Association of obesity and sleep problems among breast cancer survivors: results from a registry-based survey study

Elena N. Klyushnenkova,

Department of Surgery, University of Maryland, Baltimore, MD 21201, USA. Department of Epidemiology and Public Health, University of Maryland, Baltimore, MD 21201, USA

John D. Sorkin, and

The Baltimore Veterans Affairs Geriatric Research, Education and Clinical Center, Washington, DC 20420, USA. Department of Medicine, Division of Gerontology and Geriatric Medicine, University of Maryland, Baltimore, MD 21201, USA

Lisa Gallicchio

Department of Epidemiology and Public Health, University of Maryland, Baltimore, MD 21201, USA. The Prevention and Research Center, Mercy Medical Center, 227 St. Paul Place, 6th Floor, Baltimore, MD 21202, USA

Lisa Gallicchio: lgallic@mdmercy.com

Abstract

Purpose—Sleep-related complaints are common among breast cancer survivors. However, the risk factors underlying sleep disturbances in this population are not completely understood. Some studies have shown that maintaining normal weight can result in a reduced risk of cancer-related symptoms, including sleep problems; however, data from published studies are not consistent. This study examined the associations between body mass index (BMI) and sleep-related complaints in breast cancer survivors.

Methods—Self-reported survey data from 861 breast cancer survivors at a single institution were analyzed. BMI was calculated based on self-reported weight and height at the time of the survey. Daytime sleepiness was assessed using the Epworth Sleepiness Scale. Average sleep duration was calculated based on the reported hours of sleep on a typical weekday and weekend. Associations between BMI and the sleep outcomes were estimated using multivariable logistic regression.

Results—In adjusted models, BMI was not significantly associated with either excessive daytime sleepiness or “short” sleep pattern (< 6 h) in our sample of breast cancer survivors. Younger age, presence of strong acute pain, and lower level of education were independent risk factors for excessive daytime sleepiness. African American race, presence of strong acute pain, and lower level of education were independent risk factors for being a short sleeper.

Correspondence to: Lisa Gallicchio, lgallic@mdmercy.com.

Ethical statement All human studies have been approved by the appropriate ethics committee and have been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. All persons gave their informed consent prior to their inclusion in the study.

Conflict of interest None of the authors have a financial relationship with the organization that sponsored the research. All authors have full control of all primary data and agree to allow the journal to review the data if requested.

Conclusions—Findings from this study indicate that BMI is not independently associated with sleep-related outcomes among breast cancer survivors. More research is needed to identify cancer survivors who are at increased risk for sleep disturbances as well as the mechanisms that underlie such disturbances.

Keywords

Breast cancer survivors; Body mass index; Epworth Sleepiness Scale; Sleep duration

Introduction

Breast cancer is the most common malignancy diagnosed and the second leading cause of cancer death in American women [1]. As the breast cancer death rate declines due to the advances in early detection and therapies, the number of breast cancer survivors is steadily increasing [1]. Sleep problems are common among cancer patients, particularly in women who have undergone treatment for breast cancer [2]. In a prospective study of 823 cancer patients receiving chemotherapy, breast cancer patients had the highest number of insomnia complaints compared to patients with other cancers [3]. Among 400 breast cancer patients in the study, approximately 80 % had sleep problems, a value that is approximately 2.5 times higher than the 30 % prevalence seen in the general population [3]. Among these patients, 39 % reported some insomnia symptoms, and an additional 46 % reported having a clinical diagnosis of insomnia [3]. Although sleep quality appears to improve after completion of the initial treatment, the prevalence of impaired sleep in long-term cancer survivors remains high. In a prospective study of 962 patients with cancer, approximately 40 % of patients who had insomnia syndrome at baseline kept that status throughout the 18-month follow-up period [4]. In a study of 396 patients who were enrolled prior to surgery and completed monthly assessments for 6 months following surgery, the mean preoperative and 6-month post-operative General Sleep Disturbance Scale (GSDS) score was above the cutoff for clinically meaningful levels of sleep disturbance (> 43) [5]. Disturbed sleep can lead to excessive daytime sleepiness, which may lead to poor performance at work, increased risk of accidents, and other medical disorders. In a case-control study of 1183 cancer survivors (> 2 years since diagnosis) and spouse/friend controls, survivors were approximately 60 % more likely than controls to report excessive daytime sleepiness as measured by the Epworth Sleepiness Scale (ESS) (odds ratio (OR)=1.64, 95 % confidence interval (CI) 1.07, 2.50) [6].

Despite the high prevalence of sleep disturbances among cancer survivors and that sleep disturbance is known to decrease quality of life and shorten survival [7], little is known about risk factors for sleep problems in cancer survivors. In the general population, obesity has been shown to be significantly associated with sleep complaints among women; for example, a 2006 state-based, US-wide random-digit-dialed telephone interview survey of adults aged ≥ 18 years showed that obese women (body mass index (BMI) ≥ 30 kg/m²) had 1.4 times greater odds of reporting sleep complaints compared to women with BMI < 25 kg/m² (OR=1.41, 95 % CI 1.29, 1.53, $p < 0.0001$) [8]. Examining the relationship between obesity and sleep disturbances among breast cancer survivors is warranted, as the prevalence of sleep-related complaints is much higher in this group of individuals than in the general population, and risk factors for sleep disturbances among breast cancer survivors may not be

the same as for the general population. Using data from a prospective cohort study of approximately 1200 women with early stage breast cancer assessed at baseline and 40 months post-diagnosis, Imai et al. [9] found that patients with higher BMI ($>30 \text{ kg/m}^2$) at baseline had 18.9 % greater tendency to nap but experienced less difficulty falling asleep compared to those with BMI $<25 \text{ kg/m}^2$ [9]. In the longitudinal study of 396 patients who underwent surgery for primary breast cancer, higher BMI was associated with higher preoperative levels of daytime sleepiness [5]. Results from other studies on BMI and sleep problems among breast cancer patients or survivors have not consistently shown these relationships. In a cross-sectional study of 2645 women, no correlation was found between BMI and the Women's Health Initiative Insomnia Rating Scale score, which explores napping, difficulty falling asleep, and other aspects of sleeping [2]. A study of African American breast cancer survivors also did not find a statistically significant association between BMI and the Insomnia Severity Index, which is composed of seven items including difficulty falling asleep, difficulty staying asleep, and interferences with daily functioning [10].

Limited data are available on factors that affect daytime sleepiness or sleep duration in long-term breast cancer survivors [6]. The purpose of this study was to examine the relationship between (1) BMI and excessive daytime sleepiness, and (2) BMI and sleep duration. We hypothesized that overweight (defined as BMI $25\text{--}29.9 \text{ kg/m}^2$) and obese (defined as BMI $\geq 30 \text{ kg/m}^2$) breast cancer survivors would be more likely to report sleep-related complaints than survivors of normal and low BMI ($<25 \text{ kg/m}^2$). For this study, a cancer survivor was defined as an individual diagnosed with cancer who was either recently diagnosed and undergoing treatment or many years past her diagnosis and disease-free.

Patients and methods

Study sample

Patients diagnosed with cancer or receiving cancer treatment at Mercy Medical Center (Baltimore, Maryland) between January 1996 and July 2007 were invited to participate in a survey-based study titled "Long-Term Health Outcomes Among Cancer Patients" [6]. The questionnaire was first mailed in June 2008. For those who did not reply, a second mailing was conducted in November 2009. A total of 4401 patients were invited to participate in the study and 1211 returned the questionnaire. Among the patients who completed the survey, 863 had breast cancer. The analyses were limited to the 861 breast cancer patients who had data for at least one of the main outcomes and whose BMI was known.

The self-administered survey included questions regarding sleep habits, pain, treatments received, anthropometric data, education level, physical activity, alcohol and tobacco use, and depressive symptoms. This study was approved by the Institutional Review Board at Mercy Medical Center; consent was implied by return of the questionnaire.

Measures

BMI was calculated based on the respondents' self-reported weight and height at the time of the survey and was classified as $<25 \text{ kg/m}^2$ (normal or underweight), $25\text{--}29.9 \text{ kg/m}^2$

(overweight), or 30 kg/m^2 (obese). Daytime sleepiness was assessed using the ESS [6], an eight-item questionnaire assessing propensity for sleep in eight common situations. A score greater than 10 indicated excessive sleepiness [11]. Patients who provided answers to all eight questions were included. In addition, patients with missing data on just one question for whom the answer would not have made a difference in assignment of ESS category (≤ 10 or >10) were also included.

Self-reported average sleep duration was assessed as described previously [6]. Sleep duration was assessed based on the question “On average, how many hours do you usually sleep at night or during your main sleep period on weekdays or workdays (weekends or your non-work days)?” An average sleep duration score, weighted to account for weekdays and weekend days, was created using the equation: $\text{sleep score} = (\text{hr}_{\text{weekday}} \times 5 + \text{hr}_{\text{weekend}} \times 2) / 7$. To categorize sleep duration, average sleep duration was rounded to the nearest whole number. Because the National Sleep Foundation suggests that adults should sleep 7–9 h per night, the following three categories of sleep duration were created: ≤ 6 h, 7–9 h, and ≥ 10 h per night, referred to as “short,” “normal,” and “long” sleepers, respectively [12]. Since only 16 patients (1.9 %) reported sleep duration ≥ 10 h, analyses for sleep duration were restricted to patients who reported short sleep (≤ 6 h) and normal sleep (7–9 h) patterns.

Age was calculated from the reported date of birth and the date of survey completion. Race was self-classified as White/Caucasian, Black/African American, or Other. Highest level of education was classified as grade school/high school, college/technical school, or graduate school. Marital status was defined as single, married/living with partner, or widowed. Menopausal status was categorized based on the question “Have your menstrual periods stopped permanently?” (Yes, No, or Do not know/Missing). Patients with missing menopausal status data who were ≥ 65 years old were classified as being post-menopausal. Hot flashes status was categorized based on the question “How much during the past 4 weeks have you been bothered by hot flashes?” Possible response choices were “not at all,” “slightly,” “moderately,” “quite a bit,” and “extremely”; for the analyses, the slightly/moderately categories were combined as were the quite a bit/extremely categories. Cancer survivors indicated (Yes/No) whether they received radiation therapy, surgical treatment, chemotherapy, or tamoxifen (Nolvadex) for cancer. Treatment with aromatase inhibitors was categorized as “never,” “prior,” or “current” use; for aromatase inhibitor use, responses were verified through medical record review.

Chronic pain status was determined using the question “Have you ever been told by a doctor or other health professional that you have the following health condition?” (Yes/No). Respondents were classified as having chronic pain if they indicated a history of one or more of the following pain conditions: osteoarthritis, rheumatoid arthritis, fibromyalgia, and gout. To assess the level of acute pain, patients were asked to rate the level of bone, joint, and muscle pain they experienced during the previous 4 weeks, with each rated on a scale of 0 (not at all) to 4 (extremely). A cumulative score was then created based on whether the patient reported no pain at all, experienced slight/moderate pain, or suffered from quite a bit/extreme pain in at least one of these three anatomical sites.

Smoking status was classified as “never,” “former,” or “current.” Alcohol consumption was assessed using data collected on the average number of drinks consumed per day, and categorized as 0, 1–2, or 3–5 drinks per day. Physical activity was assessed based on the reported number of days during the past week on which the participant performed either moderate or vigorous activities, and was classified based on the Center of Disease Control (CDC) recommendations [13]. An adjusted activity score was calculated by the following equation: $\text{Total activity} = (\text{Time}_{\text{moderate activity}} + \text{Time}_{\text{vigorous activity}} \times 2)$. Sufficient physical activity was defined as an adjusted score ≥ 150 min (meeting the CDC guidelines). The presence of depressive symptoms was assessed using the Centers for Epidemiologic Studies – Depression Scale (CESD) [14]. Individuals with a score ≥ 16 were identified as having depressive symptoms.

Statistical analyses

Multivariable logistic regression was used to assess the associations between BMI and the two sleep-related outcomes, (1) an ESS score >10 and (2) being a short sleeper (<6 h). Covariates included in the multivariable models were identified based on preliminary bivariate analyses looking for potential effect modifiers and potential confounders as well as on prior evidence. In the preliminary analyses, two BMI categories were used (<25 vs ≥ 25 kg/m²); all final analyses were performed using the three BMI categories: <25 , 25 – 29.9 , and ≥ 30 kg/m². To identify potential effect modifiers, bivariate logistic regression models examining the relationship between each of the outcome variables and BMI stratified by the potential effect modifier were run. A Breslow-Day test with p value <0.05 indicated a potential effect modifier. To identify potential confounders, bivariate analyses were performed to assess the relationship between a potential confounder and BMI as well as the relation between a potential confounder and each of the outcomes. A covariate was considered as a potential confounder of the relationship between BMI and the outcome sleep variable if it was associated ($p < 0.2$) with both BMI and the outcome. The potential confounder was then tested in a multivariable logistic regression model. If inclusion of the covariate changed the regression coefficient for BMI by more than 10 %, the covariate was considered as a confounder with respect to the association between the sleep variable and BMI. Finally, the fit of the model was assessed using Hosmer and Lemeshow goodness of fit test. A p value >0.1 indicated a good fit. All analyses were performed using SAS v9.3 software (SAS Institute, Cary, NC). A two-tailed $p < 0.05$ was considered as an indication of statistical significance.

Results

Sample characteristics

Among the 861 female breast cancer survivors (Table 1), the median age was 62.0 years (range 33–95, interquartile range (IQR) 54–70), the median BMI was 26.6 kg/m² (range 16.0–79.5, IQR 23.3–30.7), and the median time since the first breast cancer diagnosis was 7 years (range 1–43, IQR 4–10). Among 833 patients with ESS data available, 138 (16.6 %) reported excessive daytime sleepiness symptoms. Among 861 patients with sleep duration data, 282 (32.7 %) were categorized as short sleepers.

Daytime sleepiness

There was no statistically significant association between BMI and ESS in the crude analyses (Table 2, model I). Among covariates considered for the multivariable regression modeling (Table 1), age, prior radiation therapy, presence of acute pain, and education level were identified as potential confounders. In addition, the presence of hot flashes was identified as an effect modifier; however, the interaction terms for hot flashes with BMI were not significant in the multivariable logistic regression model in the presence of the other covariates. Further, the main effects for radiation therapy and hot flashes (which was identified as a confounder after it was eliminated as an effect modifier) were not statistically significant in the multivariable model in the presence of other variables. Thus, only the main effects for age, presence of acute pain, and education level were included into the final model.

After adjustment for age, presence of acute pain, and education level, the association between BMI and ESS remained non-significant (Table 2, model II). Younger age, more severe acute pain, and lower level of education were significantly associated with ESS in the adjusted model (Table 2, model II). After adjustment for BMI and other covariates, an increase in 1 year of age was associated with ~3 % lower odds of having an ESS score >10 (OR=0.97, 95 % CI 0.95, 0.99). Increasing level of acute pain was associated with increased odds of daytime sleepiness ($p<0.001$). Patients who reported strong acute pain had ~3 times greater odds of having an ESS score >10 compared to the patients who experienced no pain (OR=2.94; 95 % CI 1.75, 4.91). Similarly, the odds of daytime sleepiness in patients who attended graduate school were 47 % of the odds for patients with high school or lower level of education (OR=0.47, 95 % CI 0.28, 0.82).

Short sleep pattern

The crude association between BMI categories and a short sleep pattern was statistically significant ($p<0.05$, Table 3, model I). Overweight participants ($25 \leq \text{BMI} < 30 \text{ kg/m}^2$) had ~1.4 times greater odds of being a short sleeper (OR=1.36; 95 % CI 0.96, 1.94) compared to the patients with BMI $< 25 \text{ kg/m}^2$. Obese participants ($\text{BMI} \geq 30 \text{ kg/m}^2$) had ~1.6 times greater odds of being a short sleeper (OR=1.69; 95 % CI 1.18, 2.42) compared to the patients with BMI $< 25 \text{ kg/m}^2$. Although the ORs decreased, the association between BMI and short sleep pattern remained statistically significant when adjusted only for age (Table 3, model II).

Among other covariates considered for the multivariable regression modeling (Table 1), four factors (race, education, menopausal status, and presence of acute pain) were identified as confounders; none of the covariates were effect modifiers. The main effects for these factors as well as age were included in the final multivariable logistic regression model. ORs for BMI were attenuated further and were not statistically significant after adjusting for age, race, presence of acute pain, education level, and menopausal status (Table 3, model III).

African American race, increasing level of acute pain, and lower level of education were significantly associated with a short sleep pattern in the adjusted model (Table 3, model III). Menopausal status did not have a statistically significant effect, but its inclusion improved

the model fit (based on Hosmer-Lemeshow p-value). African American participants had more than two times greater odds of being a short sleeper compared to the Caucasians (OR=2.16; 95 % CI 1.40, 3.35). Patients who reported strong acute pain had ~2 times greater odds of being a short sleeper compared to the patients who experienced no pain (OR=1.99; 95 % CI 1.31, 3.03). In contrast, the level of education was negatively associated with the short sleep pattern. The odds of being a short sleeper in patients who attended graduate school were only 63 % of the odds for patients with high school or lower level of education (OR=0.63, 95 % CI 0.42, 0.96).

Discussion

In this large cohort of women with a history of breast cancer, obesity and overweight were significantly associated with short sleep pattern in the crude analysis. However, after adjusting for age, race, presence of acute pain, education level, and menopausal status, this association was no longer statistically significant. Short sleep pattern was associated with African American race, more severe acute pain, and lower level of education. There was no statistically significant association between BMI and excessive daytime sleepiness. ESS was associated with younger age, more severe acute pain, and lower level of education.

Our data do not support previous reports that showed that obese breast cancer survivors are more likely to suffer from daytime sleepiness (a surrogate measure for obstructive sleep apnea [15]) compared to normal-weight persons. However, the existing evidence is limited and inconsistent. In the study by Imayama et al., breast cancer survivors with BMI ≥ 30 kg/m² had a greater tendency to nap but had less difficulty falling asleep compared to patients with BMI <25 kg/m² [9]. The study by Van Onselen et al. identified higher BMI as a predictor of higher preoperative levels of daytime sleepiness, which could be explained by the potential association between higher BMI and obstructive sleep apnea [5]. In contrast, Bardwell et al. did not detect significant differences in BMI between breast cancer patients that reported significant insomnia symptoms or had insomnia syndrome compared to those who had no sleep problems [2]. These studies used different measures of sleep disturbances than the present study making it difficult to directly compare the results. It may also be that previous studies that showed associations between BMI and daytime sleepiness did not measure important confounding variables that were measured in the present study, such as the presence of acute pain.

Poor physical health and physical symptoms, including pain, are known risk factors for insomnia [2]. Evidence supports an increased prevalence of primary sleep disorders, including sleep apnea, in some rheumatic disease populations, particularly rheumatoid arthritis (RA) [16]. Sleep quality has been shown to be strongly related to subsequent pain intensity in patients with acute low back pain [17]. In our sample of breast cancer patients, the presence of acute muscle, joint, or bone pain was strongly positively associated with both excessive daytime sleepiness and short sleep pattern. Interestingly, the presence of chronic pain (attributed to osteoarthritis, RA, or fibromyalgia) was not significantly associated with sleep-related complaints in our study sample.

In our study, age was significantly negatively associated with excessive daytime sleepiness. These findings are in line with several reports showing that younger cancer patients report more symptoms of insomnia compared to older patients, while in the general population, older age is associated with greater risk of developing insomnia [3]. One possible explanation is that younger patients (especially females) diagnosed with cancer may have a greater level of anticipatory anxiety associated with adjustment to diagnosis compared to older patients [18]. However, this hypothesis requires further testing. In our study sample, we did not find an independent association between age and short sleep duration in either bivariate or multivariable analyses.

Our data also demonstrated a statistically significant association between race and sleep duration. African American patients were more likely to be short sleepers compared to Caucasians controlling for other factors in the logistic regression model (BMI, age, level of acute pain, and level of education). However, we did not find a significant association between race and excessive daytime sleepiness. Shorter sleep duration and continuity and poor sleep quality in African Americans compared with Caucasians in the general population have been reported previously [10]. However, the data on this relationship in breast cancer survivors are limited and inconsistent. In the study by Otte et al., minority breast cancer survivors had approximately three times higher odds of having sleep-wake disturbances compared to Caucasians [19]. In contrast, Palesh et al. found that non-White cancer patients were 44 % less likely to report insomnia than Whites [3]. The differences in the methodology for measures of sleep disturbances as well as variations in defining racial groups make it difficult to directly compare the results of these studies. It is also unclear whether the association between race and sleep problems is caused by differences in the genetic background or is related to socio-economic factors.

In our study, lower education level was a risk factor for both excessive daytime sleepiness and short sleep duration controlling for the BMI, age, race, and the level of acute pain. Although lower education has been identified as a risk factor for insomnia in the general population [2], the exact mechanism underlying this relationship is not clear. We speculate that it is most likely attributed to the differences in the socioeconomic status and behavior characteristics associated with the level of education. Our results, however, are different from the study by Van Onselen et al., in which higher levels of education predicted an increase in sleep disturbances and daytime sleepiness from before to 3 months after surgery, followed by a gradual decline. The authors suggested that this could be due to more distress experienced by women with higher levels of education, which may be related to increased knowledge about their disease and its treatment [5]. The discrepancies between the studies warrant further investigation. One possible explanation is that the patients in the study by Van Onselen et al. were those who were newly diagnosed and undergoing treatment. In contrast, our study examined longer-term cancer survivors, most of whom had completed treatment.

The current study has a number of limitations. A major limitation is that the data are cross-sectional; therefore, any causal inferences about the effect of BMI and other risk factors on the sleep-related complaints cannot be made. Moreover, the direction of the association cannot be established. While the majority of previously published studies explored the effect

of the BMI on sleep [9], some studies suggest that the association may be bi-directional. A longitudinal analysis of the Nurses' Health Study found a positive association between short sleep duration and future weight gain and obesity [9]. Recently, evidence from both laboratory and epidemiologic studies has suggested that insufficient sleep may stimulate overeating and thus play a role in the current epidemic of obesity and diabetes [20]. Another limitation of this study is a self-reported recall of sleep duration. However, similar one- or two-item measures are commonly used in epidemiologic studies and were found to have moderate positive correlation with more objective sleep measures, such as wrist actigraphy [6]. The use of BMI as a self-report may also be a limitation since it does not provide an accurate measure of adiposity. Moreover, errors in self-reporting weight have been found to be directly related to a person's overweight status, especially in women, which may result in the underestimation of BMI [21]. In addition, factors that are known to strongly influence both weight and sleep characteristics (for example, the level of physical activity) [2, 9, 22] were not measured using a validated questionnaire in the survey. The quality of sleep was not assessed in the survey; it may be that the quality, and not quantity, is the aspect of sleep that is most influenced by BMI among breast cancer survivors.

There are, nevertheless, strengths of the current study. The sample was relatively large and diverse in terms of age, race, and other demographic and cancer-related characteristics. Moreover, the sample was derived from a community hospital allowing for a greater generalizability of the results compared to the tertiary referral hospitals [6]. In addition, the study sample was comprised of predominantly long-term cancer survivors, while the majority of the studies assessing sleep quality in breast cancer patients were focused on recently diagnosed patients undergoing anti-cancer therapies [2, 18, 23]. Finally, excessive daytime sleepiness in our study was assessed using a validated and commonly used measure, the ESS, while the majority of other studies employed one- or two-item assessments incorporated into the instruments designed to measure other sleep characteristics. For example, the study by Bardwell et al. included only two items assessing daytime sleepiness [2], and the studies by Sanford et al. and Otte et al. utilized the Pittsburgh Sleep Quality Index (PSQI) scale that contains only one item for examining daytime sleep dysfunction [18, 19].

In summary, the results of this study indicate that BMI is not independently associated with excessive daytime sleepiness or short sleep duration among breast cancer survivors. Future studies are needed to address the relationship between weight and sleep among breast cancer survivors, including a focus on certain sub-groups of patients (for example, morbidly obese patients with BMI ≥ 40 kg/m²), more accurate measurements for sleep duration and sleep quality, and longitudinal studies that can establish a causal effect and a direction of the relationship between these factors.

Acknowledgments

We are thankful to Lee J. Brooks, M.D., for critically reading the manuscript and providing insightful comments.

Grant support The work described in this paper was supported by The Baltimore Veterans Affairs Geriatric Research, Education and Clinical Center, NIA: 5P30AG028747, and NIDDK 5P30DK072488. Dr. Lisa Gallicchio is supported, in part, by a career catalyst grant from Susan G. Komen for the Cure. Dr. Elena N. Klyushnenkova is a recipient of the Paul Calabresi fellowship in Clinical Oncology.

References

1. Siegel R, Naishadham D, Jemal A. Cancer statistics, 2013. *CA Cancer J Clin*. 2013; 63:11–30.10.3322/caac.21166 [PubMed: 23335087]
2. Bardwell WA, Profant J, Casden DR, Dimsdale JE, Ancoli-Israel S, Natarajan L, Rock CL, Pierce JP. The relative importance of specific risk factors for insomnia in women treated for early-stage breast cancer. *Psychooncology*. 2008; 17:9–18. [PubMed: 17428006]
3. Palesh OG, Roscoe JA, Mustian KM, Roth T, Savard J, Ancoli-Israel S, Heckler C, Purnell JQ, Janelins MC, Morrow GR. Prevalence, demographics, and psychological associations of sleep disruption in patients with cancer: University of Rochester Cancer Center-Community Clinical Oncology Program. *J Clin Oncol*. 2010; 28:292–298.10.1200/JCO.2009.22.5011 [PubMed: 19933917]
4. Savard J, Ivers H, Villa J, Caplette-Gingras A, Morin CM. Natural course of insomnia comorbid with cancer: an 18-month longitudinal study. *J Clin Oncol*. 2011; 29:3580–3586.10.1200/JCO.2010.33.2247 [PubMed: 21825267]
5. Van Onselen C, Paul SM, Lee K, Dunn L, Aouizerat BE, West C, Dodd M, Cooper B, Miaskowski C. Trajectories of sleep disturbance and daytime sleepiness in women before and after surgery for breast cancer. *J Pain Symptom Manage*. 2013; 45:244–260.10.1016/j.jpainsymman.2012.02.020 [PubMed: 22921179]
6. Forsythe LP, Helzlsouer KJ, MacDonald R, Gallicchio L. Daytime sleepiness and sleep duration in long-term cancer survivors and non-cancer controls: results from a registry-based survey study. *Support Care Cancer*. 2012; 20:2425–2432.10.1007/s00520-011-1358-7 [PubMed: 22218738]
7. Reeves MM, Terranova CO, Eakin EG, Demark-Wahnefried W. Weight loss intervention trials in women with breast cancer: a systematic review. *Obes Rev*. 2014; 15:749–768.10.1111/obr.12190 [PubMed: 24891269]
8. Grandner MA, Patel NP, Perlis ML, Gehrman PR, Xie D, Sha D, Pigeon WR, Teff K, Weaver T, Gooneratne NS. Obesity, diabetes, and exercise associated with sleep-related complaints in the American population. *Z Gesundh Wiss*. 2011; 19:463–474. [PubMed: 22791935]
9. Imayama I, Alfano CM, Neuhouser ML, George SM, Wilder SA, Baumgartner RN, Baumgartner KB, Bernstein L, Wang CY, Duggan C, Ballard-Barbash R, McTiernan A. Weight, inflammation, cancer-related symptoms and health related quality of life among breast cancer survivors. *Breast Cancer Res Treat*. 2013; 140:159–176. [PubMed: 23797178]
10. Taylor TR, Huntley ED, Makambi K, Sween J, Adams-Campbell LL, Frederick W, Mellman TA. Understanding sleep disturbances in African-American breast cancer survivors: a pilot study. *Psychooncology*. 2011; 21:896–902.10.1002/pon.2000 [PubMed: 21648016]
11. Johns MW. Daytime sleepiness, snoring, and obstructive sleep apnea. The Epworth Sleepiness Scale. *Chest*. 1993; 103:30–36. [PubMed: 8417909]
12. Ford ES, Li C, Wheaton AG, Chapman DP, Perry GS, Croft JB. Sleep duration and body mass index and waist circumference among U.S. adults. *Obesity (Silver Spring)*. 2014; 22:598–607.10.1002/oby.20558 [PubMed: 23836704]
13. How much physical activity do adults need?. 2014. <http://www.cdc.gov/physicalactivity/everyone/guidelines/adults>. Updated 3-3-2014
14. CESD-R: The Center for Epidemiologic Studies Depression Scale Revised. 2013. <http://cesd-r.com/cesdr>. Updated 1-12-2013
15. Rosenthal LD, Dolan DC. The Epworth sleepiness scale in the identification of obstructive sleep apnea. *J Nerv Ment Dis*. 2008; 196:429–431.10.1097/NMD.0b013e31816ff3bf [PubMed: 18477888]
16. Taylor-Gjevrev RM, Nair BV, Gjevrev JA. Obstructive sleep apnoea in relation to rheumatic disease. *Rheumatology (Oxford)*. 2013; 52:15–21.10.1093/rheumatology/kes210 [PubMed: 22923759]
17. Alsaadi SM, McAuley JH, Hush JM, Lo S, Lin CW, Williams CM, Maher CG. Poor sleep quality is strongly associated with subsequent pain intensity in patients with acute low back pain. *Arthritis Rheum*. 2014; 66:1388–1394.10.1002/art.38329

18. Sanford SD, Wagner LI, Beaumont JL, Butt Z, Sweet JJ, Cella D. Longitudinal prospective assessment of sleep quality: before, during, and after adjuvant chemotherapy for breast cancer. *Support Care Cancer*. 2013; 21:959–967.10.1007/s00520-012-1612-7 [PubMed: 23052918]
19. Otte JL, Carpenter JS, Russell KM, Bigatti S, Champion VL. Prevalence, severity, and correlates of sleep-wake disturbances in long-term breast cancer survivors. *J Pain Symptom Manage*. 2010; 39:535–547.10.1016/j.jpainsymman.2009.07.004 [PubMed: 20083371]
20. Hanlon EC, Van CE. Quantification of sleep behavior and of its impact on the cross-talk between the brain and peripheral metabolism. *Proc Natl Acad Sci U S A*. 2011; 108(Suppl 3):15609–15616.10.1073/pnas.1101338108 [PubMed: 21852576]
21. Rowland ML. Self-reported weight and height. *Am J Clin Nutr*. 1990; 52:1125–1133. [PubMed: 2239790]
22. Alfano CM, Lichstein KL, Vander Wal GS, Smith AW, Reeve BB, McTiernan A, Bernstein L, Baumgartner KB, Ballard-Barbash R. Sleep duration change across breast cancer survivorship: associations with symptoms and health-related quality of life. *Breast Cancer Res Treat*. 2011; 130:243–254.10.1007/s10549-011-1530-2 [PubMed: 21567239]
23. Palesh O, Aldridge-Gerry A, Ulusakarya A, Ortiz-Tudela E, Capuron L, Innominato PF. Sleep disruption in breast cancer patients and survivors. *J Natl Compr Canc Netw*. 2013; 11:1523–1530. [PubMed: 24335687]

Table 1

Socio-demographic and health-related characteristics (N= 861)

Variable	Categories	Number	Percent
Age (years)	33–49	111	12.9
	50–59	243	28.2
	60–69	291	33.8
	70–95	216	25.1
Race	Caucasian/White	716	83.2
	African American/Black	119	13.8
	Other	26	3.0
Education	High school graduate or less	273	31.9
	Some college or technical school	370	43.2
	Graduate school	213	24.9
Marital status	Single	240	28.0
	Married/cohabitating	477	55.6
	Widowed	141	16.4
BMI (kg/m ²)	<25	341	39.6
	25–29.9	273	31.7
	30	247	28.7
Epworth sleepiness score (ESS)	10	695	83.4
	>10	138	16.6
Average sleep duration ^a	“Short” (< 6 h)	282	32.7
	“Normal” (7–9 h)	563	65.4
	“Long” (> 10 h)	16	1.9
Sleep medication use	Never	604	70.7
	Sometimes (< 4 days/month)	96	11.3
	Often (≥ 5 days/month)	154	18.0
Post-menopausal	No	60	7.0
	Yes	794	92.2
	Do not know/missing	7	0.8
Hot flashes	Not at all	441	51.7
	Slightly/moderately	264	31.0
	Quite a bit/extreme	148	17.3
Years since breast cancer diagnosis	>5	617	71.7
	2–5	226	26.2
	<2	18	2.1
Treatment with radiation	No	331	38.4
	Yes	530	61.6
Treatment with chemotherapy	No	487	56.6
	Yes	374	43.4

Variable	Categories	Number	Percent
Treatment with tamoxifen	No	514	59.9
	Yes	344	40.1
Treatment with Aromatase inhibitors	Never	535	62.4
	Prior	110	12.8
	Current	212	24.8
Pain, acute ^b	Not at all	269	31.7
	Slightly/moderately	387	45.6
	Quite a bit/extremely	192	22.6
Pain, chronic ^c	No	585	68.0
	Yes	275	32.0
Depressive symptoms ^d	No	658	80.8
	Yes	156	19.2
Physical activity ^e	Sufficient	413	48.9
	Insufficient	432	51.1
Cigarette smoking status	Never	431	50.7
	Former	360	42.4
	Current	59	6.9
Alcohol consumption	None	276	32.8
	1–2 drinks per day	509	60.4
	3–5 drinks per day	57	6.8

^aWeighted to account for weekdays and weekend days using the following equation: $\text{sleep score} = (\text{hrweekday} \times 5 + \text{hrweekend} \times 2) / 7$

^bAcute pain: presence of one or more of following during past 4 weeks: headaches, joint, bone, or muscle pain

^cA history of one or more of the following: osteoarthritis, rheumatoid arthritis, fibromyalgia, or gout

^dA score of 16 or greater on the Centers for Epidemiologic Studies – Depression Scale (CESD)

^eBased on CDC recommendations: at least 150 min/week of moderate activity, 75 min/week of vigorous activity, or an equivalent amount of both types of activity [13]. $\text{Total activity} = \text{Time}_{\text{moderate activity}} + \text{Time}_{\text{vigorous activity}} \times 2$

Table 2

Logistic regression models: association between BMI and excessive daytime sleepiness (Epworth Sleepiness Scale >10) (N=816)

Model	Model <i>p</i> value ^d	Covariates	OR	(95 % CI)	Covariate <i>p</i> value ^b
I	0.08	BMI (kg/m ²)	1.0 (ref.)		0.08
		<25			
		25–29.9	1.42	(0.91, 2.23)	
		30	1.66	(1.06, 2.62)	
II ^c	<0.001	BMI (kg/m ²)	1.0 (ref.)		0.21
		<25			
		25–29.9	1.44		
		30	1.47	(0.91, 2.37)	
		Age (years)	0.97	(0.95, 0.99)	<0.001
		Acute pain	1.0 (ref.)		<0.0001
		None			
		Slight	1.40	(0.86, 2.29)	
		Strong	2.94	(1.75, 4.91)	
		Education	1.0 (ref.)		<0.01
		High school			
		College	0.57	(0.37, 0.88)	
		Graduate	0.47	(0.28, 0.82)	

OR odds ratio, *CI* confidence interval, *BMI* body mass index^a Likelihood ratio test^b Type 3 analysis of effects^c Hosmer-Lemeshow goodness of fit test, *p*=0.66

Logistic regression models: association between BMI and “short” sleep pattern (average sleep duration 9 h) ($N=810$)**Table 3**

Model	Model p value ^d	Covariates	OR	(95 % CI)	Covariate p value ^b
I	<0.05	BMI (kg/m ²)	1.0 (ref.)		<0.05
		<25			
		25–29.9	1.36	(0.96, 1.94)	
		30	1.69	(1.18, 2.42)	
II ^c	<0.05	BMI (kg/m ²)	1.0 (ref.)		<0.05
		<25			
		25–29.9	1.33	(0.93, 1.90)	
		30	1.66	(1.16, 2.38)	
		Age (years)	1.01	(0.996, 1.02)	0.16
III ^d	<0.001	BMI (kg/m ²)	1.0 (ref.)		0.61
		<25			
		25–29.9	1.17	(0.81, 1.69)	
		30	1.19	(0.80, 1.75)	
		Age (years)	(0.99, 1.02)	0.90	
		Race	1.0 (ref.)		<0.01
		White			
		Black	2.16	(1.40, 3.35)	
		Other	1.12	(0.47, 2.67)	
		Acute pain	1.0 (ref.)		<0.01
		None			
		Slight	1.15	(0.80, 1.65)	
		Strong	1.99	(1.31, 3.03)	
		Education	1.0 (ref.)		<0.05
		High school			
		College		(0.45, 0.91)	
		Graduate	0.63	(0.42, 0.96)	
		Post-menopausal	1.0 (ref.)		0.18
		No			
		Yes	2.05	(0.97, 4.38)	
		Not known	2.25	(0.37, 13.70)	

OR odds ratio, CI confidence interval, BMI body mass index

^a Likelihood ratio test^b Type 3 analysis of effects^c Hosmer-Lemeshow goodness of fit test, $p=0.0074$

Hosmer-Lemeshow goodness of fit test, $p=0.6797$

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript