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Endometrial cancer survivors' sleep patterns before and after a physical activity intervention: a retrospective cohort analysis

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Abstract

Objective—To identify the baseline sleep patterns of endometrial cancer survivors and examine the impact of a physical activity intervention on their sleep quality via retrospective secondary analysis.

Methods—Early-stage endometrial cancer survivors participated in a 6-month single-arm exercise intervention using printed materials, telephone-based counseling, and pedometers to encourage adherence to exercise guidelines. Participants completed questionnaires evaluating their sleep (PSQI), physical activity (CHAMPS), quality of life (SF-36), and stress (PSS) at baseline and study completion.

Results—Ninety-five survivors had PSQI data at both time points. Mean age was 57.1 years (range, 25–76). Mean body mass index was 34.3 kg/m^2. The majority were non-Hispanic white (75%) and had stage I disease (80%). At baseline, most survivors (61%) had poor sleep quality (PSQI>5), with 24% reporting fairly or very bad sleep. The majority (63%) slept < 7 hours/night. At least once during the preceding month, 83% had an episode of daytime dysfunction. A pairwise comparison showed that obese survivors had more sleep disturbances than normal weight survivors ($p = 0.029$). No other clinicodemographic factors were associated with sleep. In unadjusted analyses, sleep quality significantly improved in women who increased weekly total or moderate/vigorous physical activity ($p=0.004$ and $p < 0.050$, respectively). This association

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Conflicts of interest
None of the authors have any relevant financial interests or conflicts to disclose.

persisted after adjusting for the potential covariates of age, time since diagnosis, obesity status, disease stage, and treatment ($p = 0.026$).

Conclusions—Our data demonstrated that poor sleep is common and detrimental to endometrial cancer survivors. Increasing exercise may improve this dysfunction and should be investigated as part of a prospective study.

1. Introduction

Endometrial cancer is the most common gynecologic malignancy in the United States, affecting 1 in 36 women (1). As the incidence of endometrial cancer continues to rise, related closely to the increasing number of women in the United States who are overweight or obese (1–3), the number of survivors is projected to increase from 620,000 to 750,000 by 2024 (4). After being cured of their disease, these survivors face a plethora of poorly defined issues that are detrimental to their quality of life.

The high prevalence of sleep dysfunction in all cancer survivors (30–50%) (5, 6) and general gynecologic cancer survivors (40–55%)(7, 8) is known and is higher than the prevalence of sleep disorders/complaints in the general population (4–33%) (9). However, research defining the sleep patterns of endometrial cancer survivors is limited. Data demonstrate a higher rate of insomnia in endometrial cancer survivors than in the general population (10). However, beyond those for insomnia, no further reports of sleep characterizations exist for this population. The sleep health of endometrial cancer survivors may be impacted by obesity given the association of excess adiposity with poor sleep observed in the general population (11) and survivors of breast cancer (5, 12), another obesity-related disease. Poor sleep has been associated with decreased in metabolism(13), insulin resistance (14), possibly even leading to obesity (15). Additionally, sleep disturbances are more common in obese individuals, even those without sleep-disordered breathing (16). Regardless, sleep disruption may be associated with poor quality of life, as demonstrated in ovarian cancer patients (17). However, this association has yet to be investigated in the endometrial cancer population.

One strategy to address poor sleep is to increase physical activity, which has been shown to improve total sleep time, efficiency, onset latency, and quality (18). A randomized controlled trial of gynecologic cancer survivors using a physical activity intervention demonstrated an initial but not persistent sleep benefit in the exercise group when compared to the control group (19). Although the researchers included endometrial cancer survivors in that study, they did not perform a subgroup analysis.

Given the paucity of data on the sleeping patterns of endometrial cancer survivors, we performed the present study to 1) describe the baseline sleep characteristics of endometrial cancer survivors, 2) determine the impact of clinicodemographic and treatment characteristics on sleep quality, 3) investigate the association of sleep quality with quality of life and stress level, and 4) describe the impact of a physical activity intervention on sleep. We hypothesized that endometrial cancer survivors would frequently experience sleep dysfunction, especially those who are overweight or obese; that poor sleep would be associated with poor quality of life and high stress levels; and that increased physical activity would be related to improvement in overall sleep quality.

2. Methods

2.1. Study design and participants

This study is a secondary analysis of Steps to Health, a single-arm prospective cohort study, the detailed methodology for which was published previously (20, 21). Concisely, all participants had stage I-IIIa endometrial cancer, had completed treatment at least 6 months prior to the study, and were without evidence of disease. Also, participants had not met the American College of Sports Medicine physical activity guidelines within the preceding 6 months. These guidelines require at least 30 minutes of moderate-intensity exercise 5 or more days a week or at least 20 minutes of vigorous exercise 3 or more days a week (22). Finally, medical clearance was required for study inclusion.

Recruitment occurred from January 2007 to September 2011. Potential participants at the main campus of The University of Texas MD Anderson Cancer Center in Houston, TX, were contacted via e-mail, telephone, or clinic visits. Survivors obtaining care at a private gynecologic oncology office in Houston were initially approached by their health care providers and, if interested, contacted by a research team member. The MD Anderson Institutional Review Board approved the study procedures.

Six-hundred forty-three survivors were considered for the study. Of those, 39 failed eligibility screening, and 270 were incompletely screened (for example, did not respond to letters and phone calls, or did not have appointments within the recruitment window). Of the remaining 334 survivors, 192 were not interested in the study and 42 were initially interested but did not follow through with study enrollment.

2.2. Procedures

Evaluations of the frequency and duration of physical activity occurred at baseline (T0) and 2 (T1), 4 (T2), and 6 (T3) months after enrollment, at MD Anderson. Additionally, at T0 and the T3 time point, sleep, quality of life, and stress were assessed using the measures described below. Demographic and treatment information were collected at baseline.

2.2.1. Sleep, quality of life, and stress assessment measures

2.2.1.1. Sleep: Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), which has seven components: sleep quality, sleep onset latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction(23). Each component is scored on a scale of 0, indicating the item was “not occurring in the past 4 weeks” or “not a problem,” to 3, indicating that the issue occurred “3 or more times per week” or was a “very big problem.” Taken together, the seven components have high internal consistency (Cronbach α of 0.83) (23). Lower scores indicate better sleep quality, whereas higher scores represent more dysfunction, with composite scores ranging from 0 to 21. A composite score greater than 5 indicates poor sleep quality (23). The PSQI has high test-retest reliability over time and can discriminate between individuals with sleep disorders and controls with no such disorders (23). Internal consistency and construct validity are supported in a cancer patients (24).

2.2.1.2. Physical activity: Data on the patients' amount, intensity, and frequency of physical activity were collected using the Community Health Activities Model Program for Seniors (CHAMPS) questionnaire (25). The CHAMPS questionnaire for older adults that examines the frequency, duration, and intensity of weekly exercise over the past 4 weeks. Activities are classified as part of "all-exercise related activities," while a subgroup of these activities are classified as moderate-vigorous intensity physical activities (MVPA). Activities were considered MVPA if their metabolic equivalent (MET) was > or = 3. During the questionnaire's development, its test-test reliability ranged from 0.58 to 0.67, and the CHAMPS scores were sensitive to intervention-related changes (25).

2.2.1.3. Quality of life: Quality-of-life data were obtained using the 36-item Short Form Survey, a questionnaire comprising eight components: physical function, social function, pain, mental health, energy and fatigue, general health perceptions, role limitations caused by physical problems, and role limitations caused by emotional problems (26). Additionally, items are grouped together to form the physical component score (PCS) and mental component scores (MCS). Scores range from 0 to 100, with higher scores indicating better quality of life. The internal consistency for our data was high (Cronbach α coefficient ≥0.80) for all subscales in this questionnaire apart from mental (α = 0.77) and general (α = 0.77) health.

2.2.1.4. Stress: The Perceived Stress Scale, which measures an individual's perception of stress, is a 10-question survey that uses a Likert scale of 0 to 4. A score of 0 indicates "never," whereas a score of 4 represents "very often." Higher scores indicate greater stress (27). The Cronbach α coefficient for the reliability was at least 0.84 during development (27).

2.2.2. Interventions—As described previously, Steps to Health participants completed a baseline assessment **of** their sleep, physical activity, quality of life and stress. They then received individualized exercise prescriptions based on their baseline functioning (21). The research team supported the participants' adherence to the American College of Sports Medicine guidelines, requiring 30 minutes of moderate exercise 5 or more days a week or at least 20 minutes of vigorous exercise 3 or more days a week, via telephone-based counseling sessions, printed materials, and pedometers. Telephone calls decreased in frequency from weekly in months 1 and 2 of the study to twice monthly during months 3 and 4 to monthly during months 5 and 6. The counseling in these calls addressed goal acquisition and strategies to remove barriers to goal achievement through cognitive skill utilization. The printed materials contained information that correlated with telephone call topics and also included motivational survivor stories.

2.3. Analysis

Descriptive statistics were used to describe the sample population and baseline sleep quality. The Fisher exact test of independence was used to investigate differences in the PSQI component scores among three body mass index (BMI) categories: normal (BMI <25 kg/m^2), overweight (BMI of 25–29 kg/m^2), and obese (BMI ≥30 kg/m^2). Similarly, pairwise differences in the PSQI scores among these BMI categories were analyzed.

Baseline differences in clinicodemographics, health-related quality of life, and physical activity by sleep quality (good sleep quality group with PSQI scores ≤5 versus poor sleep quality group with PSQI scores >5) were assessed using Welch's two-sample *t*-test and the Fisher exact test of independence.

The statistical significance level was set at 0.05 for all tests. Statistical analyses were performed using the SAS 9.3 software program (SAS Institute, Cary NC) and the R statistical computing environment (version 3.2.0; R Foundation for Statistical Computing, Vienna, Austria).

3. Results

One hundred women were enrolled in the trial, 95 of whom had baseline PSQI data. At enrollment, their mean age was 57.1 years (range, 25–76 years). Their mean BMI was 34.3 kg/m^2. Fourteen women had a normal BMI, 20 were overweight, and 61 were obese. The majority of the endometrial cancer survivors were non-Hispanic white (75%) and married (64%). Most of the women (80%) had stage I disease, and the average time from diagnosis was 2.2 years (range, 0.5–5.2 years). The majority of the women (59%) had less than a 4-year college degree. Fifty-seven percent of them received surgery alone, whereas the reminder underwent surgery and radiation. Additional patient characteristics can be found in Table 1. Demographic data on the entire cohort were described previously (20, 28). Fifty-eight percent of patient completed all 14 call sessions.

At baseline, 61% of the survivors had poor sleep quality, indicated by a PSQI score greater than 5. The mean (± SD) PSQI score at baseline was 7.3 ± 3.8. The majority of the respondents (63%) slept no more than 7 hours per night, with 24% rating their sleep as fair or very bad. At least once during the preceding month, 30% of the women took sleep medication, and 83% had an episode of daytime dysfunction. All sleep parameters from the PSQI are listed in Table 2.

Overall, good sleep quality (PSQI ≤5) was independent of BMI classification (50%, 35%, and 37% of normal, overweight, and obese participants, respectively; $p = 0.65$) (Table 2). We observed no statistically significant differences in any of the sleep component scores among the three BMI categories. However, pairwise comparisons indicated that obese survivors were more likely to have sleep disturbances than were their normal-weight counterparts ($p = 0.029$). No other sleep component scores differed between normal-weight and obese survivors. Also, no other clinicodemographic factors were associated with the baseline composite sleep score (Table 3).

Baseline sleep quality was related to stress and certain quality-of-life measures. Endometrial cancer survivors with a PSQI score greater than 5, indicating poor sleep quality, had significantly higher stress levels than did those who had good sleep quality ($p = 0.002$) (Table 4). Several health-related quality-of-life domains were related to sleep quality. Specifically, poor sleep quality was significantly associated with low health-related quality of life in the 36-item Short Form Survey subscales of vitality ($p < 0.001$), bodily pain ($p = 0.004$), general health ($p = 0.002$), social functioning ($p = 0.005$), role limitations caused by emotional problems ($p = 0.005$), and mental health ($p = 0.002$) and the mental component score ($p = 0.003$).

Overall, the mean global PSQI score did not statistically change from T0 (7.3 ± 3.8) to T3 (6.2 ± 3.6; $p = 0.625$). However, additional unadjusted analyses indicated that changes in sleep quality were associated with changes in the level of physical activity from T0 to T3. In particular, sleep quality improved significantly in cancer survivors who increased their weekly total physical activity or MVPA throughout the intervention ($p = 0.004$ and $p < 0.050$, respectively) (Table 5). Clinically, scoring increases could represent a change in any one of the seven components assessed by the PSQI, but as an example could represent a change in sleep quality from “fairly bad” to “very good” or increasing sleep duration by 1–3 hours/ night.

When adjusted for the potential covariates age, time since diagnosis, obesity status, disease stage, and treatment, improvement in sleep quality was associated with an increase in the number of total activity hours ($p = 0.026$) but not with an increase in hours of MVPA per week ($p = 0.201$) (Table 6).

4. Discussion

The majority of the endometrial cancer survivors in our cohort had poor sleep quality, evidenced by PSQI scores of at least 5. Most of them also experienced sleep disturbances and daytime dysfunction owing to sleep-related issues, agreeing with our observed association of poor sleep health with increased stress and poor quality of life. Sleep disturbances were more common in obese than in normal-weight participants. These findings demonstrated the correlation of increased exercise with improved sleep. In survivors who increased their total number of hours of physical activity per week during the intervention, the mean PSQI score improved, decreasing from 7.38 at T0 to 5.35 T3 and approaching the “good sleep” range of PSQI scores (<5).

Sixty one percent of our participants had sleep dysfunction, which is similar to the rate of approximately 50% reported in gynecologic cancer survivors (7, 8, 29). Data on cancer and non-cancer populations have demonstrated the relationship between sleep and quality-of-life outcomes. In the general population, investigators showed that “optimal sleepers” had fewer episodes of anxiety or depression, more positive relationships with others, and higher levels of self-purpose and self-acceptance than did suboptimal sleepers (30). Researchers also observed benefits of good sleep quality in gynecologic cancer survivors, in whom subjectively reported sleep characteristics, specifically components of the PSQI, were associated with positive affect, social support, and meaning in life (31). Conversely, insomnia has been correlated with depression and fatigue in cancer survivors (32), and sleep dysfunction has been correlated with poor quality-of-life outcomes in ovarian cancer survivors (17). Our data demonstrating associations of poor sleep health with poor quality of life and high stress levels align with the associations observed in other populations.

Despite the observed association of sleep dysfunction with elevated BMI in the general population (11, 33) and in some breast cancer survivor studies (5, 12, 34), our primary analysis did not support this relationship. However, it did demonstrate a difference in sleep disturbance between obese and normal-weight endometrial cancer survivors that could have resulted from several factors. Other studies have shown that obstructive sleep apnea (35), poorly managed acute pain (34), anxiety/depression(36), and environmental factors (37) can impact sleep quality. Sleep apnea(38) and pain (39)are more common in obese individuals and may mediate the relationship between sleep quality and obesity. We were unable to include these factors in our analyses, which may have confounded our results.

The association between increased physical activity and improved sleep we observed is in line with the results of other investigations. In the general population, individuals reporting participation in exercise were less likely than those not exercising to report sleep problems (OR=0.678, $p<0.001$) and daytime dysfunction (OR= 0.486, $p<0.001$) (33). Additionally, a randomized controlled trial for gynecologic cancer survivors, consisting of a 12-week exercise intervention versus control group, showed significantly better PSQI scores for the intervention group at 12 weeks ($\Delta = -2.59$, $p = 0.04$) (19). However, this difference was not statistically significant at 6 months of follow-up ($\Delta = -2.47$, $p = 0.08$) (19). Of note, the amount of moderate-intensity exercise in the two groups was similar at 12 weeks and 6 months ($p = 0.21$ and $p = 0.40$, respectively), indicating that a factor aside from minutes of exercise may explain the benefit of sleep. Similarly, our data did not support an association of improved sleep with increased MVPA after adjusting for potential confounders. When examining the components of the CHAMPS questionnaire, activities that counted toward total physical activity but not MVPA included golfing, light housework or gardening, walking to accomplish errands, leisure walking, stretching, and calisthenics. Many of these activities take place outside the home and involve interactions with others, which may have a psychologic benefit. Other studies support the relationship of positive mental health with high sleep quality (30, 31).

Our study has strengths and limitations that should be considered. We provide data on a relatively large number of endometrial cancer survivors that were not impacted by loss of patients to follow-up. Additionally, we used a validated questionnaire to assess sleep quality in an understudied group of cancer survivors. Despite these strengths, our study had some limitations. Specifically, the study may have been impacted by selection bias, as we only included women who were not physically active. Of note, only 10% of screened survivors were ineligible for study participation for any reason, including meeting physical activity guidelines. Sedentary women may have more medical problems, including worse sleep at baseline than the traditional endometrial cancer survivor. Also, the participants included sedentary endometrial cancer survivors whose survey responses may differ from those of survivors who are physically active or declined to participate in our study. However, if, as our manuscript suggests, increased physical activity is associated with improved sleep, we might have seen less sleep disturbance in the sample of survivors. Furthermore, without a control group, we were unable to demonstrate a causal relationship between physical activity and sleep, nor determine a direction of association as the analysis was cross-sectional. Finally, because sleep was a secondary end point in our original trial, we did not collect data on all possible confounding factors that could have impacted sleep during the study period. Specifically, depression and/or anxiety have been correlated with poor sleep and may have influenced the prevalence of sleep dysfunction in our study (36). It is possible that sleep scores could have been worse for those suffering depression or anxiety. However, physical activity has also been shown to improve depression/ anxiety and may have acted as a positive mediator of change in sleep health throughout our study(40). Additionally, sleep apnea could have impacted our results, in that women who with sleep apnea may have poorer sleep or possibly be less likely to exercise than those without sleep apnea. Additionally, weight loss has been associated with improvement in sleep apnea(38), but no significant weight loss was seen throughout the study period. Furthermore, data do support physical activity benefits for patients with obstructive sleep apnea(41). Similar to the impact of anxiety or depression, sleep apnea most likely impacted the prevalence of sleep disorders, and less likely confounded our results. Although these variables were not assessed in our study, they were mostly like present throughout the intervention, still allowing for comparisons across time and a global assessment of sleep health. Finally, not all women completed all 14 telephone sessions and the change in physical activity and sleep might be somewhat less than if we had 100 % compliance.

In conclusion, out data demonstrated that poor sleep quality affects a majority of endometrial cancer survivors and that an increase in physical activity is associated with improvement of overall sleep health. Although we cannot say that physical activity led to improvement in sleep, we are encouraged that our data aligns with that of the published literature, providing preliminary evidence of an additional benefit of physical activity for endometrial cancer survivors. Future prospective investigations are necessary to validate these findings. In the meantime, providers should be aware of the high prevalence of sleep-related dysfunction and consider recommending physical activity as an approach to improving sleep health for endometrial cancer survivors.

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HIGHLIGHTS

- The majority of endometrial cancer survivors have poor sleep quality.
- Increased exercise is related to improved sleep during an exercise intervention.

Table 1

Participant characteristics at baseline (n = 95)

Characteristic	
Mean age, years (range)	57.1 (25.0–76.0)
Mean weight, kg (range)	90.6 (47.9–185.3)
Mean BMI, kg/m^2 (range)	34.3 (18.7–69.3)
Mean time from diagnosis to enrollment, years (range)	2.2 (0.5–5.2)
BMI category, n (%)	
Normal weight	14 (15)
Overweight	20 (21)
Obese	61 (64)
Race, n (%)	
Non-Hispanic white	71 (75)
Hispanic white	12 (13)
Non-Hispanic black	6 (6)
Asian	5 (5)
American Indian/non-Hispanic	1 (1)
Education, n (%)	
Some high school/high school diploma/GED	14 (15)
Technical/vocational degree	8 (8)
Some college/2-year degree	34 (36)
At least 4-year degree	39 (41)
Marital status, n (%)	
Married/living with significant other	71 (75)
Single/divorced/widowed/separated	24 (25)
Disease stage, n (%)	
I	76 (80)
II or IIIa	19 (20)
Treatment, n (%)	
Surgery only	54 (57)
Surgery + radiotherapy	41 (43)

Table 2

PSQI component scores by BMI classification (n = 95)

	n (%)				
	Overall (n = 95)	**Normal (BMI <25 kg/m²) (n = 14)**	**Overweight (BMI 25–29 kg/m²) (n = 20)**	**Obese (BMI ≥30 kg/m²) (n = 61)**	***p* value[a]**
Global PSQI score					0.649
≤5[b]	37 (39)	7 (50)	35 (7)	23 (38)	
>5	58 (61)	7 (50)	65 (13)	38 (62)	
Global PSQI component scores[c]					
Sleep quality					0.850
Very good	41 (43)	6 (43)	35 (7)	28 (46)	
Fairly good	31 (33)	4 (29)	35 (7)	20 (33)	
Fairly bad	16 (17)	2 (14)	25 (5)	9 (15)	
Very bad	7 (7)	2 (14)	5 (1)	4 (7)	
Sleep onset latency					0.175
≤15 minutes	30 (32)	7 (50)	30 (6)	17 (28)	
16–30 minutes	41 (43)	4 (29)	45 (9)	28 (46)	
31–60 minutes	16 (17)	2 (14)	5 (1)	13 (21)	
>60 minutes	8 (8)	1 (7)	20 (4)	3 (5)	
Sleep duration					0.711
>7 hours	35 (37)	4 (29)	7 (35)	24 (39)	
6–7 hours	25 (26)	4 (29)	5 (25)	16 (26)	
5–6 hours	30 (32)	4 (29)	8 (40)	18 (30)	
<5 hours	5 (5)	2 (14)	0 (0)	3 (5)	
Habitual sleep efficiency[d]					0.273
≥85%	58 (61)	10 (71)	13 (65)	35 (57)	
75%–84%	20 (21)	1 (7)	3 (15)	16 (26)	
65%–74%	6 (6)	3 (21)	3 (15)	3 (5)	
<65%	11 (12)	0 (0)	1 (5)	7 (11)	

	n (%)				
	Overall (n = 95)	**Normal (BMI <25 kg/m^2) (n = 14)**	**Overweight (BMI 25–29 kg/m^2) (n = 20)**	**Obese (BMI ≥30 kg/m^2) (n = 61)**	***p* value[a]**
Sleep disturbances[e]					0.099
0 (minimum; best)	1 (1)	1 (7)	0 (0)	0 (0)	
1	21 (22)	5 (36)	4 (20)	12 (20)	
2	57 (60)	8 (57)	14 (70)	35 (57)	
3 (maximum; worst)	16 (17)	0 (0)	2 (10)	14 (23)	
Use of sleep medication					0.279
Not during the past month	67 (71)	11 (79)	11 (55)	45 (74)	
Less than once a week	11 (12)	1 (7)	2 (10)	8 (13)	
Once or twice a week	10 (11)	1 (7)	3 (15)	6 (10)	
Three or more times a week	7 (7)	1 (7)	4 (20)	2 (3)	
Daytime dysfunction[f]					0.585
0 (minimum; best)	16 (17)	4 (29)	2 (10)	10 (16)	
1	50 (53)	5 (36)	13 (65)	32 (52)	
2	26 (27)	4 (29)	5 (25)	17 (28)	
3 (maximum; worst)	3 (3)	1 (7)	0 (0)	2 (3)	

[a]Fisher exact test of independence.

[b]A PSQI score ≤5 indicates good sleep quality. PSQI data at baseline were available for 95 participants.

[c]The PSQI instrument has seven components with possible scores of 0, 1, 2, or 3. The global PSQI score is calculated by adding all seven component score

[d]Percent value calculated using the equation (total number of hours asleep/total number of hours in bed) × 100.

[e]Sleep disturbance score calculated as the sum of 10 items, each representing a source of sleep disturbance (cannot get to sleep within 30 minutes, wake up in the middle of the night or early morning, have to get up to use the bathroom, cannot breathe comfortably, cough or snore loudly, feel too cold, feel too hot, have bad dreams, have pain, and other reasons), rated on a Likert scale of 0 to 3 (0, not during the past month; 1, less than once a week; 2, once or twice a week; 3, three or more times a week).

[f]Daytime dysfunction score calculated as the sum of two items rated on a Likert scale of 0 to 3. (During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity? During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?)

Table 3

Participant characteristics by sleep quality (n = 95)[a]

Characteristic	Good sleep quality (global PSQI[b] ≤5) (n = 37)	Poor sleep quality (global PSQI[b] >5) (n = 58)	*p* value[c]
Mean age, years (SD)	58.6 (12.6)	56.1 (9.8)	0.310
Mean time since diagnosis, years (SD)	2.3 (1.3)	2.2 (1.3)	0.614
Education, n (%)			
Less than high school	0 (0)	2 (4)	0.590
High school diploma/GED	4 (11)	8 (14)	
Technical/vocational degree	3 (8)	5 (9)	
Some college/2-year degree	14 (38)	20 (34)	
4-year degree	7 (19)	16 (28)	
Advanced degree	9 (24)	7 (12)	
Race, n (%)			
Hispanic white	4 (11)	8 (14)	0.644
Non-Hispanic American Indian/Alaska native	0 (0)	1 (2)	
Non-Hispanic Asian	2 (5)	3 (5)	
Non-Hispanic black	4 (11)	2 (4)	
Non-Hispanic white	27 (73)	44 (76)	
Disease stage, n (%)			
I	26 (70)	50 (86)	0.103
II	8 (22)	7 (12)	
III	3 (8)	1 (2)	
Treatment, n (%)			
Surgery only	17 (46)	37 (64)	0.095
Surgery + radiotherapy	20 (54)	21 (36)	
Marital status, n (%)			
Single	5 (14)	6 (10)	0.143
Married	21 (57)	40 (69)	
Divorced	5 (14)	5 (9)	
Living with significant other	5 (14)	1 (2)	
Separated	0 (0)	1 (2)	
Widowed	1 (3)	5 (9)	

[a]A PSQI score ≤5 indicates good sleep quality. PSQI data at baseline were available for 95 participants.

[b]Welch's two-sample *t*-test was performed assuming unequal variances.

[c]Fisher exact tests of independence.

Table 4

Quality of life by sleep quality at baseline (n = 95)

	Mean (SD)		Difference (good – poor sleep)		
	Good sleep quality (global PSQI ≤5) (n = 37)	**Poor sleep quality (global PSQI >5) (n = 58)**	***Mean*[a] (*SD*[b])**	***95% CI*[c]**	***p* value[d]**
PSS score[e]	19.0 (8.3)	24.1 (6.8)	−5.15 (7.38)	(−8.39, −1.90)	0.002
SF-36 component scores[f]					
Physical	50.4 (9.7)	46.6 (10.2)	3.75 (10.02)	(−0.45, 7.94)	0.079
Mental	53.8 (9.6)	46.9 (11.6)	6.90 (10.85)	(2.50, 11.31)	0.003
SF-36 subscale scores[g]					
Physical functioning	77.8 (21.1)	72.5 (22.2)	5.34 (21.74)	(−3.66, 14.34)	0.241
Vitality	65.0 (18.0)	48.0 (18.8)	17.02 (18.50)	(9.31, 24.72)	<0.001
Role limitations caused by physical problems	77.0 (33.5)	64.2 (38.6)	12.80 (36.75)	(−2.10, 27.70)	0.091
Bodily pain	78.2 (20.0)	65.2 (22.3)	13.04 (21.37)	(4.32, 21.75)	0.004
General health	75.8 (16.8)	63.2 (21.7)	12.61 (20.00)	(4.65, 20.56)	0.002
Social functioning	90.5 (15.1)	79.1 (23.2)	11.45 (20.48)	(3.63, 19.26)	0.005
Role limitations caused by emotional problems	87.4 (27.6)	66.7 (41.9)	20.72 (37.02)	(6.56, 34.88)	0.005
Mental health	81.6 (14.8)	71.4 (15.5)	10.18 (15.27)	(3.83, 16.53)	0.002

PSS: Perceived Stress Scale; SF-36: 36-item Short Form Survey.

[a] Difference in the mean baseline score between individuals with good sleep quality compared to poor.

[b] Pooled standard deviation for the difference in the mean baseline score between individuals with good sleep quality compared to poor.

[c] 95% confidence interval for the difference between the two means assuming unequal variances.

[d] Welch's two-sample *t*-test was performed assuming unequal variances.

[e] Higher PSS indicates greater stress.

[f] Higher scores for the SF-36 subscales indicate better quality of life.

Table 5

Change in global sleep quality (PSQI) score by physical activity (n = 79)[a]

Participant characteristics based on CHAMPS	Mean hours/week (SD)		Difference (follow-up - baseline)		
	Baseline PSQI	Follow-up PSQI	Mean (SD)	95% CI	*p* value[b]
Increased total physical activity (n = 42)[c]	7.4 (3.5)	5.4 (2.9)	−1.49 (2.82)	(−2.46, −0.52)	***0.0037***
No increase in total physical activity (n = 37)[c]	6.6 (3.4)	7.1 (4.1)	0.17 (3.16)	(−1.01, 1.35)	0.7749
Increased MVPA (n = 49)[c]	7.6 (3.4)	6.2 (3.2)	−0.95 (2.97)	(−1.90, −0.0003)	***0.0499***
No increase in MVPA (n = 30)[c]	6.1 (3.3)	6.1 (4.2)	−0.36 (3.26)	(−1.71,0.99)	0.5865

[a] Seventy-nine individuals had CHAMPS questionnaire data at baseline and during follow-up assessments.

[b] Paired *t*-tests were performed.

[c] Individuals were grouped into increasers/nonincreasers according to their physical activity measurements from baseline to follow-up. Only individuals having both measurements at baseline and during follow-up were included in the analysis

Table 6

Effect of change in physical activity on change in sleep quality (n = 79)[a]

	Participants who increased their physical activity				Participants who did not increase their physical activity				
	Baseline PSQI		Follow-up PSQI		Baseline PSQI		Follow-up PSQI		
	Model-adjusted mean	SE	Model-adjusted mean	SE	Model-adjusted mean	SE	Model-adjusted mean	SE	*p* value[b]
Increase in CHAMPS total activity hours/week	7.380	0.522	5.351	0.558	6.661	0.566	7.176	0.592	**0.026**
Increase in CHAMPS MVPA hours/week	7.394	0.494	5.984	0.534	6.460	0.648	6.551	0.664	0.201

SE: standard error.

[a] Seventy-nine individuals had CHAMPS questionnaire data at baseline and during follow-up.

[b] Mixed-effects models were fitted for longitudinal measurement of PSQI scores at baseline and follow-up. The models assessed whether increases in physical activity from baseline to follow-up were associated with any changes in PSQI score over time. Adjustments were made for the confounders age, time since diagnosis, obesity status, disease stage, and treatment.