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Dose-response relationships between physical activity, social participation, and health-related quality of life in colorectal cancer survivors

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Abstract

Purpose—To examine the relationships between physical activity (PA), social participation and health-related quality of life (HQOL) in older, long-term colorectal cancer survivors.

Methods—Male and female colorectal cancer survivors (n=1768), aged 65 yrs and 5 yrs post-diagnosis, completed surveys on their current PA, social participation, HQOL, health history and relevant covariates. ANCOVA was used to evaluate the cross-sectional relationship between PA and social participation with the SF-36 subscales, as well as the physical component summary score (PCS) and mental health component summary score (MCS).

Results—The final analytic sample (n= 832) was 81.5 ± 5.8 yrs and 8.2 ± 1.7 yrs post-diagnosis (mean±SD). Meeting the current recommendation of 150 min/wk of PA was associated with higher PCS (p<0.001) but not MCS (p=0.30). Engaging in any social participation, vs. none, was associated with MCS (p=0.003), but not PCS (p=0.13). There was a dose-response relationship between moderate-vigorous intensity PA and PCS (p_{trend} =<0.001). Light intensity PA was not associated with either summary score after adjustment for moderate-vigorous PA (p>0.05), but in survivors performing no higher intensity PA, it was associated with both (p<0.01, p=0.02, respectively). Participants reporting greater amounts of both planned exercise and non-exercise PA had significantly higher PCS (p_{trend} =<0.01, p_{trend} <0.01, respectively). Individuals participating in greater weekly hours of social participation had higher PCS and MCS (p_{trend} =<0.05) than those participating in less.

Conclusions—Among older, long-term colorectal cancer survivors, PA is related to their physical health, while social participation is predominantly related to their mental health.

Implications for cancer survivors—Older colorectal cancer survivors who participate socially and are engaged in PA, even non-exercise and light intensity activities, have higher levels of physical and mental health.

Keywords

Colorectal cancer survivors; Physical activity; Social participation; Health-related quality of life

Introduction

Half of all men and one third of all women in the United States (US) will be diagnosed with cancer in their lifetime [1]. While cancer incidence remains a substantial public health problem, advances in screening and improved treatments have led to rapid growth in the number of cancer survivors, with the total survivor population doubling in the last 25 years [2]. As the US population continues to age, these numbers will inevitably climb. In doing so, a dramatic shift in our understanding of the cancer survivor is needed.

Research has documented that cancer survivors may face many challenges associated with survival [3–8]. Physical, emotional, social and financial challenges have all been linked to cancer diagnosis and associated treatments [3]. These challenges can be reflected in declines in a patient's health-related quality of life (HQOL) post diagnosis [3,4]. As a result, researchers have begun to focus on the HQOL experienced by cancer survivors and ways to ameliorate these challenges whenever possible.

In an attempt to improve the HQOL of cancer survivors, various treatment modalities have been suggested. Physical activity (PA) remains a highly regarded intervention as it has been shown to be associated with improved physical and mental health across varying populations [9]. Social participation, commonly defined as "time spent in social interaction in the presence of others" [10], has also been suggested as a potential opportunity for intervention as, it too, has been shown to improve various health outcomes, including physical and mental health [11–13], across a wide spectrum of patients.

While research involving HQOL in cancer survivors continues to grow, many gaps in our knowledge still exist. To date, most of the literature available examining HQOL in cancer survivors focuses specifically on breast cancer survivors [14–25], middle-aged cancer survivors [25–30], and short-term cancer survivors [18,19,27,30,31]. Only one study has evaluated social participation in a group of older colorectal cancer survivors [32] and this study contained only females. Most of the studies evaluating PA focus simply on those individuals performing planned moderate-vigorous exercise [14–17,19,20,22,27,28,33]. While these studies are promising, there is a lack of information on other domains, types and intensities of PA.

Thus, little is known about the association of PA, social participation and HQOL in older, long-term colorectal cancer survivors. As colorectal cancer is the third most common malignant neoplasm in men and women (excluding non-melanoma skin cancer) [34], the third leading cancer type among survivors [34], and because 78% of all colorectal cancer survivors are over the age of 60 [26,35], it is imperative that we begin to further understand these relationships. To evaluate these associations with HQOL, we performed a cross-sectional analysis on older, long-term colorectal cancer survivors from the state of Wisconsin specifically examining PA and social participation (both independently and collectively), various types and intensities of PA, and types and amounts of social participation.

Methods

Subjects

The Wisconsin Cancer Registry System (WCRS) was used to identify colorectal cancer cases within the state. There were 5,868 persons aged 65 or older who were diagnosed with colorectal cancer from 1995–2000. This time range was chosen at the time of data collection in 2006, to assure subjects would be at least five years post diagnosis, thereby limiting all subjects to long-term colorectal cancer survivors. Of these individuals, a sample of 2,360

cases were chosen, with all cases from Dane county and a random ~40% of non-Dane county cases selected. After cross checking the Social Security death index, the final sample consisted of 1,772 potential participants.

Study Design

Potential participants were sent an introductory letter, the study survey, a five dollar incentive and a postage paid return envelope by mail. Non-respondents were followed with reminder post cards, additional surveys and telephone contact when applicable using the Dillman tailored design method [36]. A total of 938 participants completed the survey by either mail (96%) or telephone (4%). Birth dates, diagnosis dates and sex were collected from the WCRS.

Survey

The survey utilized in this study consisted of many standard measures. The Community Healthy Activities Model Program for Seniors (CHAMPS) [37] questionnaire was used as a measure of both PA and social participation. The CHAMPS questionnaire is a comprehensive 41-item measure used to assess frequency, duration, intensity and type of activities typically engaged in by older adults, including leisure-time activities, walking, household activities, exercise, and social events. The questionnaire captures activities done in a typical week during the previous four weeks. This measure has been shown to be a reliable and valid method for measuring PA in older adults [38,39].

Most of the 41 individual questions found on the CHAMPS questionnaire address PA (n=28). These questions are formatted as “In a typical week during the past four weeks, did you engage in...?”. If the subject answered “yes” to the question, they in turn replied with the number of times per week and total hours per week that they spent participating in that activity. Responses to questions directly asking about PA were assigned a MET value based on the PA compendium as described by Ainsworth et al [40] with adjustments for older age [37]. These data were converted into MET-hours/week (MET-hr/wk) equivalents. Values from all questions were then summed to create total MET-hr/wk energy expenditure and total time variables.

The CHAMPS questionnaire is also able to address social participation, as there are nine questions regarding social activities in older adults that are unscored for use in the PA construct. These questions were formatted in the same way as the PA questions and evaluated “visits with friends or family; visits to a senior center; volunteer work; attendance at church activities; attendance at other club or group meetings; attendance at a concert, movie, lecture or sporting event; playing cards, bingo or board games with other people; and playing pool or billiards”. If the subject answered “yes” to any of the social participation questions other than visiting with friends and family, they were considered to participate socially. This exclusion was made as 89% of subjects reported visiting with friends or family.

The Medical Outcomes Study Short-Form Health Survey (SF-36) [41] was used to measure HQOL. The SF-36 is a 36-item measure encompassing eight individual constructs: physical function, role limitations owing to physical problems, bodily pain, general health perception, vitality, social functioning, role limitations owing to emotional problems and mental health. These eight distinct domains can be summarized into two summary scores: the physical health component summary score (PCS) and the mental health component summary score (MCS) [42]. Scores range from 0–100, with higher scores indicating better HQOL. The SF-36 has been shown to be both reliable and valid for use in many general medical

populations as well as in those with specific conditions, including cardiac, pulmonary, orthopedic, and cancer [41,43–46].

Demographic information collected includes height, weight, sex, race, ethnicity and years of education completed. A brief medical and health history was also completed that included information on cancer history (site, extent of disease, and year of diagnosis) and treatment, as well as alcohol, cigarette and medication use. Additional information was collected on comorbid conditions participants had currently (17 total conditions) or previously (15 total conditions) as well as any falls or hospitalizations in the previous 12 months. Conditions ranged from chronic conditions, such as heart disease, to physical health, such as bone fractures. Patients were also queried regarding any current pain beyond that of minor everyday pain (e.g. headaches).

Analysis

Analyses were conducted using SAS statistical software version 9.3 (SAS Institute, Inc., Cary, NC). Subjects indicating current cancer treatment on the survey were excluded from the analysis. Individuals were also excluded from analysis if all PA, social participation and HQOL information were missing. Covariates were compared across level of PA and social participation using analysis of variance (ANOVA) for continuous variables. Categorical variables were evaluated by using Mantel-Haenszel chi-square or Fisher's exact test when cell sizes were <5. Analysis of covariance (ANCOVA) was used to evaluate the cross-sectional relationship between PA or social participation with each of the SF-36 subscale scores, as well as both summary scores. PA was categorized into two groups (those meeting the recommendations of 150 minutes a week of moderate-vigorous intensity PA and those who did not) as was social participation (those participating in any social activities and those participating in no social activities). Covariates considered for these analyses included age, sex, race, ethnicity, number of comorbidities, smoking status, alcohol consumption, education, hospitalization in the previous 12 months, falls, pain, treatment type, age at diagnosis, extent of disease at diagnosis and time since diagnosis. Covariates that changed the significance of the PA and social participation terms or reduced the magnitude of the difference appreciably and were thus included in the models are age, sex, comorbidities, education, BMI, alcohol consumption, hospitalization in the past 12 months. PA and social participation were also shown to confound relationships with HQOL and were subsequently included in the model (e.g. social participation was included in all PA models). The joint association of PA and social participation on HQOL outcomes was addressed using stratified models and interaction terms were tested.

ANCOVA was also used to examine the association of PA and HQOL across type and intensities of PA, as well as the association of social participation and HQOL across type and duration of social participation. Light intensity PA included activities <3 METs while moderate-vigorous intensity PA included activities ≥3 METs. Quartiles were then created for weekly duration in each category. In order to further clarify the relationship by intensity, we also examined the HQOL with duration of light intensity activity among those who reported no participation in moderate-vigorous PA (n=202). Type of PA was categorized as non-exercise PA (including heavy work around the house, light work around the house, heavy or light gardening, working on an automobile, and walking to do errands) and planned exercise. As exercise is typically defined as a subset of PA that is planned, structured, and repetitive and has as a final or intermediate objective of improvement or maintenance of physical fitness [47], we categorized these activities accordingly. Quartiles of weekly duration in each type of activity were created. Type of social participation was categorized into three groups using Eigen values generated from a principal component analysis. Group one (SNCTR) consisted of visits to senior centers, attending club meetings and playing cards/games/bingo with others. Group two (CHRCH) consisted of volunteering,

participating in church activities/religious services and group three (CMLSE) consisted of attending concerts, movies, lectures, and sporting events. Finally, weekly hours of social participation were categorized by quartile to examine associations by duration of social participation.

Results

Of the 1,772 potential participants identified, 305 were unable to be contacted, 400 refused participation, 61 were too ill to participate, 37 were reported by family members to be deceased, and 21 were unable to participate for other reasons, resulting in a total of 938 completed surveys. This corresponds to a 53% response rate among all potential subjects and 65% among individuals with valid contact information. Survey non-respondents tended to be female, older, diagnosed at a later age, and further removed from diagnosis at time of contact as compared to respondents.

Of the 938 surveys returned, subjects without valid CHAMPS ($n=5$) and complete SF-36 ($n=90$) data, along with subjects currently undergoing cancer treatment ($n=11$), were excluded from the final analytic sample ($n=832$). The mean age of participants was 81.5 (± 5.8) years with an average of 8.2 (± 1.7) years past diagnosis. The sample was 52% female and 99% white. Sample characteristics by category of PA and participation in social participation are shown in Table 1. Individuals meeting the PA guidelines tended to be younger (both presently and at time of diagnosis), male, more highly educated, reported fewer comorbidities, were less likely to have been hospitalized in the previous 12 months, and had fewer falls in the past year than those individuals not meeting the PA guidelines. Active individuals also tended to consume more alcohol than their non-active counterparts. Subjects participating socially tended to be more highly educated, non-smokers, and consume more alcohol on average than those who did not participate socially.

When examining all eight subscales of the SF-36 by activity level in participants (Table 2), meeting PA recommendations was associated with significantly better physical function, role-physical, bodily pain, general health, vitality, and social function subscale scores after adjusting for age, sex, comorbidities, education, BMI, alcohol consumption, hospitalization in the past 12 months and social participation. It should be noted that while the role-emotional and mental health subscales are not statistically different among groups, scores in both subscales are higher among those individuals who meet PA recommendations. Engaging in social participation was associated with significantly higher physical function, role-physical, general health, vitality, social function, role-emotional, and mental health subscale scores after adjustment for the same covariates listed above as well as PA (Table 2).

When evaluating PA and social participation collectively with HQOL outcomes (Figure 1a, b), no significant interaction between PA and social participation was observed for either PCS ($p_{\text{intxn}}=0.22$) or MCS ($p_{\text{intxn}}=0.33$) scores. For the PCS score (Figure 1a), a significant PA main effect was found, with a 5.7-point higher score in those who met the PA recommendations than those who did not ($p<0.01$). There was not a significant main effect for social participation in relation to the PCS score ($p=0.13$). When measuring the MCS (Figure 1b), there was not a significant main effect for PA ($p=0.30$), but there was a significant social participation main effect with a 2.9-point higher MCS score for those who participated in any social events when compared to those who did not participate ($p<0.01$).

When examining PCS scores by level of PA intensity (Figure 2a), greater amounts of moderate-vigorous intensity PA were significantly associated with higher PCS scores ($p_{\text{trend}}<0.01$), with a 7.8-point difference between those in the lowest vs. highest quartile.

Before adjustment for moderate-vigorous activity, greater amounts of light intensity PA were associated with higher PCS scores, with a 4.5-point difference between those in the lowest and highest quartiles ($p<0.01$); however, after adjustment for moderate-vigorous intensity PA, the association was attenuated ($p_{\text{trend}}=0.04$), with the difference between lowest and highest quartiles only 1.7 points ($p=0.06$) (Figure 2a). When the analysis was limited to those reporting no moderate-vigorous PA (24% of the analytic sample; data not shown), those who reported higher amounts of light intensity activity had significantly higher PCS and MCS scores than those individuals who reported less light intensity activity, with a 5.9-point difference in PCS scores ($p<0.01$) and a 6.4-point difference in MCS scores ($p=0.02$) between those in the highest (median MET-hr/wk= 9.0) vs. lowest (median MET-hr/wk= 0.0) quartiles. When evaluating MCS scores by level of intensity (data not shown), there was no significant difference in scores in those reporting greater amounts moderate-vigorous ($p_{\text{trend}}=0.84$) or light intensity ($p_{\text{trend}}=0.33$) PA than those reporting less after mutual adjustment.

Individuals reporting greater amounts of planned exercise had significantly higher PCS scores ($p_{\text{trend}}<0.01$) than those reporting lower amounts (Figure 2b). Those with the greatest amount of planned exercise had the highest scores (42.56) with a 5.1-point difference between those in the lowest quartile and the highest quartile. Those who reported greater amounts of non-exercise PA also had significantly higher PCS scores ($p_{\text{trend}}<0.01$) than those reporting lower amounts, with a 3.7-point difference between the lowest and the highest quartile. MCS scores were unrelated (data not shown) to the amount of either non-exercise PA ($p_{\text{trend}}=0.18$), or planned exercise ($p_{\text{trend}}=0.79$).

Upon examination of social participation by type (data not shown), there was no significant difference in PCS scores in those who did some social participation as compared to those who did none of any type when mutually adjusted ($p=0.09, 0.06, 0.67$ respectively). However, there was significantly higher MCS scores in individuals reporting some volunteering and church activities as opposed to those reporting none ($p<0.01$). Total weekly duration of social participation appears important, with participants reporting greater weekly hours of social participation having higher PCS (Quartile=Mean $\pm$ SE; Q1=38.06 $\pm$ 0.63; Q2=39.70 $\pm$ 0.53; Q3=40.48 $\pm$ 0.58; Q4=40.52 $\pm$ 0.58; $p_{\text{trend}}<0.01$) and MCS scores (Q1=48.87 $\pm$ 0.78; Q2=52.51 $\pm$ 0.66; Q3=52.70 $\pm$ 0.72.; Q4=52.04 $\pm$ 0.72; $p_{\text{trend}}=0.04$) than those participating less (data not shown).

Discussion

In this study of older, long-term colorectal cancer survivors, our observations demonstrate that PA and social participation are both independently associated with HQOL. Meeting the PA recommendations was directly associated with higher PCS scores ($p<0.01$) in this sample, and was not modified by level of social participation. Similarly, participating socially was directly associated with an increase in MCS scores ($p<0.01$) and not modified by PA. These findings are similar in nature to other studies evaluating PA and HQOL in cancer survivors [18,20–22], specifically colorectal cancer survivors [27,28,30,48]. Our results are also similar to previous works describing the relationship between social participation and HQOL in cancer survivors [23,25,49], including colorectal cancer survivors [50]. Interestingly, this study is unique in that it evaluates these associations in older, long-term colorectal cancer survivors.

Many associations observed between PA, social participation and various HQOL outcomes were considered to be “clinically relevant”, defined by Ware as a 5–10 point difference in score on any SF-36 subscale [42]. Those meeting PA recommendations had significant, clinically relevant higher scores in the physical function (14.2 points), role-physical (10.3

points), general health (6.3 points), vitality (6.9 points), and social functioning (6.6 points) scales. Individuals participating socially had clinically relevant increases in the role-physical (5.8 points), vitality (5.2 points), social functioning (8.7 points) and role-emotional (6.2 points) scales. These findings reinforce the idea that PA and social participation are strongly associated with HQOL outcomes in this population.

Many of the associations reported for the eight subscales are consistent with results of previous studies evaluating PA and social participation with HQOL in cancer survivors, especially that of physical function in colorectal cancer survivors [28,30,48]. PA has consistently been associated with physical function [51, 52]. Lynch et al [30] found PA to be associated with higher HQOL outcomes in a large population-based sample of colorectal cancer survivors, including a 27% higher physical function score (using the FACT-C) for individuals meeting the PA guidelines than for those who were inactive. This is quite similar to the 29% increase we observed in the present study. Interestingly, social participation has also been shown to be clinically associated with physical function, with previous findings suggesting social participation is associated with lower levels of physical function impairment in older adults [53] and in breast cancer survivors [25]. In a study by Michael et al [25], social participation was evaluated in a group of younger, short-term breast cancer survivors. The study was unique in that it examined this relationship prospectively, finding that those who were more socially isolated post-diagnosis had lower HQOL scores on numerous SF-36 subscales, including a 6-point lower physical function score, than their peers who had a higher level of social integration prior to diagnosis. Our study also found a 6-point higher physical function score in those individuals who participated socially when compared to those who did not before adjusting for PA, but was attenuated to a 4.2-point difference after adjustment. While statistically significant, this association is possibly less likely to be clinically relevant, yet is still similar to the findings of Michael et al [25]. Notably, social participation was also significantly associated with overall PCS scores before adjustment for PA, but was attenuated after adjustment, suggesting that this relationship may have been driven, in part, by those individuals who were physically active while participating socially.

When evaluating HQOL by intensity of PA, individuals reporting greater amounts of moderate-vigorous PA had significantly higher PCS scores ($p_{\text{trend}} < 0.01$) than those who reported lower amounts. Interestingly, while the highest quartile (median: 11.25 MET-hr/wk) had the highest PCS score (42.90), the second quartile (median: 1.75 MET-hr/wk) still had a significantly higher PCS score (39.52) than those individuals in the first quartile (35.15), who performed no moderate-vigorous intensity PA. This is consistent with previous work suggesting individuals who perform some moderate-vigorous intensity exercise, even if not meeting the PA recommendations, may still experience a benefit in health outcomes [18,30,48,52]. Johnson et al [48] previously evaluated level of PA and physical function using the SF-36 in this same group of older colorectal cancer survivors. The results were similar to ours in that the largest difference in score was between the 1st (lowest) and the 2nd quartile. It should be noted, however, that light intensity PA was included in their PA measure, not just moderate-vigorous intensity. Brach et al, when evaluating well-functioning older men and women, found that exercisers had the highest function scores, but that those participating in an “active lifestyle” had significantly higher function score than those who remained inactive [52]. In our analysis, moderate-vigorous PA was more strongly associated with PCS than light intensity activity; however, among those who did not participate in any moderate-vigorous PA, those in the highest quartile of light intensity activity scored over 5 points higher on the PCS than those in the lowest quartile. Those in the lowest quartile were individuals who did not participate in any PA (light or moderate-vigorous) and had an average score of 30.0 on the PCS. Therefore, these results suggest that even among colorectal cancer survivors at the low end of physical function, significant improvements in

physical health could potentially be attained just by participating in some PA rather than none.

Evaluating HQOL by type of PA shows individuals reporting greater amounts of both non-exercise PA and planned exercise have higher PCS scores than do those individuals reporting less ($p_{\text{trend}} < 0.01$). Surprisingly, greater amounts of non-exercise PA was associated with similar PCS scores as greater amounts of planned exercise. As non-exercise PA is comparable to planned exercise in regards to associations with physical health in this population, purposeful exercise may not be necessary to maintain physical health. A potentially effective approach to improving physical health in older, long-term colorectal cancer survivors may be to encourage patients to become more active in daily living. Brown et al [54] found that respondents to the BRFSS surveys who reported any PA were less likely to report poor physical or mental health than respondents who were completely sedentary. Basen-Engquist et al [18] found similar findings when looking at total PA of all types, including domestic and household, in a group of younger breast cancer survivors. This type of activity may appeal to older cancer survivors in ways that planned exercise may not. As stated above, as this population may be at a physical health detriment, it is important to identify numerous ways to potentially help mediate physical health declines. Simply participating in activities of daily living, such as working around the house or garden, could have a significant impact on one's HQOL. These results suggest that increasing activity of any kind in the cancer survivor population should be a high priority.

When evaluating PCS by type of social participation, we found no significant differences between those reporting no social participation compared to those reporting some social participation for all three groups (SNCTR, CHRCH, CMLSE), suggesting that type of social participation appears to be less important than participation itself. Yet, those individuals reporting some social participation in CHRCH did have significantly higher MCS scores than individuals reporting none. CHRCH, consisting of volunteering and participating in church activities/religious services, had a 3.1-point increase in MCS score. This is consistent with the current social participation literature suggesting that participating in religious services can have an impact on HQOL [55]. Greater amounts of social participation was associated with higher PCS and MCS scores ($p_{\text{trend}} < 0.01$, 0.04 respectively), yet the association was greater for MCS (3.2 point-increase) than PCS (2.5 point-increase). Specifically, a cut-point of 1.75 hrs/wk was needed to improve both PCS and MCS scores.

While these results are promising, there were some limitations to the current study, most notably its cross-sectional design. This does not allow us to suggest that greater amounts of PA or social participation are responsible for the higher HQOL observed. All information on PA, social participation and HQOL was collected through self-reported measures, and therefore, misclassification is possible. While objective measurement of PA could potentially reduce measurement error, self-reported data offers a rich source of information beyond the information provided by tools such as accelerometers. The measure of social participation used in this study has not been validated; however, as social participation is defined as "time spent in social interaction in the presence of others", the CHAMPS clearly contains items that address this construct. While previously validated measures of social participation may present more sophisticated ways of establishing associations between social participation and HQOL, the method used in the current study is appropriate. Another limitation of this study was the inability to distinguish activities that would involve both PA and social participation. As PA could be performed in the presence of other individuals, PA itself could be considered a social participation event. Due to the measure of PA/social participation used, it is not possible to determine if a given PA was done socially. This could not only potentially mask social participation events in the analysis, but it does not allow for investigation of social PA specifically. Similarly, engaging in more social activities can also

result in greater levels of physical activity, so that there may be some overlap in our measures of these constructs. Also of note, participants reported engaging in 33.9 MET-hr/wk (~2800 kcals/wk) of PA on average, with a median level of 27.4 MET-hr/wk (~2130 kcals/wk). As most adults do not meet the recommended weekly amount of PA (8.3–16.7 MET-hr/wk ;1,000 kcals/wk) [56], over-reporting is likely; however, this is consistent with other reports using the CHAMPS, including a study by Stewart et al [37] who reported a mean energy expenditure of 2420 kcals $\pm$ 1831 in a sample of older men and women (aged 65–90 years). As over-reporting is likely consistent across levels of activity, our data should be ranked accordingly, and therefore should not affect our ability to compare trends. Finally, as this study chose a very specific population of older, long-term colorectal cancer survivors, generalizability to other cancer survivors may be limited.

Strengths of this study include the large sample size, consisting of both older men and women surviving >5 yrs with the same primary cancer. The measures of PA and HQOL used in this study were shown to be both reliable and valid for use in older adults, as well as in cancer survivors. Use of the CHAMPS instrument also allowed for not only examination of planned exercise behaviors, but light intensity, non-exercise PA which has great potential to be translatable to the older cancer survivor population. Finally, there have been no studies to date evaluating PA and social participation collectively in a group of colorectal cancer survivors.

Results from this study suggest that PA and social participation are associated with HQOL in older, long-term colorectal cancer survivors. While PA is related to the physical health of these subjects, social participation is predominantly related to mental health. While unable to directly address causality due to the study design, these results, when taken in context with other previous studies, suggest that PA – even light intensity PA – and social participation may be an effective means for improving HQOL in older, long-term colorectal cancer survivors. Prospective studies evaluating these relationships are needed to further explore the temporality of these relationships.

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Fig 1. Mean SF-36 (a:PCS; b:MCS) score by level of PA/SP with adjustment for age, sex, comorbidities, education, BMI, alcohol consumption, hospitalization in the past 12 months. **=Denotes statistically significant difference from No SP/Did not meet PA recommendations ($p<0.01$). *=Denotes statistically significant difference from No SP/Did not meet PA recommendations ($p<0.05$)

Fig 2.

Mean PCS (by a:Intensity of PA; b:Type of PA) with adjustment for age, sex, comorbidities, education, BMI, alcohol consumption, hospitalizations in the past 12 months and social participation. a) Light intensity PA was also adjusted for Mod-Vig Intensity PA; Mod-vig was also adjusted for light intensity PA. P_{trend} light intensity=0.04; P_{trend} mod-vig intensity=<0.01. Quartile medians (MET-hr/wk): Light intensity Q1=1.50; Q2=4.00; Q3=7.25; Q4=13.00. Moderate-vigorous: Q1=0.00; Q2=1.75; Q3=5.25; Q4=11.25. b) Non-exercise PA was also adjusted for planned exercise; Planned exercise was also adjusted for light intensity PA. P_{trend} Non-exercise PA=<0.01; P_{trend} Planned Exercise=<0.01. Quartile medians (MET-hr/wk): Non-exercise PA: Q1=1.625; Q2=5.5; Q3=9.75; Q4=16.50. Planned Exercise: Q1=0.00; Q2=1.75; Q3=3.75; Q4=9.50. **=Denotes statistically significant difference from Quartile 1 ($p<0.01$). *=Denotes statistically significant difference from Quartile 1 ($p<0.05$).

Characteristics of Long-term Colorectal Cancer Survivors by Level of Physical Activity and Social Participation^a

Table 1

<i>Characteristic</i>	Met Physical Activity Recommendations			Social Participation		
	No (n=399)	Yes (n=433)	p-value	None (n=148)	Any (n=684)	p-value
<i>Characteristic</i>						
Age (yrs)	83.3 ±6.0	79.8 ±5.0	<0.001	82.3 ±6.2	81.3 ±5.7	0.05
Time since dx (yrs)	8.3 ±1.7	8.1 ±1.6	0.02	8.4 ±1.8	8.2 ±1.7	0.14
Age at time of dx (yrs)	74.9 ±6.0	71.7 ±4.8	<0.001	74.0 ±6.2	73.1 ±5.5	0.12
BMI (kg/m ²)	27.0 ±5.1	26.6 ±4.2	0.19	26.3 ±5.8	26.9 ±4.4	0.20
Sex (% female)	65.9%	39.3%	<0.001	50.0%	52.5%	0.58
Number of Comorbidities (% with):						
0	7.3%	10.4%	<0.01	8.1%	9.1%	0.38
1	8.3%	13.2%		7.4%	11.6%	
2	11.5%	15.7%		15.5%	13.3%	
3	15.8%	17.8%		18.9%	16.4%	
4	16.3%	15.2%		19.6%	14.9%	
5	40.9%	27.7%		30.4%	34.8%	
Alcohol Consumption (%):						
None	46.9%	28.6%	<0.001	51.4%	34.4%	<0.001
Occasional	29.3%	23.8%		17.6%	28.4%	
1–7 drinks/wk	18.3%	35.3%		25%	27.6%	
> 7 drinks/wk	5.5%	12.2%		6.1%	9.7%	
Hospitalization in <12 months	32.6%	22.2%	<0.001	31.8%	26.2%	0.17
Current smoker (% yes) ‡	3.6%	5.2%	0.29	10.1%	3.3%	<0.01
Pain (% with) ‡	54.3%	47.3%	0.05	50.7%	50.7%	0.99
Education						

	Met Physical Activity Recommendations			Social Participation		
	No (n=399)	Yes (n=433)	p-value	None (n=148)	Any (n=684)	p-value
<High School	26.3%	18.7%	0.02	31.8%	20.3%	<0.01
High School	41.1%	41.6%		39.2%	41.9%	
>High School	32.6%	39.7%		29.1%	37.9%	
Fell in past year (%) ‡	33.3%	22.7%	<0.01	28.6%	27.6%	0.81

^a Categorical variables compared between categories by Chi-square; continuous variables compared using ANOVA. Current smoker, any surgery, and race were compared using Fisher's exact test due to cell size.

‡ subjects missing from analysis: Stage (n=40); Current smoker (n=19); Pain (n=15); Falls (n=4).

Table 2

Physical Activity, Social Participation and Health-related Quality of Life among Long-term Colorectal Cancer Survivors ^a

SF-36 Subscale	Met Physical Activity Recommendations		Social Participation	
	No (n=399)	Yes (n=433)	None (n=148)	Any (n=684)
Physical Function	47.8 ±1.2	62.0 ±1.1 #	51.8 ±1.9	56.0 ±0.9 *
Role-Physical	50.3 ±1.2	60.6 ±1.2 #	50.9 ±1.9	56.7 ±0.9 #
Vitality	52.2 ±0.9	59.1 ±0.9 #	51.5 ±1.4	56.7 ±0.6 #
Social Function	74.5 ±1.2	81.1 ±1.2 #	70.8 ±1.9	79.5 ±0.9 #
Role-Emotional	73.7 ±1.4	76.2 ±1.3	69.9 ±2.1	76.1 ±1.0 #
Mental Health	77.0 ±0.8	78.7 ±0.8	75.2 ±1.3	78.4 ±0.6 *
Bodily Pain	61.2 ±1.2	65.9 ±1.1 #	62.5 ±1.8	63.9 ±0.8
General Health	56.6 ±0.9	62.9 ±0.9 #	56.7 ±1.5	60.6 ±0.7 *

^a Mean SF-36 subscale score with adjustment for age, sex, comorbidities, education, BMI, alcohol consumption, hospitalizations in past 12 months and physical activity or social participation.

* statistically significant at the 0.05 level;

statistically significant at the 0.01 level.