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The Roles of Negative Affect and Goal Adjustment Capacities in Breast Cancer Survivors: Associations With Physical Activity and Diurnal Cortisol Secretion

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Abstract

Objective: This study examined whether within-person changes of breast cancer survivors' high-arousal negative affect (e.g., feeling scared, upset, anxious, or guilty) could predict high levels of diurnal cortisol secretion and moderate-to-vigorous physical activity (MVPA). In addition, goal adjustment capacities (goal disengagement and goal reengagement) were expected to buffer the effect of negative affect on cortisol and to increase its effect on MVPA. **Methods**: High-arousal negative affect, self-reported MVPA, area-under-the-curve of diurnal cortisol secretion, and goal adjustment capacities were assessed in a longitudinal sample of 145 female breast cancer survivors. **Results:** Based on hierarchical linear modeling, breast cancer survivors reported increased levels of both MVPA and cortisol secretion if they experienced higher (as compared to lower) levels of high-arousal negative affect than their personal average. Furthermore, within-person negative affect was associated with: (i) higher MVPA among participants with high (but not low) goal reengagement capacities, and (ii) elevated cortisol secretion among participants with low (but not high) goal reengagement capacities.
Conclusions: High-arousal negative affect may exert differing functions among breast cancer survivors in that it can trigger adaptive health behaviors, yet simultaneously elevate diurnal cortisol secretion. In addition, being able to engage in new goals may be a necessary condition for breast cancer survivors to experience the beneficial behavioral effects of high-arousal negative affect, and it may prevent the adverse effect of negative affect on enhanced cortisol output.

Keywords: negative affect, self-regulation, breast cancer, cortisol, physical activity.

Introduction

It is well-known that the experience of severe health threats, such as cancer, can elicit high-arousal negative emotions (e.g., anxiety, anger, or guilt) (Diefenbach et al., 2008). However, the health-related consequences of high-arousal emotions are not well-understood. While functional approaches to negative emotions (Frijda, 1988; Izard, 1971) highlight their adaptive role in facilitating necessary behavioral changes including physical activity (Castonguay, Pila, Wrosch, & Sabiston, 2015), negative emotions can also be maladaptive and dysregulate health-relevant biological processes (e.g., cortisol; Cohen, Janicki-Deverts, & Miller, 2007). In addition, researchers suggest that certain health threats, such as a cancer diagnosis, may require individuals to engage in goal adjustment processes to promote effective health behaviors and reduce biological disturbances (i.e., goal adjustment capacities; Wrosch, Scheier, & Miller, 2013). Although there may be several factors that could influence moderate-to-vigorous physical activity (MVPA) and cortisol secretion, on the basis of these findings, we examined whether high-arousal negative affect (e.g., feeling guilty, scared, or angry) would predict increased levels of MVPA and diurnal cortisol secretion in a sample of recent post-treatment breast cancer survivors. In addition, we investigated whether adaptive goal adjustment processes would enhance the effect of these negative emotions on MVPA, and buffer their associations with cortisol output.

Functional and Dysfunctional Consequences of Negative Affect

Research on the roles of emotions has suggested that negative affect can exert motivational functions and may be central to overt and often adaptive behavioral patterns (Frijda, 1988). Although certain low-arousal negative emotions, such as depressive mood, may be associated with a cessation of behavior (Seligman, 1972), the experience of high-arousal negative emotions (e.g., anger or guilt) may facilitate self-assertion, direct the pursuit of social support, or provide a moral guide for behavior (Ekman, 1999; Izard, 2006; Izard, Stark, Trentacosta, & Schultz, 2008; Kunzmann, Kappes, & Wrosch, 2014; Levenson, 1994; Nesse & Ellsworth, 2009). Further, health-related motivational benefits of high-arousal negative emotions have been evidenced in healthy populations as well as those confronted by an adverse life event such as cancer, bereavement, or aging (e.g., Castonguay, Wrosch, Pila, & Sabiston, 2015; Hershfield, Scheibe, Sims, & Carstensen, 2013; Sabiston et al., 2010; Spiegel, 1998). For example, the experience of guilt has been associated with enhanced physical activity among breast cancer survivors, which in part is related to motivational drives to improve the self (Castonguay, Wrosch, et al., 2015). As such, there is reason to believe that high-arousal negative emotions could act as a trigger to motivate breast cancer survivors' engagement in adaptive health behaviors in the aftermath of a cancer diagnosis and treatment.

The experience of negative affect also plays a role in the etiology of illness. In support of this more traditional research paradigm (e.g., Selye, 1956), researchers have suggested that high-arousal negative emotions can adversely affect physical health (Cohen et al., 2007). Although such health effects can be related to the influence of negative emotions on maladaptive behavioral patterns, feelings of anxiety or anger can also disturb the hypothalamic-pituitary-adrenocortical (HPA) axis, a major part of the neuroendocrine system involving the interactions of the hypothalamus, the pituitary gland, and the adrenal cortex (e.g., metastatic breast cancer patients, older adults; Cohen et al., 2007; Giese-Davis, Abercrombie, Sephton, Durán, & Spiegel, 2004). In this scenario, high-arousal negative emotions may set in motion different processes including the enhanced secretion of cortisol across the day, which could have consequences on physical health (Heim, Ehlert, & Hellhammer, 2000). Nonetheless, it is important to note that not all individuals' physiological responses are equally affected by the same stressful circumstances. As such, individual differences in the ability to regulate stressful circumstances as they unfold over time may significantly alter known biological consequences of negative affect (Luecken & Compas, 2002; Urry et al., 2006) and need to be identified.

The Role of Goal Adjustment Capacities

Goal adjustment theory (Mens, Wrosch, & Scheier, 2015; Wrosch et al., 2013) assumes that a person's general capacity to respond to the experience of unattainable goals across life domains is important to the behavioral and biological consequences of stressful life experiences. Goal adjustment capacities reflect a person's general tendency to respond to the experience of unattainable goals across life domains. These capacities are associated with two independent self-regulation processes: goal disengagement and goal reengagement. Goal disengagement capacities entail the tendency to withdraw effort and commitment from unattainable goals. Goal reengagement capacities reflect the tendency to identify, commit to, and pursue alternative goals when a person confronts an unattainable goal (Wrosch et al., 2013; Wrosch, Scheier, Miller, Schulz, & Carver, 2003).

Since diagnosis and treatment of cancer often involves an alteration of former roles, behaviors, and goals (Stanton, Rowland, & Ganz, 2015), there are several reasons to consider goal adjustment capacities as particularly relevant among recently treated breast cancer survivors. First, a cancer diagnosis and treatment can prevent a person from achieving a number of important goals (e.g., keep working on a promotion, traveling abroad, or regaining certain physical attributes; Arman & Rehnsfeldt, 2003; Ward, Battersby, & Kilbreath, 2009). Second, in order to manage the consequences of the cancer effectively, breast cancer survivors may have to abandon more peripheral goals (e.g., working on a promotion) and redirect time and energy to addressing cancer-related demands (e.g., managing treatment regimens and adjusting to the physical consequences of cancer treatment). Third, recent guidelines encourage breast cancer survivors to engage in healthy life-style behaviors including at least 150 minutes of MVPA per week to reduce their risk for developing subsequent health problems (e.g., with respect to mortality, immune function, weight management, psychological and health-related quality of life; Courneya, Katzmarzyk, & Bacon, 2008; Sabiston & Brunet, 2012; Schmitz et al., 2010). Unfortunately, few survivors are engaging in recommended levels of physical activity (Devoogdt et al., 2010), and success for meeting such recommendations may be facilitated by an individual's capacity to commit and start pursuing new goals.

The small, but growing, literature on the role of goal adjustment capacities in breast cancer survivors lends support to these assumptions (for non-cancer populations, see Wrosch et al., 2013). Based on cross-sectional data, researchers suggest that goal disengagement and goal reengagement capacities can be associated with higher levels of subjective well-being, and that goal disengagement capacities predict lower levels of systemic inflammation among breast cancer survivors (Castonguay, Wrosch, & Sabiston, 2014; Mens & Scheier, 2015; Thompson, Stanton, & Bower, 2013; Wrosch & Sabiston, 2013). Longitudinal data further document that goal disengagement and goal reengagement capacities can forecast improvements in breast cancer survivors' subjective well-being and physical activity, although the effects of goal reengagement seem to be somewhat stronger than the effects of goal disengagement (Mens & Scheier, 2015).

Notwithstanding the adaptive functions of goal adjustment capacities among breast cancer survivors, the influence of these self-regulation processes on health-relevant behavioral and physiological consequences of negative emotions has not yet been tested. To this end, we postulate that goal adjustment capacities could play an important role in determining whether high-arousal negative affect translates into adaptive health behaviors, such as MVPA, and predicts higher levels of cortisol secretion. These processes could occur because the negative emotions alone may not always be sufficient to motivate successful engagement in physical activity. In addition, breast cancer survivors may have to free resources such as time and energy from other more peripheral goals (facilitated by goal disengagement), and adopt a new goal such as engagement in physical activity (facilitated by goal reengagement). Thus, the potentially adaptive role of negative emotions in promoting physical activity could be undermined among breast cancer survivors with low levels of goal adjustment capacities, but enhanced among women with high levels of goal adjustment capacities.

Similarly, goal adjustment capacities may determine whether high-arousal negative emotions are associated with a dysregulation of cortisol secretion. Since goal disengagement and goal reengagement capacities could ameliorate some of the physiological disturbances of negative emotions (Wrosch, Miller, Scheier, & Brun de Pontet, 2007)), associations between negative affect and cortisol output may be enhanced among breast cancer survivors with poor goal adjustment capacities, but become reduced among breast cancer survivors who are better able to adjust their goals.

The Present Study

This study examined the predictive value of high-arousal negative affect and goal adjustment capacities for MVPA and diurnal cortisol secretion in 5 waves of data from a longitudinal study of breast cancer survivors. Since emotional experiences may vary substantially for each patient during the course of a cancer diagnosis, treatment, and recovery, we chose a within-person approach for evaluating the effects of negative affect on MVPA and cortisol level. Differences in goal adjustment capacities were tested between individuals. We hypothesized that breast cancer survivors would engage more frequently in MVPA and secrete higher levels of cortisol during assessments in which they experienced higher (as compared to lower) levels of negative affect. In addition, we expected that goal adjustment capacities would moderate this association. Specifically, we reasoned that higher goal adjustment capacities may enhance the effect of negative affect on levels of MVPA, and reduce the effect of negative affect on levels of cortisol secretion.

Method

Participants and Procedures

The study is based on a one-year longitudinal sample of breast cancer survivors who took part in the *Life After Breast Cancer: Moving On* study. Following University and Hospital Ethics approval, women were recruited through advertisements and oncologist referrals. Those who were interested were asked to contact the research team by phone to obtain additional details on the study and were screened for eligibility. Women were eligible to participate in the study if they met the following criteria: (i) ≥ 18 years of age; (ii) ≤ 20 weeks post primary treatment (i.e., radiation therapy, chemotherapy, and surgery); (iii) diagnosed with stage I to III breast cancer; and (iv) able to provide written informed consent, read, and speak in English or French. Two hundred and one breast cancer survivors met the eligibility criteria, provided written consent, completed self-administered questionnaire, and provided saliva samples for cortisol at baseline (T1), 3 (T2), 6 (T3), 9 (T4), and 12 (T5) months later. Saliva samples for cortisol and questionnaires were completed during the same week. Participants who provided data for cortisol and physical activity in at least three waves of the study were included into the analyses (n = 145). These participants did not significantly differ from the excluded participants in baseline levels of age, education, smoking, body mass index (BMI), cancer stage, time since diagnosis, or the main predictor variables (ps > .05).

Instrumentation

Physical activity was assessed across waves using the Leisure-Time Exercise Questionnaire (LTEQ; Godin & Shephard, 1985). The LTEQ assesses quantity of weekly strenuous (e.g., running, vigorous bicycling), moderate (e.g., fast walking, easy bicycling), and mild (easy walking, yoga) activity. A total score was calculated by multiplying the weekly frequencies by nine, five, and three, respectively, for a total metabolic equivalent intensity value. Given the known health benefits of MVPA among breast cancer survivors (Sabiston & Brunet, 2012), we combined the scores for moderate and vigorous activities. This scale has been used with breast cancer survivor populations and has shown positive associations with accelerometer and fitness measures (e.g., Armireault, Godin, Lacombe, & Sabiston, 2015a, 2015b; Vallance, Courneya, Plotnikoff, Yasui, & Mackey, 2007).

Diurnal cortisol was assessed across waves, on three non-consecutive days for T1 and two non-consecutive days for T2 to T5. Non-consecutive days were chosen to offset the possibility that a single, unusual event on a given single day may bias individuals' typical cortisol volume. Women were asked to collect saliva samples as they engaged in their normal daily activities. On each of the days, the participants collected five saliva samples (by using salivettes) at specific times of day: awakening, 30 minutes after awakening, 2 PM, 4 PM, and before bedtime. Participants were asked not to eat or brush their teeth immediately prior to saliva collection to prevent contamination with food or blood. Participants were further instructed not to engage in physical activity in the 30 minutes preceding saliva collection. The actual time of day was recorded by the participant for all of the collected saliva samples, allowing for a calculation of hours after awakening.

The saliva samples were stored in participants' home refrigerators until they were returned to the lab within seven days after collection was completed. After the saliva samples were returned to the lab they were frozen at -80°C until the completion of the study. Cortisol assays were performed at the University of Trier, Germany, in duplicate, using a time-resolved fluorescence immuno-assay with a cortisol-biotin conjugate as a tracer (Kirschbaum, Kudielka, Gaab, Schommer, & Hellhammer, 1999). The intra-assay coefficient of variation was 5.30% and the inter-assay variability from the cortisol analyses performed in this laboratory has been routinely found to be below 10% (e.g., Lieb et al., 2004). The obtained cortisol scores, averaged across days for each patient ($M_{\text{awakening}}$ = 14.34, SD = 4.13; M_{30min} = 16.29, SD = 6.67; M_{2PM} = 5.86, SD = 1.53; M_{4PM} = 4.55, SD = 1.24; M_{bedtime} = 3.41, SD = 1.12 log nmol/Lxh), were comparable to results found in other breast cancer samples (e.g., Carlson, Speca, Faris, & Patel, 2007; Luecken, Dausch, Gulla, Hong, & Compas, 2004).

To obtain measures of participants' levels of cortisol secretion over the day, the area under the curve (AUC) of cortisol secretion was calculated for each day (in log nmol/Lxh) using the trapezoidal method, based on hours after awakening (see Pruessner et al., 2003). AUC was selected as the main dependent variable for two reasons. First, our theoretical model predicted that negative affect can be associated with high levels of cortisol across the day (see introduction), and AUC is thus an optimal construct for testing this assumption (other indicators of cortisol dysregulation, such as a flattened diurnal cortisol slope, may not only occur as a function of higher afternoon/evening cortisol, but also of lower morning cortisol; but see Limitation Section and Table OSM 3 for results on cortisol slope). Second, we think that AUC is an appropriate choice, given its psychometric properties. The AUC may be less sensitive than other indicators of cortisol (e.g., slope) to missing samples or timing of sample collection (Segerstrom, Boggero, Smith, & Sephton, 2014). Given that some saliva samples may have been contaminated, with food or blood, all samples that deviated more than three *SDs* from the mean cortisol secretion for the time of day were excluded (3.59%). In addition, AUC was calculated only if participants provided at least four out of five samples for a specific day. In cases in which a single saliva sample was missing, missing values were replaced with the sample mean for that particular time of day prior to calculating AUC. The 30 minutes measure was excluded from the calculation of AUC because the cortisol awakening response has been shown to be independent from the diurnal rhythm of cortisol (Chida & Steptoe, 2009). Since there is intra-individual variability in cortisol secretion across days (Ross et al., 2014), single-day measures of AUC were moderately correlated (*rs* = .38 to .88, *ps* < .001) and were averaged across each study wave separately (e.g., days 1, 2, and 3 were averaged across wave 1) to obtain stable indicators of individual differences in cortisol secretion across waves.

High-arousal negative affect was assessed across waves using 10 items (e.g., "guilty", "distressed", or "scared") from the negative affect subscale of the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Participants were asked to rate the extent to which they experienced each particular emotion within the last week, with reference to a 4-point Likert-type scale ranging from 1 (*very slightly or not at all*) to 4 (*extremely*). Higher scores on the scale indicated greater negative affect. The negative affect scale showed high reliability across waves (α_{T1} = .87, α_{T2} = .90, α_{T3} = .90, α_{T4} = .89, α_{T5} = .90).

Goal adjustment capacities were assessed at T1 using the Goal Adjustment Scale (GAS; Wrosch et al., 2003). The GAS is a widely used measure to assess goal adjustment capacities and the subscales have demonstrated appropriate internal consistency and associations with well-being and health-relevant outcomes in breast cancer populations (e.g., Mens & Scheier, 2015; Schroevers, Kraaij, & Garnefski, 2008; Thompson et al., 2013). Participants responded to 10 items measuring how they usually react if they have to stop pursuing an important goal in their life. Item responses ranged from 1 (*almost never true*) to 5 (*almost always true*). Four items measured a person's capacity to disengage from unattainable goals (e.g., "It's easy for me to reduce my effort towards the goal") and six items measured a person's tendency to reengage with new goals (e.g., "I seek other meaningful goals"). An average score was computed separately for goal disengagement and goal reengagement capacities. The item scores of goal disengagement and goal reengagement showed internal consistency reliability coefficients of α =

.75 and .89, respectively.

Demographics. Information was collected on participants' age, education (from 0 = *did not complete high school* to 5 = *postgraduate degree*), ethnicity, annual household income, marital status (0 = *single, widowed, or divorced*, 1 = *married or living with a life partner*), smoking (0 = *daily or occasionally*, 1 = *not at all*), body mass index (trained technician-measured weight in kilograms divided by measured height in meters squared), cancer stage (stage I to stage III), and months since diagnosis.

Data Analysis

Descriptive sample statistics were calculated using SPSS (version 20.0). To minimize the possibility of spurious associations, sociodemographic and cancer-related variables that have been identified as correlates of diurnal cortisol secretion or physical activity in oncology populations were examined as potential covariates (e.g., Carlson et al., 2007; Verloop, Rookus, van der Kooy, & van Leeuwen, 2000). Variables were included as covariates if they showed significant associations with MVPA or cortisol (Rothman, Greenlans, & Lash, 2008). Age (r = .17), education (r = .19), and BMI (r = -.22) were significantly (ps < .05) associated with MVPA, and cancer stage (r = -.34) and months since diagnosis (r = -.16) were significantly related to cortisol (ps < .05).

The hypotheses were tested in two separate sets of hierarchical linear analyses (using HLM 7.0) to predict within-person variability in a) MVPA and b) cortisol. In the Level-1 models, we estimated within-person variability in MVPA/cortisol variables across waves as a function of person-centered scores of negative affect and a residual term. The Level-1 model further controlled for person-centered scores of time in study to adjust for potential confounds with longitudinal changes in the outcomes. Specifically, the Level-1 intercept corresponded to participants' average levels of MVPA/cortisol across waves, and the slope represented the within-person associations between negative affect and MVPA/cortisol over time. The subsequent Level-2 model tested whether inter-individual differences in baseline levels of goal disengagement and goal reengagement capacities would produce significant cross-level interactions and moderate the effects of within-person changes in negative affect on levels of participants' MVPA and cortisol. That is, the Level-2 model predicted the variability in the obtained Level-1 coefficients (intercept = average levels of MVPA/cortisol; slope = associations between negative affect and MVPA/cortisol) from inter-individual differences in goal adjustment capacities and the covariates (i.e., age, education, breast cancer stage, months since diagnosis, BMI, and smoking status). Specifications of the models are reported in Supplemental Tables 1 and 2 (see the online supplemental materials). Level-2 predictors were standardized prior to conducting the analysis, and the reported effects are based on models using restricted maximum likelihood estimation and robust standard errors. Missing data did not exceed 5% on any one of the variables (i.e., age = 0.7%, education = 0.0%, stage of cancer = 0.0%, months since diagnosis = 1.4%, BMI = 0.0%, smoking status = 2.1%, goal disengagement = 2.8%, goal reengagement = 2.8%). Across waves, between 99% and 88% of participants reported sufficient data to compute AUC of cortisol, and between 100% and 95% of participants reported useable MVPA scores. Similarly, there was between 99% and 95% of usable negative affect scores. Since HLM is capable of handling missing data on Level-1, missing data of Level-1 variables were not replaced. Missing data of Level-2 variables were replaced with the sample mean (Tabachnick & Fidell, 2007).

Results

Preliminary Analyses

Descriptive sample statistics are presented in Table 1. At baseline, participants ranged in age from young adulthood to old age. The majority of participants had been diagnosed with stage

I or II breast cancer and reported being an average of 11 months past cancer diagnosis. Women were predominantly overweight based on BMI. Participants reported moderate to high levels of goal adjustment capacities, which are comparable with values reported in other studies (e.g., Wrosch et al., 2003). Participants reported engaging in an average of approximately 25 minutes of MVPA per week and secreted between 10 and 11 log nmol/Lxh of cortisol and these values are comparable with published data from other studies (Irwin et al., 2004; Mason et al., 2013; Ross, Murphy, Adam, Chen, & Miller, 2014).

Main Analyses

Physical activity. The main results of the analysis for predicting MVPA are reported in Table 2. The results of the Level-1 model showed a positive intercept for MVPA, implying that average levels of MVPA were significantly different from zero. In addition, the model suggested a significant positive slope effect of negative affect, suggesting that participants engaged in higher levels of MPVA in waves in which they reported higher (as compared to lower) than average levels of negative affect. The Level-1 model further demonstrated that there was significant variability in the intercept (variance component = 233; $\chi^2 = 585.55$, $p = < 0.001$) and slopes (variance component = 360.57; $\chi^2 = 585.55$, $p = < 0.001$) across participants.

In the subsequent Level-2 model, significant effects on the intercept were observed for BMI and goal reengagement capacities, but not for the other variables (see Table 2). Participants with a lower BMI and higher levels of goal reengagement engaged in higher average levels of MVPA across waves than participants with an elevated BMI or lower levels of goal reengagement capacities (see estimates for intercept in Table 2). In terms of predicting the negative affect slope, the results of the Level-2 model showed a significant cross-level interaction effect for participants' goal reengagement capacities on the association between within-person negative affect and MVPA, but not for the other variables (see estimates for intercept in Table 2). Above and beyond other predictors, goal reengagement explained 3.31% of the variability in the within-person association between negative affect and MVPA.

The significant cross-level interaction is illustrated in Figure 1 by plotting the within-person association between negative affect and MVPA separately for participants who reported high versus low levels of goal reengagement (using the average upper [UQ] and lower [LQ] quartiles of the predictor variables as reference points [negative affect: LQ = -0.99, UQ = 0.89; goal reengagement: LQ = -1.44, UQ = 1.03]). The experience of higher than average negative affect was significantly associated with increased levels of MVPA, but only among participants who had high levels of goal reengagement (*coefficient* = 7.54, *SE* = 2.43, $p = .002$). By contrast, this association was not significant among participants with low levels of goal reengagement capacities (*coefficient* = -0.84, *SE* = 1.84, $p = .65$).

Diurnal cortisol. The Level-1 model estimates for predicting diurnal cortisol volume (AUC) are presented in Table 2. Similar to the findings for MVPA, a significant and positive intercept was observed, suggesting that average levels of cortisol were different from zero. The results further showed a significant positive slope effect of negative affect, indicating that participants exhibited higher levels of diurnal cortisol volume in waves in which they reported higher (as compared to lower) than average levels of negative affect (see coefficients in Table 2).[1] The Level-1 model further revealed that there was significant variability in the intercept (variance component = 2.33; $\chi^2 = 503.10$, $p = < 0.001$) and slope values (variance component = 4.20; $\chi^2 = 503.10$, $p = < 0.001$) across participants.

The results of the Level-2 model showed significant effects on the intercept for age and breast cancer stage, but not for the other variables (see Table 2). Specifically, older participants and participants with lower breast cancer stage secreted higher average levels of cortisol across waves than younger participants and participants with higher breast cancer stage (see estimates for intercept in Table 2). With respect to predicting the negative affect slope, a significant cross-level interaction effect was obtained for participants' goal reengagement capacities on the association between within-person negative affect and cortisol level, but not for the other variables (see estimates for intercept in Table 2). Above and beyond the other predictors, goal reengagement explained 37.58% of the variability in the within-person association between negative affect and cortisol output.[2]

The significant cross-level interaction is illustrated in Figure 2 by plotting the within-person association between negative affect and cortisol secretion separately for participants who reported high versus low levels of goal reengagement (using the average UQ and LQ of negative affect [LQ = -1.02, UQ = 0.89] and goal reengagement [LQ = -1.44, UQ = 1.03] as reference points). As illustrated in Figure 2, the experience of higher than average negative affect was significantly related to increased levels of cortisol secretion, but only among breast cancer survivors who had low levels of goal reengagement capacities (*coefficient* = -0.38, $SE = 0.07$, $p < .001$). In contrast, this association was not significant among their counterparts with high levels of goal reengagement capacities (*coefficient* = 0.20, $SE = 0.18$, $p = .27$).

Discussion

The results of this study showed that within-person increases in high-arousal negative emotions, such as guilt, anxiety, or distress, predicted enhanced levels of MVPA and diurnal cortisol secretion among a sample of recently diagnosed and treated breast cancer survivors. However, high-arousal negative affect was associated with increased levels of MVPA only among breast cancer survivors with high (and not low) levels of goal reengagement capacities, and predicted increased levels of diurnal cortisol only among breast cancer survivors with low (but not high) levels of goal reengagement capacities. These effects were independent of relevant covariates (i.e., age, education, breast cancer stage, months since diagnosis, BMI, and smoking status) and specific to high-arousal negative emotions (e.g., feeling scared, upset, or guilty). In fact, the reported supplemental analyses showed that low-arousal emotional states, such as depressive symptoms or fatigue, were not involved in participants' cortisol secretion, and depressive symptoms showed, consistent with previous research (Brunet, Amireault, Chaiton, & Sabiston, 2014; Norton & Mehta, 2007; Roshanaei-Moghaddam, Katin, & Russo, 2009), a reversed effect in predicting reduced levels of physical activity (see Footnotes 3 and 4).[3,4]

These findings suggest that high-arousal negative affect can exert both adaptive and maladaptive consequences on health-relevant outcomes among some breast cancer survivors. First, these negative emotions may motivate breast cancer survivors to engage in physical activity if they act as a signal for implementing necessary life-style changes (cf. Frijda, 1988). Recent guidelines have suggested that breast cancer survivors should engage in at least 150 minutes of MVPA per week to gain health benefits (e.g., with respect to mortality, immune function, psychological and health-related quality of life, (Sabiston & Brunet, 2012; Schmitz et al., 2010). Women in the current sample engaged in an average of 25 minutes of MVPA per week over the 12-month period, indicating that a substantial portion of the sample may be at risk for poor health given they are not engaging in sufficient MVPA. Based on these results, we conclude that certain high-arousal negative emotions can play an important role in directing adaptive health behaviors among some cancer survivors and potentially contribute to long-term benefits on their physical health.

Second, and consistent with the literature on negative emotions and neuroendocrine regulation (Cohen et al., 2007), high levels of negative affect may have contributed to an increase in cortisol secretion among some breast cancer survivors. If the latter process should extend over longer periods of time, it may enhance breast cancer survivors' risk for developing a number of health-related problems (Heim et al., 2000; Talbbott, 2002). For instance, different indicators of cortisol (e.g., slope or levels) have been associated with a larger waist circumference, fatigue, immune dysfunction, greater disease severity, cancer progression, and shortened survival time in breast cancer survivors (Abercrombie et al., 2004; Bower et al., 2005; Sephton, Sapolsky, Kraemer, & Spiegel, 2000; Van Der Pompe, Antoni, & Heijnen, 1996). Although it is challenging to compare cortisol outputs across studies given the differences in instruments, timing of assessments, sample characteristics, and number of measures, some of the women in the current sample could develop similar health problems over time, considering that the observed average levels of cortisol volume were comparable to or higher than the levels observed in some other at-risk populations and those obtained in healthy middle-aged adults, respectfully (e.g., caregivers of brain cancer patients; Ross et al., 2014).

Of note, the reported effects on cortisol secretion were not statistically explained by participants' levels of MVPA, and vice versa (see Footnote 1). This finding indicates the presence of two independent processes, and excludes the possibility that increases in cortisol levels were temporarily driven by enhanced levels of physical activity (Hill et al., 2008). It further suggests that high-arousal negative affect may be related to enhanced cortisol output only among some participants, while it contributes to engagement in MVPA among other participants. Thus, negative affect may represent a risk factor for some breast cancer survivors and could compromise their long-term physical health.

The importance of goal reengagement capacities in the associations between breast cancer survivors' high-arousal negative emotions, MVPA, and cortisol regulation was also identified in the study. First, negative emotions were associated with increases in MVPA only among participants with high (but not low) levels of goal reengagement capacities. This finding implies that in order to implement necessary lifestyle changes, negative emotions may need to be coupled with a person's capacity to commit to and start pursuing new goals. In the absence of such self-regulation capacities, however, negative emotions may not translate into the same adaptive health behaviors. Second, the adverse effect of negative emotions on enhanced levels of diurnal cortisol secretion was observed only among breast cancer survivors with low (but not high) goal reengagement capacities. This buffering effect on participants' physiological stress response could be associated with the frequently observed benefits of goal reengagement for positive indicators of subjective well-being (e.g., purpose in life; Mens & Scheier, 2015; Wrosch et al., 2003), which may ameliorate some of the physiological stress responses associated with negative affect. Nonetheless, the specific mechanisms through which self-regulation capacities benefit health-relevant physiological processes in cancer survivors are not yet fully understood (Institute of Medicine, 2001) and should be subject to further research.

Inconsistent with research on non-cancer populations (Wrosch et al., 2013), this study did not document effects of participants' goal disengagement capacities. However, the emerging goal adjustment literature among breast cancer survivors seems to indicate a pattern that is more consistent with our findings, suggesting stronger benefits deriving from goal reengagement, as compared to goal disengagement, capacities. (Mens & Scheier, 2015; Offerman, Schroevers, van der Velden, de Boer, & Pruyn, 2010; Schroevers et al., 2008; Thompson et al., 2013; Wrosch & Sabiston, 2013). This pattern of findings may imply that goal adjustment capacities function somewhat differently in the context of cancer. Unlike some other stressors (e.g., caregiving or the onset of functional disability, Wrosch et al., 2013), breast cancer represents a particularly severe and existential threat for many women, which poses a unique set of challenges. For example, fear of cancer recurrence or death and uncontrollable side effects of treatment (Thompson et al., 2013) may result in circumstances that make it difficult for breast cancer survivors to regulate negative emotions effectively and contribute to significant variability in negative emotions over time.

To this end, results from non-cancer populations would have suggested that goal disengagement could ameliorate the experience of negative emotions by redirecting time and energy from more peripheral goals to effectively overcoming a pressing problem (Wrosch et al., 2013). In the context of a severe and existential threat such as cancer, however, it may be less likely that the provision of resources through goal disengagement is sufficient to effectively cope with the emerging threats. Instead, goal reengagement capacities may become paramount for managing those stressors that are difficult to resolve and keep eliciting high levels of negative affect. In such circumstances, the commitment to and pursuit of new goals may facilitate new and adaptive behaviors among breast cancer survivors who experience high-arousal negative emotions. In addition, the positive psychological consequences often derived from new goal pursuits (e.g., purpose for living; Mens & Scheier, 2015) may ameliorate some of the maladaptive physiological disturbances associated with increased levels of negative affect.

Overall, the reported findings have important implications for psychological theories of physical health and for clinical practitioners. First, they contribute to the literature on the adaptive and maladaptive effects of negative emotions (e.g., Izard, 2006; Izard et al., 2008; Kunzmann et al., 2014). In this regard, our study suggests that the consequences of high-arousal negative affect represent a double-edged sword in the context of breast cancer. While such negative emotions can facilitate engagement in health-promoting behaviors such as physical activity, they may also be associated with increases in breast cancer survivors' cortisol output, which could have detrimental long-term consequences on their physical health (Cohen et al., 2007; Talbbott, 2002). Second, our study informs self-regulation theories of physical health by demonstrating that general effects of high-arousal negative affect on physical activity and cortisol do not automatically occur among all breast cancer survivors. Here, the reported findings identify the capacity to commit to and engage in new goals as an important personal resource.

Goal reengagement capacities may assist breast cancer survivors in benefiting from the motivating function of certain negative emotions on their life-style behaviors, and help them to avert potential maladaptive effects of negative affect on their diurnal cortisol secretion. Third, the identification of this mechanism may foster the development of new interventions designed to help breast cancer survivors cope with the threats related to their cancer experience. Clinical practitioners may be able to identify breast cancer survivors who generally have difficulty engaging in new goals, and work with them on the identification of, commitment to, and pursuit of specific new goals. Encouraging and facilitating new meaningful goal pursuits could foster adaptive health behaviors, biological functioning, and physical health among cancer survivors.

Limitations and Future Directions

There are limitations to the current study that should be addressed in future investigations. First, the present sample of breast cancer survivors predominantly consisted of Caucasians with relatively high socio-economic status. Thus, future research should cross-validate the reported findings in more diverse and representative samples. Second, our analysis focused on female breast cancer survivors, but we would expect to observe similar patterns of findings among men and other cancer populations as well. Future work should therefore sample female and male individuals who are confronted with a variety of different cancers to examine the presence of comparable mechanisms in these populations. Third, although our analyses documented evidence that the observed effects were specific to high-arousal negative affect (see Footnote 3), more systematic research is needed to investigate the health-related consequences of low- and high-arousal negative emotions in at-risk populations. In addition, such research should examine the specific cancer-related circumstances that could give rise to the experiences of negative emotions and predict associated levels of cortisol and physical activity. To this end, the current sample and timing of the assessments may be unique given that in the year post-treatment for breast cancer, women may fall ill more frequently than during other times in the survivorship trajectory, may encounter personal stressors such as return to work, family and social dynamic challenges, treatment plan changes, and/or experience late-and longer-term effects from the treatment. Fourth, our main analyses predicted AUC of cortisol and did not address cortisol slope. Supplemental analyses suggested that cortisol slope was not associated with patients' negative affect (see Table OSM 3). These findings could imply that a measure that represents the accumulated cortisol volume across a day (AUC) is more sensitive to intra-individual changes in negative affect than a measure that varies as a function of cortisol secretion during different times of day (i.e., a flattened slope can be indicated by either higher afternoon/evening cortisol, lower morning cortisol, or both). Given that a reliable measurement of AUC may require less samples per day and fewer assessment days compared to cortisol slope (Segerstrom, Boggero, Smith, & Sephton, 2014), however, it is also possible that the psychometric properties of AUC resulted in a comparatively higher sensitivity to changes in negative affect. Fifth, the reported findings are based on examining the effects of a personality dimension, which is associated with individuals' general capacity to react to goal constraints across different domains. From this perspective, we would expect that the reported beneficial effects of goal reengagement capacities could be explained by an enhanced commitment to breast cancer survivors' specific new goals; a possibility that should be tested in future research. Sixth, goal reengagement accounted for a relatively modest portion of the variability in the within-person association between negative affect and MVPA. Thus, future research should investigate additional factors that may foster physical activity among breast cancer survivors, such as other personality dimensions (e.g., conscientiousness or optimism), motivational regulations, self-efficacy, body image concerns, social support, and physical and environmental constraints. Finally, this study investigated health-relevant behavioral and biological processes, but it did not predict changes in physical health. In this regard, our theoretical framework (Wrosch & Sabiston, 2013; Wrosch et al., 2013) would assume that the observed mechanisms could contribute over longer periods of time to changes in physical health. Future analyses should therefore examine in long-term longitudinal research how emotional experiences and personal resources as well as their biological and behavioral consequences prospectively predict physical health (e.g., chronic disease or cancer recurrence). Research along these lines may illuminate the psychological pathways that contribute to maintaining physical health among vulnerable cancer populations.

Conclusions

The findings from this study showed that high-arousal negative affect may contribute to increases in physical activity and cortisol secretion among breast cancer survivors. In addition, they showed evidence that a cancer survivor's capacity to commit to, and engage in, new goals (i.e., goal reengagement) may facilitate the beneficial effect of negative affect on physical activity engagement and help prevent a disturbance of cortisol function. The identification of goal reengagement capacities as a mechanism linking negative emotional states to health-relevant behavioral and physiological processes advances theory on the health-related consequences of adaptive self-regulation in stressful life circumstances. In addition, it will be helpful for health care professionals who work with cancer populations because self-regulation processes are modifiable psychological dimensions that represent a non-invasive option for improving physical health.

References

Abercrombie, H. C., Giese-Davis, J., Sephton, S., Epel, E. S., Turner-Cobb, J. M., & Spiegel, D. (2004). Flattened cortisol rhythms in metastatic breast cancer patients. *Psychoneuroendocrinology, 29*, 1082-1092. doi: 10.1016/j.psyneuen.2003.11.003

Arman, M., & Rehnsfeldt, A. T. (2003). The hidden suffering among breast cancer patients: A qualitative metasynthesis. *Qualitative Health Research, 13*, 510-527. doi: 10.1177/1049732302250721

Armireault, S., Godin, G., Lacombe, J., & Sabiston, C. M. (2015a). The use of the godin-shephard leisure-time physical activity questionnaire in oncology research: A systematic review. *BioMed Central, 15*. doi: 10.1186/s12874-015-0045-7

Armireault, S., Godin, G., Lacombe, J., & Sabiston, C. M. (2015b). Validation of the godin-shephard leisure-time physical activity questionnaire classification coding system using accelerometer assessment among breast cancer survivors. *Journal of Cancer Survivorship, 9*, 532-540. doi: 10.1007/s11764-015-0430-6

Bower, J. E., Ganz, P. A., Dickerson, S. S., Petersen, L., Aziz, N., & Fahey, L. (2005). Diurnal cortisol rhythm and fatigue in breast cancer survivors. *Psychoneuroendocrinology, 30*, 92-100. doi: 10.1016/j.psyneuen.2004.06.003

Carlson, L. E., Speca, M., Faris, P., & Patel, K. (2007). One year pre-post intervention follow-up of psychological, immmune, endocrine and blood pressure outcomes of mindfulness-based stress reduction (mbsr) in breast and prostate cancer outpatients. *Brain, Behavior, and Immunity, 21*, 1038-1049. doi: 10.1016/j.bbi.2007.04.002

Castonguay, A. L., Pila, E., Wrosch, C., & Sabiston, C. M. (2015). Body-related self-conscious emotions relate to physical activity motivation and behavior in men. *American Journal of Men's Health, 9*, 209-221. doi: 10.1177/1557988314537517

Castonguay, A. L., Wrosch, C., Pila, E., & Sabiston, C. M. (2015). Body-related shame and guilt predict physical activity in breast cancer survivors over time. *Submitted to Psycho-Oncology*.

Castonguay, A. L., Wrosch, C., & Sabiston, C. M. (2014). Coping with breast cancer and systemic inflammation: The roles of goal adjustment capacities and health-related self-protection. *Psycho-Oncology, 23*, 878-885. doi: 10.1002/pon.3489

Chida, Y., & Steptoe, A. (2009). Cortisol awakening response and psychosocial factor: A systematic review and meta-analysis. *Biological Psychology, 80*, 265-278. doi: 10.1016/j.biopsycho.2008.10.004

Cohen, S., Janicki-Deverts, D., & Miller, G. E. (2007). Psychological stress and disease. *Journal of the American Medical Association, 298*, 1685-1687. doi: 10.1001/jama.298.14.1685

Courneya, K. S., Katzmarzyk, P. T., & Bacon, E. (2008). Physical activity and obesity in canadian cancer curvivors: Population-based estimates from the 2005 canadian community health survey. *Cancer, 112*, 2475-2482. doi: 10.1002/cncr.23455

Devoogdt, N., Van Kampen, M., Geraerts, I., Coremans, T., Fieuws, S., Lefevre, J., . . . Chistiaens, M. R. (2010). Physical activity levels after treatment for breast cancer: One-year follow-up. *Breast Cancer Research and Treatment, 123*, 417-425. doi: 10.1007/s10549-010-0997-6

Diefenbach, M. A., Miller, S. M., Porter, M., Peters, E., Stefanek, M., & Leventhal, H. (2008). Emotions and health behavior: A self-regulation perspective. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook of emotions* (3rd ed., pp. 645-660). New York, NY: The Guilford Press.

Ekman, P. (1999). "Basic emotions". In T. Dalgleish & M. J. Power (Eds.), *Handbook of cognition and emotion* (pp. 45-60). New York, NY: John Wiley & Sons Ltd.

Frijda, N. H. (1988). The laws of emotion. *American Psychologist, 43*, 349-358.

Giese-Davis, J., Abercrombie, H. C., Sephton, S. E., Durán, R. E. F., & Spiegel, D. (2004). Repression and high anxiety are associated with aberrant diurnal cortisol rhythms in women with metastatic breast cancer. *Health Psychology, 23*, 645-650. doi: 10.1037/0278-6133.23.6.645

Godin, G., & Shephard, R. J. (1985). A simple method to assess exercise behaviour in the community. *Canadian Journal of Applied Sport Sciences, 10*, 141-146.

Heim, C., Ehlert, U., & Hellhammer, D. H. (2000). The potential role of hypocortisolism in the pathophysiology of stress-related bodily disorders. *Psychoneuroendocrinology*, *25*, 1-35.

Hershfield, H. E., Scheibe, S., Sims, T. L., & Carstensen, L. L. (2013). When feeling bad can be good: Mixed emotions benefit physical health across adulthood. *Social Psychological and Personality Science, 4*, 54-61. doi: 10.1177/1948550612444616

Hill, E. E., Zack, E., Battaglini, C., Viru, M., Viru, A., & Hackney, A. C. (2008). Exercise and circulating cortisol levels: The intensity threshold effect. *Journal of Endocrinological Investigation, 31*, 587-591. doi: 10.1007/BF03345606

Institute of Medicine. (2001). *Health and behavior: The interplay of biological, behavioral, and societal influences*. Washington, DC: National Academy of Sciences.

Irwin, M. L., McTiernan, A., Bernstein, L., Gilliland, F. D., Baumgartner, R., Baumgartner, K., & Ballard-Barbash, R. (2004). Physical activity among breast cancer survivors. *Medicine & Science in Sports & Exercise, 36*, 1484-1491.

Izard, C. E. (1971). *The face of emotion*. New York, NY: Appleton-Century-Crofts.

Izard, C. E. (2006). *Experts' definitions of emotion and their ratings of its components and characteristics*. University of Delaware, Newark: Unpublished manuscript.

Izard, C. E., Stark, K., Trentacosta, C., & Schultz, D. (2008). Beyond emotion regulation: Emotion utilization and adaptive functioning. *Child Development Perspectives, 2*, 156-163. doi: 10.1111%2Fj.1750-8606.2008.00058.x

Kirschbaum, C., Kudielka, B. M., Gaab, J., Schommer, N. C., & Hellhammer, D. C. (1999). Impact of gender, menstrual cycle phase, and oral contraceptives on the activity of the hypothalamus-pituitary-adrenal axis. *Psychosomatic Medicine, 61*, 154-162. doi: 10.1097/00006842-199903000-00006

Kunzmann, U., Kappes, C., & Wrosch, C. (2014). Emotional aging: A discrete emotion perspective. *Frontiers in Psychology, 5*, 380. doi: 10.3389/fpsyg.2014.00380

Levenson, R. W. (1994). I. Human emotion: Variation and consequences. In P. Ekman & R. Davidson (Eds.), *In the nature of emotion. Fundamental questions*. New York, NY: Oxford University Press.

Lieb, K., Rexhausen, J. E., Kahl, K. G., Schweiger, U., Philipsen, A., Hellhammer, D. H., & Bohus, M. (2004). Increased diurnal salivary cortisol in women with borderline personality disorder. *Journal of Psychiatric Research, 38*, 559-565. doi: 10.1016/j.jpsychires.2004.04.002

Luecken, L. J., & Compas, B. E. (2002). Stress, coping, and immune function in breast cancer. *Journal of Behavioral Medicine, 24*, 336-344. doi: 10.1207/S15324796ABM2404_10

Luecken, L. J., Dausch, B., Gulla, V., Hong, R., & Compas, B. E. (2004). Alterations in morning cortisol associated with ptsd in women with breast cancer. *Journal of Psychosomatic Research, 56*, 13-15. doi: 10.1016/S0022-3999(03)00561-0

Mason, C., Alfano, C. M., Smith, A. W., Wang, C.-Y., Neuhouser, M. L., Duggan, C., . . . McTiernan, A. (2013). Long-term physican activity trends in breast cancer survivors.

Cancer Epidemiology, Biomarkers & Prevention, 22, 1153-1161. doi: 10.1158/1055-9965.EPI-13-0141

Mens, M. G., & Scheier, M. F. (2015). The benefits of goal adjustment capacities for well-being among women with breast cancer: Potential mechanisms of action. *Journal of Personality*. doi: 10.1111/jopy.12217

Mens, M. G., Wrosch, C., & Scheier, M. F. (2015). Goal adjustment theory. In S. K. Whitbourne (Ed.), *The encyclopedia of adult development and aging* (pp. 571-576). London, UK: Wiley-Blackwell.

Nesse, R. M., & Ellsworth, P. C. (2009). Evolution, emotions, and emotional disorders. *American Psychologist, 64*, 129-139. doi: 10.1037/a0013503

Offerman, M. P. J., Schroevers, M. J., van der Velden, L., de Boer, M. F., & Pruyn, J. F. A. (2010). Goal processes and self-efficacy related to psychological distress in head and neck cancer patients and their partners. *European Journal of Oncology Nursing, 14*, 231-237. doi: 10.1016/j.ejon.2010.01.022

Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology, 28*, 916-931. doi: 10.1016/S0306-4530(02)00108-7

Ross, K. M., Murphy, M. L. M., Adam, E. K., Chen, E., & Miller, G. E. (2014). How stable are diurnal cortisol activity indices in healthy individuals? Evidence from three multi-wave studies. *Psychoneuroendocrinology, 39*, 184-193. doi: 10.1016/j.psyneuen.2013.09.016

Sabiston, C. M., & Brunet, J. (2012). Reviewing the benefits of physical activity during cancer survivorship. *American Journal of Lifestyle Medicine, 6*, 167-177. doi: 10.1177/1559827611407023

Sabiston, C. M., Brunet, J., Kowalski, K. C., Wilson, P., Mack, D. E., & Crocker, P. R. E. (2010). The role of body-related self-conscious emotions in motivating physical activity among women. *Journal of Sport & Exercise Psychology, 32*, 417-437.

Schmitz, K. H., Courneya, K. S., Matthews, C., Demark-Wahnefried, W., Galvão, D. A., Pinto, B. M., . . . Schwartz, A. L. (2010). American college of sports medicine roundtable on exercise guidelines for cancer survivors. *Medicine & Science in Sports & Exercise, 42*, 1409-1426.

Schroevers, M., Kraaij, V., & Garnefski, N. (2008). How do cancer patients manage unattainable personal goals and regulate their emotions? *British Journal of Health Psychology, 13*, 551-562. doi: 10.1348/135910707X241497

Segerstrom, S. C., Boggero, I. A., Smith, G. T., & Sephton, S. E. (2014). Variability and reliability of diurnal cortisol in younger and older adults: Implications for design decisions. *Psychoneuroendocrinology, 49*, 299-309. doi: 10.1016/j.psyneuen.2014.07.022

Seligman, M. E. (1972). Learned helplessness. *Annual Review of Medicine, 23*, 407-412.

Selye, H. (1956). *The stress of life*. New York, NY: McGraw-Hill.

Sephton, S. E., Sapolsky, R. M., Kraemer, H. C., & Spiegel, D. (2000). Diurnal cortisol rhythm as a predictor of breast cancer survival. *Journal of the National Cancer Institute, 92*, 994-1000. doi: 10.1093/jnci/92.12.994

Spiegel, D. (1998). Getting there is half the fun: Relating happiness to health. *Psychological Inquiry, 9*, 66-68. doi: 10.1207/s15327965pli0901_10

Stanton, A. L., Rowland, J. H., & Ganz, P. A. (2015). Life after diagnosis and treatment of cancer in adulthood: Contributions from psychosocial oncology research. *The American Psychologist, 70*, 159-174. doi: 10.1037/a0037875

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics*. Boston, MA: Allyn and Bacon.

Talbbott, S. (2002). *The cortisol connection: Why stress makes you fat and ruins your health-and what can you do about it*. Alameda, CA: Hunter House.

Thompson, E. H., Stanton, A. L., & Bower, J. E. (2013). Situational and dispositional goal adjustment in the context of metastatic cancer. *Journal of Personality, 81*, 441-451. doi: 10.1111/jopy.12025

Urry, H. L., van Reekum, C. M., Johnstone, T., Kalin, N. H., Thurow, M. E., Schaefer, H. S., . . . Davidson, R. J. (2006). Amygdala and ventromedial prefrontal cortex are inversely coupled during regulation of negative affect and predict the diurnal pattern of cortisol secretion among older adults. *The Journal of Neuroscience, 26*, 4415-4425. doi: 10.1523/JNEUROSCI.3215-05.2006

Vallance, J. K., Courneya, K. S., Plotnikoff, R. C., Yasui, Y., & Mackey, J. R. (2007). Randomized controlled trial of the effects of print materials and step pedometers on physical activity and quality of life in breast cancer survivors. *Journal of Clinical Oncology, 25*, 2352-2359. doi: 10.1200/JCO.2006.07.9988

Van Der Pompe, G., Antoni, M. H., & Heijnen, C. J. (1996). Elevated basal cortisol levels and attenuated acth and cortisol responses to a behavioral challenge in women with metastatic breast cancer. *Psychoneuroendocrinology, 21*, 361-374. doi: 10.1016/0306-4530(96)00009-1

Verloop, J., Rookus, M. A., van der Kooy, K., & van Leeuwen, F. E. (2000). Physical activity and breat cancer risk in women aged 20-54 years. *Journal of the National Cancer Institute, 92*, 128-135. doi: 10.1093/jnci/92.2.128

Ward, L. C., Battersby, K. J., & Kilbreath, S. L. (2009). Airplane travel and lymphedema: A case study. *Lymphology, 42*, 139-145.

Watson, D., Clark, L. A., & Tellegen, A. (1988). A development and validation of brief measures of positive and negative affect: The panas scales. *Journal of Personality and Social Psychology, 47*, 1063-1070. doi: 10.1037/0022-3514.54.6.1063

Wrosch, C., Miller, G. E., Scheier, M. F., & Brun de Pontet, S. (2007). Giving up on unattainable goals: Benefits for health? *Personality and Social Psychology Bulletin, 33*, 251-265. doi: 10.1177/0146167206294905

Wrosch, C., & Sabiston, C. M. (2013). Goal adjustment, physical and sedentary, and well-being and health among breast cancer survivors. *Psycho-Oncology, 22*, 581-589. doi: 10.1002/pon.3037

Wrosch, C., Scheier, M. F., & Miller, G. E. (2013). Goal adjustment capacities, subjective well-being, and physical health. *Social and Personality Psychology Compass, 7*, 847-860. doi: 10.1111/spc3

Wrosch, C., Scheier, M. F., Miller, G. E., Schulz, R., & Carver, C. S. (2003). Adaptive self-regulation of unatainable goals: Goal disengagement, goal reengagement, and subjective well-being. *Personality and Social Psychology Bulletin, 29*, 1494-1508. doi: 10.1177/0146167203256921

Footnotes

[1] The obtained effects on both physical activity and cortisol were independent of each other. Post-hoc analyses controlling the effects on physical activity for cortisol at Level-1 (and vice versa) showed that the main effects of negative affect (AUC: $ß$ = 0.38 [0.18], p = .04; MVPA: $ß$ = 4.95 [2.06], p = .02), and the interactions between negative affect and goal reengagement (AUC: $ß$ = -0.29 [0.14], p = .04; MVPA: $ß$ = 4.18 [1.67], p = .01) remained significant. Within-person associations between MVPA and cortisol level showed only a small positive, but non-significant, effect (ts[144] = 1.79 to 1.86, ps > .06).

[2] Note that our data also allowed us to analyze cortisol slope across day. Supplemental analyses predicting intra-individual changes in cortisol slope showed that neither the main effects of negative affect and goal adjustment capacities predicted cortisol slope, nor did the interactions between negative affect and goal adjustment capacities (see Table OSM 3).

[3] To examine whether the results were specific to high-arousal negative emotions, two sets of hierarchical models (for predicting MVPA and cortisol) were conducted with depressive symptoms (CES-D) as predictor variable and compared to the original models. The first model assessed depressive symptoms as a Level-1 predictor, while the second model examined depressive symptoms as a Level-2 covariate. In the first set of analyses, depressive symptoms significantly predicted physical activity ($ß$ = -6.90 [2.76], p = .01) but not cortisol levels ($ß$ = -0.50 [0.28], p = .08) as a Level-1 predictor and there were no significant cross-level interactions for goal disengagement or goal reengagement on the association between depression and physical activity or cortisol (ps > .06). In the second set of analyses, depressive symptoms were not a significant Level-2 covariate in the models for physical activity ($ß$ = 0.06 [2.12], p = .98) or cortisol ($ß$ = 0.38 [0.23], p = .10). In addition, the interaction for goal reengagement in the association between negative affect and physical activity ($ß$ = 4.40 [1.88], p = .02) and cortisol ($ß$

= -0.25 [0.12], $p = .04$) remained significant, suggesting that the reported findings are independent of breast cancer survivors' depressive symptoms.

[4] Note that other psychological states, such as fatigue, could also exert effects on cortisol and MVPA. Given that fatigue has been closely related to depressive symptoms in cancer patients (Visser & Smets, 1998), however, we would not expect that it would show the same effects as high-arousal negative affect. Nonetheless, bivariate correlations were conducted between depressive symptoms and fatigue averaged across waves, which indicated only moderate associations ($r = .46$). Subsequent analyses with fatigue (Brief Fatigue Inventory; BFI) suggested that it did not significantly predict intra-individual changes in physical activity (β = -0.52 [0.56], $p = .35$) or cortisol levels (β = -0.02 [0.08], $p = .81$) as a Level-1 predictor and there were no significant cross-level interactions for goal disengagement or goal reengagement on the association between fatigue and physical activity or cortisol (ps > .49). In addition, fatigue was not a significant Level-2 covariate in the models for predicting physical activity (β = -3.03 [1.83], $p = .10$) or cortisol (β = 0.12 [0.19], $p = .51$), and the interaction for goal reengagement in the association between negative affect and physical activity (β = 3.93 [1.89], $p = .04$) and cortisol (β = -0.28 [0.14], $p = .04$) remained significant if fatigue was included in the original model.

Table 1

Ranges, means, standard deviations, and frequencies of study variables among breast cancer survivors (N = 145)

Variable	Score Range	Mean (*SD*) or Percentage[a]
Age	28-79	56.00 (10.55)
Education (baseline)	0-5	3.27 (1.56)
Did not complete high school (%)		5.6
High school diploma (%)		14.6
Post-secondary no diploma (%)		6.9
College/technical diploma (%)		19.4
Undergraduate degree (%)		27.1
Post-graduate degree %)		26.4
Ethnicity, white (%)		86.8
Annual household income	9,000-500,000	88,582.32 (79,781.45)
Married or living with a life partner (%)		60.4%
Stage of cancer (baseline)	1-3	1.74 (0.75)
Stage I (%)		43.8
Stage II (%)		38.2
Stage III (%)		18.1
Months since diagnosis (baseline)	2-20	10.52 (3.47)
Body Mass Index (baseline)	18-50	26.10 (5.61)
Smoking status yes (%)		5.8
Cortisol (AUC; log nmol/Lxh)		
Baseline	5-15	10.86 (1.79)
3 months	1-16	10.44 (2.91)
6 months	5-19	10.79 (2.51)
9 months	2-17	9.95 (2.83)
12 months	4-18	10.63 (2.62)
Moderate-to-vigorous physical activity (min/week)		
Baseline	0-196	21.84 (24.83)
3 months	0-168	26.45 (25.92)
6 months	0-168	26.52 (26.68)
9 months	0-98	22.89 (21.80)
12 months	0-106	24.89 (22.36)
Negative affect	1-5	
Baseline		3.28 (0.68)
3 months		3.23 (0.71)
6 months		3.29 (0.71)
9 months		3.23 (0.71)
12 months		3.25 (0.75)
Goal disengagement capacities (baseline)	1-5	2.83 (0.80)
Goal reengagement capacities (baseline)	1-5	3.66 (0.67)

Note: [a]Mean and *SD* are presented for continuous variables. AUC = area under the curve.

Table 2

Table 2

Results of HLM analyses examining the longitudinal effects of within-person feelings of negative affect and goal adjustment capacities on moderate-to-vigorous physical activity (MVPA) and diurnal cortisol secretion (AUC)

	Moderate-to-vigorous physical activity				Diurnal cortisol secretion			
	Average level of MVPA (Intercept)		Association between negative affect and MVPA (Slope)		Average level of AUC (Intercept)		Association between negative affect and AUC (Slope)	
	ß (SE)	T-ratio	*ß (SE)*	T-ratio	*ß (SE)*	T-ratio	*ß (SE)*	T-ratio
Level - 1	24.51 (1.47)	16.68**	5.53 (1.94)	.85**	10.58 (0.15)	70.06**	0.44 (0.19)	2.36*
Level - 2								
Age	-2.57 (1.49)	-1.72	-1.61 (2.12)	-0.76	0.38 (0.17)	2.26*	-0.24 (0.20)	-1.22
Education	1.34 (1.57)	0.86	-3.86 (2.22)	-1.74	0.12 (0.16)	0.70	-0.08 (0.20)	-0.43
Smoking status	-1.18 (1.31)	-0.91	-2.70 (1.69)	-1.60	-0.19 (0.14)	-1.39	-0.19 (0.17)	-1.08
Body mass index	-3.15 (1.19)	-2.65*	1.77 (1.63)	1.09	0.11 (0.15)	0.80	0.03 (0.21)	0.16
Breast cancer stage	-1.06 (1.35)	-0.78	1.34 (2.11)	0.63	-0.46 (0.16)	-2.80*	0.11 (0.20)	0.52
Time since diagnosis	0.61 (1.47)	0.42	-2.58 (2.07)	-1.25	-0.10 (0.15)	-0.69	-0.08 (0.17)	-0.46
Goal disengagement capacities (GD)	-2.40 (1.27)	-1.89	-0.68 (1.56)	-0.44	0.05 (0.16)	0.33	0.13 (0.18)	0.69
Goal reengagement capacities (GR)	3.57 (1.12)	3.17**	4.46 (1.86)	2.40**	-0.11 (0.13)	-0.81	-0.30 (0.14)	-2.14*

Note: Level – 1 model had 141 df. Level – 2 had 130 df. Level – 1 and Level – 2 coefficients were additionally controlled for wave. *$p < .05$, ** $p < .01$.

Figure 1

Figure 1. The moderating effect of goal reengagement capacities on the within-person associations between negative affect and moderate-to-vigorous physical activity among breast cancer survivors (N = 145).

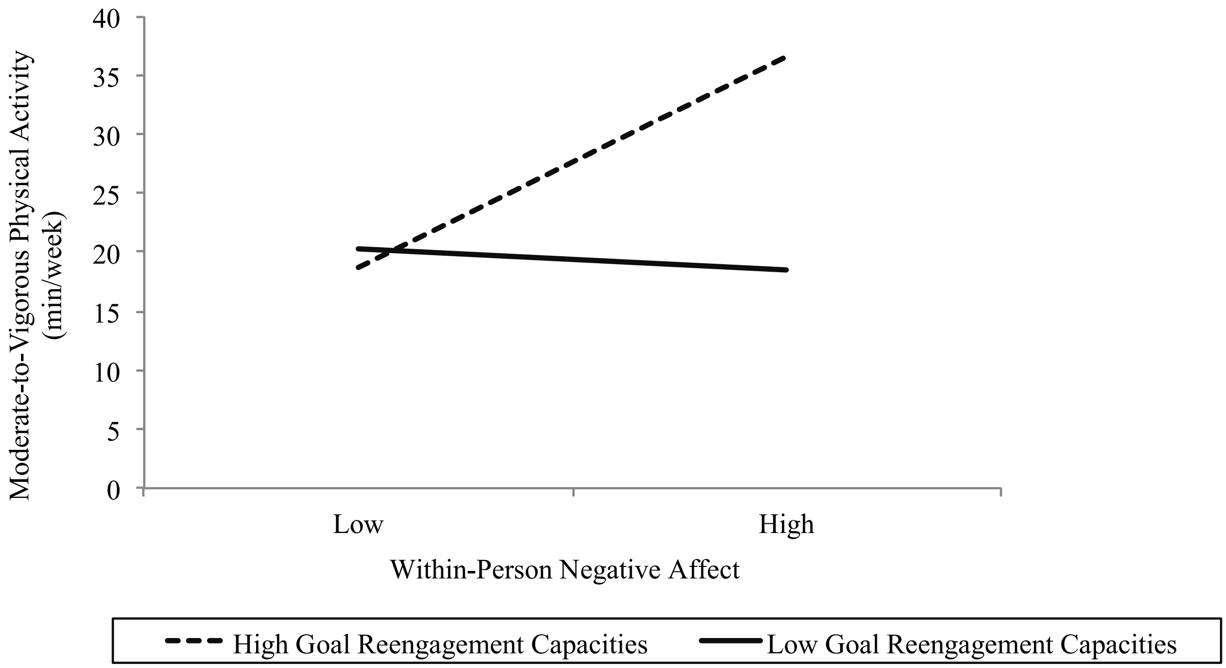
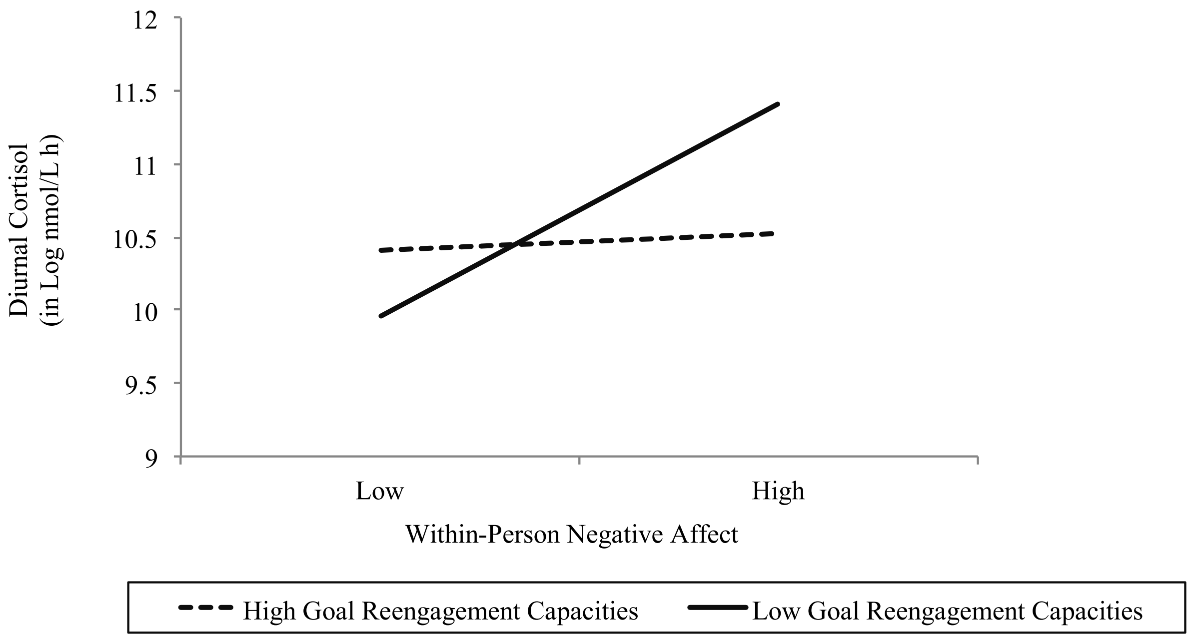


Figure 2

Figure 2. The moderating effect of goal reengagement capacities on the within-person associations between negative affect and diurnal cortisol secretion (AUC) among breast cancer survivors (N = 145).



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