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## Factors Associated with Health-Related Quality of Life Among Colorectal Cancer Survivors

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### Abstract

**Introduction:** Assessment of health-related quality of life (HRQOL) can provide insights into cancer survivors' physical and mental functioning, their social relationships, and perceptions of their health and well-being. Understanding factors associated with HRQOL may help identify those who are at greater risk for diminished functioning and improve targeted delivery of health promotion programs. This analysis sought to assess sociodemographic and medical factors associated with HRQOL among colorectal cancer survivors and factors that may put survivors at risk for poor functioning. In addition, associations between BMI and physical activity and HRQOL were explored.

**Methods:** Data from a cross-sectional study of health behaviors among 593 long-term colorectal cancer survivors recruited through the California Cancer Registry in early 2010 were analyzed in late 2014 to early 2015. Multivariable linear and logistic regression models were used to assess factors associated with physical, mental, and overall HRQOL.

**Results:** The mean physical and mental HRQOL scores of survivors were 46.88 and 42.28, respectively, and lower than the population norm (50). Being older, having more comorbid conditions, and having had a recurrence were associated with lower physical and overall HRQOL, whereas being physically active was associated with higher physical and overall HRQOL.

**Conclusions:** Findings highlight the need to encourage healthcare providers to promote physical activity among sedentary cancer survivors, even at modest levels. In addition, lower mental HRQOL scores may indicate a greater need to screen cancer survivors for psychosocial issues and link them with appropriate services.

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Appendix

Supplementary data

Supplementary data associated with this article can be found at, <http://dx.doi.org/10.1016/j.amepre.2015.08.007>.

## Introduction

Assessment of health-related quality of life (HRQOL) can provide insights into cancer survivors' physical and mental functioning, their social relationships, and perceptions of their health and well-being. Though studies have shown that about 75% of cancer survivors report population levels of HRQOL,<sup>1-3</sup> there is also evidence that certain subgroups of survivors may be at risk for decreased HRQOL.<sup>1</sup>

Although colorectal cancer (CRC) is the third leading cancer diagnosed in the U.S.,<sup>4</sup> there have been marked improvements in survival over the last 30 years with 5-year survival at approximately 65%.<sup>5</sup> However, late or long-term side effects of the disease and its treatment may persist years after diagnosis.

Studies of HRQOL in CRC survivors have found that age,<sup>1,3,6</sup> gender,<sup>1</sup> comorbid conditions,<sup>1-3</sup> income,<sup>2,6</sup> and education<sup>1,6</sup> may influence perceptions of health. Cancer-related factors, like time since diagnosis, cancer recurrence or multiple primary cancers, and recent receipt of cancer treatment have also been associated with HRQOL<sup>1,6</sup> among cancer survivors.

Physical activity (PA) and BMI may also play a role in the HRQOL of cancer survivors. Studies assessing the association between BMI and HRQOL in CRC survivors have found that obesity is associated with poorer HRQOL.<sup>6,7</sup> In addition, meeting PA guidelines (150 minutes of moderate to vigorous PA [MVPA] a week) and reporting greater minutes of weekly MVPA are associated with increased HRQOL among cancer survivors.<sup>8-13</sup> Light-intensity exercise has also been associated with increased HRQOL among older non-cancer adults.<sup>14</sup>

Understanding factors associated with HRQOL among CRC survivors can help medical providers and public health programs better identify those who may be at greater risk for diminished functioning and improve targeted delivery of health promotion programs. This analysis sought to assess sociodemographic and medical factors associated with HRQOL among long-term CRC survivors. HRQOL was assessed as separate physical and mental health scores to identify differing factors that may impact functioning. In addition, associations between BMI, PA across all intensity levels, and HRQOL were explored.

## Methods

### Participants

Data for this analysis are from CDC's Prevention among Colorectal Cancer Survivors study, a cross-sectional study of the health behaviors of 5- to 7-year CRC survivors recruited from the California Cancer Registry in early 2010. A more detailed account of study methodology can be found elsewhere.<sup>15</sup> Briefly, a stratified random sample of CRC survivors were selected and mailed a study survey. Eligibility criteria were:

1. having been diagnosed with colorectal cancer in 2003 or 2004;
2. localized or regional stage (early stage), primary diagnosis, with no previous history of cancer;

3. residing in California;
4. aged >18 years at diagnosis;
5. not having been contacted for research participation in the last year;
6. no “do not contact” flag; and
7. being able to read and write in English.

The study protocol was reviewed and approved by IRBs at CDC, ICF Macro, the Public Health Institute, and the state of California. U.S. Office of Management and Budget Paperwork Reduction Act approval was also obtained.

## Measures

HRQOL was measured using the 10-item Patient-Reported Outcomes Measurement Information System Global Scale (PROMIS Global 10).<sup>16</sup> Scale items assess general health, physical health, mental health, social health, pain, and fatigue. Previous research among a general population sample has identified two factors with four items each: physical health (overall physical health, physical functioning, pain, and fatigue) and mental health (QOL, overall mental health, social health, and emotional problems).<sup>16</sup> Physical and mental HRQOL scores were calculated and transformed to a T-score distribution with a mean of 50 and an SD of 10, an established population norm.<sup>17,18</sup> The PROMIS T-score distribution and population norms were developed with a study population demographically similar to those of the 2000 U.S. Census.<sup>18</sup> Given the lack of clinically meaningful values for this scale, scores were then dichotomized based on 1 SD from the mean (T-score = 40)<sup>1</sup> to indicate poorer functioning. EuroQol scores, estimated using raw scores from the PROMIS Global 10,<sup>19</sup> measured overall HRQOL.

A modified version of the Godin Leisure-Time exercise questionnaire<sup>20,21</sup> was used to assess survivors' levels of PA. Respondents were asked if they had engaged in any PA in their free time in the last 3 months. If yes, they were asked if they had engaged in light, moderate, or vigorous exercise in the last 3 months, the number of days per week they engaged in these types of PA, the number of sessions per day, and minutes per session. Respondents were provided with a definition for light, moderate, and vigorous exercise, as well as examples of the types of activities representative of each intensity level. Total minutes of exercise per intensity level were calculated (number of days exercised, multiplied by number of sessions in day, multiplied by minutes per session) and summed across intensity levels to obtain total minutes of exercise per week. Minutes of total weekly PA were categorized into five levels: no PA, < 60 minutes, 61–149 minutes, 150–249 minutes, and ≥ 250 minutes of PA per week. An additional variable was calculated for weekly minutes of MVPA and categorized into four levels: no MVPA (includes those who reported sedentary behavior or only light exercise), < 60 minutes, 61–149 minutes, and ≥ 150 minutes of MVPA per week.

Sociodemographic variables included age at time of survey, gender, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and non-Hispanic other— composed primarily of those who were Asian), marital status, education, and employment status.

Survey respondents were asked if they had been diagnosed with any of ten different non-cancer conditions in the past year (arthritis, asthma, diabetes, emphysema or chronic obstructive pulmonary disease, kidney disease, chronic liver disease, heart disease, hypertension, osteoporosis, and digestive issues). Responses were then summed and classified into three categories of comorbidity (zero conditions, one condition, and two or more conditions). Questions on receipt of surgery, chemotherapy, and radiation for cancer treatment were classified into two categories: those who received no or one treatment versus receipt of two or three treatments. Treatments were categorized this way owing to small numbers of survivors who received no treatment. Participants were also asked if they were currently undergoing any treatment for cancer, had been diagnosed with a cancer recurrence, or had been diagnosed with additional primary cancers. BMI was calculated from self-reported height and weight and classified into three groups indicating under or healthy weight, overweight, and obese.

### Statistical Analysis

Weighted analyses were conducted in late 2014 to early 2015 using SPSS, version 22 to account for the complex sampling design and generalize results to the population of CRC survivors in California. Physical and mental HRQOL T-scores and overall (EuroQol) HRQOL scores were examined in unadjusted and adjusted ordinary least-squares regression models and used to generate least squares means (estimated marginal means) using IBM SPSS (IBM SPSS Complex Samples 22). Contrasts were performed to assess differences within categorical variables significantly associated with each of the three outcomes in the adjusted models. Owing to a high correlation ( $r > 0.7$ ) between the two PA variables, separate models were run with each variable to obtain estimates of physical, mental, and overall HRQOL.

Unadjusted and adjusted logistic regression models were used to examine predictors of poorer physical and mental HRQOL (defined as a T-score  $< 40$ ). A backward selection method, driven by a  $p$ -value approach, was used to develop final models. Variables significantly associated with poorer physical and mental HRQOL at  $p < 0.2$  were retained in the final models, with the exception of age and total minutes of weekly PA, which were included in all models.

### Results

A more detailed description of the recruitment process has been published elsewhere.<sup>15</sup> Briefly, survey packets were sent to 1,414 CRC survivors, 593 of which completed the study survey. The adjusted response rate (estimates ineligibility in non-responders) was 46.3% and the cooperation rate (rate of participation among those with verified contact) was 64.0%. An analysis comparing responders and non-responders indicated that those who were divorced, widowed or separated, of minority descent (non-Hispanic [NH] black, Hispanic, or Asian/Pacific Islander), and were uninsured or had government sponsored insurance had decreased odds of participating in the study (data not shown).

On average, survivors were aged 73.8 years and 6.2 years from diagnosis (range, 5.2–7.2 years). More than 60% were NH white, married or living with a partner, retired or not

employed, and had attended some college or more. About 6% were undergoing treatment for cancer at the time of the survey and 7.8% were diagnosed with a CRC recurrence. A total of 63.3% of survivors had engaged in some kind of weekly PA in their free time in the previous 3 months, and 40.4% participated in 150 minutes of light, moderate, or vigorous exercise each week (Table 1).

Findings from the multivariable linear model show that after adjusting for all variables in the model, the estimated overall mean physical HRQOL score was 46.88, below the population norm of 50. In addition, results indicated that mean physical HRQOL score decreased with increasing age, starting at age 60 years, with survivors aged 80 years having the lowest mean score (Table 2). Survivors aged 80 years had a significantly lower mean score than those aged <60 years ( $p=0.035$ ). The adjusted mean physical HRQOL score decreased significantly with increasing number of comorbid conditions ( $p<0.001$ ) and was also lower among survivors who had experienced a CRC recurrence ( $p=0.005$ ). After controlling for all other variables in the model, assessment of the association between total minutes of weekly PA and physical HRQOL indicated a significantly higher mean score among survivors who engaged in weekly PA for any length of time compared with those who did not engage in any PA ( $p=0.023$ ,  $p=0.008$ ,  $p=0.009$ , and  $p<0.001$ , respectively; Table 3). The relationship between physical HRQOL and total MVPA was marginally significant ( $p=0.054$ ) and followed a similar pattern to that seen in weekly minutes of total PA.

The estimated overall mean mental HRQOL score was 42.28, below the population norm of 50. Findings from the adjusted model indicated significantly higher estimated mean mental HRQOL scores among survivors of NH other race compared with NH whites ( $p=0.003$ ), among those with a high school degree or less and those who completed some college compared with those with a college degree or higher ( $p<0.001$  and  $p=0.006$ , respectively), among uncoupled survivors compared with those who were coupled ( $p=0.023$ ), and among survivors with two or more comorbid conditions than those with no comorbid conditions ( $p=0.007$ ). No associations were observed between mental HRQOL and total weekly PA or total weekly MVPA in the adjusted models (Table 3).

In multivariable analysis, scores were significantly lower among survivors aged 80 years than among those aged 70–79 years ( $p=0.003$ ), 60–69 years ( $p=0.004$ ), and marginally significantly lower than those aged <60 years ( $p=0.06$ ). Overall mean HRQOL score decreased with increasing number of comorbid conditions ( $p<0.001$ ), and was also lower among survivors who had a cancer recurrence than among those who did not ( $p=0.018$ ). After controlling for all other variables in each model, both total minutes of weekly PA and total minutes of weekly MVPA were significantly associated with overall HRQOL. For total minutes of weekly PA, survivors engaging in any amount of PA were significantly more likely to have a higher mean overall HRQOL score than those who did not exercise ( $p=0.01$  for each of the categories). For total MVPA, survivors engaging in 61 minutes per week of MVPA had a significantly higher mean overall HRQOL score than those who did not engage in weekly MVPA ( $p=0.01$  for both categories).

Results of the unadjusted linear models for the three measures of HRQOL are presented in Appendix 1 (available online). Age, education, employment, number of comorbid

conditions, total minutes of weekly PA, and total minutes of weekly MVPA were significantly associated with each of the three measures of HRQOL. Additionally, marital status was significantly associated with mental and overall HRQOL, but only marginally significantly associated with physical HRQOL. Race/ethnicity was significantly associated with mental HRQOL and number of cancer treatments received was significantly associated with overall HRQOL.

Table 4 presents findings from two unadjusted and multivariable logistic regression models describing the associations between sociodemographic, cancer-related, and behavioral characteristics associated with poor physical and mental HRQOL. Survivors with two or more comorbid conditions had more than three times the odds of having poorer physical HRQOL than those with no comorbid conditions ( $p=0.024$ ). Survivors diagnosed with a CRC recurrence had more than five times the odds of having poorer HRQOL than those without a recurrence ( $p=0.011$ ). However, survivors who engaged in at least 250 minutes of PA per week had 72% lower odds of having poorer physical HRQOL compared with those who did not exercise ( $p=0.030$ ). Being aged  $\geq 80$  years, having at most a high school education, and being retired or not employed were associated with greater odds of having poorer physical HRQOL in the unadjusted models, but were not significant in the adjusted model.

The odds of having poorer mental HRQOL among women were twice the odds among men ( $p=0.036$ ). Uncoupled survivors had less than half the odds of having poorer mental HRQOL compared with the odds among those who were married or partnered ( $p=0.002$ ), and the odds of having poorer mental HRQOL increased with increasing education ( $p<0.001$ ). Being aged  $\geq 70$  years, and being retired or not employed were associated with decreased odds of having poor mental HRQOL in unadjusted models, but not in the adjusted model.

## Discussion

Findings indicated that, on average, mean physical and mental HRQOL scores are below the population norm of 50. It is unclear if these lower HRQOL estimates are actually indicative of poorer health. Results from the National Health Interview Survey, estimated with the same scale and similar methods, found that CRC survivors' mean physical HRQOL score was 50.7 and mean mental HRQOL score was 53.3 (53.2 and 53.9, respectively, for adults without cancer).<sup>1</sup> National estimates of mean physical HRQOL are within 1 SD of study estimates. However, National Health Interview Survey estimates for mean mental HRQOL scores are more than 1 SD higher than those from this study. This may be indicative of poorer mental HRQOL among these CRC survivors than the mental HRQOL of a national sample of CRC survivors and the general non-cancer U.S. population.

Reports by IOM<sup>22</sup> and standards set by the Commission on Cancer<sup>23</sup> have stressed the importance of caring for the psychosocial needs of cancer survivors. In addition, research has indicated that most survivors are not discussing the psychosocial effects of cancer with their medical providers.<sup>24</sup> Poorer mental HRQOL scores may be indicative of psychosocial issues among cancer survivors that are not being adequately addressed, which would

underscore the need for screening cancer survivors for psychosocial distress and linking them to appropriate support services.

Though previous research has indicated that increased MVPA is associated with increased QOL,<sup>8-13</sup> results indicated that lower levels of exercise of varied intensity were associated with modestly higher physical and overall HRQOL when compared with sedentary cancer survivors. In addition, exercising at the highest levels was protective against poor physical HRQOL. Although causality cannot be inferred, these results add further evidence to the growing body of work showing that PA is important for the health and well-being of cancer survivors. Even though differences in physical and overall HRQOL were significantly higher among those who exercised, it is unclear if these differences indicate clinically meaningful health benefits from exercise. Results also showed that, in the adjusted models, minutes of MVPA were not associated with physical HRQOL. This may be because the referent category included not only those who were sedentary but also those who engaged in light-intensity PA, which may also provide physical HRQOL benefits to cancer survivors.

Previous research has indicated that being physically active is associated with better mental health or improvements in psychological and emotional distress.<sup>25,26</sup> Results, however, showed little association between greater levels of PA and mental HRQOL. This may be because the questions used to measure mental HRQOL are multidimensional and capture more than just emotional and psychological distress. A systematic review of QOL among CRC survivors found that although most survivors had good psychological QOL, they were also more likely to have higher levels of depression and anxiety than non-cancer controls, and fear over experiencing a recurrence.<sup>6</sup> This may indicate a discordance between mental health and mental HRQOL or respondents answering questions on mental HRQOL differently than more-specific questions on symptomology associated with anxiety and depression.

### Limitations

Though this study provides insights on factors associated with different aspects of HRQOL among CRC survivors, there are several weaknesses that should be noted. First, data were collected via self-report, thus reports of amount and intensity of PA may be subject to social desirability bias.<sup>27</sup> Also, provided definitions of PA intensity may not have been appropriate for cancer survivors, or those with multiple chronic conditions. It is unclear if respondents used the provided PA intensity definitions or their perceptions when answering questions. The study was cross-sectional in design and unable to assess temporal or causal relationships between study variables. Although the study has a diverse population based sample, study recruitment was limited to 5- to 7-year early stage CRC cancer survivors from the state of California. Therefore, results may not be generalizable beyond this group. In addition, sociodemographic differences between responders and non-responders indicated some bias.

### Conclusions

Results indicate that engaging in PA is associated with better physical and overall HRQOL among a sample of older CRC survivors. In addition, those with more comorbid conditions and those who have had a cancer recurrence may be more vulnerable to poorer HRQOL.

Results should encourage healthcare providers to promote PA among sedentary cancer survivors, even at modest levels. In addition, lower mental HRQOL scores may indicate a greater need to screen cancer survivors for psychosocial issues and link them with appropriate services.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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**Table 1.**

Sociodemographic and Cancer-Related Characteristics, and BMI and Physical Activity of CRC Survivors

Characteristics	<i>n</i> (Weighted %)
Age (years)	
<60	113 (11.8)
60–69	164 (16.7)
70–79	187 (40.1)
80+	128 (31.4)
Gender	
Male	295 (50.4)
Female	296 (49.6)
Race/ethnicity	
NH white	291 (64.7)
NH black	101 (5.5)
NH other <sup>a</sup>	93 (13.9)
Hispanic	107 (15.8)
Marital status	
Married/Partnered	362 (63.0)
Single/Divorced/Widowed/Separated	207 (37.0)
Education	
High school degree	196 (35)
Some college	191 (32.3)
College graduate	180 (32.7)
Employment status	
Employed/Self-employed	175 (23.2)
Retired/Not employed for wages	390 (76.8)
Comorbidity	
0	144 (22.3)
1	173 (28.5)
2+	275 (49.2)
Number of treatments received	
0–1	260 (52.2)
2–3	264 (47.8)
Currently undergoing treatment	
Yes	34 (6.2)
No	544 (93.8)
Cancer recurrence	
Yes	54 (7.8)
No	527 (92.2)
Multiple primary cancers	
Yes	469 (76.8)
No	111 (23.2)

Characteristics	<i>n</i> (Weighted %)
BMI category	
<25	205 (39.2)
25–29.9	195 (34.4)
30+	154 (26.4)
Minutes of weekly PA	
No physical activity	200 (36.7)
60 minutes	64 (9.6)
61–149 minutes	78 (13.3)
150–249 minutes	85 (14.8)
250+ minutes	150 (25.6)
Minutes of weekly MVPA	
No MVPA	324 (59.0)
60 minutes	73 (11.1)
61–149 minutes	60 (9.5)
150+ minutes	121 (20.4)

*Note:* Descriptive statistics are weighted and incorporate design and post-stratification adjustments. The additional participants ( $n=124$ ) that appear in the “No MVPA” category only reported engaging in light intensity exercise.

<sup>a</sup>“NH other” includes mostly Asian race.

CRC, colorectal cancer; MVPA, moderate to vigorous physical activity; NH, non-Hispanic; PA, physical activity.

Adjusted Estimated Marginal Means for Physical, Mental, and Overall HRQOL by Sociodemographic and Cancer-Related Variables

Table 2.

Characteristics	Physical HRQOL		Mental HRQOL		Overall HRQOL	
	T-score, M (SE)	p-value	T-score, M (SE)	p-value	EQ-5D score, M (SE)	p-value
Overall mean score	<b>46.88 (0.71)</b>		<b>42.28 (0.75)</b>		<b>0.70 (0.010)</b>	
Age (years)						
<60	<b>47.25 (0.80)</b>	<b>0.030</b>	41.43 (0.85)	0.250	<b>0.70 (0.011)</b>	<b>0.012</b>
60–69	<b>47.93 (0.76)</b>	–	41.94 (0.85)	–	<b>0.71 (0.010)</b>	–
70–79	<b>47.13 (0.85)</b>	–	42.41 (0.87)	–	<b>0.71 (0.012)</b>	–
80+	<b>45.23 (1.03)</b>	–	43.33 (1.02)	–	<b>0.67 (0.014)</b>	–
Gender						
Male	46.73 (0.79)	0.619	42.80 (0.79)	0.088	0.69 (0.011)	0.665
Female	47.04 (0.76)	–	41.74 (0.84)	–	0.70 (0.010)	–
Race/ethnicity						
NH white	47.05 (0.73)	0.794	<b>41.32 (0.75)</b>	<b>0.026</b>	0.70 (0.010)	0.460
NH black	46.69 (0.99)	–	<b>41.77 (1.04)</b>	–	0.70 (0.013)	–
NH other	46.46 (0.98)	–	<b>43.66 (1.01)</b>	–	0.68 (0.014)	–
Hispanic	47.34 (0.95)	–	<b>42.35 (1.01)</b>	–	0.71 (0.013)	–
Marital status						
Married/Partnered	47.27 (0.73)	0.233	<b>41.53 (0.76)</b>	<b>0.023</b>	0.70 (0.010)	0.530
Single/Divorced/Widowed/Separated	46.50 (0.82)	–	<b>43.02 (0.88)</b>	–	0.69 (0.011)	–
Education						
High school degree or less	46.59 (0.84)	0.696	<b>43.80 (0.86)</b>	< <b>0.001</b>	0.68 (0.012)	0.146
Some college	46.82 (0.88)	–	<b>42.45 (0.86)</b>	–	0.70 (0.011)	–
College degree or more	47.25 (0.78)	–	<b>40.58 (0.85)</b>	–	0.71 (0.010)	–
Employment status						
Employed/Self-employed	47.18 (0.85)	0.403	42.31 (0.87)	0.896	0.69 (0.010)	0.227
Retired/Not employed for wages	46.60 (0.72)	–	42.24 (0.75)	–	0.70 (0.011)	–
Comorbidity						
0	<b>48.02 (0.84)</b>	< <b>0.001</b>	<b>41.49 (0.88)</b>	<b>0.023</b>	<b>0.72 (0.011)</b>	< <b>0.001</b>
1	<b>47.59 (0.84)</b>	–	<b>42.08 (0.88)</b>	–	<b>0.70 (0.011)</b>	–

Characteristics	Physical HRQOL T-score, M (SE)	p-value	Mental HRQOL T-score, M (SE)	p-value	Overall HRQOL EQ-5D score, M (SE)	p-value
2+	<b>45.05 (0.77)</b>	–	<b>43.26 (0.78)</b>	–	<b>0.66 (0.011)</b>	–
Number of treatments received						
0–1	46.92 (0.75)	0.903	42.59 (0.80)	0.272	0.69 (0.010)	0.455
2–3	46.85 (0.78)	–	41.97 (0.81)	–	0.69 (0.011)	–
Currently undergoing treatment						
Yes	47.95 (1.29)	0.127	42.15 (1.34)	0.852	0.71 (0.017)	0.297
No	45.83 (0.55)	–	42.41 (0.55)	–	0.69 (0.008)	–
Cancer recurrence						
Yes	<b>45.56 (0.93)</b>	<b>0.005</b>	42.48 (1.02)	0.668	<b>0.68 (0.013)</b>	<b>0.018</b>
No	<b>48.22 (0.75)</b>	–	42.07 (0.74)	–	<b>0.71 (0.011)</b>	–
Multiple primary cancers						
Yes	46.46 (0.83)	0.297	42.92 (0.82)	0.081	0.69 (0.011)	0.435
No	47.31 (0.80)	–	41.63 (0.86)	–	0.70 (0.011)	–
BMI category						
<25	47.21 (0.79)	0.680	42.47 (0.82)	0.761	0.70 (0.011)	0.333
25–29.9	46.93 (0.80)	–	42.01 (0.79)	–	0.70 (0.011)	–
30+	46.51 (0.92)	–	42.35 (0.96)	–	0.69 (0.012)	–

Note: Adjusted estimated marginal means are weighted and incorporate design and post-stratification adjustments. Estimates are adjusted for all other variables in the model. Boldface indicates statistical significance ( $p < 0.05$ ) for associations with each outcome based on Wald F-tests from multivariable linear regression models. Contrasts between categories of significant variables are presented in the text. Unweighted sample sizes for each multivariable linear regression were  $n=394$ ,  $n=428$ , and  $n=387$ , respectively.

EQ-5D, EuroQol; HRQOL, health-related quality of life; NH, non-Hispanic.

**Table 3.** Adjusted Estimated Marginal Means for Physical, Mental, and Overall HRQOL for Each Physical Activity Variable

Characteristics	Physical HRQOL T-score, M (SE)	<i>p</i> -value	Mental HRQOL T-score, M (SE)	<i>p</i> -value	EQ-5D HRQOL score, M (SE)	<i>p</i> -value
Minutes of weekly PA						
No physical activity	<b>45.18 (0.79)</b>	<b>0.001</b>	43.02 (0.90)	0.424	<b>0.67 (0.010)</b>	<b>&lt;0.001</b>
60 minutes	<b>47.59 (1.05)</b>	–	42.07 (1.04)	–	<b>0.70 (0.013)</b>	–
61–149 minutes	<b>47.58 (0.96)</b>	–	42.13 (0.94)	–	<b>0.71 (0.012)</b>	–
150–249 minutes	<b>47.40 (0.91)</b>	–	41.66 (0.99)	–	<b>0.71 (0.012)</b>	–
250+ minutes	<b>48.33 (0.93)</b>	–	41.77 (0.99)	–	<b>0.73 (0.012)</b>	–
Minutes of weekly MVPA						
No MVPA	46.25 (0.74)	0.054	42.75 (0.76)	0.084	<b>0.68 (0.010)</b>	<b>&lt;0.001</b>
60 minutes	47.77 (0.99)	–	42.37 (1.09)	–	<b>0.70 (0.014)</b>	–
61–149 minutes	47.22 (1.09)	–	40.94 (0.98)	–	<b>0.71 (0.014)</b>	–
150+ minutes	48.07 (0.93)	–	41.44 (0.97)	–	<b>0.72 (0.012)</b>	–

*Note:* Adjusted estimated marginal means are weighted and incorporate design and post-stratification adjustments. Models are adjusted for age, gender, race/ethnicity, marital status, education, employment status, number of comorbid conditions, number of treatments received, currently undergoing treatment, having a cancer recurrence, diagnosed with multiple cancers, and BMI. Boldface indicates statistical significance ( $p < 0.05$ ) for associations with each outcome based on Wald F-tests from multivariable linear regression models. Contrasts between categories of significant variables are presented in the text.

EQ-5D, EuroQol; HRQOL, health-related quality of life; MVPA, moderate to vigorous physical activity; PA, physical activity.

Unadjusted and Adjusted Multivariable Predictors of Poor Physical and Mental HRQOL Among CRC Cancer Survivors

Table 4.

Characteristics	Physical HRQOL T-score <40			Mental HRQOL T-score <40		
	Unadjusted, OR (95% CI)	Final model, AOR (95% CI)	p-value	Unadjusted, OR (95% CI)	Final model, AOR (95% CI)	p-value
Age (years)						
<60	ref	ref	0.143	ref	ref	0.663
60–69	1.23 (0.50, 2.99)	0.68 (0.23, 2.02)	–	0.62 (0.37, 1.04)	0.65 (0.36, 1.20)	–
70–79	1.81 (0.77, 4.23)	0.74 (0.21, 2.63)	–	<b>0.52 (0.31, 0.87)</b>	0.65 (0.36, 1.18)	–
80+	<b>5.59 (2.47, 12.66)</b>	1.62 (0.49, 5.39)	–	<b>0.36 (0.20, 0.65)</b>	0.57 (0.29, 1.11)	–
Gender						
Male	ref	–	–	ref	ref	<b>0.036</b>
Female	1.26 (0.73, 2.18)	–	–	1.25 (0.84, 1.88)	<b>2.06 (1.28, 3.32)</b>	–
Race/Ethnicity						
NH white	ref	–	–	ref	–	–
NH black	1.73 (0.90, 3.34)	–	–	0.67 (0.39, 1.15)	–	–
NH other	0.98 (0.45, 2.15)	–	–	0.96 (0.56, 1.63)	–	–
Hispanic	1.87 (0.99, 3.51)	–	–	0.69 (0.42, 1.15)	–	–
Marital status						
Married/Partnered	ref	–	–	ref	ref	<b>0.002</b>
Single/Divorced/Widowed/Separated	1.30 (0.73, 2.30)	–	–	<b>0.51 (0.33, 0.79)</b>	<b>0.44 (0.26, 0.74)</b>	–
Education						
High school degree	<b>2.21 (1.06, 4.58)</b>	–	–	<b>0.32 (0.19, 0.53)</b>	<b>0.33 (0.19, 0.57)</b>	<b>&lt;0.001</b>
Some college	1.27 (0.56, 2.89)	–	–	0.65 (0.39, 1.07)	0.60 (0.36, 1.03)	–
College graduate	ref	–	–	ref	ref	–
Employment status						
Employed/Self-employed	ref	ref	0.102	ref	–	–
Retired/Not employed for wages	<b>4.43 (1.85, 10.61)</b>	2.77 (0.82, 9.43)	–	<b>0.53 (0.35, 0.81)</b>	–	–
Comorbidity						
0	ref	ref	<b>0.039</b>	ref	ref	0.105
1	1.87 (0.64, 5.50)	1.51 (0.45, 5.00)	–	1.21 (0.70, 2.08)	1.28 (0.71, 2.30)	–
2+	<b>4.83 (1.88, 12.39)</b>	<b>3.28 (1.17, 9.16)</b>	–	0.72 (0.43, 1.20)	0.77 (0.43, 1.39)	–

Characteristics	Physical HRQOL T-score <40			Mental HRQOL T-score <40		
	Unadjusted, OR (95% CI)	Final model, AOR (95% CI)	p-value	Unadjusted, OR (95% CI)	Final model, AOR (95% CI)	p-value
Number of treatments received						
0–1	ref	–	–	ref	–	–
2–3	0.62 (0.34, 1.14)	–	–	1.48 (0.97, 2.26)	–	–
Currently undergoing treatment						
Yes	0.50 (0.13, 1.86)	0.270 (0.05, 1.56)	0.143	0.73 (0.29, 1.88)	–	–
No	ref	ref	–	ref	–	–
Cancer recurrence						
Yes	1.89 (0.81, 4.42)	<b>5.34 (1.59, 17.96)</b>	<b>0.011</b>	0.99 (0.49, 2.03)	–	–
No	ref	ref	–	ref	–	–
Multiple primary cancers						
Yes	1.60 (0.84, 3.05)	–	–	0.76 (0.45, 1.28)	–	–
No	ref	–	–	ref	–	–
BMI category						
<25	ref	–	–	ref	–	–
25–29.9	1.21 (0.60, 2.43)	–	–	0.93 (0.57, 1.51)	–	–
30+	1.86 (0.96, 3.61)	–	–	0.96 (0.57, 1.62)	–	–
Minutes of weekly PA						
No physical activity	ref	ref	0.134	ref	ref	0.556
60 minutes	0.33 (0.11, 1.00)	0.33 (0.09, 1.23)	–	0.79 (0.38, 1.64)	0.60 (0.27, 1.36)	–
61–149 minutes	0.63 (0.28, 1.42)	0.57 (0.23, 1.44)	–	1.23 (0.65, 2.36)	0.90 (0.45, 1.83)	–
150–249 minutes	0.40 (0.16, 1.01)	0.51 (0.17, 1.51)	–	1.52 (0.81, 2.83)	1.30 (0.67, 2.53)	–
250+ minutes	<b>0.28 (0.12, 0.67)</b>	<b>0.30 (0.10, 0.89)</b>	–	1.55 (0.91, 2.65)	0.99 (0.56, 1.73)	–

Note: ORs are weighted and incorporate design and post-stratification adjustments. Boldface indicates statistical significance ( $p < 0.05$ ). Unweighted sample size for final poor physical HRQOL model was  $n=464$ , and  $n=518$  for final poor mental HRQOL model.

CRC, colorectal cancer; HRQOL, health-related quality of life; NH, non-Hispanic; PA, physical activity.