Research Article

Effects of a Clinic-Based Exercise Program on Sleep Disturbance Among Cancer Survivors

Integrative Cancer Therapies
Volume 19: 1–8

DOI: 10.1177/1534735420975852
journals.sagepub.com/home/ict
SAGE

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Abstract

Introduction: Sleep disturbance is the second leading negative side effect reported by cancer survivors, and evidence exists to suggest that exercise may improve sleep for cancer survivors. This study examined changes in sleep following a 3-month, clinic-based exercise program among a diverse group of cancer survivors. **Methods:** Single group, pre-post study design. Participants were enrolled in a supervised exercise program which consisted of moderate intensity aerobic and resistance training, twice per week for 3-months. To be eligible, individuals had to be diagnosed with cancer, and undergoing, or within 6-months of completing chemo and/or radiation therapy. Sleep was assessed at pre-and post-program using 3 self-report questions as part of a standard wellness assessment conducted at the program's facility. Changes in categorical outcomes were evaluated using McNemar and Wilcoxon Signed-Rank Tests. **Results:** Participants ($N = 94$) were mostly female (68.1%, $N = 64$), mean age = 54.26 ± 14.26 (20-78), and diagnosed with more than 8 different cancer types. Half ($N = 48$, 51.1%) of participants improved on 1 or more of the questions assessing sleep. At post-program, 39% of participants reported that they did not awaken feeling rested versus 48% at pre-program ($P = .08$). At post-program, 47% reported awakening ≥1 time per night versus 46% at pre-program ($P = .97$), and 17% reported poor or very poor sleep quality at post-program versus 24% at pre-program ($P = .16$). There were no differences in demographic, cancer-related, psychosocial, and physical fitness variables between participants who improved on any of the questions assessing sleep versus those who did not. **Conclusions:** A clinically implemented exercise program may help some cancer survivors improve sleep, however more studies utilizing validated, objective measures of sleep are needed to confirm effectiveness.

Keywords

sleep disturbance, cancer, clinic-based exercise, physical activity

Submitted June 2, 2020; revised September 30, 2020; accepted November 3, 2020

Introduction

Improvement in early detection and treatment for many cancers has increased 5-year survival rates, resulting in an estimated 16.9 million cancer survivors in the United States.[1] However, diagnosis and treatment of cancer (e.g., surgery, radiation, chemo and hormone-based therapies, etc.), is often accompanied by multiple physical and psychosocial side effects that can persist long after treatment has ended, and can negatively impact a survivors' quality of life (QOL).[2] With an increasing number of individuals living well beyond their cancer diagnosis, the need for strategies to combat negative side effects from cancer treatment is of growing public health importance.

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For cancer survivors, sleep disturbance is the second mostly commonly reported side effect of cancer treatment,[3] with reported sleep disturbance rates approximately twice that of the general population.[4] Sleep disturbance includes difficulty initiating or maintaining sleep, excessive fatigue, dysfunction related to sleep-wake cycles, and/or dysfunction related to sleep and sleep stages.[5,6] Sleep disturbance is considered a clinically significant outcome as it can exacerbate, or lead to issues such as psychological distress, fatigue, decreased work productivity, poor healing, increased risk of infections, increased risk of cancer recurrence, disrupted cognitive functioning, and increased health care costs.[6,7] Currently, pharmacological agents are a common treatment strategy for sleep disturbance; however, the cost of these sleep agents as well as the additional side effects and dependency risks, makes the pharmacological approach less desirable for cancer survivors.[8,9] Thus, there is a need for non-pharmacological approaches to improve sleep disturbances among cancer survivors.

Among adults not diagnosed with cancer, exercise has been shown to improve sleep disturbances.[10] However, due to the negative effects of chemotherapy and/or radiation therapy on sleep,[11] the effects of exercise for improving sleep outcomes among healthy, older adults may not be transferable to cancer survivors. Only within the last decade, have researchers begun to synthesize the effects of randomized controlled trials (RCTs) of exercise on sleep among cancer survivors.[4,12] Mercier et al. (2017)[4] conducted a systematic review and meta-analysis of exercise interventions in cancer survivors which included sleep as an outcome. Approximately half of the studies reviewed showed significant improvements in sleep following an exercise intervention, whereas the other half reported no effect. This review also found that among the studies which demonstrated improvements in sleep, the majority of participants had completed cancer treatment and interventions consisted of either an aerobic or combination of aerobic and resistance training (60%). In a review by Medysky et al,[12] also conducted in (2017), findings suggested that combined, moderate intensity aerobic and resistance exercise interventions were effective for improving disordered sleep among cancer survivors. More recently, Bernard et al[13] conducted a meta-analysis to determine the effects of exercise on sleep among cancer survivors, and found that overall, exercise interventions improved sleep compared to those allocated to a control group.

Based on this current literature, combined aerobic and resistance training exercise interventions seem to be effective for improving sleep among cancer survivors.[4,12,13] However, one limitation to disseminating this evidence broadly is that it has been compiled exclusively from research or "laboratory-based" randomized controlled trials (RCTs). The transition from RCTs conducted in well-controlled laboratory settings to community or clinic-based settings is challenging, and may require adaptations to the sample, or target population (e.g., expanded eligibility criteria) and implementation characteristics (e.g., personnel delivering intervention, duration, setting, etc.) to enhance external validity.[14,15] Thus, it is currently unknown if exercise programs delivered in "real-world settings" (e.g., community or clinic-based facilities) demonstrate similar effectiveness to research-based interventions for improving sleep for cancer survivors.

Presently, the effectiveness of community and clinic-based exercise programs to improve QOL and physical fitness/function in cancer survivors is well established,[16-18] but the knowledge related to the effects of these programs on sleep outcomes is limited.[19,20] Given the known sleep disturbances in cancer survivors, the potential benefits of exercise for improving sleep in cancer survivors, and the growing popularity of cancer specific community and clinic-based exercise programs,[17,21] it is important to understand whether these programs, in addition to improving QOL and fitness or functional outcomes, can also improve sleep for individuals who are undergoing, or have recently completed treatment for cancer.

Therefore, the aims of this study were to (1) examine the effects of a clinic-based exercise program on sleep among cancer survivors and (2) explore differences in demographic, cancer-related, psychosocial, and physical fitness variables among those who did versus did not report improvements in sleep. Based on the findings from previous RCTs, we expect that a clinic-based exercise program which includes aerobic and resistance training will improve self-reported sleep in cancer survivors.

Methods

This study was a retrospective analysis of data collected as part of the BfitBwell cancer-exercise program at the University of Colorado Anschutz Health and Wellness Center (AHWC). BfitBwell is a 3-month supervised exercise program for cancer survivors based on NCCN guidelines for physical activity during survivorship and other previously published exercise recommendations for cancer survivors.[22,23] To be eligible, participants must be (1) adults ($\geq$18 years old), (2) currently undergoing medical cancer treatment (chemotherapy and/or radiation) OR are within 6 months of completing medical cancer treatment at the University of Colorado Cancer Center, (3) must provide a signed physician clearance to participate in exercise, and (4) are able and willing to travel to the AHWC at least 2 times per week for the duration of the program. No exclusions are made based on cancer type. Participants in the program provide written, informed consent for program data to be entered into a research database. Data from participants

Table 1. Participant Characteristics (N = 94).

	Mean ± standard deviation
Age	54.26 ± 14.26
BMI (kg/m^2)	26.73 ± 6.11
Total exercise sessions attended (**n** = 82)	20.56 ± 6.16
Pre-program grip strength (kg)	32.71 ± 9.67
Pre-program 6-minute walk test (m)	647.53 ± 108.76
	N (%)
Gender (% male)	30 (31.9)
Race	
Asian	5 (5.3)
Black or African American	3 (3.2)
White	82 (87.2)
Cancer diagnosis	
Breast	34 (36.2)
Prostate	7 (7.4)
Colorectal	6 (6.4)
Blood or Hematological	6 (6.4)
Lung	5 (5.3)
Brain	4 (4.3)
Esophageal	4 (4.3)
Ovarian	3 (3.2)
Pancreatic	1 (1.1)
Other	24 (25.5)
Receiving **only chemotherapy during program**	21 (22.8)
Receiving **only radiation during program**	16 (17.4)
Receiving **chemotherapy and radiation during program**	7 (7.6)
Surgery completed within previous 6-months	36 (38.3)

enrolled between August 2013 and December 2019 who completed sleep measures at pre- and post-program were included in this study. Access to and use of this data for this investigation was approved by the Colorado Multiple Institutional Review Board (COMIRB).

Exercise Program Details

BfitBwell consists of 2 one-on-one training sessions per week for the first month of the program and 2 small group-training sessions (up to 4 participants) per week in the second and third months of the program. Each training session is approximately 50-minutes in length, and led by a Cancer Exercise Specialist or trained and supervised program interns completing a degree in Exercise Science or a related field. Participants are encouraged to complete at least 10 minutes of aerobic exercise of their choice prior to the start of the session, which then focuses on a combination of resistance, aerobic, and flexibility exercises, based on each participants' baseline fitness assessment, with an intensity of ≤8 out of 10 rating of perceived exertion (RPE) throughout the session. Preliminary effectiveness of this program for improving physical fitness, fatigue, and depression has been previously published.[24]

Assessments

Prior to beginning the program, self-reported past medical history, demographics, and cancer treatment history are collected. Pre- and post-program assessments include detailed measures of physical fitness (ie, muscular strength and endurance, aerobic endurance, balance, gait, etc.), and questionnaires to measure a variety of patient-reported outcomes, which includes sleep (under review).[25]

Sleep

Sleep was assessed at pre-and post-program using 3 self-report questions as part of a standard wellness assessment conducted at the program's facility. The following questions assessed sleep:

1. "Do you awaken feeling rested?"
   (1) Yes
   (2) No
2. "How often do you wake up or get up during the night for any of the following reasons: to go to the bathroom, have pain, restless legs, hot flashes, a disruptive sleep partner?"

Table 2. Changes in Sleep From Pre- to Post-Program.

Question	Pre-program	Post-program	*P* value
	n, (%) reporting "no"		
"Do you awaken feeling rested"	48, (51.1)	39, (41.5)	.08
	n, (%) reporting awakening ≥1 time per night		
"How often do you wake up or get up during the night for [variety of reasons]"	46, (49.5)	47, (50.5)	.97
	n, (%) reporting very poor or poor		
"During the past 4 weeks, how would you rate your sleep quality overall?"	24, (25.5)	17, (18.1)	.16

(1) Never
(2) 1-3 times per week
(3) 4-6 times a week
(4) Once or twice a night.
(5) More than 2 times per night

3. "During the past 4 weeks, how would you rate your sleep quality overall?"
   (1) Very Poor
   (2) Poor
   (3) Fair
   (4) Good
   (5) Very Good

Demographic, Cancer-Related, Psychosocial, and Physical Fitness Variables

Self-reported demographic information included age, gender, and race. Cancer-related information was also self-reported and consisted of diagnosis, and treatment status (ie, receiving chemotherapy and/or radiation at the time of the pre-program assessment). Fatigue, using the Functional Assessment of Chronic Illness Therapy-Fatigue questionnaire,[26] and QOL, using Functional Assessment of Cancer Therapy-General questionnaire,[27] were measured to evaluate psychosocial differences between those that did not change categories, or changed categories in a negative direction (eg, reported waking more times in the night compared to baseline) versus those that changed categories in a positive direction.

Physical fitness was assessed using tests of aerobic fitness and muscular strength. Aerobic fitness was measured by the 6 minute walk test (which measures how far, in meters, an individual can walk in 6 minutes), an assessment validated in cancer survivors.[28] An improvement of 14-30.5 m is considered a clinically meaningful difference across multiple patient groups.[29] Muscular strength was assessed using grip dynamometry (Digital Jamar Plus; Patterson Medical, Warrenville, Illinois) according to NIH recommendations (www.nihtoolbox.org), with the participant seated with elbow flexed to 90°. One maximal trial was performed and recorded after a submaximal practice trial. An improvement of 5-6.5 kg equates to clinically meaningful change in grip strength.[30]

Statistical Analysis

Participant characteristics are reported as mean ± standard deviation or frequencies, as appropriate. A change in category from pre- to post-program for (1) "Do you awaken feeling rested" (yes/no) was evaluated using a McNemar Test. The change in category from pre-to post-program (ie, Likert scale response) for (2) "How often do you wake up or get up during the night," and (3) "During the past 4 weeks, how would you rate your sleep quality overall" were evaluated using Wilcoxon Signed-Rank Tests. Evaluation of differences in medical, demographic and fitness variables between those that changed categories to indicate sleep improvement (eg, "very poor" to "fair" or "more than 2 times per night" to "never") in ≥1 sleep question versus those who did not (ie, response stayed the same or indicated worse sleep) was completed using Fisher's Exact or Chi-Square analysis for categorical variables, and Independent Samples *t*-tests for continuous variables. Data were analyzed using SPSS for Windows (Version 26) with statistical significance set at $P < .05$.

Results

Ninety-four BfitBwell participants had pre and post-program sleep questionnaire data and were included in analyses. Table 1 displays participant characteristics. Briefly, participants were on average 54.26 ± 14.26 years old, and majority female (68.1%). Breast cancer was the most common diagnosis (36.2%) followed by prostate cancer (7.4%).

Approximately half of participants (51.1%, n = 48) demonstrated an improvement in sleep from pre- to post-program, indicated by changing categories in a positive direction (eg, "fair" to "good" or "good" to "very" good"), in 1 or more of

Table 3. Differences Between Participants Who Improved Sleep From Pre- to Post-Program versus Those Who Did Not.

	Improved ≥1 sleep question (N = 48)	No change or worsened in all sleep questions (N = 46)			*P* value*
	N (%)				
Gender (% male)	18 (37.5)	12 (26.1)			.27
Race (% white)	41 (85.4)	41 (89.1)			.37
Cancer diagnosis (% breast)	17 (35.4)	17 (37.0)			.81
Receiving chemotherapy during program	14 (29.2)	14 (30.4)			1.00
Receiving radiation during program	14 (29.2)	9 (19.6)			.34
	Mean (Standard Deviation)		*t*-statistic	df	*P* value*
Age (years)	55.08 ± 13.17	53.39 ± 15.41	−.58	92	.57
BMI (kg/m^2)	26.77 ± 6.07	26.70 ± 6.21	−.57	92	.96
Exercise sessions attended	21.74 ± 6.02	19.33 ± 6.13	1.80	80	.08
Change in grip strength from pre- to post-program (kg)	0.9 ± 3.55	1.66 ± 3.55	.99	86	.32
Change in 6MWT from pre- to post-program (m)	44.92 ± 51.40	38.68 ± 61.84	−.49	79	.63
Baseline QOL	78.69 ± 13.88	82.87 ± 13.74	1.47	92	.15
Baseline fatigue	33.90 ± 11.94	35.25 ± 11.40	.56	92	.58

Abbreviations: BMI, body mass index; 6MWT, 6-minute walk test; QOL, quality of life.
*Fisher's Exact, Chi-Square, or Independent Samples T-test were utilized to determine differences between groups.

the sleep questions. Of those that saw improvement in 1 or more of the questions assessing sleep, most (79.2%, n = 38) showed improvement on only one of the questions assessing of sleep, 18.8% (n = 9) on two, and only 2.1% (n = 1) showed improvement on all three of the questions assessing sleep. The remaining 48.9% (n = 46) of participants showed no change or worsening in all 3 questions measures of sleep.

From pre- to post-program, there were no significant difference in changes in sleep categories. Specifically, "How often do you wake up or get up during the night for (various reasons)" revealed no significant differences between pre- and post-program (z = .04, P = .97). However, there were trends in the direction of fewer participants answering "no" to the question "Do you awaken feeling rested?" (P = .08), and fewer participants reporting "poor or very" poor sleep quality at post-program vs pre-program (z = 1.42, P = .16) (see Table 2).

There were no differences in demographic, cancer-related, psychosocial, and physical fitness variables between those that improved categories on 1 or more of the questions assessing sleep compared to those who worsened or had no change in sleep categories (Table 3).

Discussion

This study examined changes in sleep following a 3-month, clinic-based exercise program for cancer survivors, and explored differences in demographic, cancer-related, psychosocial, and fitness variables among participants who did versus did not report an improvement in at least one of the questions assessing sleep.

Half of participants reported an improvement in 1 or more of the questions assessing sleep, and trends suggested that more participants reported awakening feeling rested at post–program compared to pre-program, and fewer rated their overall sleep quality as very poor. The absence of a robust, statistically significant improvement in sleep outcomes may be attributed to only half of participants reporting lower sleep ratings (ie, "poor" or "very poor" sleep) at pre-program. Two previous studies have demonstrated post-exercise improvements in sleep outcomes only among cancer survivors who reported poor sleep at baseline. Courneya et al[31] evaluated the effects of an exercise intervention on sleep quality in lymphoma survivors, and found that only those with poor sleep quality at baseline trended toward sleep benefits at post-intervention. Similarly, Tang et al[32] only saw significant improvements in sleep quality in cancer survivors who reported poor sleep quality at baseline, following an 8-week home-based walking program. We conducted exploratory analyses stratified by pre-program sleep categories, which revealed a similar trend; participants who reported worse sleep categories at pre-program (i.e. answered "no" to the question "do you awaken feeling rested" (n = 48) or rated overall sleep quality as "very

poor" or "poor" (n=24)) saw significant improvements in sleep at post-program (ie, significantly more of these participants reported awakening feeling more rested and improved overall sleep quality). These results are displayed in the Supplemental Figure 1. Taken together, these findings along with the findings from Courneya et al[31] and Tang et al,[32] suggest that cancer survivors experiencing disturbance at pre-program, are most likely to experience sleep-related benefits following an exercise program. This is likely due to a ceiling effect, as those that already report low levels of sleep disturbance are less likely to see significant changes compared to those with more severe sleep disturbance.[33] Additionally, Buman et al[34] found that baseline physical activity level was a significant moderator of objectively measured sleep improvements in a sample of older adults participating in a moderate intensity exercise intervention, indicating that those with less severe sleep disturbance may require a higher dose of exercise to elicit further improvement in sleep disturbance compared to those with severe sleep disturbance.

We also found no differences in demographic, cancer-related, psychosocial, and fitness variables, between participants who reported an improvement in at least one of the questions assessing sleep, versus those that reported no change or worsening on all 3 questions. One previous study that explored sleep between varying subgroups of chemotherapy patients found that being female, younger age, having lower functional status, more comorbidities, childcare responsibilities, and unemployment contributed to higher levels of sleep disturbance.[35] The participants in our sample tended to be older (ie, 52.1% were older than 55 years) with higher functional status (ie, grip strength, 6 minute walk test), providing a potential explanation for lack of significant findings regarding medical, demographic, and fitness variable differences between groups. Additionally, we found that participants who reported an improvement in at least one of the questions assessing sleep attended, on average, 3 more exercise sessions than those that reported no change or worsening on all 3 questions, revealing a trend toward the potential importance of exercise dose on sleep improvement. Although not statistically significant, the effects of exercise program adherence on sleep outcomes may warrant further exploration.

Strengths of this study include examining changes in sleep following an exercise program delivered in a "real-world" setting. Although several RCTs have demonstrated benefits of exercise on sleep, the ability to translate these effects to a clinic-based program was unknown. Further, the BfitBwell exercise program targets survivors during, and within 6-months of treatment completion, when sleep disturbance seems to be most prevalent.[11] Therefore, an exercise program delivered during this time can provide a potentially valuable resource to help cancer survivors experiencing sleep disturbance while undergoing adjuvant treatment. An additional strength of this study is the diverse sample of cancer survivors, which enhances the generalizability of findings.

This study was not without limitations. First, there was the possibility of selection bias due to convenience sampling, meaning cancer survivors who are more motivated or current exercisers may have been more likely to join the program. This could potentially limit the effectiveness of an exercise program to further improve sleep as those that are more active tend to have less sleep disturbance at baseline than those who are inactive.[36] Second, there was no control group. This limits the ability to determine whether a clinic-based exercise program was more effective than standard of care (e.g., "nothing") for improving sleep, or to control for the effect of time (i.e., does sleep improve as participants move further from completing chemotherapy and/or radiation treatment). Third, since sleep was not considered ad-hoc as an outcome of the program, the measures used may not have been sensitive enough to detect changes. Additionally, information regarding current/past sleep history and/or interventions (i.e., pharmacological intervention, cognitive-behavioral therapy) was not collected. Further, the questions utilized are single-item questions evaluating potentially different aspects of sleep (i.e., sleep quality, sleep efficiency); therefore, research using objective measures of sleep as well as validated questionnaires (e.g., Pittsburgh Sleep Quality Index or Insomnia Severity Index) is needed to determine the effectiveness of a clinic-based exercise program for improving sleep among cancer survivors. Future exercise programs should utilize validated self-report measures, (e.g., Pittsburgh Sleep Quality Index), and/or objective measures of sleep duration and quality (i.e., actigraphy).[37] These measures would allow for more detailed and accurate measurements related to the effects of an exercise program on sleep disturbance.

Conclusion

This study found that cancer survivors currently undergoing or within 6-months of completing active cancer treatment who fall in worse sleep categories, may awaken feeling more rested, and/or improve overall sleep quality following a clinic-based exercise program. Although there was a trend for improving sleep among all participants, findings suggests that those who report worse sleep (ie, "poor" or "very poor") at pre-program may improve sleep to a greater extent following completion of a clinic-based exercise program than those who report better sleep (ie, "good" or "very good"). Overall, this study provides preliminary evidence to suggest that in addition to the well-established benefits of community and clinic-based exercise programs for physical fitness and psychosocial outcomes, there is potential for these programs to aid cancer survivors in improving some aspects of sleep.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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Supplemental Material

Supplemental material for this article is available online.

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