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Self-Regulatory Fatigue, Quality of Life, Health Behaviors, and Coping in Patients with Hematologic Malignancies

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Abstract

Background—Self-regulatory fatigue may play an important role in a complex medical illness.

Purpose—Examine associations between self-regulatory fatigue, quality of life, and health behaviors in patients pre- ($N=213$) and 1-year post-hematopoietic stem cell transplantation (HSCT; $N=140$). Associations between self-regulatory fatigue and coping strategies pre-HSCT were also examined.

Method—Pre- and 1-year post-HSCT data collection. Hierarchical linear regression modeling.

Results—Higher self-regulatory fatigue pre-HSCT associated with lower overall, physical, social, emotional, and functional quality of life pre- ($p's < .001$) and 1-year post-HSCT ($p's < .01$); lower physical activity pre-HSCT ($p < .02$) and post-HSCT ($p < .03$) and less healthy nutritional intake post-HSCT ($p < .01$); changes (i.e., decrease) in quality of life and healthy nutrition over the follow-up year; and use of avoidance coping strategies pre-HSCT ($p's < .001$).

Conclusion—This is the first study to show self-regulatory fatigue pre-HSCT relating to decreased quality of life and health behaviors, and predicting changes in these variables 1-year post-HSCT.

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Authors' Statement of Conflict of Interest and Adherence to Ethical Standards

Authors Lise Solberg Nes, Shawna L. Ehlers, Christi A. Patten, Dennis A. Gastineau declare that they have no conflict of interest. All procedures, including the informed consent process, were conducted in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

Keywords

Hematologic malignancies; Hematopoietic stem cell transplantation; Self-regulatory fatigue; Quality of life; Health behaviors; Coping

Introduction

How people act and react to stressors generally depend on their ability to regulate thoughts, feelings, and behavior. Capacity for such self-regulation can vary based on individual resources, the stress of the situation at hand, and whether self-regulatory effort has already been exerted. Facing a serious illness and undergoing a challenging treatment may drain self-regulatory resources in particular, resulting in self-regulatory fatigue. Whereas a cancer diagnosis can be a highly distressing experience, as can the toxic treatment that frequently follows, hematologic cancers or malignancies can be especially taxing to live with, particularly if first-line treatments such as chemotherapy and radiation therapies are unsuccessful in achieving cancer remission. Hematopoietic stem cell transplantation (HSCT), an intensive treatment with significant toxicity beyond standard first-line therapies [1, 2], is primarily a second-line treatment for hematologic malignancies that have not adequately responded to a first-line therapy. For patients undergoing HSCT, the ability to self-regulate, i.e., regulate thoughts, emotions, and behavior, can be critical in coping with side effects, complications, and cancer rehabilitation. The current study sought to examine the potential role of self-regulation, particularly self-regulatory fatigue, in patients preparing for, undergoing, and recovering from HSCT.

Self-Regulation and Coping with Chronic Illness

The theory of self-regulation [3] refers to human behavior as an ongoing goal pursuit for which the ability to self-regulate is essential. Self-regulation involves capacity to regulate cognitions, such as focusing and making decisions; regulate emotions, such as controlling feelings and mood; and regulate behavior, such as engaging in recommended health behaviors or adhering to medical recommendations [3–5]. Capacity to self-regulate is a limited resource that can be depleted or fatigued [6], and when self-regulatory effort is required on one task, there is less self-regulatory capacity left for subsequent tasks, and effect known as self-regulatory fatigue or ego depletion [6–10]. The concept of self-regulation has been tested in a wide variety of experimental studies, generally showing how participants assigned to tasks involving selfregulatory effort (e.g., control of thoughts or urges) display greater self-regulatory fatigue through less capacity to persist on a subsequent task (e.g., problem solving or goal pursuit) [6–8]. The concept of self-regulatory fatigue also transfers easily to day-to-day experiences, and most people can relate to aspects like finding it challenging to maintain a diet or remain patient with a demanding colleague or a frustrated child at the end of a strenuous day.

Self-regulatory fatigue likely also plays an essential role in the day-to-day life of people coping with chronic illness. Health issues and chronic medical conditions present with a multitude of challenges, all of which invoke self-regulatory effort and may contribute to self-regulatory fatigue. For a review on this topic, please see [9]. Patients living with chronic

multi-symptom pain conditions such as temporomandibular disorders and/or fibromyalgia have, for example, exhibited higher self-regulatory fatigue compared with matched pain-free controls [10]. This was even the case when not first exposed to tasks requiring self-regulatory effort, indicating that patients with chronic multi-symptom conditions may be experiencing chronic self-regulatory fatigue. In chronic pain populations, self-reported pain has partially mediated the self-regulatory fatigue outcomes [10], but the impact of self-regulatory fatigue has been above and beyond traditional factors such as physical fatigue and psychological well-being.

Research on the impact of self-regulatory fatigue in chronic illness is still in its infancy. Findings pointing to links between chronic multi-symptom conditions and self-regulatory fatigue are, however, compelling, and further research is needed. Transplantation of hematopoietic stem cells, HSCT, is an aggressive treatment mainly for patients with life-threatening cancers of the blood and bone marrow, such as multiple myeloma and leukemia, where the disease appears resistant to traditional first-line treatments such as chemotherapy and radiotherapy [1]. In HSCT, the patients' immune system is practically depleted or eradicated through high doses of chemotherapy and/or radiotherapy before they receive their own previously stored stem cells (i.e., autologous HSCT), or, depending on the severity of the disease, the stem cells of a matched healthy related or unrelated donor (i.e., allogeneic HSCT). Although generally enhancing chance of survival, HSCT has been associated with a multitude of side effects and high symptom burden, ranging from nausea and mucositis to infections and graft vs. host disease (mainly allogeneic HSCT) and overall decreased quality of life [1, 11–13]. Fear of recurrence or other psychological effects frequently also occur [1, 13, 14]. Given the multitude of challenges these patients may face, it would not be surprising if they also experience significant levels of self-regulatory fatigue. In a recently published study, items reflecting self-regulatory effort or control were extracted from existing psychosocial measures, yielding a scale gauging self-regulatory fatigue in patients preparing for HSCT [15]. Using this scale and collecting data pre-HSCT, the study found higher self-regulatory fatigue to be associated with lower quality of life, more use of avoidance coping strategies, and lower self-reported adherence to medical recommendations for these patients [15].

Study Aims

The current study aimed to further explore the potential role of self-regulatory fatigue for patients preparing for, undergoing, and recovering from HSCT. We first sought to confirm internal consistency and factor structure of the extracted self-regulatory fatigue item scale as noted above [15]. Using this scale to measure self-regulatory fatigue, we then aimed to replicate findings of links between self-regulatory fatigue, quality of life, and coping pre-HSCT. A number of health behaviors are known to be associated with HSCT outcomes, and the study also sought to explore pre-HSCT relationships between self-regulatory fatigue and health behaviors such as physical activity, nutrition, alcohol, and tobacco. To our knowledge, potential impact of self-regulatory fatigue on quality of life and health behaviors *following* HSCT has yet to be examined. The study therefore sought to explore whether pre-HSCT self-regulatory fatigue (from here on referred to as self-regulatory fatigue) would be related to quality of life and health behaviors 1-year post-HSCT, and whether self-regulatory

fatigue would be related to changes in quality of life and health behaviors over the 1-year follow-up.

The primary study aim was to examine the association between self-regulatory fatigue and quality of life (pre- and post-HSCT) in both cross-sectional and prospective models. Secondly, associations of self-regulatory fatigue to health behaviors (pre- and post-HSCT) and choice of coping strategies (pre-HSCT) were examined. It was hypothesized that higher self-regulatory fatigue would be associated with lower quality of life pre- and 1-year post-HSCT, and with greater change (i.e., decrease) in quality of life at the 1-year follow-up. It was also hypothesized that higher self-regulatory fatigue would be related to more maladaptive health behaviors pre- and 1-year post-HSCT, as well as greater change (i.e., decrease) in adaptive health behaviors during the follow-up. Finally, replicating previous findings, it was hypothesized that self-regulatory fatigue would be associated with less use of approach coping strategies and more use of avoidance-type coping strategies (measured pre-HSCT only).

Method

Procedure Overview

This study was approved by the Institutional Review Board at a major medical center in the USA. The study utilized an existing prospective research cohort and employed cross-sectional and prospective psychometric measures. Items related to self-regulatory control or capacity were identified and extracted from existing measures of psychological adjustment and well-being in a clinical database of patients preparing for HSCT. A factor analysis of these items was conducted aiming to replicate previous findings forming a scale measuring self-regulatory fatigue [15]. The scale was then used to examine self-regulatory fatigue in relation to quality of life, health behaviors, and coping in patients ($N = 213$) preparing for HSCT, with follow-up 1-year post-HSCT ($N=140$). Self-regulatory fatigue and coping were measured pre-HSCT, while quality of life and health behaviors were measured both pre- and 1-year post-HSCT.

Participants

Participants ($N=213$) were enrolled in a larger prospective cohort study to examine the impact of health behaviors on HSCT outcomes. Psychometric measures were collected, while participants were preparing for HSCT within standard clinical care via research survey, and 1-year post-HSCT via research survey. The sample is characterized as 19–76 years old (median age 57 years old; standard deviation [SD] 12.03), 51.6 % male, and the majority Caucasian (90.1 %), with 2.8 % African American, 1.9 % Native American or Alaska Indians, 1.4 % Asian, 0.9 % Hispanic, and 2.8 % other or unknown (i.e., forgot or opted not to report race/ethnicity). Most participants were married (81.2 %), with 11.3 % being single, 6.1 % divorced, and 1.4 % widowed. Patients were diagnosed with multiple myeloma (33.3 %), non-Hodgkin's lymphoma (25.8 %), leukemia (19.2 %), amyloidosis (7.5 %; a non-malignant condition associated with multiple myeloma), and others (e.g., lymphomas, MDS, myelofibrosis; 14.1 %). The majority of participants received autologous (80.3 %) vs. allogeneic (19.7 %) stem cell transplant. For details on demographics, please

also see Table 1. Of the patients completing the psychometric measures pre-HSCT, 33 patients passed away before the 1-year follow-up and 40 declined to remain in the study or did not complete all post-HSCT follow-up measures. Comparing participants completing only pre- HSCT measures ($N=73$) with participants completing both pre- and post-HSCT measures ($N = 140$), there were no significant differences in self-regulatory fatigue, pain, fatigue, or depression scores. This was also the case for the group of participants passing away ($N=33$) before follow-up. For participants who dropped out or failed to complete all post-HSCT measures ($N=40$), there was no significant difference in self-regulatory fatigue, but some differences in pain (mean dropped out 2.88 vs. remained 2.36), fatigue (mean dropped out 32.6 vs. remained 30.33), depression (mean dropped out 8.46 vs. remained 7.46), and quality of life (mean dropped out 80.33 vs. remained 82.33), indicating that participants who dropped out or failed to complete all measures may have experienced higher symptom burden in terms of these measures. Whereas only 19–20 % of the participants remaining in the study were diagnosed with leukemia and had undergone allogeneic HSCT; this number was significantly higher for the participants who dropped out (24 %) or passed away (34.8 %), which could suggest that symptom burden played a role in attrition for this study.

Self-Regulatory Fatigue Scale Item Extraction—Measures

Items indicative of self-regulatory control or capacity were extracted from measures of personality, state and trait anger and anxiety, and psychological impact of diagnosis and preparation for transplantation (for details, please see [15]).

The *Big Five Inventory* [16] is a 44-item multidimensional self-report personality inventory designed to measure the Big Five personality dimensions [16]. Items are scored on a 5-point Likert scale. The Big Five Inventory has acceptable psychometric values [17]. In terms of self-regulation, the Big Five Inventory was selected in order to capture aspects of trait ability to exercise control over reactions and behavior from a personality perspective (i.e., general ability to control thoughts, mood, and behavior, as well as cope with stressors) [15].

The *Impact of Events Scale* [18] is a 15-item measure assessing cognitive and emotional impact of traumatic events. The measure focuses on experience of intrusive thoughts, avoidance, and emotional numbing related to a stressful event, and has good reliability with a Cronbach alpha of $\alpha=.92$ [19]. The Impact of Events Scale was chosen for self-regulation item extraction in order to capture ability to control and cope with thoughts and emotions related to impact of the illness (i.e., impact of diagnosis and preparation for HSCT) [15].

State Trait Anger Expression Inventory (STAXI)—The STAXI [19, 20] is a 20-item self-report measure of the intensity of anger as both an emotional state (state anger) and the disposition to experience angry feelings as a personality trait (trait anger). Items consist of 4-point scales. Internal consistencies for the STAXI is acceptable ($\alpha=.73$ – $.84$) [20]. The STAXI was utilized for self-regulation item extraction in this study to capture ability for emotional and behavioral control [15].

The State Trait Anxiety Inventory (STAI)—The STAI [21] is a 40-item measure of state and trait anxiety, measuring the severity of overall anxiety level. Test-retest reliability

of the STAI is acceptable at $r=.54$ (state) and $r=.86$ (trait) [21]. Like the STAXI, the STAI was chosen for self-regulation item extraction in order to capture ability for emotional and behavioral control [15].

Statistical Analyses

All statistical analyses were carried out using the Statistical Package for the Social Sciences, Release 20 (SPSS Inc., 1989–2012). Following published item extraction procedures [15], 23 items reflecting ability to regulate thoughts, feelings, and behavior were extracted from existing scales related to psychological adjustment and well-being (i.e., Big Five Inventory, Impact of Events Scale, STAXI-2, and STAI). All items were converted to a common 1–5 Likert scale if not already measured that way. A principal factor analysis with oblique rotation [22] was employed to examine factor structures.

Relationship of Self-Regulatory Fatigue to Clinical Patient Outcomes

Outcome Measures

Functional Assessment of Cancer Treatment-General (FACT-G): The FACT-G [23] is a 27-item measure of four primary quality of life domains involving physical, social/family, emotional, and functional well-being. The FACT-G distinguishes between stage I, II, III, and IV disease ($p<.05$), and has acceptable validity and reliability [23].

Functional Assessment of Cancer Therapy-Bone Marrow Transplant (FACT-BMT): The FACT-BMT [24] is a 20-item bone marrow transplant subscale for the general FACT-G with good psychometric properties for assessing quality of life in HSCT. Reliability and validity coefficients have ranged from 0.86 to 0.89 for the full scale (FACT-G + BMT) and 0.54 to 0.63 for the BMT subscale alone [24].

Health Behaviors: Physical activity, nutrition, tobacco, and alcohol use were measured through a research lifestyle survey for transplant patients. Physical activity was measured through questions related to duration and type of exercise in the prior week (Stanford Exercise Scale) [25]. Nutrition was measured through fruit and vegetable consumption in terms of weekly quantity [26], and tobacco and alcohol use were measured through frequency, duration, and history of packyears [27, 28].

Coping: The brief COPE [29] is a 28-item brief version of the COPE [29] assessing approach and avoidance coping including, among others, active coping, planning, acceptance, self-distraction, and denial. The brief COPE has alpha reliabilities at or above 0.50 with similar or identical scales from the COPE in cancer populations, which is extensively used in health settings and considered to have acceptable reliability and validity [30].

Covariates

Demographics, Disease, and Transplant Covariates: Information related to gender, marital status, race/ethnicity, marital status, diagnosis (e.g., leukemia, myeloma, other) and transplant type (autologous vs. allogeneic), status of death/alive, and drop out before 1-year follow-up are listed in Table 1. In addition, information regarding age, body mass index

(BMI), the Eastern Cooperative Oncology Group (ECOG) score (i.e., where 0=perfect health and 5=death) [31], and number of inpatient stay days were collected.

Pain: Pain assessment scale [32]. Physical pain in the current study was measured through a 3-item self-report measure assessing current pain, average pain, and worst pain over the past week. Each question is measured on a 0- to 10-Likert scale with 0=no pain and 10=worst possible pain.

Brief Fatigue Inventory: The Brief Fatigue Inventory [33] is a 9-item measure assessing degree and level of fatigue, focusing on impact on general activity, mood, walking ability, normal work, relations with other people, and enjoyment of life. The Brief Fatigue Inventory has reasonable psychometric properties [33] and has been validated for use in a mixed cancer population.

Beck Depression Inventory (BDI-II): The BDI-II [34] is a 21-item self-report inventory measuring severity of depression symptoms that includes cognitive and somatic symptoms. Reliability of the BDI-II is acceptable with test-retest reliability $r=.93$, and internal consistency $\alpha=.92$ [34].

Statistical Analyses—Primary multivariate hierarchical linear regression models were used to examine the associations between self-regulatory fatigue scores (main independent variable), overall quality of life, and quality of life subscales (main dependent variables). Secondary analyses examined similar regression models using health behaviors and coping strategies as dependent variables. Tobacco analyses utilized only data from participants with a history of tobacco use. Analyses controlled for pain, physical fatigue, depression, transplant type, and Eastern Cooperative Oncology Group (ECOG; covariates) in the first step. Analyses testing whether pre-HSCT self-regulatory fatigue could be related to changes in dependent variables (i.e., quality of life and health behaviors) over the 1-year follow-up also controlled for pre-HSCT dependent variable values. This procedure was chosen over computing residualized change scores as it provided a better model fit. Standard alpha level of 0.05 was used for all statistical analyses.

Results

Self-Regulatory Fatigue Scale Item Extraction—Factor Analysis

Supporting previous findings [15], the extracted self-regulatory fatigue item scale showed acceptable internal consistency and reliability ($\alpha=.89$). Examination of the scree plot and the pattern matrix suggested loadings on three factors related to cognitive (7 items $\alpha=.86$), emotional (11 items $\alpha=.85$), and behavioral control (5 items $\alpha=.70$), also supporting previous research [15]. Please see Table 2 for details. As the aim of this study was to first replicate previous findings and then explore impact of self-regulatory fatigue in HSCT outcomes both pre- and 1-year post-HSCT, the full self-regulatory fatigue scale (i.e., all 23 items, $\alpha=.89$) was used in the analyses. Obtainable score range for the scale was 23–115, with higher number reflecting higher self-regulatory fatigue. Lowest reported self-regulatory fatigue score in the current study was 27 (0.3 %), and highest score reported was 99 (0.6 %). Mean self-regulatory fatigue score was 46.92 (median 45.25 and SD 11.83).

Please see Table 3 for descriptives on self-regulatory fatigue, age, BMI, Eastern Cooperative Oncology Group (ECOG) score, pain, fatigue, depression, quality of life, health behaviors, and coping. For zero-order correlations among potential impact factors, please see Table 4. Factors significantly correlated with self-regulatory fatigue: pain, fatigue, depression, transplant type, and Eastern Cooperative Oncology Group (ECOG) score are included as covariates in primary and secondary analyses (see also Tables 5, 6, and 7).

Relationship of Self-Regulatory Fatigue to Clinical Outcomes

Primary Analyses: Quality of Life—Higher self-regulatory fatigue pre-HSCT was associated with lower self-reported *overall quality of life* both pre- and 1-year post-HSCT (p 's<.001), as well as to higher change (i.e., decrease) in overall quality of life at 1-year post-HSCT (p <.001). Higher self-regulatory fatigue was also consistently associated with lower quality of life subscale domains, i.e., lower physical, social, emotional, and functional quality of life both pre- and 1-year post-HSCT (all p 's .001). In addition, higher self-regulatory fatigue pre-HSCT was related to higher change (i.e., decrease) in physical, emotional, functional, and overall quality of life from pre-HSCT to 1-year follow-up. See Table 5. Finally, higher self-regulatory fatigue pre-HSCT was also associated with lower self-reported blood and marrow transplant specific *quality of life* (i.e., FACT-BMT [24]) 1-year post-HSCT (p =.001). Please see Table 5 for details on self-regulatory fatigue and quality of life.

Traditional Predictors as Covariates: Pre-HSCT pain, physical fatigue, depression, type of transplant, and Eastern Cooperative Oncology Group (ECOG) scores were significantly correlated with self-regulatory fatigue and therefore included in the multivariate models. Controlling for *pain* attenuated the relationship between self-regulatory fatigue and changes in social and functional quality of life at follow-up, but otherwise had no significant impact. Controlling for *physical fatigue* had no significant impact on the relationship between self-regulatory fatigue and quality of life pre-HSCT, but attenuated the relationship between self-regulatory fatigue, physical, and social quality of life post-HSCT. Controlling for physical fatigue also attenuated the relationship between self-regulatory fatigue and changes in physical, social, functional, and total quality of life at follow-up. Including *depression* in the model significantly impacted the relationship between self-regulatory fatigue and physical and functional quality of life pre-HSCT, as well as the relationship between self-regulatory fatigue and quality of life for most subscales, including follow-up change scores, at 1-year post-HSCT. The association of self-regulatory fatigue to emotional quality of life remained significant at all time points regardless of covariate(s) included. Including *transplant type* and *Eastern Cooperative Oncology Group (ECOG) score* as covariates in the analyses did not significantly attenuate the relationship between self-regulatory fatigue and quality of life apart from changes in social quality of life at 1-year post-HSCT. Please see Table 5 for details.

Secondary Analyses: Health Behaviors and Coping

Physical Activity: Higher self-regulatory fatigue pre-HSCT was associated with lower physical activity both pre-HSCT (p <.02) and 1-year post-HSCT (p <.03). There was no link between self-regulatory fatigue and changes in physical activity over the 1-year follow-up.

The association between self-regulatory fatigue and physical activity pre-HSCT was attenuated when controlling for pain, fatigue, depression, and Eastern Cooperative Oncology Group (ECOG) score but remained significant controlling for transplant type. One-year post-HSCT, the association was attenuated when controlling for physical fatigue and depression but remained significant controlling for pain, transplant type, and Eastern Cooperative Oncology Group (ECOG) score. Please see Table 6 for details.

Nutrition: Higher self-regulatory fatigue was not associated with nutritional intake pre-HSCT but was associated with less self-reported fruit and vegetable intake 1-year post-HSCT ($p < .01$). Higher self-regulatory fatigue pre-HSCT was also related to changes in nutrition (i.e., less reported intake of fruit and vegetables) over the 1-year follow-up ($p < .02$). Controlling for traditional predictors and covariates did not attenuate these links. Please see Table 6 for details.

Alcohol and Tobacco Use: Self-regulatory fatigue was not significantly associated with reported use of alcohol or tobacco pre- or post-HSCT, nor with reported changes in alcohol or tobacco use over the 1-year follow-up. Please see Table 6 for details.

Coping: Higher self-regulatory fatigue was pre-HSCT significantly associated with more use of overall *avoidant coping* strategies, including more use of *self distraction* and *denial* (p 's $< .001$), and less use of *approach coping* strategies such as *acceptance* ($p < .001$). Associations between self-regulatory fatigue and coping 1-year post-HSCT were not available as coping was only measured pre-HSCT. Within multivariate models, controlling for traditional predictors and covariates did not significantly impact the relationship between self-regulatory fatigue and use of avoidance/acceptance coping strategies. Please see Table 7 for details.

Discussion

Results of the current study support the notion that self-regulatory fatigue can be measured through use of a self-report scale as evidenced by predictive criterion validity. We replicated the factor structure of a previously compiled scale where items reflecting self-regulatory fatigue were extracted from existing measures of psychological adjustment and well-being [15]. The final 23-item scale showed good internal consistency and reliability ($\alpha = .89$). Findings also support previous research suggesting self-regulatory fatigue significantly impacts quality of life and may play an important role in choice of coping strategies for patients preparing for and undergoing cancer treatment [15]. In addition, results indicate that self-regulatory fatigue may play a role in engagement in adaptive health behaviors for these patients. To our knowledge, this is the first study to examine potential links between self-regulatory fatigue, quality of life, and health behaviors *both* pre- and 1-year post-HSCT, and the first to examine how pre-HSCT self-regulatory fatigue may relate to *changes* in quality of life and health behaviors over the 1-year follow-up post-HSCT.

HSCT, Self-Regulatory Fatigue, and Quality of Life

For many patients living with life-threatening blood- and marrow-type cancers, HSCT may be the only option for increasing chance of survival. The trade-off can be significant and

longstanding decrease in quality of life, however, including decrease in physical, psychological, and social functioning [13]. In the current study, lower self-reported capacity to control and regulate thoughts, feelings, and behavior, i.e., self-regulatory fatigue, was associated with lower quality of life both pre- and 1-year post-HSCT. In addition, self-regulatory fatigue pre-HSCT was related to change (i.e., decrease) in quality of life over the 1-year follow-up, indicating that level of self-regulatory fatigue pre-transplant may predict change in quality of life post-HSCT. These findings support the notion of self-regulatory fatigue as an important factor when considering the well-being of patients preparing for, undergoing, and recovering/rehabilitating from HSCT.

The impact of self-regulatory fatigue on pre-HSCT quality of life was largely independent of traditional predictors such as pain and physical fatigue, but was somewhat more impacted by depression, particularly for physical and functional quality of life. The link between self-regulatory fatigue and quality of life remained significant 1-year post-HSCT, largely independent of factors such as pain, transplant type, and Eastern Cooperative Oncology Group (ECOG) score, but impacted to some degree by depression and physical fatigue. The same was the case for the link between pre-HSCT self-regulatory fatigue and change in quality of life over the follow-up year. Self-regulatory fatigue and emotional quality of life appeared to have the strongest link, as this relationship remained significant at all time points, regardless of covariates. It is possible that the moderating effect of traditional predictors on impact of self-regulatory fatigue may vary depending on the patient population and/or medical condition at hand. For example, while depression and physical fatigue, but not pain, seem to have had some moderating effects for the cancer patients in this study, previous research have found the role of self-regulatory fatigue in chronic pain conditions to be partly moderated by pain but not by fatigue or psychological well-being [10].

HSCT, Self-Regulatory Fatigue, and Health Behaviors

This is the first study to examine potential associations among self-regulatory fatigue and health behaviors in HSCT. As seen, higher self-regulatory fatigue pre-HSCT was associated with lower self-reported physical activity both pre- and 1-year post-HSCT, less self-reported healthy nutritional intake 1-year post-HSCT, and higher change (i.e., decrease) in healthy nutritional intake over the 1-year follow-up. While the link between self-regulatory fatigue and physical activity was partly attenuated by traditional predictors, the relationship between self-regulatory fatigue and nutrition remained significant regardless of covariates included in the model. There were no significant links between self-regulatory fatigue and self-reported tobacco or alcohol use in the current study. However, social desirability may have played a role here as initial data collection took place during pre-transplant evaluations, which again may have yielded underreported information about tobacco and alcohol use. Research indicates that most survivors preparing for HSCT fail to meet current guidelines from the American Cancer Society regarding recommended healthy lifestyles [35]. The current study suggests that presence of self-regulatory fatigue could be a contributing factor to this, as higher self-regulatory fatigue pre-HSCT was associated with lower level of physical activity, less healthy nutritional intake, and predicted larger decrease in healthy nutritional intake post-HSCT.

HSCT, Self-Regulatory Fatigue, and Coping

Self-reported self-regulatory fatigue has previously been associated with use of avoidance-type coping strategies for patients preparing for HSCT [15]. The current study supported these findings, as higher self-regulatory fatigue predicted more use of avoidance coping strategies such as self-distraction and denial, and significantly less use of approach coping strategies such as acceptance. As previously also seen [15], including traditional predictors in the model did not significantly attenuate the relationship between self-regulatory fatigue and avoidance coping strategies. In the face of aggressive medical treatments such as HSCT, use of adaptive coping strategies may be essential in terms of patients' approach, engagement, adherence, adjustment, and successful outcome. If self-regulatory fatigue predicts avoidance coping, however, this is another reason for enhanced attention to self-regulatory fatigue and its potential role in medical settings.

Understanding and Improving Self-Regulatory Fatigue in Medical Settings

Capacity to self-regulate is likely dependent on state as well as trait functions [9, 36]. Situational factors such as long and demanding days, challenging tasks or situations, and activities generally requiring self-regulatory effort can all induce self-regulatory fatigue [6–9, 36, 37]. On the trait side, individual differences such as heart rate variability have predicted self-regulatory strength [8], but more research is needed to explore whether other factors, for example, personality [38], may play a role in this concept. The many challenges of a chronic or severe illness may create state-induced self-regulatory fatigue. However, long-term illness likely also links to what appears as more chronic self-regulatory fatigue. For example, following a task requiring no self-regulatory effort, patients with chronic multi-symptom illnesses displayed similar self-regulatory fatigue patterns as matched pain-free controls having to exert self-regulatory effort, suggesting these patients may suffer from chronic self-regulatory fatigue [10]. Future research should strive to better understand why some people experience more, or less, self-regulatory fatigue than others, in which situations self-regulatory fatigue can be avoided or decreased, and whether “buffers” exist preventing or decreasing the likelihood and potential impact of self-regulatory fatigue. Finally, research indicates that self-regulatory fatigue might be improved through interventions [39, 40], and given the shown links between self-regulatory fatigue and quality of life, health behaviors, choice of coping strategies, as well as adherence to medical recommendations for patients with chronic and severe illnesses, development of interventions seeking to improve self-regulatory fatigue for patients facing chronic or severe illness is clearly warranted.

Limitations and Further Future Directions

This study is based on secondary analyses of existing cross-sectional and prospective data. However, the existing data were designed and collected for analysis of psychosocial, health behavior, and medical outcomes. As this is a single-site study, with somewhat limited ethnic diversity, future studies are needed to examine this concept in multi-site, more culturally diverse settings. The current study measured self-regulatory fatigue through identifying and extracting items with self-regulatory context from other existing psychosocial measures. Results, however, support previous findings utilizing the same method. Even though some measures exist gauging self-regulatory fatigue and self-control [41, 42], to our knowledge,

no validated scale currently exist measuring self-regulatory fatigue in cancer, and future studies aiming to develop and validate acceptable measures for such a purpose are needed. Related to the measurement of self-regulatory fatigue, the current study examines self-regulatory fatigue only pre-HSCT, and as the concept of self-regulatory fatigue has both state and trait components [9, 36], it would be interesting to, in the same setting, investigate degree, change, and potential impact of self-regulatory fatigue as assessed post-HSCT. Gauging choice of coping strategies pre- as well as post-HSCT could also add information to this setting.

Conclusion

Cancer and aggressive cancer treatments present with a multitude of physical, practical, and emotional challenges, challenges which likely result in self-regulatory fatigue. This study replicated findings pointing to the feasibility of using a self-report scale to measure self-regulatory fatigue in populations undergoing HSCT. It also supports previous findings showing a strong association of self-regulatory fatigue to decreased quality of life and avoidance coping strategies, and contributes a novel link between self-regulatory fatigue and maladaptive health behaviors. To our knowledge, this is the first study to examine the impact of self-regulatory fatigue both pre- and 1-year post-HSCT, and the first study to examine and find self-regulatory fatigue pre-HSCT to be related to *changes* in dependent variables such as quality of life and health behaviors over a follow-up year post-HSCT. The association of self-regulatory fatigue to overall quality of life and emotional aspects of quality of life appeared especially robust, even after controlling for traditional factors such as depression, fatigue, pain, transplant type, and Eastern Cooperative Oncology Group (ECOG) score in multivariate models. In sum, self-regulatory fatigue may in the context of cancer represent reduced ability to preserve quality of life, adopt healthy behaviors associated with HSCT outcomes, and engage in adaptive coping strategies. Advances in self-regulatory fatigue research promise to aid identification of patients who could potentially benefit from supportive care interventions targeting self-regulatory fatigue. Results from this study emphasize the utility of identifying self-regulatory fatigue in complex medical conditions and call for development of interventions that target and improve self-regulatory capacity in chronic or severe illness.

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Table 1**Demographics**

	Pre-HSCT		Post-HSCT	
	<i>N</i>	%	<i>N</i>	%
Gender				
Male	110	51.6	73	52.1
Female	103	48.4	67	47.9
Marital Status				
Married	173	81.2	117	83.6
Single	24	11.3	15	10.7
Divorced	13	6.1	5	3.6
Widowed	3	1.4	3	2.1
Race/ethnicity				
Caucasian/White	192	90.1	129	92.1
African American	6	2.8	2	1.4
Native American/Alaska Indian	4	1.9	1	0.7
Asian	3	1.4	1	0.7
Hispanic	2	0.9	2	1.4
Unknown	6	2.8	5	3.6
Diagnosis				
Amyloidosis	16	7.5	11	7.9
Leukemia	41	19.2	21	15
Multiple myeloma	71	33.3	50	35.7
Non-Hodgkin's lymphoma	55	25.8	35	25
Other malignancies	30	14.1	23	16.4
HSCT type				
Autologous	171	80.3	118	84.3
Allogeneic	42	19.7	22	15.7
Passed away before 1-year follow-up			33	15.5
Dropped out of study before 1-year follow-up			40	18.8
Or did not complete all post-HSCT measures				

HSCT hematopoietic stem cell transplant

Table 2

Self-regulatory fatigue scale—full scale 23 extracted items

Items ($\alpha=.89$)			Factor loading r
Factor 1: cognitive (attention) control			
1	IES_1	Thought intrusion	.618
2	IES_3	Memory avoidance	.730
3	IES_5	Strong feelings	.719
4	IES_7	Reminder avoidance	.803
5	IES_9	Suppressing need to talk	.835
6	IES_10	Flash backs	.682
7	IES_13	Thought suppression	.803
Factor 2: emotional (worry and emotion) control			
8	BFI_4	Emotional stability (R)	.688
9	BFI_14	Moodiness	.632
10	BFI_17	Relaxed in stressful situations (R)	.821
11	BFI_21	Energetic (R)	.430
12	BFI_24	Calm in stressful situations (R)	.571
13	BFI_27	Tenseness	.714
14	BFI_34	Nervousness	.773
15	BFI_37	Worry	.805
16	STAI_22	Anxiety and restlessness	.491
17	STAI_27	Calmness (R)	.536
18	STAI_29	Excessive and unnecessary worry	.598
Factor 3: behavioral control			
19	STAXI_4	Urges to yell	.575
20	STAXI_5	Urges to break	.853
21	STAXI_7	Urges to hit something	.889
22	STAXI_8	Urges to hit someone	.724
23	STAXI_10	Urges to swear	.618

Full scale (23 items) $\alpha=.89$

(R) item reversed

Table 3

Descriptives

	<i>N</i>	Range	Min	Max	Mean	SE	SD
Self-regulatory fatigue	213	72.50	26.75	99.25	46.92	.81	11.82
Age	213	57	19	76	54.60	.82	12.03
BMI	213	33.10	18	51.10	29.07	.41	5.98
ECOG	213	3	0	3	78	.04	.61
Pain	213	10	0	10	2.36	.17	2.41
Fatigue	213	86	0	86	30.33	1.50	20.88
Depression	213	41	0	41	7.46	.41	5.92
Quality of life (QoL) pre-HSCT							
Physical	213	28	0	28	20.90	.44	6.21
Social	213	28	0	28	24.35	.27	3.96
Emotional	213	24	0	24	18.01	.31	4.43
Functional	213	27	1	28	18.86	.43	6.21
Total QoL pre-HSCT	213	76	32	108	82.23	1.13	16.15
Quality of life (QoL) 1-year post-HSCT							
Physical	140	20	13	33	28.18	.30	3.63
Social	140	19	16	35	30.08	.31	3.71
Emotional	140	22	7	29	22.90	.26	3.10
Functional	140	24	11	35	27.08	.49	5.87
Total QoL 1-year post-HSCT	140	67	60	127	108.25	1.02	12.22
BMT QoL 1-year post-HSCT	140	47	67	114	93.63	.88	10.60
Physical activity							
Pre-HSCT	213	13	0	13	3.10	.17	2.40
1-year post-HSCT	140	13	0	13	3.89	.22	2.69
Nutrition							
Pre-HSCT	213	8	0	8	3.62	.11	1.60
1-year post-HSCT	140	13	0	13	3.82	.15	1.81
Alcohol use							
Pre-HSCT	213	5	0	5	2.45	.09	1.30
1-year post-HSCT	140	5	0	5	2.27	.11	1.34
Tobacco use							
Pre-HSCT	213	2	0	2	70	.05	.74
Post-HSCT	140	5	0	5	34	.09	1.10
Coping (pre-HSCT)							
Active	213	18	6	24	16.99	.29	3.83
Planning	213	6	2	8	5.50	.13	1.72
Acceptance	213	6	2	8	3.59	.11	1.14
Avoidant	213	12	4	16	8.66	.20	2.57
Distraction	213	6	2	8	5.04	.14	1.75
Denial	213	4	2	6	2.57	.07	.94

BMI body mass index; *ECOG* Eastern Cooperative Oncology Group; *HSCT* hematopoietic stem cell transplant; *BMT* blood and marrow transplant

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Table 4

Zero-order correlations potential impact factors

	SRF	Pain	Fatigue	BDI	Age	Gender	Married	Race	Disease	Transplant type	BMI	ECOG	Inpatient stay days	Death
Self-regulatory fatigue (SRF)	1													
Pain	.34**	1												
Fatigue	.44**	.59**	1											
Depression—Beck's Depression Inventory (BDI)	.67**	.46**	.67**	1										
Age at transplant	-.02	-.08	-.03	-.06	1									
Gender	.01	.07	.08	.08	-.10	1								
Marital status	.01	.06	.05	.01	-.44**	.03	1							
Race	-.10	.03	-.03	.01	-.01	-.10	-.10	1						
Disease type	.02	.02	.06	.01	-.17*	-.09	.01	.05	1					
Transplant type	.15*	.19**	.07	.12	.05	-.04	-.03	.05	.49**	1				
Body mass index (BMI)	.06	.05	.07	.02	.05	-.08	-.08	.10	.12	.11	1			
Eastern Cooperative Oncology Group (ECOG) score	.20**	.37**	.38**	.27**	.03	.01	-.02	.13	.10	.13	.09	1		
Inpatient stay days	-.07	-.07	-.15	-.12	-.10	.06	-.11	-.03	-.12	-.21*	-.04	.09	1	
Death	.03	-.01	-.09	-.04	.01	-.03	.01	-.06	.01	-.11	-.01	.07	.25**	1

*** $p < .001$ level, correlation significant* $p < .05$ level, correlation significant;** $p < .01$ level, correlation significant;

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Table 5
Hierarchical regression analyses, self-regulatory fatigue (SRF), and primary outcome variables; quality of life (QoL)

SRF		SRF controlling for																										
		Pain				Fatigue				Depression				Transplant				ECOG				All ^d						
		R ²	t	β	p	R ²	t	β	p	R ²	t	β	p	R ²	t	β	p	R ²	t	β	p	R ²	t	β	p			
QoL PRE																												
Physical	.22	-7.39	-.47	<.001	.06	-5.23	-.25	<.001	.01	-2.11	-.11	.036	.00	-.22	-.02	.83	.22	-7.17	-.46	<.001	.35	-6.71	-.40	<.001	.77	.97	.05	.34
Social	.12	-5.39	-.35	<.001	.09	-4.51	-.32	<.001	.05	-3.19	-.24	.002	.02	2.09	-.18	.036	.12	-5.36	-.35	<.001	.12	-5.26	-.35	<.001	.14	-1.93	-.18	.05
Emotional	.37	-10.96	-.61	<.001	.27	-9.30	-.55	<.001	.20	-7.66	-.50	<.001	.10	5.89	-.43	<.001	.38	-10.98	-.62	<.001	.37	-10.60	-.60	<.001	.40	-5.14	-.42	<.001
Functional	.22	-7.57	-.47	<.001	.11	-5.89	-.36	<.001	.02	-2.73	-.16	.007	.00	-.43	-.03	.67	.23	-7.73	-.48	<.001	.28	-6.86	-.42	<.001	.57	-.55	-.04	.59
QoL total PRE	.36	-10.69	-.60	<.001	.18	-8.98	-.45	<.001	.07	-5.95	-.29	<.001	.02	2.93	-.18	.004	.36	-10.65	-.60	<.001	.42	-10.04	-.55	<.001	.70	-2.92	-.17	<.01
QoL POST																												
Physical	.06	-3.04	-.25	.003	.02	-1.81	-.15	.07	.01	-1.02	-.09	.31	.00	.43	.05	.67	.06	-3.07	-.25	.003	.09	-2.73	.22	.007	.28	.09	.01	.93
Social	.07	-3.18	-.26	.002	.07	-3.19	-.27	.002	.02	-1.64	-.15	.10	.01	-.91	-.10	.37	.07	-3.18	-.26	.002	.07	-3.12	-.26	.002	.13	-1.10	-.13	.28
Emotional	.26	-6.98	-.51	<.001	.25	-6.73	-.53	<.001	.22	-6.41	-.53	<.001	.06	3.34	-.32	.001	.26	-6.85	-.50	<.001	.28	-7.27	-.53	<.001	.41	-3.16	-.32	.002
Functional	.13	-4.51	-.35	<.001	.10	-4.02	-.33	<.001	.03	-2.33	-.20	.021	.00	-.11	-.01	.92	.14	-4.66	-.37	<.001	.16	-4.20	-.33	<.001	.29	-.76	-.08	.45
QoL total POST	.20	-6.00	-.45	<.001	.16	-5.39	-.42	<.001	.08	-3.78	-.31	<.001	.01	1.11	-.10	.27	.21	-6.05	-.46	<.001	.21	-5.77	-.44	<.001	.40	-1.58	-.16	.12
BMT QoL POST	.11	-4.17	-.33	<.001	.39	-3.42	-.29	.001	.03	-2.25	-.20	.026	.00	-.24	-.03	.81	.13	-4.35	-.34	<.001	.11	-4.07	-.33	<.001	.26	-.02	-.00	.99
QoL Change																												
Physical	.15	-4.97	-.39	<.001	.28	-3.32	-.26	.001	.31	-1.79	-.15	.08	.26	-.85	-.09	.40	.16	-4.90	-.39	<.001	.21	-4.66	-.36	<.001	.36	-.29	-.03	.77
Social	.00	-.45	-.04	.66	.00	-.24	-.02	.81	.00	-.31	-.03	.76	.00	-.00	-.00	.99	.00	-.46	-.04	.65	.01	-.58	-.05	.56	.01	-.15	-.02	.88
Emotional	.15	-5.26	-.48	<.001	.18	-5.58	-.53	.001	.15	-5.11	-.49	<.001	.05	3.03	-.32	.003	.26	-5.03	-.46	<.001	.28	-5.55	-.50	<.001	.40	-2.95	-.32	.004
Functional	.03	-2.18	-.18	.031	.07	-1.17	-.11	.24	.09	-.16	-.02	.87	.07	-.13	-.02	.90	.03	-2.14	-.18	.034	.04	-1.99	-.17	.048	.12	-.26	-.03	.79
QoL total Change	.09	-3.71	-.30	<.001	.17	-2.27	-.19	.025	.15	-1.11	-.10	.27	.14	-.95	-.10	.34	.09	-3.72	-.30	<.001	.12	-3.38	-.28	.001	.18	-.51	-.06	.61

Table 6

Hierarchical regression analyses, self-regulatory fatigue (SRF), and secondary outcome variables; health behaviors

SRF controlling for																												
SRF					Pain			Fatigue			Depression			Transplant			ECOG			All ^a								
	<i>R</i> ²	<i>t</i>	β	<i>p</i>	<i>R</i> ²	<i>t</i>	β	<i>p</i>	<i>R</i> ²	<i>t</i>	β	<i>p</i>	<i>R</i> ²	<i>t</i>	β	<i>p</i>	<i>R</i> ²	<i>t</i>	β	<i>p</i>	<i>R</i> ²	<i>t</i>	β	<i>p</i>				
Health behaviors PRE																												
Nutrition	.001	.38	.03	.70	.00	.66	.05	.51	.02	1.66	.14	.10	.00	.81	.00	.42	.00	.32	.02	.75	.01	.66	.05	.51	.02	1.59	.17	.12
Physical activity	.03	-2.44	-.17	.015	.01	-1.67	-.13	.10	.00	-.73	-.06	.47	.00	-.23	.00	.82	.05	-2.13	-.15	.034	.11	-1.60	-.11	.11	.13	.83	.08	.41
Tobacco use	.01	1.25	.09	.21	.01	1.06	.08	.29	.00	.85	.07	.40	.00	.33	.00	.74	.26	1.37	.10	.17	.01	1.17	.08	.24	.01	.08	.01	.94
Alcohol use	.01	-1.54	-.11	.13	.00	-.84	-.07	.41	.00	-.41	-.03	.69	.00	.34	.00	.73	.02	-1.66	-.12	.10	.02	-1.36	-.10	.18	.08	-.06	-.01	.96
Health behaviors POST																												
Nutrition	.05	-2.73	-.22	.007	.05	-2.59	-.23	.011	.03	-2.17	-.21	.031	.03	-2.23	.03	.027	.05	-2.64	-.22	.009	.07	-2.46	-.20	.015	.11	-2.54	-.31	.012
Physical activity	.03	-2.20	-.18	.03	.03	-1.98	-.18	.05	.01	-1.34	-.13	.18	.02	-1.75	.02	.08	.05	-2.05	-.17	.043	.04	-2.01	-.17	.047	.07	-.53	-.07	.60
Tobacco use	.02	1.66	.14	.10	.02	1.64	.15	.10	.02	1.60	.16	.11	.01	-.84	.01	.40	.02	1.67	.14	.10	.02	1.55	.13	.12	.09	-.31	.04	.76
Alcohol use	.00	-.13	-.01	.90	.00	-.18	-.02	.86	.00	.57	.06	.57	.00	.43	.00	.67	.03	-.33	-.03	.74	.00	-.14	-.01	.89	.06	.46	.06	.65
Health behaviors Change																												
Nutrition	.05	-2.58	-.21	.011	.06	-2.47	-.22	.015	.07	-.26	-2.71	.008	.06	-2.77	.06	.006	.06	-2.45	-.20	.016	.05	-2.51	.21	.013	.11	-2.99	-.38	.003
Physical activity	.00	-.09	-.00	.93	.00	-.14	-.01	.89	.02	-.22	-.02	.83	.00	-.44	.00	.66	.02	.09	.01	.93	.02	-.33	-.03	.74	.09	.61	.08	.55
Tobacco use	.01	1.36	.10	.18	.28	1.62	.13	.11	.25	1.35	.12	.18	.29	-.60	.06	.55	.26	1.37	.10	.17	.26	1.37	.10	.18	.32	-.59	-.07	.56
Alcohol use	.01	1.43	.08	.15	.55	1.34	.09	.18	.57	1.11	.07	.27	.57	2.04	.17	.044	.57	1.29	.08	.20	.57	1.48	.09	.14	.57	1.72	.15	.09

PRE pre-HSCT, POST post-HSCT, Change pre-HSCT SRF as related to 1-year follow-up values of DVs controlling for pre-HSCT DV values

^aImpact of SRF pre-hematopoietic stem cell transplant (HSCT) on outcome variable(s) controlling for pre-transplant pain, fatigue, depression, transplant type, and Eastern Cooperative Oncology Group (ECOG) score

Table 7

Hierarchical regression analyses, self-regulatory fatigue (SRF), and secondary outcome variables; coping (measured pre-HSCT only)

SRF		SRF controlling for																										
		Pain			Fatigue			Depression			Transplant			ECOG			All ^a											
<i>R</i> ²	<i>t</i>	β	<i>p</i>	<i>R</i> ²	<i>t</i>	β	<i>p</i>	<i>R</i> ²	<i>t</i>	β	<i>p</i>	<i>R</i> ²	<i>t</i>	β	<i>p</i>	<i>R</i> ²	<i>t</i>	β	<i>p</i>	<i>R</i> ²	<i>t</i>	β	<i>p</i>					
Coping (pre-HSCT only)																												
Active coping	.00	−.66	−.05	.51	.01	−.64	−.05	.53	.02	.45	.04	.65	.00	−.68	−.07	.50	.00	−.58	−.05	.56	.01	−.50	−.04	.62	.02	−.36	−.04	.72
Planning	.00	.49	.04	.63	.01	.19	.02	.85	.03	1.66	.14	.10	.00	.49	.05	.62	.00	.44	.04	.66	.00	.59	.05	.56	.02	.60	.07	.55
Acceptance	.08	−3.86	−.59	<.001	.10	−3.14	−.25	.002	.08	−3.06	−.26	.003	.08	−3.17	−.32	.002	.09	−3.61	−.27	<.001	.11	−3.27	−.25	.001	.12	−2.50	−.27	.013
Avoidant coping	.16	5.65	.40	<.001	.14	4.90	.38	<.001	.17	5.39	.43	<.001	.17	3.93	.38	<.001	.16	5.42	.39	<.001	.18	6.04	.44	<.001	.18	3.58	.37	<.001
Self distraction	.09	3.97	.29	<.001	.07	3.52	.28	.001	.11	4.19	.35	<.001	.09	3.21	.32	.002	.09	3.85	.29	<.001	.12	4.53	.34	<.001	.13	3.30	.35	.001
Denial	.26	7.70	.51	<.001	.27	7.46	.53	<.001	.29	6.04	.45	<.001	.29	4.13	.37	<.001	.27	7.87	.53	<.001	.27	7.27	.50	<.001	.33	4.09	.39	<.001

HSCT hematopoietic stem cell transplant, ECOG Eastern Cooperative Oncology Group score

^a Impact of SRF on coping variables controlling for pain, fatigue, depression, transplant type, and ECOG score (all variables pre-HSCT)