Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_____ _____

Lauren Dempsey Date

Independent and Interactive Associations of Light and Moderate-to-Vigorous Physical Activity with Quality of Life among Cancer Survivors

By

Lauren Dempsey
Master of Science in Public Health

Epidemiology

_____

Michael Goodman, MD, MPH
Committee Chair

_____

Elizabeth Fallon, PhD, MPH
Committee Member

_____

Corinne Leach, PhD, MPH, MS
Committee Member

Independent and Interactive Associations of Light and Moderate-to-Vigorous Physical Activity with Quality of Life among Cancer Survivors

By

Lauren Dempsey

Bachelor of Science
University of Georgia
2018

Thesis Committee Chair: Michael Goodman, MD, MPH

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Science in Public Health
in Epidemiology

2020

Abstract

Independent and Interactive Associations of Light and Moderate-to-Vigorous Physical Activity with Quality of Life among Cancer Survivors

By Lauren Dempsey

Background

Previous research demonstrates that moderate-to-vigorous physical activity (MVPA) improves quality of life among cancer survivors. But some cancer survivors find it difficult to initiate and maintain sufficient levels of MVPA. Supporting the promotion of light-intensity physical activity (LPA) may improve quality of life among cancer survivors who are not meeting MVPA guidelines.

Methods

Data are from the second cross-sectional survey cycle of the American Cancer Society's Study of Cancer Survivors-I. ANCOVAs were used evaluate the independent and interactive associations of leisure-time light-intensity physical activity and moderate-to-vigorous physical activity with physical/mental quality of life. We compare and contrast our findings within the context of the American Cancer Society and American College of Sports Medicine physical activity guidelines, which recommend 150 min/week and 90 min/week of MVPA, respectively.

Results

23% of individuals reported no LPA or MVPA, while 36% of cancer survivors met ACSM guidelines and 24% met ACS guidelines. Results of the ANCOVA for physical QoL revealed a significant main effect of MVPA [ACSM: $F(2) = 82.62$, $p < .0001$; ACS: $F(2)=74.03$, $p < .0001$], an insignificant main effect of LPA [ACSM: $F(3) = 1.26$, $p=0.29$; ACS: $F(3)=0.97$, $p=0.40$] and a significant interaction between LPA and MVPA [ACSM: $F(6) = 3.13$, $p < .01$; ACS: $F(6)=2.23$, $p=0.04$]. There was a significant mean difference in physical quality of life score between persons reporting high level of light-intensity physical activity and those not engaged in light-intensity activity among those with no moderate-to-vigorous physical activity [LS mean difference 1.42, 95% CI: 0.38, 2.46].

Results of the ANCOVA for mental QoL revealed a significant main effect of MVPA [ACSM: $F(2) = 6.99$, $p < .001$; ACS: $F(2)=4.97$, $p < .01$], an insignificant main effect of LPA [ACSM: $F(3) = 2.03$, $p=0.11$; ACS: $F(3)=1.30$, $p=0.27$] and no statistically significant interaction between LPA and MVPA [ACSM: $F(6) = 1.15$, $p=0.33$; ACS: $F(6)=0.88$, $p=0.51$].

Conclusion

This study adds to the literature by demonstrating an interaction between leisure-time light-intensity physical activity and moderate-to-vigorous physical activity in relation to physical quality of life among cancer survivors. While MVPA continues to drive the positive association between physical activity and physical QOL, light-intensity activity may be beneficial for improving physical quality of life among cancer survivors who do engage in any moderate-to-vigorous physical activity.

Independent and Interactive Associations of Light and Moderate-to-Vigorous Physical Activity with Quality of Life among Cancer Survivors

By

Lauren Dempsey

Bachelor of Science
University of Georgia
2018

Faculty Thesis Advisor: Michael Goodman, MD, MPH

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements for the degree of
Master of Science in Public Health
in Epidemiology
2020

Table of Contents

Background/Literature Review

More than 16.9 million Americans have a history of cancer, with the number of cancer survivors projecting to grow to more than 22.1 million by 2030 due to advancements in treatment and screening (1). Over half of cancer survivors report problems with physical functioning as a result of their disease or treatment (2). These problems may occur immediately after diagnosis or years later as the cancer survivor ages. Cancer survivors are also vulnerable to poor mental health including anxiety, depression, fear of cancer recurrence, and post-traumatic stress (3).

With a large amount of cancer survivors that possess diminished physical and mental quality of life (QoL), the effectiveness of physical activity and other low-cost non-pharmaceutical interventions is being studied as a maintainable alternative to medications for cancer survivors (4). One such treatment is moderate-to-vigorous physical activity (MVPA), which is defined as ≥ 3 metabolic equivalents (METs), and consists of activities such as walking at least 3 miles per hour, bicycling at least 5 miles per hour, and swimming (5). Sufficient amounts of MVPA have been shown to prevent risk of premature mortality (6), as well as positively impact health-related quality of life (7). Yet, research also shows low prevalence of sufficient MVPA among cancer survivors (8) and that some cancer survivors find it difficult to initiate and maintain sufficient MVPA (9, 10).

Substantially less research has focused on light-intensity physical activity (LPA), defined as >1.5 and < 3 METs and consists of activities such as walking less than 3 miles per hour, light cleaning, and stretching (5). Because dose-response curves show the greatest health benefits of physical activity are realized when transitioning from no physical activity to some physical activity (11), promoting LPA may improve QoL among cancer survivors who are not engaging in MVPA or are not meeting MVPA guidelines.

Only seven studies exploring the benefit of LPA for QoL in cancer survivors were located (12-18). The only longitudinal study to date on LPA and QoL showed that higher levels of LPA were positively associated with physical functioning among older breast, prostate, and colorectal cancer survivors (13). Three studies explored the cross-sectional association between LPA and QoL among colorectal cancer survivors (15, 17, 18), with conflicting results. Among breast cancer survivors, one study found that higher levels of objectively-measured LPA were associated with lower fatigue duration and breast-cancer specific concerns (16). The only known study to examine LPA and mental QoL among cancer survivors suggested that higher levels of LPA were associated with better mental QoL only in older women after controlling for MVPA (12).

Current American Cancer Society guidelines suggest that cancer survivors should accumulate 150 min/week of aerobic MVPA (9). Guidelines recently published by the American College of Sports Medicine recommend 90 min/week of aerobic MVPA (19). Due to insufficient research on the benefits of LPA among

cancer survivors, neither the American Cancer Society nor the American College of Sports Medicine guidelines contain a specific minutes/week recommendation for LPA. Furthermore, the association of LPA and QoL across levels of MVPA may be different for American Cancer Society (ACS) and American College of Sports Medicine (ACSM) MVPA guidelines.

In summary, there are few studies exploring the relationship between LPA and QoL among cancer survivors. Limitations within the literature include small sample sizes (N < 850) (12-18), a lack of information on less common cancers (12, 13, 15-18), and lack of longitudinal data (12, 14-18). Methodologically, all studies control for MVPA, but have not explicitly examined the interaction between LPA and MVPA in relation to quality of life (12-18). To address these research gaps, our aim is to explore the association between LPA and QoL in cancer survivors while taking into consideration both the confounding and potential effect modifying effect of MVPA. To achieve this, we evaluate both the independent and interactive associations of leisure-time LPA and leisure-time MVPA with both physical and mental QoL of cancer survivors. The MVPA in these analyses is categorized using guidelines from both the American Cancer Society (150 min/week of aerobic MVPA) and the American College of Sports Medicine (90 min/week of aerobic MVPA).

Methods

Survey Procedure

This study uses data from the second survey of the American Cancer Society's Studies of Cancer Survivors-I (SCS-I) (20). SCS-I is a cohort study designed to investigate cancer survivors' adjustment to the disease and their physical and psychological changes in QoL. Adults diagnosed with one of 10 common cancers (breast, colorectal, prostate, bladder, uterine, melanoma, kidney, lung, ovarian, and non-Hodgkin's lymphoma) were recruited through 11 state cancer registries, utilizing active or passive physician consent for recruitment. Approval for SCS-I was obtained from the Institutional Review Board of Emory University (IRB #1853 587-2000) as well as each participating state's cancer registry. Patients were surveyed at three time-points, occurring an average of 1.28 (standard deviation [SD] = 0.34), 2.32 (SD = 0.40) and 8.91 (SD = 0.56) years posttreatment. SCS-I data collection is now complete, and a description of SCS-I methodology was previously published (20).

Survey Participants

There were 6309 people enrolled in SCS-I. Eligibility criteria for SCS-I included being >18 years of age at time of diagnosis, and diagnosed with local, regional, or distant SEER Summary Stage cancer (for urinary bladder, patients with in situ disease were also recruited). For the present analysis, survey cycle non-responders, persons with missing data on any of the variables of interest, those

indicating poor mobility and being unable to exercise, or those indicating a surrogate completed the survey on their behalf were excluded.

Primary outcome variables

The Medical Outcomes Study Short-Form Health Survey (SF-36) is a reliable and valid measure of QoL, consisting of two summary scores: the physical health component summary score and the mental health component summary score (21). Scores range from 0-100, and the scores were normed for analysis with an approximate mean of 50 and a standard deviation of 10. Higher scores indicate better QoL.

Exposure/Independent variables

Godin's Leisure-time Exercise Questionnaire is a validated self-administered instrument frequently used in cancer survivorship (22-24). A modified version of Godin's Leisure-time Exercise Questionnaire (See Appendix A) was used to measure the frequency of mild/light, moderate, and strenuous leisure-time physical activity in a typical week (23). Average amount of time per session was added, and minutes per week in each activity intensity (mild/light, moderate, strenuous) were calculated (22). The median level of leisure-time LPA in the SCS-I sample was 60 minutes per week, and therefore the following four categories were based on the median leisure-time LPA level of the sample: 0 min/week, 1-59 min/week, 60-119 min/week, and ≥120 min/week. Leisure-time MVPA was grouped in two ways: according to the American Cancer Society's guidelines for cancer survivors (9): inactive (0 min/week), insufficiently active (1-149

min/week), and meeting guidelines (≥150 min/week) and based on the American College of Sports Medicine's guidelines for cancer survivors (19): inactive (0 min/week), insufficiently active (1-89 min/week), and meeting guidelines (≥90 min/week).

Covariates

Potential covariates were examined for inclusion in the adjusted models by evaluating their bivariate relationship with MVPA, LPA, physical component summary score and mental component summary score as well as through review of the literature. For variables not used as covariates in previous studies, those that demonstrated a statistically significant association with both the independent variables and the dependent variables were included in the adjusted models. The final list covariates included the number of physical comorbidities (0, 1, ≥ 2), number of mental comorbidities (0, 1, ≥ 2), age at cancer diagnosis, cancer type by sex (female breast, male prostate, female colorectal, male colorectal, female other, male other), cancer stage at diagnosis, smoking status (current, former, never), employment in the past 12 months, and marriage status.

Self-reported physical comorbid conditions included Alzheimer's disease, gastrointestinal problems, diabetes, high blood pressure, heart attack, heart disease/other heart conditions, stroke, arthritis, asthma, or osteoporosis. Mental health comorbidities included anxiety, depression, and "other mental health problems".

Analysis

Two-way analysis of covariances (ANCOVA) was used to evaluate the independent and interactive effects of LPA and MVPA for both PCS and MCS. We did not conduct a longitudinal analysis because physical activity was only measured during the second and third in SCS-I surveys, and the sample size of the third survey was too small to allow analyses of physical activity. The current analysis was replicated using cutoffs from both the American Cancer Society and the American College of Sports Medicine guidelines. Least-Square Group Means and corresponding 95% CIs were calculated by categorizing participants by their self-reported LPA and MVPA status. Differences in group mean QoL scores and their corresponding 95% CI between physical activity groups were also calculated to determine difference in QoL by physical activity group. For sensitivity analyses, we tested the robustness of the model by including a covariate that controlled for self-reported recurrence, metastasis, or multiple cancers. We also looked at differences in those used in the complete case sample and those excluded from the study due to missingness. All analyses were conducted using SAS 9.4.

Results

Descriptive data

Among 5110 participants who responded to the survey, after exclusions (Figure 1), the complete analytic dataset included 3373 subjects. The study participants were on average 57.1 years old (SE ±12.2), 2.3 ± 0.4 years since diagnosis, 60.8% female, and 89.9% non-Hispanic white. Almost half of participants (48%) reported no leisure-time MVPA; and nearly one-quarter (23%) reported no leisure-time LPA and no MVPA. Individuals with higher leisure-time LPA levels were more likely to have an in situ/localized cancer stage, no physical or mental comorbidities, and not reporting a cancer recurrence, metastasis, or multiple cancers (Table 1).

Analyses of association

Physical QoL. The average physical QoL score for the total sample was 48.1 ± 9.8. Table 2a-b and Figure 2 illustrate the cross-sectional least square means for physical QoL by leisure-time LPA and MVPA status separately for American Cancer Society and American College of Sports Medicine guidelines. For both sets of guidelines, there was an independent and positive effect of MVPA on physical QoL [ACSM: $F(2) = 82.62$, $p < .0001$; ACS: $F(2)=74.03$, $p < .0001$]. There was no independent effect of LPA for physical QoL for either ACSM, nor ACS guidelines [ACSM: $F(3) = 1.26$, $p=0.29$; ACS: $F(3)=0.97$, $p=0.40$].

For both sets of guidelines, there was a statistically significant MVPA by LPA interaction [ACSM: $F(6) = 3.13$, $p < .01$; ACS: $F(6)=2.23$, $p=0.04$; See Table 2,

Figure 2]. Among those reporting 0 min/week LPA, there were significant differences in mean physical QoL when comparing those meeting MVPA recommendations to 0 min/week MVPA [ACSM: LS mean difference 5.88, 95% CI: 4.84, 6.93; ACS: LS mean difference 6.02, 95% CI: 4.83, 7.21]. Among those reporting 1-59 min/week LPA, there were significant differences in mean physical QoL when comparing those meeting MVPA recommendations to 0 min/week MVPA [ACSM: LS mean difference 5.69, 95% CI: 3.69, 7.69; ACS: LS mean difference 5.07, 95% CI 2.67, 7.47]. Among those reporting 60-119 min/week LPA, there were significant differences in mean physical QoL when comparing those meeting MVPA recommendations to 0 min/week MVPA [ACSM: LS mean difference 4.41, 95% CI: 2.92, 5.91; ACS: LS mean difference 5.07, 95% CI 3.29, 6.85]. Among those reporting at least 120 min/week LPA, there were significant differences in mean physical QoL when comparing those meeting MVPA recommendations to 0 min/week MVPA [ACSM: LS mean difference 3.64, 95% CI: 2.49, 4.80; ACS: LS mean difference 4.10, 95% CI 2.84, 5.35]. Among those reporting 0 min/week LPA, there was a significant difference in mean physical QoL when comparing those engaging in MVPA but not meeting recommendations to 0 min/week MVPA [ACSM: LS mean difference 4.48, 95% CI: 2.82, 6.14; ACS: LS mean difference 5.02, 95% CI 3.78, 6.26].

Among those reporting 0 min/week MVPA, there was a significant difference in mean physical QoL when comparing those engaging in at least 120 minutes per week of LPA (highest level) to 0 minutes per week of LPA (lowest

level) [LS mean difference 1.42, 95% CI: 0.38, 2.46]. Among those engaging in insufficient MVPA, there were no significant difference in mean physical QoL by highest (≥120 min LPA) and lowest (0 min LPA) LPA level [ACSM: LS mean difference -0.84, 95% CI: -2.93, 1.25; ACS: LS mean difference -1.26, 95% CI: -2.73, 0.21]. Similarly among those meeting recommendations, there were no significant difference in mean physical QoL by highest (≥120 min LPA) and lowest (0 min LPA) [ACSM: LS mean difference -0.82, 95% CI: -1.96, 0.31; ACS: LS mean difference -0.51, 95% CI: -1.87, 0.85]. When examining physical QoL by highest overall activity level (meets MVPA recommendations and reported at least 120 min/week LPA) and lowest overall activity level (0 min/week MVPA and 0 min/week LPA), there were significant differences [ACSM: LS mean difference 5.06, 95% CI 4.08, 6.04; ACS: LS mean difference 5.52, 95% CI 4.42, 6.61].

Mental QoL

The average mental QoL score for the total sample was 50.63 ± 10.44. Table 3a-b and Figure 3 illustrate the cross-sectional least square means for mental QoL by leisure-time LPA and MVPA status separately for American Cancer Society and American College of Sports Medicine guidelines. For both guidelines, there was an independent and positive effect of MVPA on mental QoL [ACSM: $F(2) = 6.99$, $p < .001$; ACS: $F(2)=4.97$, $p < .01$]. There was no independent effect of LPA on mental QoL for either set of guidelines [ACSM: $F(3) = 2.03$, $p=0.11$; ACS: $F(3)=1.30$, $p=0.27$].

There was no statistically significant MVPA by LPA interaction for either set of guidelines [ACSM: F(6) = 1.15, p=0.33; ACS: F(6)=0.88, p=0.51; See Table 3, Figure 3],. Among those reporting 0 min/week LPA, there were significant differences in mean mental QoL when comparing those meeting MVPA recommendations to 0 min/week MVPA [ACSM: LS mean difference 1.81, 95% CI: 0.65, 2.97; ACS: LS mean difference 1.69, 95% CI 0.37, 3.01]. Among those reporting 1-59 min/week LPA, there were no significant differences in mean mental QoL when comparing those meeting MVPA recommendations to 0 min/week MVPA [ACSM: LS mean difference 2.12, 95% CI: -0.10, 4.35; ACS: LS mean difference 2.10, 95% CI -0.58, 4.77]. Among those reporting 60-119 min/week LPA, there were no significant differences in mean mental QoL when comparing those meeting MVPA recommendations to 0 min/week MVPA [ACSM: LS mean difference 1.48, 95% CI: -0.19, 3.14; ACS: LS mean difference 1.26, 95% CI -0.71, 3.24]. Among those reporting at least 120 min/week LPA, there were no significant differences in mean mental QoL when comparing those meeting MVPA recommendations to 0 min/week MVPA [ACSM: LS mean difference 0.92, 95% CI: -0.37, 2.21; ACS: LS mean difference 0.83, 95% CI -0.57, 2.23]. Among those reporting 0 min/week LPA, there was a significant difference in mean mental QoL when comparing those engaging in MVPA but not meeting recommendations to 0 min/week MVPA [ACSM: LS mean difference 2.17, 95% CI: 0.33, 4.02; ACS: LS mean difference 2.10, 95% CI 0.72, 3.48].

Among those reporting no MVPA, there was a significant difference in mean mental QoL when comparing those engaging in at least 120 minutes per week of LPA to 0 minutes per week of LPA [LS mean difference 0.82, 95% CI: -0.34, 1.98]. There were no significant differences in mean mental QoL by highest to lowest LPA level among those engaging in insufficient MVPA [ACSM: LS mean difference -1.03, 95% CI: -3.36, 1.29; ACS: LS mean difference -0.57, 95% CI: -2.20, 1.06]. Similarly, there were no significant difference in mean mental QoL by LPA level among those meeting recommendations [ACSM: LS mean difference -0.07, 95% CI: -1.78, 1.16; ACS: LS mean difference -0.04, 95% CI: -1.56, 1.47]. There were no significant differences in mean mental QoL by highest activity level (meets MVPA recommendations, reported at least 120 min/week LPA) and lowest activity level (0 min/week MVPA, 0 min/week LPA) [ACSM: LS mean difference 1.74, 95% CI 0.64, 2.83; ACS: LS mean difference 1.65, 95% CI 0.43, 2.87].

Discussion

Key Results and Interpretation

In this cross-sectional study, we replicated previous research documenting the benefit of MVPA for physical QoL among cancer survivors (25). In this study, the effect of physical activity on physical QoL is primarily driven by MVPA (Figure 2, Table 2a-b), such that mean physical QoL was higher among those meeting MVPA guidelines, when compared to those engaging in no MVPA. We also identified a LPA by MVPA interaction for physical QoL, such that among those engaging in no MVPA, engaging in ≥120 min of LPA/week is associated with higher physical QoL. These results were consistent across both ACS and ACSM guidelines (Figure 2, Table 2a-b). Even though we found a statistically significant interaction between leisure-time LPA and MVPA in estimating physical QoL, it is unlikely that the relationship is clinically significant. One common way to examine clinical significance is to use a half-standard deviation difference (26). Given that our sample standard deviation for physical QoL is 9.81, we need to be cautious on whether the interaction between LPA and MVPA is clinically significant compared to the effect of MVPA alone. It appears that only increasing MVPA status shows a clinically significant difference in physical QoL.

This is the first study to examine the interaction between LPA and MVPA for cancer survivor QoL, which allows consideration of both the confounding and potential effect modifying effect of MVPA on the LPA-QoL relationship. In a

previous study, LPA was associated with physical QoL only in people reporting no higher intensity PA (17), which is the similar to the results in our study. Other studies came to the conclusion that MVPA, not LPA, is associated with higher physical QoL. In a previous study, MVPA was associated with higher physical functioning, and not LPA (15), which would be the same effects as our study if we did not take into account an interaction between MVPA and LPA. Since they did not include an interaction term between MVPA and LPA, they were unable to show the statistically significant difference LPA has on QoL for those who did not report any MVPA. Another possible reason why other studies did not find statistically significant associations between LPA and physical QoL could be that they were studying physical functioning, a sub-score of the Physical Component Summary Score in our study, and not the overall Physical Component Summary Score (13, 18). Therefore, for cancer survivors performing no MVPA, LPA may improve physical QoL.

For mental QoL, results show a positive association between MVPA status and mental QoL. But results showed neither an independent association between LPA and mental QoL, nor a LPA and MVPA interaction for mental QoL. These results were consistent across both American Cancer Society and American College of Sports Medicine guidelines (Figure 3a-b). The only statistically significant group difference for mental QoL is comparing meeting MVPA recommendations to 0 min/week MVPA among those engaging in 0 min/week LPA. Among those engaging in no MVPA per week, there were no significant

group differences amongst LPA status and mental QoL. Neither MVPA or LPA appear to contribute clinically significant differences to mental QoL. Thraen-Borowski et al. (17) also stated that among older, long-term colorectal cancer survivors, physical activity is related to their physical QoL, while social participation is predominantly related to their mental QoL. Our results are consistent with other research (12, 17) showing that the MVPA and mental QoL relationship is not as strong as the relationship between MVPA and physical QoL.

Strengths and Limitations

This study adds to the literature in several important ways. First, there are only a few existing studies examining the LPA-QoL relationship (12-18), and additional studies contribute to a better understanding of if, and by how much, LPA may benefit QOL. Second, because our sample was at least four times larger than samples in previous studies, we have more statistical power to detect LPA-QOL relationships (12-18). Third, previous studies (12-18) did not examine the interactive effect of LPA and MVPA, which is necessary to explore the association between LPA or MVPA and QoL in cancer survivors while taking into consideration both the confounding and potential effect modifying effect of the other PA intensity. Fourth, we explored LPA-QoL associations based on different MVPA guidelines, which is important to use because PA guidelines use prior research of physical activity to show the amount that will maximize its benefits for cancer survivors. The benefits of MVPA on QoL may not be

estimated best when only using raw minutes/week. Previous studies either only used raw minutes/week LPA (14) or sample LPA cut-points (12, 13, 15-18) which may not represent activity levels of the general population.

Perhaps the most important limitation of our study is its cross-sectional design, which precludes meaningful causal inference. In addition, we were unable to control for body mass index, which could have been a potential confounder or an effect modifier (27). As all information was self-reported, this poses a threat of self-presentation bias and misclassification, particularly with respect to reporting weekly average of minutes spent in physical activity. This study also used a modified version of the Godin's LTEQ, which is noted to have questionable generalizability to cancer survivors due to recall bias and accurate reporting of PA intensity. Since cancer survivors may be undergoing treatment or may have comorbidities related to their cancer, their perception of PA intensity may be different than a healthy adult (23). Future research will benefit from longitudinal studies, and objectively measuring PA to reduce misclassification of PA, as well as measure sedentary time, which has been shown to be associated with QoL in cancer survivors (28).

Future Directions

Dose-response data show the greatest health benefits of PA when transitioning from completely sedentary lifestyle to at least some PA (11). For this reason, this study offers additional evidence to support the promotion of LPA as a way of improving QoL among cancer survivors not engaged in moderate-to-vigorous PA. This study aligns with the Physical Activity Guidelines Scientific Report suggesting the need to study the effect of light-intensity PA on health (29) as well as the ACS 2035 Challenge Goal to reduce cancer mortality by 40% (30). This study also aligns with the Exercise is Medicine initiative to engage clinicians in helping patients living with and beyond cancer be physically active (31). Future research should focus on effective messaging barrier-reducing strategies and socio-ecological reasons that may facilitate LPA among persons with primarily sedentary lifestyles.

Some theory-based modifiable behavior change constructs have proven to be correlated with LPA. Self-efficacy was a strong correlate of LPA among lung cancer survivors (32). A previous study also using the SCS-I data explored the modifiable factors that facilitate or hinder LPA behavior in cancer survivors (33). Among those with no MVPA, greater provider support for PA, greater perceived health competence, and greater unsupportive partner behaviors were significantly correlated with higher levels of LPA. We should use the above socio-ecological associations to determine effective public health messaging.

Knowing these correlates of LPA may help identify target populations for specific public health messaging. A simple way for clinicians to provide support for PA is to assess, advise, and refer patients to either home-based or community-based exercise or to further evaluation and intervention in outpatient rehabilitation (31). Specific sub-populations that may especially benefit from LPA recommendations include women and people with multiple comorbidities (18). Promising novel approaches for increasing prevalence of PA may take advantage of mobile applications for cancer survivors. Formative research has shown that cancer survivors would be likely to use these mobile applications if the messages are casual, concise, and use positive tone, incorporate tools for personal goal attainment, provide experience that is tailored to the user (34).

One of the main goals of this paper was to compare PA-QoL associations by physical activity guideline. We conclude that as little as 90 min/week of MVPA can provide a statistically and clinically significant improvement in physical QoL. Given that both guidelines produced similar results in terms of QoL, public health officials will need to evaluate both guidelines by other outcomes for cancer survivors and assess whether a more conservative PA guideline is necessary. In conclusion, there is a statistically significant interaction between increasing MVPA and LPA levels for physical QoL, but only MVPA seems to affect mental QoL. Only increasing MVPA levels appeared to improve physical QoL to a clinically significant level.

References

1. Miller KD, Nogueira L, Mariotto AB, Rowland JH, Yabroff KR, Alfano CM, et al. Cancer treatment and survivorship statistics, 2019. CA: a cancer journal for clinicians. 2019. Epub 2019/06/12. doi: 10.3322/caac.21565. PubMed PMID: 31184787.

2. Stubblefield MD, Schmitz KH, Ness KK. Physical functioning and rehabilitation for the cancer survivor. Semin Oncol. 2013;40(6):784-95. Epub 2013/12/18. doi: 10.1053/j.seminoncol.2013.09.008. PubMed PMID: 24331197.

3. Yi JC, Syrjala KL. Anxiety and Depression in Cancer Survivors. The Medical clinics of North America. 2017;101(6):1099-113. Epub 2017/10/11. doi: 10.1016/j.mcna.2017.06.005. PubMed PMID: 28992857; PubMed Central PMCID: PMCPMC5915316.

4. Duncan M, Moschopoulou E, Herrington E, Deane J, Roylance R, Jones L, et al. Review of systematic reviews of non-pharmacological interventions to improve quality of life in cancer survivors. BMJ Open. 2017;7(11):e015860. Epub 2017/12/01. doi: 10.1136/bmjopen-2017-015860. PubMed PMID: 29187408; PubMed Central PMCID: PMCPMC5719270.

5. AINSWORTH BE, HASKELL WL, HERRMANN SD, MECKES N, BASSETT DRJ, TUDOR-LOCKE C, et al. 2011 Compendium of Physical Activities: A Second Update of Codes and MET Values. Medicine & Science in Sports & Exercise. 2011;43(8):1575-81. doi: 10.1249/MSS.0b013e31821ece12. PubMed PMID: 00005768-201108000-00025.

6. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet. 2012;380(9838):219-29. Epub 2012/07/24. doi: 10.1016/S0140-6736(12)61031-9. PubMed PMID: 22818936; PubMed Central PMCID: PMCPMC3645500.

7. Anokye NK, Trueman P, Green C, Pavey TG, Taylor RS. Physical activity and health related quality of life. BMC Public Health. 2012;12:624. Epub 2012/08/09. doi: 10.1186/1471-2458-12-624. PubMed PMID: 22871153; PubMed Central PMCID: PMCPMC3490805.

8. Blanchard CM, Courneya KS, Stein K, American Cancer Society's SCS, II. Cancer survivors' adherence to lifestyle behavior recommendations and associations with health-related quality of life: results from the American Cancer Society's SCS-II. Journal of clinical oncology : official journal of the American Society of Clinical Oncology. 2008;26(13):2198-204. Epub 2008/05/01. doi: 10.1200/JCO.2007.14.6217. PubMed PMID: 18445845.

9. Rock CL, Doyle C, Demark-Wahnefried W, Meyerhardt J, Courneya KS, Schwartz AL, et al. Nutrition and physical activity guidelines for cancer survivors. CA: a cancer journal for clinicians. 2012;62(4):243-74. Epub 2012/04/28. doi: 10.3322/caac.21142. PubMed PMID: 22539238.

10. Tannenbaum SL, McClure LA, Asfar T, Sherman RL, LeBlanc WG, Lee DJ. Are Cancer Survivors Physically Active? A Comparison by US States. J Phys Act

Health. 2016;13(2):159-67. Epub 2015/06/25. doi: 10.1123/jpah.2014-0493. PubMed PMID: 26107718.

11. Martin CK, Church TS, Thompson AM, Earnest CP, Blair SN. Exercise dose and quality of life: a randomized controlled trial. Arch Intern Med. 2009;169(3):269-78. Epub 2009/02/11. doi: 10.1001/archinternmed.2008.545. PubMed PMID: 19204218; PubMed Central PMCID: PMCPMC2745102.

12. Conroy DE, Wolin KY, Blair CK, Demark-Wahnefried W. Gender-varying associations between physical activity intensity and mental quality of life in older cancer survivors. Supportive care in cancer : official journal of the Multinational Association of Supportive Care in Cancer. 2017;25(11):3465-73. Epub 2017/06/18. doi: 10.1007/s00520-017-3769-6. PubMed PMID: 28620700; PubMed Central PMCID: PMCPMC5693626.

13. Blair CK, Morey MC, Desmond RA, Cohen HJ, Sloane R, Snyder DC, et al. Light-intensity activity attenuates functional decline in older cancer survivors. Medicine and science in sports and exercise. 2014;46(7):1375-83. Epub 2014/01/07. doi: 10.1249/mss.0000000000000241. PubMed PMID: 24389524; PubMed Central PMCID: PMCPMC4061152.

14. Coups EJ, Park BJ, Feinstein MB, Steingart RM, Egleston BL, Wilson DJ, et al. Physical activity among lung cancer survivors: changes across the cancer trajectory and associations with quality of life. Cancer epidemiology, biomarkers & prevention : a publication of the American Association for Cancer Research, cosponsored by the American Society of Preventive Oncology. 2009;18(2):664-72.

Epub 2009/02/05. doi: 10.1158/1055-9965.Epi-08-0589. PubMed PMID: 19190151; PubMed Central PMCID: PMCPMC2674013.

15. Johnson BL, Trentham-Dietz A, Koltyn KF, Colbert LH. Physical activity and function in older, long-term colorectal cancer survivors. Cancer causes & control : CCC. 2009;20(5):775-84. Epub 2009/01/06. doi: 10.1007/s10552-008-9292-9. PubMed PMID: 19123055; PubMed Central PMCID: PMCPMC2716661.

16. Phillips SM, Awick EA, Conroy DE, Pellegrini CA, Mailey EL, McAuley E. Objectively measured physical activity and sedentary behavior and quality of life indicators in survivors of breast cancer. Cancer. 2015;121(22):4044-52. Epub 2015/08/27. doi: 10.1002/cncr.29620. PubMed PMID: 26308157; PubMed Central PMCID: PMCPMC4635035.

17. Thraen-Borowski KM, Trentham-Dietz A, Edwards DF, Koltyn KF, Colbert LH. Dose-response relationships between physical activity, social participation, and health-related quality of life in colorectal cancer survivors. Journal of cancer survivorship : research and practice. 2013;7(3):369-78. Epub 2013/04/03. doi: 10.1007/s11764-013-0277-7. PubMed PMID: 23546822; PubMed Central PMCID: PMCPMC3737238.

18. Van Roekel EH, Bours MJ, Breedveld-Peters JJ, Meijer K, Kant I, Van Den Brandt PA, et al. Light Physical Activity Is Associated with Quality of Life after Colorectal Cancer. Medicine and science in sports and exercise. 2015;47(12):2493-503. Epub 2015/05/15. doi: 10.1249/mss.0000000000000698. PubMed PMID: 25970666.

19. CAMPBELL KL, WINTERS-STONE KM, WISKEMANN J, MAY AM, SCHWARTZ AL, COURNEYA KS, et al. Exercise Guidelines for Cancer Survivors: Consensus Statement from International Multidisciplinary Roundtable. Medicine & Science in Sports & Exercise. 2019;51(11):2375-90. doi: 10.1249/mss.0000000000002116. PubMed PMID: 00005768-201911000-00023.

20. Smith T, Stein KD, Mehta CC, Kaw C, Kepner JL, Buskirk T, et al. The rationale, design, and implementation of the American Cancer Society's studies of cancer survivors. Cancer. 2007;109(1):1-12. Epub 2006/12/06. doi: 10.1002/cncr.22387. PubMed PMID: 17146781.

21. Treanor C, Donnelly M. A methodological review of the Short Form Health Survey 36 (SF-36) and its derivatives among breast cancer survivors. Quality of life research : an international journal of quality of life aspects of treatment, care and rehabilitation. 2015;24(2):339-62. Epub 2014/08/21. doi: 10.1007/s11136-014-0785-6. PubMed PMID: 25139502.

22. Amireault S, Godin G. The Godin-Shephard leisure-time physical activity questionnaire: validity evidence supporting its use for classifying healthy adults into active and insufficiently active categories. Percept Mot Skills. 2015;120(2):604-22. Epub 2015/03/24. doi: 10.2466/03.27.PMS.120v19x7. PubMed PMID: 25799030.

23. Amireault S, Godin G, Lacombe J, Sabiston CM. The use of the Godin-Shephard Leisure-Time Physical Activity Questionnaire in oncology research: a systematic review. BMC medical research methodology. 2015;15:60. Epub

2015/08/13. doi: 10.1186/s12874-015-0045-7. PubMed PMID: 26264621; PubMed Central PMCID: PMCPMC4542103.

24. Amireault S, Godin G, Lacombe J, Sabiston CM. Validation of the Godin-Shephard Leisure-Time Physical Activity Questionnaire classification coding system using accelerometer assessment among breast cancer survivors. Journal of cancer survivorship : research and practice. 2015;9(3):532-40. Epub 2015/02/11. doi: 10.1007/s11764-015-0430-6. PubMed PMID: 25666749.

25. Buffart LM, Kalter J, Sweegers MG, Courneya KS, Newton RU, Aaronson NK, et al. Effects and moderators of exercise on quality of life and physical function in patients with cancer: An individual patient data meta-analysis of 34 RCTs. Cancer treatment reviews. 2017;52:91-104. Epub 2016/12/23. doi: 10.1016/j.ctrv.2016.11.010. PubMed PMID: 28006694.

26. Farivar SS, Liu H, Hays RD. Half standard deviation estimate of the minimally important difference in HRQOL scores? Expert review of pharmacoeconomics & outcomes research. 2004;4(5):515-23. Epub 2004/10/01. doi: 10.1586/14737167.4.5.515. PubMed PMID: 19807545.

27. Blanchard CM, Stein K, Courneya KS. Body mass index, physical activity, and health-related quality of life in cancer survivors. Medicine and science in sports and exercise. 2010;42(4):665-71. Epub 2009/12/03. doi: 10.1249/MSS.0b013e3181bdc685. PubMed PMID: 19952838.

28. George SM, Alfano CM, Groves J, Karabulut Z, Haman KL, Murphy BA, et al. Objectively measured sedentary time is related to quality of life among

cancer survivors. PloS one. 2014;9(2):e87937. Epub 2014/02/08. doi: 10.1371/journal.pone.0087937. PubMed PMID: 24505335; PubMed Central PMCID: PMCPMC3914895.

29. Piercy KL, Troiano RP, Ballard RM, Carlson SA, Fulton JE, Galuska DA, et al. The Physical Activity Guidelines for Americans. JAMA. 2018;320(19):2020-8. Epub 2018/11/13. doi: 10.1001/jama.2018.14854. PubMed PMID: 30418471.

30. Ma J, Jemal A, Fedewa SA, Islami F, Lichtenfeld JL, Wender RC, et al. The American Cancer Society 2035 challenge goal on cancer mortality reduction. CA: a cancer journal for clinicians. 2019;69(5):351-62. Epub 2019/05/09. doi: 10.3322/caac.21564. PubMed PMID: 31066919.

31. Schmitz KH, Campbell AM, Stuiver MM, Pinto BM, Schwartz AL, Morris GS, et al. Exercise is medicine in oncology: Engaging clinicians to help patients move through cancer. CA: a cancer journal for clinicians. 2019;69(6):468-84. Epub 2019/10/17. doi: 10.3322/caac.21579. PubMed PMID: 31617590.

32. Coups EJ, Park BJ, Feinstein MB, Steingart RM, Egleston BL, Wilson DJ, et al. Correlates of physical activity among lung cancer survivors. Psycho-oncology. 2009;18(4):395-404. Epub 2009/02/26. doi: 10.1002/pon.1520. PubMed PMID: 19241488; PubMed Central PMCID: PMCPMC2778598.

33. Johnson RS, Fallon EA, Berg CJ. Correlates of light physical activity among cancer survivors. Psycho-oncology. 2019;28(4):726-34. Epub 2019/01/27. doi: 10.1002/pon.5008. PubMed PMID: 30681233.

34. Robertson MC, Tsai E, Lyons EJ, Srinivasan S, Swartz MC, Baum ML, et al. Mobile Health Physical Activity Intervention Preferences in Cancer Survivors: A Qualitative Study. JMIR Mhealth Uhealth. 2017;5(1):e3. Epub 2017/01/26. doi: 10.2196/mhealth.6970. PubMed PMID: 28119278; PubMed Central PMCID: PMCPMC5296620.

Tables

Table 1. Descriptive Statistics for the study sample by Light-Intensity PA Status (min/week) (N = 3373)

	0 min/week (n = 1294)		1 - 59 min/week (n = 439)		60-119 min/week (n = 644)		≥ 120 min/week (n = 996)	
	%	m (sd)	%	m (sd)	%	m (sd)	%	m (sd)
Age (yrs)		57.7 (12.2)		55.9 (11.9)		55.3 (12.1)		57.7 (12.2)
Cancer Type by Sex								
Female Breast	27		23		29		25	
Male Prostate	16		21		15		23	
Female Colorectal	7		10		12		6	
Male Colorectal	7		5		6		7	
Female Other	29		28		27		22	
Male Other	14		13		12		17	
Cancer Stage								
In situ/Localized	64		62		62		66	
Regional	26		28		29		26	
Distant	10		10		9		8	
Married or in a Marriage-like Relationship	74		74		76		77	
Employed in Past Year	63		70		69		65	
Current Smoker	11		10		9		11	
≥ 2 Physical Comorbidities	23		20		16		19	
≥ 2 Mental Comorbidities	4		4		2		3	
American Cancer Society MVPA Recommendations								
None	60		48		41		38	
Insufficiently Active	19		38		38		28	
Meets Recommendations	21		14		21		34	
American College of Sports Medicine MVPA Recommendations								
None	60		48		41		38	
Insufficiently Active	9		28		22		14	
Meets Recommendations	31		24		37		48	
Physical QoL (normed score)		47.4 (10.3)		48.0 (9.7)		48.6 (9.3)		49.1 (9.4)
Mental QoL (normed score)		50.4 (11.0)		49.2 (11.1)		50.9 (10.0)		51.3 (9.8)

Table 1. Descriptive statistics of the complete case sample of cancer survivors by light-intensity physical activity status.

MVPA = moderate-to-vigorous physical activity, PA = physical activity, QoL = Quality of Life

Table 2a. Physical Component Summary Score Group Means by Moderate-to-Vigorous and Light-Intensity Physical Activity Status Under American College of Sports Medicine Guidelines

MVPA Group	N	LPA group	N	LS Mean (95% CI)
No MVPA (0 min/week)	1629	0 min/week	776	45.55 (44.94, 46.15)
No MVPA (0 min/week)		1-59 min/week	211	46.31 (45.16, 47.46)
No MVPA (0 min/week)		60-119 min/week	264	45.85 (44.82, 46.88)
No MVPA (0 min/week)		≥120 min/week	378	46.97 (46.11, 47.83)
Insufficient MVPA (1-89 min/week)	520	0 min/week	116	50.03 (48.48, 51.57)
Insufficient MVPA (1-89 min/week)		1-59 min/week	123	46.99 (45.49, 48.49)
Insufficient MVPA (1-89 min/week)		60-119 min/week	142	48.53 (47.13, 49.93)
Insufficient MVPA (1-89 min/week)		≥120 min/week	139	49.19 (47.77, 50.60)
Meets MVPA Recommendations (≥90 min/week)	1224	0 min/week	401	51.43 (50.59, 52.27)
Meets MVPA Recommendations (≥90 min/week)		1-59 min/week	106	52.00 (50.36, 53.64)
Meets MVPA Recommendations (≥90 min/week)		60-119 min/week	238	50.26 (49.18, 51.34)
Meets MVPA Recommendations (≥90 min/week)		≥120 min/week	478	50.61 (49.84, 51.38)

Table 2a. Moderate-to-Vigorous physical activity, light-intensity physical activity, and the interaction between leisure-time moderate-to-vigorous and light-intensity physical activity on the SF-36 Physical Component Summary Score using American College of Sports Medicine guidelines.
LPA = light-intensity physical activity, MVPA = moderate-to-vigorous physical activity

Table 2b. Physical Component Summary Score Group Means by Moderate-to-Vigorous and Light-Intensity Physical Activity Status Under American Cancer Society Guidelines

MVPA Group	N	LPA group	N	LS Mean (95% CI)
No MVPA (0 min/week)	1629	0 min/week	776	45.56 (44.95, 46.16)
No MVPA (0 min/week)		1-59 min/week	211	46.32 (45.17, 47.47)
No MVPA (0 min/week)		60-119 min/week	264	45.85 (44.82, 46.88)
No MVPA (0 min/week)		≥120 min/week	378	46.98 (46.12, 47.84)
Insufficient MVPA (1-89 min/week)	937	0 min/week	246	50.58 (49.50, 51.65)
Insufficient MVPA (1-89 min/week)		1-59 min/week	167	48.45 (47.15, 49.76)
Insufficient MVPA (1-89 min/week)		60-119 min/week	245	48.90 (47.83, 49.96)
Insufficient MVPA (1-89 min/week)		≥120 min/week	279	49.32 (48.31, 50.32)
Meets MVPA Recommendations (≥90 min/week)	807	0 min/week	272	51.58 (50.56, 52.59)
Meets MVPA Recommendations (≥90 min/week)		1-59 min/week	61	51.39 (49.29, 53.50)
Meets MVPA Recommendations (≥90 min/week)		60-119 min/week	135	50.92 (49.48, 52.37)
Meets MVPA Recommendations (≥90 min/week)		≥120 min/week	339	45.85 (44.82, 46.88)

Table 2b. Moderate-to-Vigorous physical activity, light-intensity physical activity, and the interaction between leisure-time moderate-to-vigorous and light-intensity physical activity on the SF-36 Physical Component Summary Score using American Cancer Society guidelines.
LPA = light-intensity physical activity, MVPA = moderate-to-vigorous physical activity

Table 3a. Mental Component Summary Score Group Means by Moderate-to-Vigorous and Light-Intensity Physical Activity Status Under American College of Sports Medicine Guidelines

MVPA Group	N	LPA group	N	LS Mean (95% CI)
No MVPA (0 min/week)	1629	0 min/week	776	49.74 (49.07, 50.42)
No MVPA (0 min/week)		1-59 min/week	211	49.30 (48.03, 50.58)
No MVPA (0 min/week)		60-119 min/week	264	50.32 (49.17, 51.46)
No MVPA (0 min/week)		≥120 min/week	378	50.56 (49.60, 51.52)
Insufficient MVPA (1-89 min/week)	520	0 min/week	116	51.92 (50.20, 53.63)
Insufficient MVPA (1-89 min/week)		1-59 min/week	123	48.43 (46.76, 50.10)
Insufficient MVPA (1-89 min/week)		60-119 min/week	142	50.51 (48.95, 52.07)
Insufficient MVPA (1-89 min/week)		≥120 min/week	139	50.88 (49.31, 52.46)
Meets MVPA Recommendations (≥90 min/week)	1224	0 min/week	401	51.55 (50.62, 52.49)
Meets MVPA Recommendations (≥90 min/week)		1-59 min/week	106	51.43 (49.61, 53.25)
Meets MVPA Recommendations (≥90 min/week)		60-119 min/week	238	51.79 (50.59, 53.00)
Meets MVPA Recommendations (≥90 min/week)		≥120 min/week	478	51.48 (50.63, 52.33)

Table 3a. Moderate-to-Vigorous physical activity, light-intensity physical activity, and the interaction between leisure-time moderate-to-vigorous and light-intensity physical activity on the SF-36 Mental Component Summary Score using American College of Sports Medicine guidelines.
LPA = light-intensity physical activity, MVPA = moderate-to-vigorous physical activity

Table 3b. Mental Component Summary Score Group Means by Moderate-to-Vigorous and Light-Intensity Physical Activity Status Under American Cancer Society Guidelines

MVPA Group	N	LPA group	N	LS Mean (95% CI)
No MVPA (0 min/week)	1629	0 min/week	776	49.75 (49.08, 50.42)
No MVPA (0 min/week)		1-59 min/week	211	49.31 (48.03, 50.58)
No MVPA (0 min/week)		60-119 min/week	264	50.32 (49.17, 51.46)
No MVPA (0 min/week)		≥120 min/week	378	50.56 (49.61, 51.52)
Insufficient MVPA (1-89 min/week)	937	0 min/week	246	51.85 (50.65, 53.04)
Insufficient MVPA (1-89 min/week)		1-59 min/week	167	49.18 (47.73, 50.63)
Insufficient MVPA (1-89 min/week)		60-119 min/week	245	51.16 (49.98, 52.35)
Insufficient MVPA (1-89 min/week)		≥120 min/week	279	51.28 (50.16, 52.40)
Meets MVPA Recommendations (≥90 min/week)	807	0 min/week	272	51.44 (50.31, 52.57)
Meets MVPA Recommendations (≥90 min/week)		1-59 min/week	61	51.40 (49.06, 53.74)
Meets MVPA Recommendations (≥90 min/week)		60-119 min/week	135	51.58 (49.97, 53.19)
Meets MVPA Recommendations (≥90 min/week)		≥120 min/week	339	51.40 (50.38, 52.41)

Table 3b. Moderate-to-Vigorous physical activity, light-intensity physical activity, and the interaction between leisure-time moderate-to-vigorous and light-intensity physical activity on the SF-36 Mental Component Summary Score using American Cancer Society guidelines.
LPA = light-intensity physical activity, MVPA = moderate-to-vigorous physical activity

Figures and Figure Legends

Figure 1. Flow diagram of participants included in complete case sample.

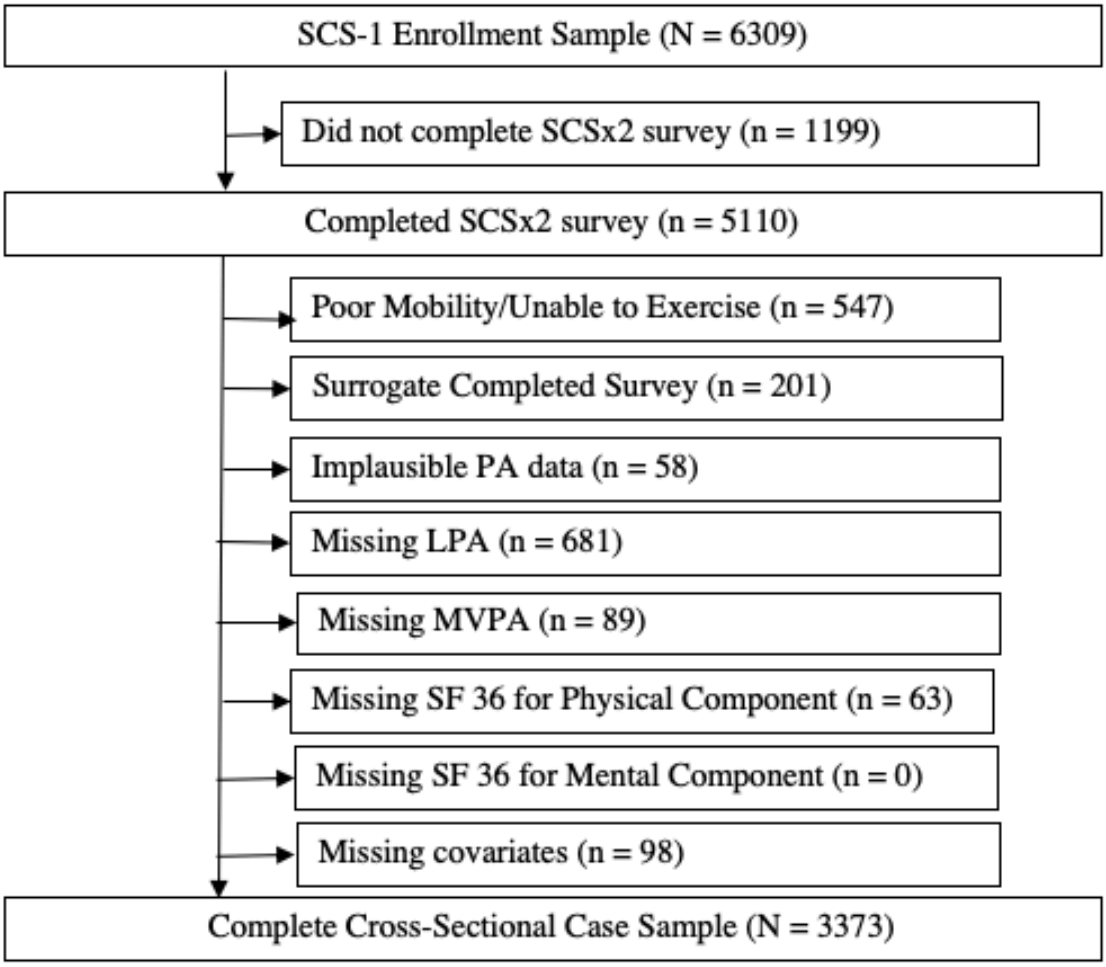

Figure 1 . Consort flow diagram of participants included in complete case sample of cross-sectional study.

SCS-I = American Cancer Society's Study of Cancer Survivors-I, SCSx2 = SCS-I second survey cycle, PA = physical activity, LPA = light-intensity physical activity, MVPA = moderate-to-vigorous physical activity

Figure 2.

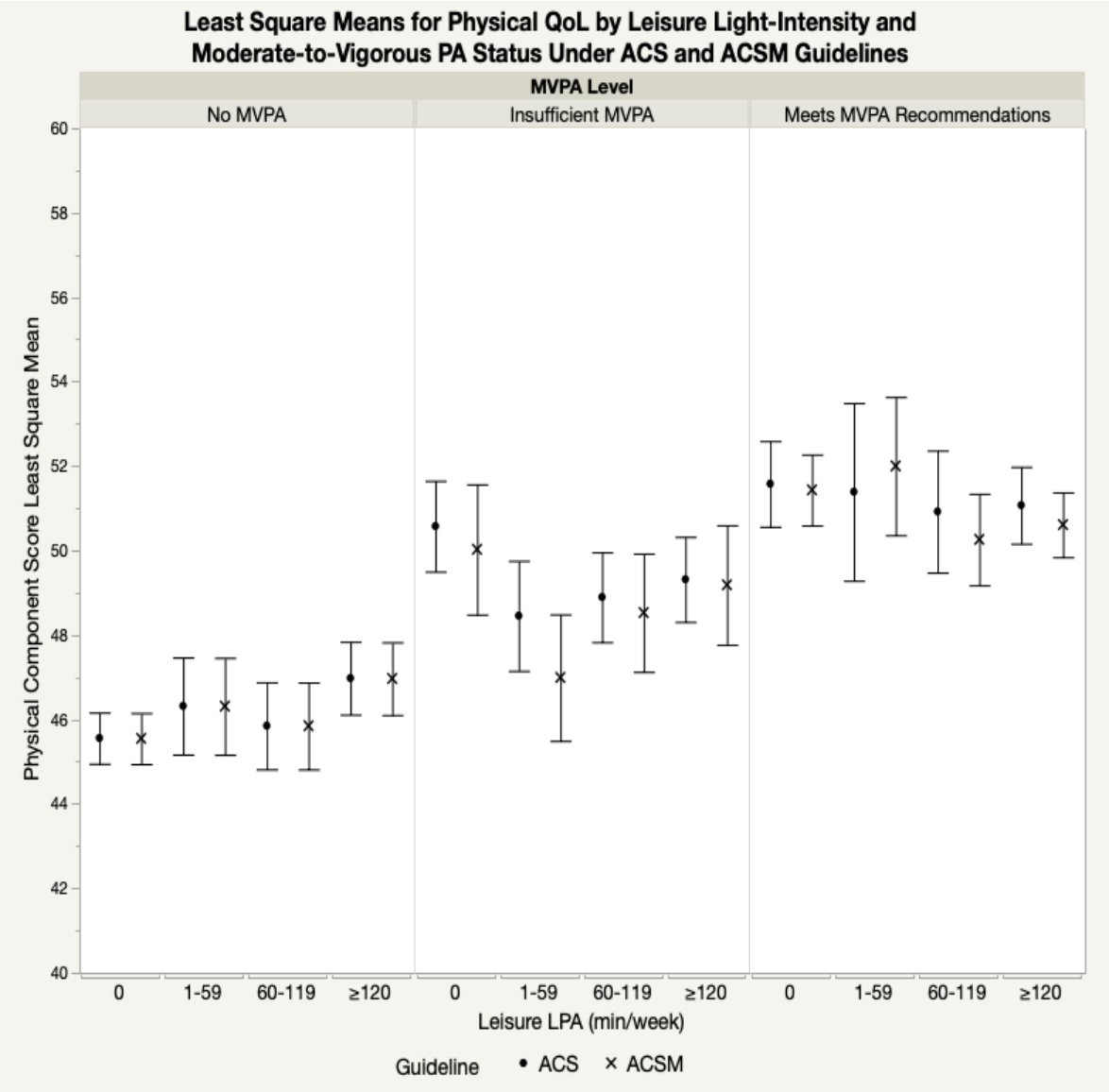

Figure 2. Graph of SF-36 Physical Component Score Least-Square Means grouped by leisure-time light-intensity and moderate-to-vigorous physical activity status. ACS = American Cancer Society, ACSM = American College of Sports Medicine, LPA = light-intensity physical activity, MVPA = moderate-to-vigorous physical activity, QoL = Quality of Life

Figure 3.

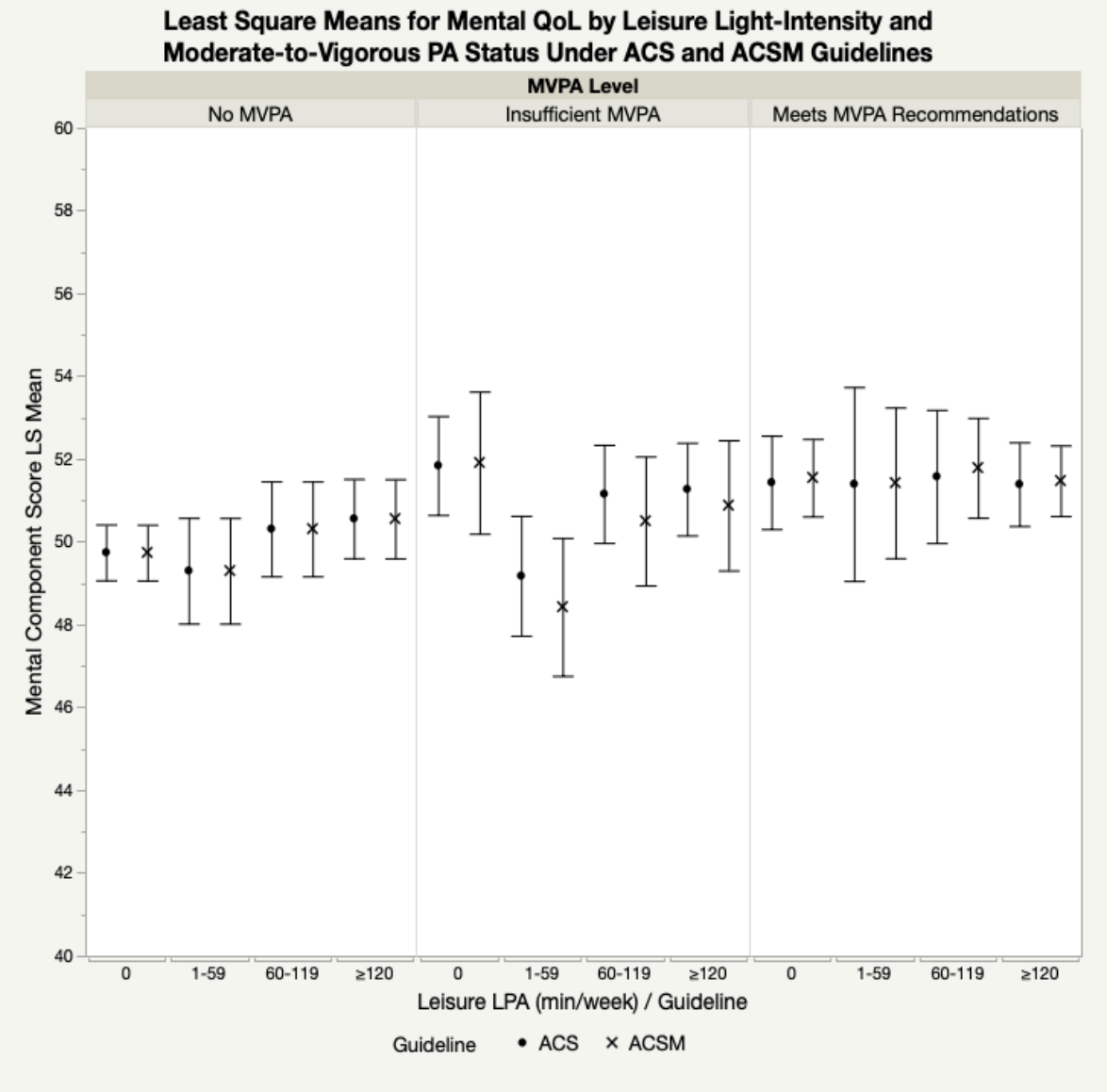

Figure 3. Graph of SF-36 Mental Component Score Least-Square Means grouped by leisure-time light-intensity and moderate-to-vigorous physical activity status. ACS = American Cancer Society, ACSM = American College of Sports Medicine, LPA = light-intensity physical activity, MVPA = moderate-to-vigorous physical activity, QoL = Quality of Life

Appendices

Appendix A: Modified Godin Leisure-Time Exercise Questionnaire

Considering a typical **7-day period** (a week) in the past month, how many times on the average did you do the following kinds of exercise for **more than 15 minutes** during your **free time** and for how long per exercise session (in minutes)? Please write the number of times per week in the first box and the average amount of time for each exercise session in the second box. *If you did not do a particular recreational activity in the past month, please put a zero (0) in the spaces provided. Do not leave any blanks.*

	Times Per Week	Average Amount of Time
a) Strenuous activity (heart beats rapidly, heavy sweating) (e.g., running, jogging, hockey, soccer, squash, cross country skiing, judo, roller skating, vigorous swimming, vigorous long-distance bicycling, vigorous aerobic dance classes, heavy weight training)		→ min
b) Moderate activity (not exhausting, light sweating) (e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)		→ min
c) Mild activity (minimal effort, no sweating) (e.g., easy walking, yoga, archery, fishing, bowling, lawn bowling, shuffleboard, horseshoes, golf, snowmobiling)		→ min