model approach, repeated measures (within subjects) are defined as Level 1 and between subjects as Level 2.

Two models were examined in the present study. In the first model, baseline assessment of PE was modeled as a predictor of the course of functional status during the 3-year period following hospitalization (Model 1). Analysis included baseline adjustment for functional status, age, sex, social support, marital status, congestive heart failure, left ventricular ejection fraction, and comorbidity. Along with the repeated assessment of PE at each follow-up, negative emotion and rehospitalization were modeled as Level 1 time-varying covariates. This second model provides the unique opportunity to assess the co-occurring relation between PE and functional status over time controlled for baseline functional status as well as for negative emotion ratings that were concurrently assessed with PE ratings. As in the first model, a Sex × PE interaction term was initially included and removed if found to be nonsignificant.

Thus, initially, we modeled the degree to which PE at hospitalization predicts changes in functional status over follow-up; Next, we examined associations between dynamic changes in PE with changes in functional status. It was hypothesized that higher levels of baseline PE would predict a smaller decrease in function over time (Model 1) and that decreases in PE will accompany decreases in function (Model 2).

Models were fitted using SAS PROC MIXED (SAS, Cary, NC) with maximum likelihood estimation. Preliminary analyses suggested that the best fitting covariance structure was unstructured and this selection was preserved for all analyses. Positive affect at baseline was centered at its mean value. Follow-up time was rescaled such that Years 1, 2, and 3 were coded as 0, 1, and 2, respectively, in all analyses. This recoding of time allows us to interpret the main effects of the predictors as the expected change in functional status at Year 1 for every 1 unit increase in the predictor. Alpha was set at $p < .05$ for all significance tests.

RESULTS

Background Analyses

Table 1 presents the characteristics of the study sample at baseline. The sample consisted predominately of men with an average age of 71 years. The majority of patients were married, did not have congestive heart failure, and had one comorbidity. Table 2 presents the means and standard deviations for functional status, PE, and negative emotion at baseline and each follow-up. The mean for functional status improved somewhat from hospitalization to the first follow-up and then declined slightly over the 3-year follow-up period. Similarly, the mean for PEs increased somewhat from hospitalization to 1-year follow-up, then stabilized during follow-up, and the mean for negative emotions declined somewhat from hospitalization to Year-1 follow-up, then stabilized.

Prior to examination of our two specified models, we tested the extent to which there was sufficient variability in slopes across individuals to allow for the addition of hypothesized predictors. This was done by modeling time as the sole predictor of functional status during follow-up. Results indicated that significant variability exists during the
3-year follow-up for both the intercept ($p < .001$) and the slope ($p < .001$). Thus, although the mean levels for functional status remained fairly stable during follow-up, there was significant individual variability in change over time in levels of functional status.

Table 3 presents the unadjusted correlations among functional status, PE, and negative emotion at baseline and each follow-up. The only nonsignificant relation was that between functional status and PE at baseline.

### PE as a Predictor of Functional Status

Results of Model 1 (see Table 4 and Figure 1) [The values in the figures are fitted [predicted] values from the regression model that used the full continuous form of the predictor variable. The values used for plotting were generated by selecting two values of the predictor that represented, respectively, a typical high value [at the 75th percentile] and a typical low value [at the 25th percentile] along the predictor’s continuous range. Each of these selected values of the continuous predictor is associated with a corresponding predicted response [dependent or criterion variable] value. These predicted response values were then plotted.] indicated that PE assessed at baseline was significantly related to the change in functional status during follow-up (PE × Time, $p < .05$). Lower levels of PE at baseline were related to greater decline in functional status over time, adjusted for negative affect, baseline functional status, and other potentially relevant confounders. Several covariates were also related to functional status. Patients with lower baseline levels of functional status, lower left ventricular ejection fraction, greater comorbidity, a higher number of rehospitalizations, lower social support, and who were women and older were more likely to have greater decline in functional status during follow-up ($ps < .05$). Sex did not moderate the association between baseline PE and change in functional status over time (Sex × PE × Time, $p = $ not significant).

Results of Model 2 (see Table 5 and Figure 2) [The values in the figures are fitted [predicted] values from the regression model that used the full continuous form of the predictor variable. The values used for plotting were generated by]

<table>
<thead>
<tr>
<th>Assessment time, $M (SD)$</th>
<th>Functional status</th>
<th>PE</th>
<th>Negative emotion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>615</td>
<td>20.7 (14.6)</td>
<td>12.5 (3.7)</td>
</tr>
<tr>
<td>Women</td>
<td>333</td>
<td>12.2 (10.8)</td>
<td>12.3 (3.4)</td>
</tr>
<tr>
<td>Year 1</td>
<td>488</td>
<td>25.8 (15.7)</td>
<td>13.3 (3.7)</td>
</tr>
<tr>
<td>Men</td>
<td>269</td>
<td>15.1 (10.0)</td>
<td>13.2 (3.4)</td>
</tr>
<tr>
<td>Women</td>
<td>245</td>
<td>15.4 (10.4)</td>
<td>12.6 (3.1)</td>
</tr>
<tr>
<td>Year 2</td>
<td>273</td>
<td>23.9 (15.6)</td>
<td>13.2 (3.1)</td>
</tr>
<tr>
<td>Men</td>
<td>148</td>
<td>16.2 (11.3)</td>
<td>13.3 (3.1)</td>
</tr>
<tr>
<td>Women</td>
<td>121</td>
<td>15.6 (11.3)</td>
<td>13.3 (3.1)</td>
</tr>
</tbody>
</table>

**Note:** Higher scores = better functional status and higher ratings of positive emotion (PE) or negative emotion.
Table 5. Results From Random Effects Model Examining PE During Follow-up as a Predictor of Change in Functional Status During 3 Years Posthospitalization for CAD

<table>
<thead>
<tr>
<th>Effect</th>
<th>Regression coefficients (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>27.86 (5.53)**</td>
</tr>
<tr>
<td>Baseline functional status</td>
<td>0.40 (0.03)**</td>
</tr>
<tr>
<td>Baseline PE</td>
<td>0.17 (0.11)</td>
</tr>
<tr>
<td>Baseline negative emotion</td>
<td>-0.01 (0.09)</td>
</tr>
<tr>
<td>Age in years</td>
<td>-0.12 (0.06)</td>
</tr>
<tr>
<td>Sex (women)</td>
<td>-5.77 (2.70)*</td>
</tr>
<tr>
<td>Marital status (married)</td>
<td>-0.44 (0.97)</td>
</tr>
<tr>
<td>Presence/severity of congestive heart failure</td>
<td>0.16 (0.28)</td>
</tr>
<tr>
<td>Left ventricular ejection fraction</td>
<td>0.10 (0.03)**</td>
</tr>
<tr>
<td>Rehospitalization (yes)</td>
<td>-2.16 (0.53)**</td>
</tr>
<tr>
<td>Comorbidity index</td>
<td>-5.08 (0.37)**</td>
</tr>
<tr>
<td>Social support</td>
<td>0.13 (0.06)*</td>
</tr>
<tr>
<td>Time</td>
<td>-2.90 (1.60)</td>
</tr>
<tr>
<td>Time × Negative Emotion</td>
<td>-0.08 (0.07)</td>
</tr>
<tr>
<td>Time × PE</td>
<td>0.23 (0.09)*</td>
</tr>
<tr>
<td>Time × Sex</td>
<td>4.90 (0.25)*</td>
</tr>
<tr>
<td>Sex × PE</td>
<td>0.04 (0.19)*</td>
</tr>
<tr>
<td>Time × Sex × PE</td>
<td>-0.35 (0.16)*</td>
</tr>
</tbody>
</table>

Notes: PE, positive emotion; CAD, coronary artery disease.
*p < .05; **p < .001.

selecting two values of the predictor that represented, respectively, a typical high value [at the 75th percentile] and a typical low value [at the 25th percentile] along the predictor’s continuous range. Each of these selected values of the continuous predictor is associated with a corresponding predicted response [dependent or criterion variable] value. These predicted response values were then plotted.] indicated that for men only, changes in PE were related to changes in functional status during follow-up (Sex × PE × Time, p < .05). For men, decline in PE during follow-up was significantly related to decline in functional status; For women, the changes in PE during follow-up were unrelated to changes in functional status over time. As in our first model, several covariates were related to functional status. Patients with lower baseline function, lower left ventricular ejection fraction, greater comorbidity, a higher number of rehospitalizations, and lower social support were more likely to have decreased levels of functional status during follow-up (p < .05).

**DISCUSSION**

The present findings add support to a growing body of work that indicates PEs are beneficial for physical well-being. Specifically, less frequent experience of PE was associated with decline in functional status over time in older CAD patients, whereas the presence of higher levels of PE was related to stability in function in individuals who might otherwise be expected to experience loss of function with age. The observed effects of emotion on function were also modified by sex. In the present study, for men, higher PE ratings during hospitalization and over the course of follow-up were associated with a similar pattern of less decline in functional status. Whereas, for women, ratings of PE during hospitalization but not during follow-up were associated with changes in functional status.

Both physical and psychosocial experiences following recovery from a cardiac event have been shown to be significantly different for women compared with men (Badger, 1992; Czajkowski, 1998; Hawthorne, 1994). Women report more chronic illness, poorer health, and more days of reduced activity following myocardial infarction compared with men (Conn, Taylor, & Abele, 1991). Women also seem to be more concerned about noncardiac illness, noncardiac physical symptoms of anxiety, household responsibilities, and relationship problems (Cossette, Frasure-Smith, & Lesperance, 2002). Research that is perhaps most closely related to the present findings has shown that stress is a stronger predictor of impaired functioning in women with CAD compared with male patients (Forthofer et al., 2001). Such sex differences suggest that it may be more difficult to detect any relations that may exist between positive affect and functioning in women with CAD, especially following return home to daily life. That is, the strong relation among negative emotional experience and functioning in women upon return home may overwhelm effects of PE.

The observed difference in functional status between patients with higher ratings of PE during hospitalization and those with lower ratings exceeded three points on the DASI measure of peak oxygen uptake (Model 1). When divided by 3.5, DASI scores yield an estimate of metabolic equivalent tasks (METs). Thus, lower ratings of PE during hospitalization were associated with a change of approximately one MET during the course of follow-up. Men with lower PE ratings over the course of follow-up showed an increased decline approaching six points on the DASI compared with those with higher PE ratings (Model 2). This change reflects a difference of 1.7 METs. These observed differences for MET change are clinically significant, especially for CAD patients. One study of a sample of 906 CAD patients reported that each one MET increase in DASI score was associated with an 8% decrease in...
risk of major adverse cardiovascular events during follow-up (Wessel et al., 2004). Moreover, the 3-point difference in change between patients with higher versus lower positive affect is equal to an effect size of almost one-third standard deviation, and the 6-point difference in change approximates an effect size of one-half standard deviation—effect sizes that are considered moderate to large (J. Cohen, 1988). Thus, the observed relations among PEs and functional status in the present study were sizable and clinically significant.

When attempting to quantify relations among measures of emotion and functional status using observational data, it is difficult to eliminate the effects of other constructs that may confound any observed association. In the present study, we attempted to minimize the number of potential confounds. As touched upon in our Introduction, some have argued that emotions exist on a continuum from positive to negative and that the absence of one therefore reflects the presence of another. This would suggest that the present relations demonstrated between PE and functional status may not be due to PE per se but rather to a lack of negative affect. However, the fact that negative emotion was controlled makes this explanation unlikely in the current study.

Decreased left ventricular ejection fraction, rehospitalization, and higher comorbidity were all significant predictors of poorer function over time in the present study. This is noteworthy for two reasons. First, the association between these health-related measures and functional status helps increase confidence in the construct validity of DASI ratings. Second, adjustment for these health measures did not eliminate the associations among PE and function.

Two areas of research suggest that adjustment for social support is likely to be important when examining relations among emotion and functional status. Numerous findings indicate that social support is beneficial for CAD patients (Barefoot et al., 2000; Brummett et al., 1998; Cohen, Kaplan, & Manuck, 1994) and that social support is positively associated with emotional well-being (Cohen & Wills, 1985). The present results corroborate the link between social support and health by demonstrating that patients with higher ratings of social support had less decline in functional status during follow-up. Moreover, associations among PE and functional status survived adjustment for ratings of social support in the current study. Although such findings do not rule out the possibility that PE is linked to functional status, in part, through associations with better social support, they suggest that additional factors are responsible for this relation.

The present associations between PE and functional status fit well within the framework of Fredrickson’s (1998, 2004) broaden-and-build model of PEs. As noted in our Introduction, a key implication of Fredrickson’s model is that PEs represent more than the absence of negative emotions. Briefly, this model suggests that one of the principle functions of PEs is to broaden cognition and serve to motivate a wide variety of action tendencies that may facilitate personal growth and promote survival. PEs are said to lead to expansive behaviors that reflect greater psychological resiliency—expanding behaviors beyond the narrow focus directed by the negative emotions, and as a result of this redirection of behavior and cognition may be the “undoing” of the consequences of negative affect. Another aspect of the model suggests that PEs promote flexibility with regard to problem solving (Fredrickson & Branigan, 2005), and research has shown that PE and broad-minded coping enhance one another in a serial fashion, ultimately leading to a generalized pattern of increased well-being over time (Fredrickson & Joiner, 2002). Application of this model to the present findings would suggest that CAD patients who experienced PE were less likely to be hampered by negative arousal that may have accompanied a diagnosis of CAD. Furthermore, patients with higher PE may have been more flexible and creative with respect to their approach to rehabilitation and are likely to have been more expansive in their associations with their social and physical environment, all of which are likely to lead to increased functional status over time. Finally, it may be that those patients who are low in PE simply lack motivation and therefore fail to remain active and as a result decline in functional status.

There are considerations that should be taken into account with respect to the current findings. These results are based on prospective data, and the proposed theoretical model suggests that PEs are causally related to better functional status. It would be naive, however, to argue that increased functional status does not lead to increased PE. The observed relations are likely, to some degree, bidirectional in nature. We would note, however, that all analyses included baseline adjustment for functional status, which mitigates to some extent the concern that functional status causally precedes PE. It is also possible that, even though we attempted to statistically control for possible confounding factors, an underlying third factor was responsible for PE ratings and the resulting changes in functional status. In addition, patients who failed to provide follow-up data had lower ratings of positive affect. This was perhaps not unexpected as prior studies suggest that participants with higher negative affect tend to drop out of studies at higher rates compared with those with lower scores (e.g., Angst, Gamma, Rössler, Ajdacic, & Klein, 2008; Brummett et al., 1998). In addition, patients in the present study with lower levels of functioning at baseline tended to drop out at higher rates than those with higher ratings of functional status. This finding has also been observed in similar research in this area (Chatfield, Brayne, & Matthews, 2005). Thus, our present findings may not generalize well to those with particularly low levels of functional status or positive affect at baseline. However, it should also be noted that these biases may have restricted the range of data and tended to influence our estimates in a conservative direction, that is, effects may have been stronger if dropouts had been retained.

In sum, the present findings are among the first to show that PEs account for a significant amount of the change observed in functional status over time in older CAD patients, in particular...
for men. Related research in CAD samples has shown that PEs are associated with increased longevity (Brummett et al., 2005). Our findings suggest that the ability to influence changes in functional status may be one way in which PE leads to increased longevity. It is hoped that the present findings will suggest to health care professionals that patients who have been diagnosed with significant CAD may continue to experience PEs that may facilitate their future recovery. In addition to assessment of depressive symptoms and other negative emotions, clinicians may find it beneficial to measure PE in order to help identify patients who may experience higher levels of physical decline over a prolonged period following a diagnosis of CAD. Clinicians may want to encourage patients who are lacking in PE to reflect positively on their diagnosis of CAD, perhaps by suggesting that they take this time to develop new goals and coping strategies that may benefit both their physical and mental health.

**Funding**

Work was partially supported by grant number P30AG028716 (Claude Pepper Older American Independence Center, Duke University) from the National Institute on Aging and by grant number P01 HL36587 from the National Heart Lung and Blood Institute.

**Conflict of Interest**

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute on Aging or the National Institutes of Health.

**Acknowledgments**

We would like to thank Maragatha Kuchibhatla, PhD, and Michael A. Babyak, PhD, for statistical consultation; and Gerda Fillenbaum, PhD, and Ilene Siegler, PhD, MPH, for suggestions on the manuscript.

**Correspondence**

Address correspondence to Beverly H. Brummett, PhD, Department of Psychiatry and Behavioral Sciences, Duke University Medical Center, Box 2969, Durham, NC 27710. Email: brummett@duke.edu

**References**


Received September 9, 2008
Accepted February 28, 2009
Decision Editor: Rosemary Blieszner, PhD

**POSITIVE EMOTION AND FUNCTIONAL STATUS**

469