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Gender-Varying Associations between Physical Activity Intensity and Mental Quality of Life in Older Cancer Survivors

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Abstract

Purpose—Physical activity can enhance quality of life in cancer survivors, but this conclusion is based largely on research linking moderate-to-vigorous physical activity with quality of life. Light-intensity physical activity may be more feasible than more strenuous exercise for many older cancer survivors. This study reports a secondary analysis of baseline data from a lifestyle behavior intervention trial and examines the hypothesis that older cancer survivors who engage in more light-intensity physical activity, independent of moderate-to-vigorous activity, will report better mental quality of life.

Methods—Older (≥65 years), overweight or obese breast, prostate, or colorectal cancer survivors (n=641, 54% female) self-reported their physical activity and mental quality of life (i.e., mental health, emotional role functioning, vitality and social role functioning from the SF-36) as a part of the RENEW trial baseline assessment. Analysis of Covariance was used to test hypotheses.

Results—For older women (but not men), light physical activity was positively associated with mental quality of life after adjusting for moderate-to-vigorous physical activity. Light physical activity that involved social participation appeared to be responsible for this association. For older men (but not women), moderate-to-vigorous physical activity was positively associated with mental quality of life.

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Conclusions—Some activity appears to be better than none for important dimensions of mental quality of life. Experimental research is needed to test the hypothesis that older cancer survivors should strive to avoid inactivity regardless of whether they are able to engage in moderate-to-vigorous physical activity.

Keywords

cancer; oncology; walking; exercise; social participation; well-being

BACKGROUND

Cancer and its treatments can adversely impact patients' quality of life, and these effects can endure for years after treatment. Survivors frequently report high levels of fatigue and pain along with reduced global well-being following their diagnosis and treatment [1,2]. Moderate-to-vigorous physical activity can improve quality of life in cancer survivors [3–6]. Recent reports introduced the first evidence linking light-intensity physical activity with better quality of life, reduced symptom interference, and greater physical function in older cancer survivors [6–10].

Accumulating evidence that physical activity is beneficial for the health of cancer survivors led to the publication of exercise guidelines for cancer survivors [11,12]. These guidelines parallel the physical activity guidelines for healthy adults which recommend engagement in 75 minutes/week of vigorous-intensity physical activity, 150 minutes/week of moderate-intensity physical activity, or some combination of the two, as well as doing muscle-strengthening exercises on two or more days/week [13]. Unfortunately, cancer survivors endure many of the same barriers to moderate-to-vigorous physical activity as other adults (e.g., competing time demands, lack of willpower) in addition to cancer-specific barriers due to treatment side effects (e.g., incontinence, lymphedema) and symptoms such as pain and fatigue [14–17].

More than half of American adults fail to meet the prescribed level of physical activity in the national guidelines [18]. Cancer survivors report even lower levels of physical activity, with prevalence estimates ranging from less than 10% to 32% [19–22]. Compared to pre-diagnosis levels, there are 21% and 75% reductions in the (already low) proportions of colorectal and breast cancer survivors, respectively, who report meeting physical activity guidelines [16,22]. These low activity levels signal the difficulty of motivating cancer survivors to engage in moderate-to-vigorous physical activity.

When regular moderate-to-vigorous physical activity is impractical or not feasible, cancer survivors can benefit from alternative behavioral prescriptions that can enhance their quality of life. The national physical activity guidelines were premised on the conclusion that "some physical activity is better than none," and explicitly urge adults to avoid inactivity even if they cannot attain the level of activity prescribed in the guidelines [13]. In these cases, light-intensity physical activities – ranging from visiting family/friends and doing arts/crafts to completing light housework/gardening and walking leisurely – afford survivors practical and feasible alternatives to sedentary behavior. In fact, men and women engage in a much greater

volume of light than moderate-to-vigorous physical activity across the adult lifespan, yet this high-volume activity has received far less research attention [23].

Promising physical and mental health benefits of light-intensity physical activity have emerged in recent research. For example, after controlling for moderate-to-vigorous physical activity, light-intensity physical activity has been linked with lower plasma glucose concentrations, lower levels of depression, and greater self-reported physical health and well-being [24–26]. Only one of those studies sampled older adults exclusively [25]. In cancer survivors, light-intensity physical activity has been linked with improved physical health and physical function [7,9,10]. Light-intensity physical activity has also shown a positive association with global mental health in older colorectal cancer survivors who engage in no moderate-to-vigorous physical activity [9]. Less is known about associations between light physical activity and specific dimensions of mental quality of life or about associations in survivors of other cancers. The purpose of this study was to examine the hypothesis that light-intensity physical activity, independent of moderate-to-vigorous physical activity, is positively associated with mental quality of life in a sample of older breast, colorectal, and prostate cancer survivors from the RENEW trial [27,28]. This trial involved a lifestyle intervention that aimed to increase moderate- (but not light-) intensity physical activity so our hypotheses were tested using cross-sectional data from the baseline assessments.

METHODS

Study Design and Participants

The RENEW randomized controlled trial results and methods were previously published [27,28]. Briefly, the trial, conducted among older, long-term cancer survivors compared a year-long, diet and exercise intervention delivered via tailored print materials and telephone counseling to a wait-list control with a primary endpoint of physical functioning. Subjects were identified from the North Carolina Central Cancer registry, with a small percentage (0.5%) self-referring. Eligibility criteria were: 1) ≥65 years of age, 2) ≥5 years post-diagnosis from breast, prostate, or colorectal cancer, 3) overweight or obese (25 ≤ BMI (kg/m2) ≤ 40), 4) <150 minutes/week of moderate intensity strength training and endurance exercise, 5) had no contraindications to unsupervised exercise, and 6) English speaking and writing, without severe speaking or hearing impairments. Subjects (n=641) were block randomized by gender, race and cancer type. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The protocol was approved by the Duke University Institutional Review Board and the North Carolina Central Cancer Registry. Written informed consent was obtained from all study participants.

Outcomes and Measures

Outcomes were assessed via telephone interview at baseline. Physical activity was self-reported using the Community Health Activities Model Program for Seniors (CHAMPS) questionnaire, which has been shown to be both valid and reliable among older adults

[29,30]. CHAMPS asks subjects about frequency and duration (hours/week, continuous) of 41 activities performed in a typical week during the last 4 weeks; activities range from sedentary to vigorous-intensity. Activities are coded using MET values that account for the probable reduced exertion among older adults (≥65 years) compared with younger adults [30–32]. For example, the intensity of playing golf (using a cart) was reduced from 3.5 METs to 2.5 METs [32]. Light physical activities were defined as 1.5–2.9 METs and moderate-to-vigorous physical activities were ≥3 METs [32]. Building on prior work, complementary analyses were conducted which differentiated between low-light (1.5–2.0 METs) and high-light physical activity (2.1–2.9 METs) [7,32]. The low-light physical activities on this measure are more likely to involve social participation whereas the high-light physical activities are more likely to combine standing, ambulation, and upper-body movement. For each intensity variable, MET hours/week were divided into tertiles. Social participation (calculated as hours per week and divided into tertiles) was measured as a secondary indicator of light physical activity using responses to seven out of eight items on this measure that involved some level of either low-light ("visit with friends or family", "go to the senior center", "attend church or take part in church activities", "attend other club or group meetings", "play cards, bingo, or board games with other people") or high-light ("do volunteer work", "shoot pool or billiards") physical activity [9].

Quality of life was collected via self-report using the Short-Form 36 Health Status Survey (SF-36) [33,34]. Findings from the physical function scale were reported previously by Blair et al. [7]. This report focuses on data from the four mental quality of life sub-scales: vitality, emotional role functioning, social role functioning, and mental health. The raw scores (range: 0–100) for each scale were analyzed (vs. transformation) for ease of interpretation and comparison with other studies.

RENEW also collected data on height and weight, six common medical conditions (arthritis or rheumatism, hypertension, heart problems, circulatory problems, osteoporosis, and cataracts), 22 symptoms (e.g., chest pain, shortness of breath, muscle weakness), and cancer treatment (e.g., history of surgery, chemotherapy, radiation, hormonal therapy, and, for prostate cancer only, brachytherapy).

Statistical Analyses

This secondary data analysis included data on 641 participants with study baseline data for the cross-sectional analysis. The median levels of low-light, high-light and moderate-to-vigorous activity and social participation were calculated across categories of demographic, lifestyle, and medical characteristics. Analysis of Covariance (ANCOVA) was used to compare least-square means of mental quality of life across tertiles of each physical activity intensity as well as for social participation. Since men typically report higher amounts of moderate-to-vigorous intensity activities and prior results have indicated gender differences in associations between light physical activity and quality of life [10], we chose to analyze and report results stratified by gender. Analyses were controlled for moderate-to-vigorous physical activity levels, as well as age (continuous), obesity (yes/no), number of symptoms (0–2, 3–5, 6+), and cancer type (breast, prostate, colorectal). Additional variables, e.g., race, education, income, time since diagnosis, cancer treatment, comorbidities, fruit and vegetable

servings per week, and Healthy Eating Index scores, were evaluated but not included in the final models because they did not alter conclusions (i.e., <10% change in regression coefficients). Pairwise comparisons were only performed if the trend test was significant ($p < .05$). The significance level for pairwise comparisons also was set at .05. We conducted additional exploratory analyses using non-stratified data to test whether sex moderated relations between each activity variable and each indicator of mental quality of life. Analyses were conducted using SAS 9.3 statistical software (SAS Institute, Inc.).

RESULTS

Participants ranged in age from 65 to 87 with a mean age of 73.1 years (SD = 5.1). The study population was slightly more female (54%) than male (46%) and largely non-Hispanic White (89%). Most women in this study were breast cancer survivors (83%) and most men were prostate cancer survivors (89%). Participants were lower income (67% reporting income < $50,000/year), but the majority had attended some college (62%). As seen in Table 1, men, younger survivors, and survivors with higher socioeconomic status reported more moderate-to-vigorous physical activity at baseline. Patterns of light-intensity physical activity also differed demographically, with women reporting more low-light and high-light activity than men. Higher income and more educated participants reported higher levels of low-light and high-light intensity physical activity. Younger age groups reported more low-light physical activity but older individuals reported more high-light physical activity. Overweight participants reported more activity than obese across all activity intensity categories.

The four mental quality of life outcomes were significantly correlated with each other, albeit only a weak-to-moderate correlation (Rho values between 0.20 and 0.46 for women and 0.28 and 0.46 for men). The strongest correlations were between mental health and role emotional (Rho = 0.46 [for both men and women]) and role emotional and social functioning (0.46 [in men]). Among women, low-light activities were significantly associated with activities involving social participation (Rho = 0.66, $p < 0.0001$). There was no correlation between light physical activity and moderate-to-vigorous intensity activities (all Rho ≤ 0.06 for low-light, high-light, and total light activities with MVPA; all $p > 0.20$). Similarly, among men, low-light activities were associated with social participation (Rho = 0.66, $p < 0.0001$, but there was no correlation between the other activity variables (all Rho < 0.12; all $p \geq 0.50$, except high-light and MVPA [Rho = 0.11; $p = 0.052$]). Social participation was modeled separately from light physical activity so none of the models we tested included variables with even a moderate correlation; therefore, multicollinearity was not a threat in these analyses.

The cross-sectional analysis of stratified baseline data yielded different patterns of results for women and men. Table 2 shows that light, but not moderate-to-vigorous, physical activity was positively associated with three mental quality of life indicators in women - mental health, vitality, and social role functioning. Variation in low-light rather than high-light physical activity appeared to drive associations with mental health and social role functioning; differences in vitality were specific to total light physical activity. For women, moderate-to-vigorous physical activity was only associated with one aspect of mental

quality of life, namely social role functioning. In contrast, Table 3 shows that differences in moderate-to-vigorous, but not light, physical activity were positively associated with three mental quality of life indicators in men – mental health, emotional role functioning, and vitality.

This gender-varying pattern of associations replicated with the measure of social participation. As seen in Table 4, social participation by men was not associated with mental quality of life whereas greater social participation by women was associated with greater overall mental health, vitality, and social role functioning.

In an additional analysis, there was a significant interaction between sex and the social function/social participation activities association ($p < 0.005$) and a borderline significant interaction between sex and the vitality and social participation activities association ($p = 0.10$). There was no evidence for an interaction for any of the other models (all $p > 0.20$).

CONCLUSIONS

This study established relations between physical activity and mental quality of life in older, overweight or obese, breast, colorectal, and prostate cancer survivors that varied both by the gender of the survivor and the intensity of the activity. Female survivors exhibited a positive association between light physical activity and three aspects of mental quality of life: mental health, vitality, and social role functioning. Male survivors of colorectal and prostate cancers exhibited a positive association between their moderate-to-vigorous physical activity and two aspects of mental quality of life, namely emotional role functioning and vitality. This finding generally corresponded with the conclusion from a systematic review of randomized clinical trials of exercise effects on quality of life in post-treatment cancer survivors, namely that exercise improves overall quality of life and some aspects of quality of life are more impacted than others [3]. Prior work on exercise and quality of life has largely sampled younger, female and breast cancer survivors. The present study provided the first indication that older female survivors of breast and colorectal cancers may not exhibit the same association between exercise and mental quality of life. Further research is needed to determine whether age, gender, or cancer type moderate this association.

This study was the first to link light physical activity with multiple indicators of mental quality of life in older female survivors of breast and colorectal cancers. Older adults without cancer have exhibited a positive association between light-intensity physical activity and enhanced psychological well-being, social participation, and social relationships [35]. Previous work with colorectal cancer survivors established links between light physical activity and health-related quality of life, including mental health component scores among survivors who reported no moderate-to-vigorous physical activity [9], and physical, role, and social role functioning among female (but not male) colorectal cancer survivors [10]. The present findings extend those results to female survivors with a variety of cancers and a range of moderate-to-vigorous physical activity levels (zero to nine hours/week), as well as across age, obesity status, and symptoms.

Defining minimal clinically-important differences in quality of life is a complicated question that requires consideration of intervention costs as well as effect sizes [36]. The largest differences in this study were observed in female survivors' social role functioning as a function of low-light physical activity levels, and those differences exceeded the 3–5 point criterion proposed for the SF-36 (although we view that criterion with caution) [37]. This important finding replicated with an alternative indicator of light physical activity (i.e., social participation). Differences in social participation were associated with large differences in vitality and social role functioning. Further work is needed to determine whether light physical or social activity (or their combination) is responsible for these associations as well as the origins of that difference.

These gender-varying associations may reflect differences in physical activity patterns. Men in the RENEW sample engaged in more moderate-to-vigorous physical activity than women. In contrast, women engaged in significantly more light, and particularly low-light, physical activity than men. Future work should investigate the possibility that a threshold of activity at a given intensity (e.g., 2 hours/week of moderate-to-vigorous intensity physical activity) must be exceeded to couple this behavior with mental quality of life. Alternatively, these gender differences may represent differences as a function of cancer site. We did not investigate this possibility because our theoretical premise was based on gender-based activity differences, but the present analyses cannot rule out that possibility.

Overall, the findings reported in this analysis reinforce the importance of older cancer survivors avoiding inactivity. Strong causal conclusions are inappropriate based on the cross-sectional results presented here, but moderate-to-vigorous physical activity may be more important for enhancing mental quality of life in men than women whereas women may benefit more from engaging in light physical activities. Given the challenges attendant with increasing moderate-to-vigorous physical activity, especially in older adults, this result highlights the promise of more feasible and accessible behavior change targets, specifically increasing low-light activity, for inactive women [38]. Thus, the conclusion that "some physical activity is better than none" is strongly supported by these cross-sectional differences in mental quality of life [11,13]. Studies with prospective and experimental designs are needed to strengthen confidence in this working conclusion.

Unlike mental health, social role functioning, and vitality, emotional role functioning was not associated with differences in light physical activity. The RENEW trial recruited participants 5+ years following diagnosis; emotional role functioning may be impacted more immediately after diagnosis and during active treatment [27,28]. This sample also reported relatively high (but varying) levels of emotional role functioning, so a ceiling effect may be obscuring differences. Future research would benefit from incorporating measures with a higher range of this latent trait.

These findings are also based on self-reported physical activity. For high-volume, relatively habitual behaviors such as light-intensity physical activity, survivors may not provide accurate recalls. Future work should consider ambulatory monitoring of physical activity. Many self-reported light physical activities can also be completed while seated. Although the current guidelines recommend counseling survivors to "avoid inactivity," the role of

posture and sedentary behavior in the quality of life of survivors should be studied in more detail in future research [11,39].

The cross-sectional nature of these data begs the question of causal ordering. Although the literature led us to assume that activity would influence mental quality of life, these data do not permit us to rule out the possibility that greater mental quality of life leads to increased light and moderate-to-vigorous physical activity among women and men, respectively. Experimental work that manipulates the duration of physical activity at different intensities is needed to establish the direction of these relations. The RENEW trial includes longitudinal data on these variables; however, these participants also participated in an intervention that increased moderate-to-vigorous physical activity so any effects of light-intensity physical activity will be confounded and difficult to interpret in these data.

The RENEW trial excluded older cancer survivors with contraindications to unsupervised exercise as well as those who were already meeting physical activity guidelines. Associations may be stronger for older adults with contraindications to unsupervised exercise because light physical activity will account for more variation in total physical activity. The present results indicate that this hypothesis warrants consideration in future research with older adults. The RENEW trial was also delimited to overweight and obese survivors. The majority of older adults are also overweight or obese so conclusions may generalize beyond the sub-population of older cancer survivors.

Finally, conclusions may be impacted by limitations in the assessment of survivors' medical histories. Symptoms appeared to be more relevant than comorbidities but this finding may reflect that 22 symptoms and only 6 medical conditions were assessed. Also, stage and treatment were assessed by self-report and survivors may not have recalled these details.

In sum, this study reinforced the importance of promoting physical activity with older, overweight and obese cancer survivors. It extended previous research by documenting gender differences in associations between physical activity and mental quality of life and by showing consistent associations between light (and particularly low-light) physical activity and mental quality of life for female cancer survivors. Notwithstanding gender differences in intensity- specific activity levels, mental quality of life was associated with their light and moderate-to-vigorous physical activity for women and men, respectively. This research supports the recommendation for older cancer survivors to avoid inactivity even when moderate-to-vigorous physical activity is not possible.

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Table 1

Demographic and health characteristics of study participants and hours per week of social participation and MET hours per week of physical activity (N=641)

		N (%)	Social Participation[α] Median (IQR)	Low-light PA[β] Median (IQR)	High-light PA[β] Median (IQR)	Mod-Vig PA[β] Median (IQR)
Tumor Type						
	Breast	289 (45%)	9.0 (5.0, 16.5)	25.4 (13.2, 40.3)	18.1 (9.2, 30.7)	3.0 (0.0, 9.0)
	Colorectal	91 (14%)	8.5 (5.3, 13.5)	20.9 (12.5, 35.7)	18.8 (8.0, 32.3)	2.0 (0.0, 7.3)
	Prostate	261 (41%)	8.0 (4.8, 13.0)	19.8 (11.3, 33.9)	16.2 (6.9, 26.6)	6.0 (0.0, 16.0)
Age						
	65 – 70	227 (35%)	9.0 (5.0, 15.0)	27.6 (14.9, 42.8)	17.5 (8.5, 28.4)	4.2 (0.0, 12.0)
	71 – 75	206 (32%)	8.0 (4.8, 15.0)	22.2 (11.3, 35.8)	17.2 (8.1, 30.4)	5.0 (0.0, 12.0)
	76 – 87	208 (32%)	8.2 (5,0, 13.0)	18.8 (11.4, 32.9)	19.0 (8.4, 29.3)	3.4 (0.0, 9.1)
Gender						
	Female	349 (54%)	9.0 (5.0, 16.0)	25.4 (13.5, 40.2)	19.1 (9.6, 31.4)	3.0 (0.0, 8.8)
	Male	292 (46%)	8.0 (4.5, 13.0)	19.7 (11.3, 34.2)	15.2 (6.2, 25.3)	5.9 (0.0, 15.8)
Race-Ethnicity						
	Non-Hispanic	569 (89%)	8.5 (5.0, 14.0)	23.0 (13.1, 37.6)	17.5 (8.2, 28.8)	4.2 (0.0, 11.5)
	Other	72 (11%)	7.9 (4.8, 16.0)	16.2 (9.4, 28.1)	18.8 (7.2, 31.0)	2.5 (0.0, 8.7)
Education						
	No college	246 (38%)	7.0 (4.0, 13.0)	17.1 (9.3, 32.0)	16.3 (7.5, 28.4)	3.0 (0.0, 10.3)
	Any college	395 (62%)	9.0 (5.0, 16.0)	25.8 (14.1, 40.4)	18.1 (8.9, 29.4)	4.7 (0.0, 11.9)
Income						
	<$50,000	431 (67%)	8.0 (4.0, 13.5)	19.8 (10.7, 36.2)	17.5 (8.3, 28.6)	3.0 (0.0, 10.5)
	≥$50,000	209 (33%)	10.0 (5.5, 17.0)	26.7 (16.4, 39.0)	17.6 (8.1, 30.6)	6.0 (0.5, 12.1)
BMI						
	Overweight	385 (60%)	9.0 (5.0, 15.0)	22.8 (12.6, 36.3)	18.7 (8.5, 29.2)	4.5 (0.0, 11.8)
	Obese	256 (40%)	8.0 (4.5, 14.0)	21.1 (12.0, 36.8)	17.0 (7.5, 28.7)	3.8 (0.0, 10.5)
Number of comorbidities						
	<2	230 (36%)	9.8 (5.5, 16.5)	23.6 (14.1, 40.3)	17.7 (8.1, 28.8)	5.3 (0.0, 14.5)
	2	204 (32%)	7.0 (3.9, 13.0)	22.2 (10.5, 36.9)	18.0 (8.5, 30.7)	4.0 (0.0, 10.0)
	>2	207 (32%)	8.3 (5.0, 13.5)	20.5 (12.0, 34.3)	17.5 (8.6, 28.8)	3.0 (0.0, 9.3)

	N (%)	Social Participation[a] Median (IQR)	Low-light PA[β] Median (IQR)	High-light PA[β] Median (IQR)	Mod-Vig PA[β] Median (IQR)
Number of symptoms					
0 – 2	215 (34%)	8.3 (5.0, 14.0)	23.2 (12.6, 39.0)	16.7 (8.1, 28.2)	5.0 (0.0, 12.0)
3 – 5	222 (35%)	8.2 (5.0, 16.0)	21.0 (12.9, 35.7)	18.5 (8.2, 30.8)	3.1 (0.0, 10.5)
>5	204 (32%)	9.0 (4.5, 13.5)	22.4 (12.0, 38.0)	17.7 (8.3, 29.5)	4.0 (0.0, 10.9)
Fruit & vegetable servings/day					
0 – 2.0	191 (30%)	8.5 (5.0, 15.0)	20.7 (11.3, 36.5)	17.9 (7.5, 28.3)	4.7 (0.0, 10.7)
2.1 – 3.9	253 (39%)	8.2 (4.0, 13.0)	21.6 (12.1, 37.2)	17.1 (8.6, 27.9)	3.0 (0.0, 9.3)
≥4	197 (31%)	9.0 (5.0, 14.0)	23.4 (14.2, 35.8)	17.6 (8.1, 35.0)	5.0 (0.0, 12.0)
Healthy Eating Index					
<53.5	213 (33%)	8.5 (4.5, 16.0)	25.2 (11.4, 40.2)	18.4 (7.5, 27.1)	4.5 (0.0, 12.0)
53.5–65.7	216 (34%)	8.0 (5.0, 13.0)	21.5 (12.5, 34.7)	15.7 (8.4, 28.3)	3.0 (0.0, 10.8)
≥65.7	212 (33%)	9.0 (5.0, 14.1)	20.4 (13.5, 36.4)	17.8 (9.1, 33.8)	4.7 (0.0, 10.5)

Note. PA = physical activity.

[a] Social participation: hours per week of social activities, which includes 1 sedentary activity, 5 low-light and 2 high-light intensity activities.

[β] Low-light intensity PA: 1.5 to 2 METs; high-light intensity PA: 2.1–2.9 METs; moderate to vigorous intensity PA: ≥3 METs.

Table 2

Cross-sectional association between physical activity intensity (MET hours per week) and quality of life in females (N=349)

	Model 1		Model 2		
	Total Light- Intensity PA (LPA) (adj. MVPA)	**Mod-Vig Intensity PA (MVPA) (adj. LPA)**	**Low-light Intensity PA (LLPA) (adj. HLPA, MVPA)**	**High-light Intensity PA (HLPA) (adj. LLPA, MVPA)**	**Mod-Vig Intensity PA (MVPA) (adj. LLPA, HLPA)**
Mental Health					
T1	84.4 ± 1.22[a]	85.5 ± 1.12	83.9 ± 1.21[a]	85.7 ± 1.24	85.6 ± 1.12
T2	85.6 ± 1.18	86.4 ± 1.21	86.0 ± 1.19	85.1 ± 1.19	86.6 ± 1.21
T3	87.5 ± 1.22[a]	85.5 ± 1.30	87.6 ± 1.22[a]	86.7 ± 1.19	85.2 ± 1.30
	p-value = **0.04**	p-value = 0.97	p-value = **0.02**	p-value = 0.53	p-value = 0.84
Emotional Role Functioning					
T1	92.9 ± 2.46	92.5 ± 2.26	91.8 ± 2.44	92.3 ± 2.52	92.7 ± 2.27
T2	91.0 ± 2.38	94.2 ± 2.45	92.5 ± 2.41	91.7 ± 2.41	94.1 ± 2.46
T3	92.7 ± 2.46	89.9 ± 2.62	92.1 ± 2.48	92.4 ± 2.42	89.7 ± 2.64
	p-value = 0.96	p-value = 0.42	p-value = 0.93	p-value = 0.98	p-value = 0.37
Vitality					
T1	60.2 ± 1.78[a]	60.9 ± 1.63	60.2 ± 1.76	60.8 ± 1.81	61.0 ± 1.63
T2	62.9 ± 1.72	63.2 ± 1.77	63.1 ± 1.74	62.2 ± 1.73	63.3 ± 1.77
T3	64.9 ± 1.76[a]	63.8 ± 1.90	64.4 ± 1.78	64.7 ± 1.74	63.5 ± 1.90
	p-value = **0.03**	p-value = 0.20	p-value = 0.06	p-value = 0.08	p-value = 0.26
Social Role Functioning					
T1	89.2 ± 1.76[a]	88.6 ± 1.61[a]	88.3 ± 1.73[a]	91.1 ± 1.78	88.7 ± 1.60[a]
T2	92.3 ± 1.70	92.1 ± 1.75	91.7 ± 1.71	91.9 ± 1.70	92.3 ± 1.74
T3	93.6 ± 1.75[a]	94.5 ± 1.87[a]	95.2 ± 1.75[a]	92.2 ± 1.71	94.2 ± 1.87[a]
	p-value < **0.05**	p-value = **0.008**	p-value = **0.002**	p-value = 0.61	p-value = **0.01**

Notes. LPA = light-intensity physical activity; LLPA = low-light intensity physical activity; HLPA = high-light intensity physical activity; MVPA = moderate-to-vigorous physical activity. Models are adjusted for age (continuous), obese (yes/no), number of symptoms (0–2, 3–5, 6+), cancer type (breast, colorectal), and other intensity PA variables, i.e., Model 1: includes total light PA and MVPA, Model 2: includes LLPA, HLPA, and MVPA. P-value is from the ANCOVA test for trend. LSMeans with the same letter subscript are significantly different at the 0.05 alpha level. Low-light intensity (METS 1.5–2.0); High-light intensity (METS 2.1–2.9); ModVig intensity (METS ≥3).

Table 3

Cross-sectional association between physical activity intensity (MET hours per week) and quality of life in males (N=292)

	Model 1		Model 2		
	Total Light- Intensity PA (LPA) (adj. MVPA)	**Mod-Vig Intensity PA (MVPA) (adj. LPA)**	**Low-light Intensity PA (LLPA) (adj. HLPA, MVPA)**	**High-light Intensity PA (HLPA) (adj. LLPA, MVPA)**	**Mod-Vig Intensity PA (MVPA) (adj. LLPA, HLPA)**
Mental Health					
T1	87.7 ± 1.35	84.9 ± 1.44[a]	86.5 ± 1.46	86.2 ± 1.35	85.6 ± 1.45
T2	84.4 ± 1.53	85.3± 1.41	87.3 ± 1.48	86.6 ± 1.48	85.6 ± 1.44
T3	86.3 ± 1.45	88.2 ± 1.44[a]	85.8 ± 1.44	86.8 ± 1.54	88.5 ± 1.45
	p-value = 0.39	p-value = **0.04**	p-value = 0.63	p-value = 0.75	p-value = 0.08
Emotional Role Functioning					
T1	90.2 ± 2.20	88.8 ± 2.35[a]	90.6 ± 2.36	89.7 ± 2.18	89.1 ± 2.35[a]
T2	91.0 ± 2.49	89.0 ± 2. 30[b]	91.8 ± 2.40	92.6 ± 2.40	89.2 ± 2.33[b]
T3	91.3 ± 2.36	94.7 ± 2.34[ab]	90.6 ± 2.33	90.8 ± 2.50	94.8 ± 2.35[ab]
	p-value = 0.69	p-value = **0.02**	p-value = 0.98	p-value = 0.68	p-value = **0.03**
Vitality					
T1	58.8 ± 1.78	57.0 ± 1.90[a]	58.5 ± 1.91	58.4 ± 1.76	57.4 ± 1.90[a]
T2	59.0 ± 2.02	59.1 ± 1.86	59.8 ± 1.94	59.7 ± 1.94	59.3 ± 1.88
T3	60.1 ± 1.91	61.9 ± 1.90[a]	60.3 ± 1.88	60.5 ± 2.02	61.9 ± 1.90[a]
	p-value = 0.53	p-value = **0.02**	p-value = 0.40	p-value = 0.33	p-value = **0.03**
Social Role Functioning					
T1	89.1 ± 1.88	88.2 ± 2.01	87.9 ± 2.03	90.6 ± 1.87	88.4 ± 2.01
T2	87.7 ± 2.14	87.6 ± 1.97	90.5 ± 2.06	88.0 ± 2.06	87.2 ± 2.00
T3	91.1 ± 2.02	92.1 ± 2.01	89.4 ± 1.99	89.2 ± 2.14	92.3 ± 2.02
	p-value = 0.37	p-value = 0.08	p-value = 0.53	p-value = 0.55	p-value = 0.08

Notes. LPA = light-intensity physical activity; LLPA = low-light intensity physical activity; HLPA = high-light intensity physical activity; MVPA = moderate-to-vigorous physical activity. Models are adjusted for age (continuous), obese (yes/no), number of symptoms (0–2, 3–5, 6+), cancer type (prostate, colorectal), and other intensity PA variables, i.e., Model 1: includes total light PA and MVPA, Model 2: includes LLPA, HLPA, and MVPA. P-value is from the ANCOVA test for trend. LSMeans with the same letter subscript are significantly different at the 0.05 alpha level. Low-light intensity (METS 1.5–2.0); High-light intensity (METS 2.1–2.9); ModVig intensity (METS ≥3).

Table 4

Cross-sectional association between social participation (hours per week) and quality of life (N=641)

	Model 1			Model 2		
	Males	**Females**	**p-value**	**Males**	**Females**	**p-value**
Mental Health						
T1	86.5 ± 1.42	83.5 ± 1.23[a]		86.6 ± 1.51	83.5 ± 1.26[a]	
T2	86.2 ± 1.40	86.4 ± 1.20	0.17	86.3 ± 1.44	86.1 ± 1.23	0.18
T3	86.5 ± 1.50	87.2 ± 1.14[a]		86.4 ± 1.53	86.9 ± 1.18[a]	
Trend Test	p-value = 0.97	p-value = **0.01**		p-value = 0.90	p-value = **0.03**	
Emotional Role Functioning						
T1	90.3 ± 2.31	88.9 ± 2.49		90.0 ± 2.43	88.3 ± 2.55	
T2	91.1 ± 2.27	93.9 ± 2.42	0.52	91.2 ± 2.32	93.5 ± 2.48	0.57
T3	90.5 ± 2.44	93.7 ± 2.31		90.6 ± 2.47	93.4 ± 2.39	
Trend Test	p-value = 0.94	p-value = 0.12		p-value = 0.80	p-value = 0.12	
Vitality						
T1	58.1 ± 1.85	57.2 ± 1.78[ab]		58.3 ± 1.96	57.6 ± 1.82[ab]	
T2	58.1 ± 1.82	63.6 ± 1.73[a]	0.10	58.2 ± 1.86	63.7 ± 1.77[a]	0.13
T3	62.2 ± 1.95	65.6 ± 1.65[b]		61.9 ± 1.99	65.5 ± 1.71[b]	
Trend Test	p-value = 0.06	p-value = **0.0001**		p-value = 0.12	p-value = **0.0006**	
Social Role Functioning						
T1	89.0 ± 1.98	84.8 ± 1.75[ab]		88.5 ± 2.10	85.3 ± 1.78[ab]	
T2	88.6 ± 1.95	94.4 ± 1.70[a]	**0.005**	88.4 ± 2.00	94.9 ± 1.73[a]	**0.005**
T3	90.6 ± 2.09	93.6 ± 1.62[b]		90.7 ± 2.14	94.0 ± 1.67[b]	
Trend Test	p-value = 0.51	p-value < **0.0001**		p-value = 0.37	p-value = **0.0002**	

Notes. Model 1 is adjusted for age (continuous), obese (yes/no), and number of symptoms (0–2, 3–5, 6+), and cancer type. Model 2 is additionally adjusted for high-light intensity physical activity and moderate-to-vigorous physical activity. Interaction p-value is from the cross-product term. Trend test p-value is from the ANCOVA test for trend. LSMeans with the same letter subscript are significantly different at the 0.05 alpha level.

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