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Using a Wearable Device and Patient Reported Outcome to Evaluate the Influence of Sleep on Quality of Life Among Breast and Prostate Cancer Patients

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Abstract:

Few studies have used the combination of subjective and objective measures to investigate sleep problems as a primary outcome of concern in cancer patients. This study highlights the influence of sleep quality and duration on quality of life among breast and prostate cancer patients. Thirty-one participants were included in this study. Sleep quality and duration was assessed using a wearable actigraphy device and Pittsburgh Sleep Quality Index questionnaire . Quality of life was measured by European-Organization-For-Research-And-Treatment-Of-Cancer Quality of Life Questionnaire . t-test statistics further investigates the influence of sleep quality and duration with quality of life in participants. Results implied that those breast cancer patients who were poor sleepers and short sleepers showed greater deficits in areas of quality of life. In contrast, those prostate cancer patients who were long sleepers and good sleepers displayed poorer quality of life using actigraphy.

Keywords:

quality of life , sleep quality, cancer

Introduction

Poor sleep quality has been commonly reported among cancer patients [1] and also relates to a reduced quality of life (QoL) [2]. QoL is an essential outcome indicator of cancer patient management and care due to the deteriorating existence and treatment of the disease [3]. More than 50 percent of breast cancer (BC) patients have disrupted sleep along with a negative correlation with health- related quality of life [4]. Based on the kind of treatment received, prostate cancer (PC) survivors suffer with sleep problems and also a decline in the health related QoL [5]. A study showed that PC patients indicated major sleep disruption as poor sleepers [6]. Most studies until date have concentrated on adverse physical effects of the disease and its treatment, with far less focus on sleep disruption [7].

The most widely used sleep quality assessment questionnaire is the Pittsburgh Sleep Quality Index (PSQI) [8]. It can distinguish between "good" and "poor" sleepers; however, may not identify clinically significant changes in sleep quality arising due to age, illness, or treatments. Sleep problems can also be assessed objectively by techniques such as polysomnography and actigraphy [9]. A wrist worn actigraphy device is considered a more practical technique for assessing long-term sleep patterns as they are cheaper, light-weight, and contain motion accelerometers [10]. Few studies have already tested these devices for sleep analysis [11] [12]. The European-Organization-For-Research-And-Treatment-Of-Cancer Quality of Life Questionnaire (EORTCQLQ-C30)[9] is a commonly used, objective and valid indicator of the quality of life of cancer survivors[13]. Our study aimed to determine the influence of sleep quality and duration on quality of life in breast and prostate cancer patients. The study was conducted by collecting and statistically analyzing patients' self-reported questionnaires and actigraphy data.

Methods

Study settings and participants

Forty participants were recruited from two cancer centers in Taipei, Taiwan from April to June 2018. Only 31 patients' data were usable due to a technical malfunction in 9 of the devices. This study included 16 BC and 15 PC patients if (1) ≥20 years or older; (2) diagnosed with either breast or prostate cancer; (3) receiving evaluation, treatment, or follow-up care at Wan Fang Hospital or Taipei Medical University Hospital at the time of enrollment; (4) understand Mandarin Chinese; (5) gives informed consent to participate in the study. Patients were excluded if (1) they could not understand the intent of the study; (2) clinician believed that the patient was not fit to participate. The Berg Balance Scale test was done to ensure balance abilities, and Mandarin Chinese version of the Mini-mental State Evaluation (CMMSE) was conducted to ensure the normality of cognitive levels.

Data collection

Ethical approval for the study was obtained from the Taipei Medical University-Joint Institutional Review Board under approval number N201803041. The patient was included in the study, after he/ she fulfilled the eligibility criteria and had signed the patient consent form. The patients were asked to wear the wearable actigraphy device, continuously during day and night times for a period of 7 days. Participants were asked to fill the Chinese version of EORTC and PSQI questionnaire at the end of 7 days. Objective data was collected using the actigraphy device and subjective data was collected using questionnaires EORTC and PSQI.

Actigraphy

Actigraphy (designed in-house by K&Y Labs, Taipei, Taiwan) had previously been used at Yang-Ming University Hospital and Taipei City Hospital and validated by Kuo et al. [14]. The actigraphy (ACT) device is a compact unit, measuring 44 * 19 * 8 mm and weighing approximately 7 g. It has a lithium ion battery of 80mAh capacity to last up to 14 days. It is worn on the non-dominant wrist of the user and collects data that is sent via Bluetooth to a mobile device application. These data are then uploaded to the cloud and stored there, where they can be accessed for evaluation. Every second, it gathers 3-dimensional data and transforms it into 10-second movement statistics. Milligravity, angle, and spin variations are the measurements from the ACT. The total amount of time that the patient was asleep was named the total sleeping time (TST). The 'sleep efficiency' was TST divided by the total time spent in bed. In order to differentiate between poor and good sleepers, median of total sleep efficiency (ACT SE) was considered as a cut-off, where, greater than or equal the median among all participants was described as poor sleepers. To differentiate between long and short sleeper, median of TST was considered as a cut-off, where, greater than or equal the median of sleeping hours among all participants (ACT TST) was described as long sleepers. Median is considered a good method to determine an optimal cutoff points [15]. Gorny et al. had proposed an algorithm that was used to detect sleep and wakefulness [16].

PSQI (Pittsburgh Sleep Quality Index)

The Pittsburgh Sleep Quality Index (PSQI) measures the subjective sleep quality over the past month. Buysse et al. created it in 1988 [8] and the Chinese version of the questionnaire has also been validated [17] . This is a 19-item self-report questionnaire composed of seven subscales: sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, sleep medication use, and sleep dysfunction. For scoring of each individual components of 19 items, the ranges observed were 0-3. The seven component results are then accumulated to give a global sleep quality score of 0-21; higher scores imply worse sleep quality.

PSQI distinguishes between poor sleepers (global PSQI $\geq$ 5) from good sleepers (PSQI < 5) [8]. Global PSQI cut-off score discriminated good and poor sleep in breast cancer survivors[18] and thus was used in our study . A number of actual sleeping hours per night equal to or greater than the median of sleeping hours among all participants (PSQI sleep hours) was considered as long sleepers[19].

EORTC (European Organization for Cancer Research and Treatment)

European Organization for Cancer Research and Treatment (EORTC) was implemented in 1986 for assessing the quality of life of [13]. EORTC QLQ-C30 was also validated in the Taiwan Chinese version among lung cancer patients [20]. The scale includes nine multi-item scales: five functional scales (physical, role, cognitive, emotional and social); three symptom scales (fatigue, pain and nausea and vomiting); and a global health and quality of life scale [13]. Additional symptoms commonly reported by cancer patients (dyspnoea, loss of appetite, insomnia, constipation and diarrhea) and perceived financial impact of the disease are also assessed using single items. Each of the scales and single-item measurements vary in value from 0 to 100. A high score for a functional scale signifies a high / healthy level of functioning, a high score for a global health status / QoL signifies a high QoL, but a high score for a symptom scale / item signifies a high level of symptomatology / problem.

Data analysis

Statistical software used in this research was SPSS vers. 21 (SPSS, Chicago, II, USA). The data was analysed using t-test. Missing data was resolved by imputation. Significance level was set at $p < 0.05$, two-sided.

Results

Figure 1. demontrates the proportion of different age groups based on sleep quality and sleep duration using PSQI questionnaire among breast and prostate cancer patients.

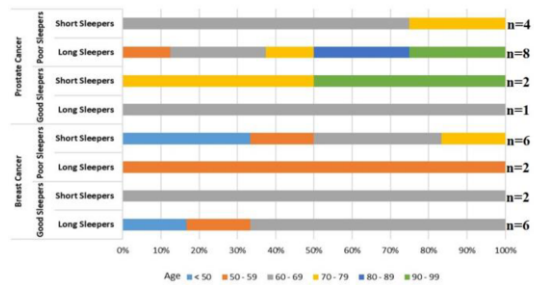

Figure 1. Age-wise proportion of participants based on sleep quality and sleep duration using PSQI

Sleep Quality and Quality of Life

Table 1. gives us influence of QOL subscales in good and poor sleepers among breast and prostate cancer patients. For BC patients , the 'p' values were significant for 'global health status/qol', 'emotional functioning', 'dyspnoea', 'constipation' and 'financial difficulties' for sleep quality assessed by using PSQI questionnaire while constipation was found to be significant using both PSQI and actigraphy measures. Both measurements indicated statistical significance for constipation among breast cancer patients with the good sleep in comparison to poor sleepers.

Table 1. Influence of sleep on EORTC QLQ-C30 sub-scale scores in good and poor sleepers among breast and prostate cancer patients

Subscales of QoL	**Pittsburgh Sleep Quality Index (PSQI)**					**Actigraphy (ACT)**				
	Good Sleepers		**Poor Sleepers**			**Good Sleepers**		**Poor Sleepers**		
BC (PSQI≥5; ACT<71.45)**	**n=8**		**n=8**			**n=10**		**n=6**		
PC (PSQI≥5; ACT<62.26)**	**n= 3**		**n =12**			**n=8**		**n=7**		
	Mean	**SD**	**Mean**	**SD**	**P-value**	**Mean**	**SD**	**Mean**	**SD**	**P-value**
Breast cancer										
Global Health Status/QoL	68.75	112.40	67.71	25.37	**0.015***	-	-	-	-	-
Emotional Functioning	94.79	8.84	82.29	24.98	**0.016***	-	-	-	-	-
Dyspnoea	0.00	0.00	20.83	35.36	**0.004***	-	-	-	-	-
Constipation	0.00	0.00	8.33	15.43	**0.000***	6.67	14.06	0.00	0.00	**0.009***
Financial Difficulties	4.17	11.79	29.17	45.21	**0.005***	-	-	-	-	-
Prostate cancer										
Constipation	0.00	0.00	13.89	17.16	**0.000***	-	-	-	-	-
Nausea and Vomiting	-	-	-	-	-	2.08	5.89	0.00	0.00	**0.049***
Appetite Loss	-	-	-	-	-	16.67	17.82	0.00	0.00	**0.000***
Diarrhea	-	-	-	-	-	4.17	11.7	0.00	0.00	**0.049***

*Difference between good and poor sleepers significant at the 5%, level respectively; PC-prostate cancer; BC- breast cancer
**Fulfilling this criterion refers to poor sleepers

For PC patients, the p values were significant for 'constipation' assessed by using PSQI questionnaire, while 'nausea and vomiting', 'appetite loss' and 'diarrhea' were found to be significant by using actigraphy. The actigraphy analysis indicated that even PC patients with good sleep experienced more symptoms or poor QoL in certain components of quality of life in comparison to poor sleepers.

Sleep Duration and Quality of Life

Table 2. gives us influence of QoL subscales in long sleepers and short sleepers among breast and prostate cancer patients. For breast cancer patients, the p values were significant for 'nausea and vomiting', 'constipation', and 'diarrhea' assessed by PSQI questionnaire, while 'emotional functioning', 'dyspnoea', 'appetite loss', 'diarrhea' and 'financial difficulties' were found to be significant by using actigraphy. Both PSQI questionnaire and actigraphy indicated that short sleepers experienced more symptoms or poor QoL in certain components of health-related quality of life in comparison to poor sleepers. For prostate cancer patients, the p values were significant for nausea and 'vomitting', 'insomnia', 'constipation' and 'diarrhea' assessed by using PSQI questionnaire, while 'nausea and vomitting', 'appetite loss', 'diarrhea' and 'financial difficulties' were significant by using actigraphy. Components of QoL such as 'nausea and vomitting', and 'diarrhea' were found to be significant using both PSQI and actigraphy measures.

Discussion

This research investigated the influence of sleep on the functional and symptom scales of quality of life (QoL) among breast cancer and prostate cancer patients.

In this study, sleep quality and duration measured using actigraphy device were found to have more influence on the symptoms subscale of QoL. Not all of these had an influence on QoL when subjectively measured using PSQI. PSQI measured sleep quality showed an influence on the QoL subscales namely, global health status, emotional functioning, dyspnea, constipation and financial difficulties among breast cancer patients. This is in contrast to a study where sleep problems were found to be associated with all dimensions of QoL[9].

Actigraphy measured sleep duration showed that breast cancer patients who were short sleepers significantly suffered from physical symptoms like breathing discomfort (dyspnea), diarrhea, appetite loss as well as emotional functioning. This was similar to a study by Liu et al. that showed significant relationship between low physical health related-QOL and poor objective sleep in patients with shorter sleep duration[21].

Table 2. Influence of sleep on EORTC QLQ-C30 sub-scale scores in long sleepers and short sleepers among breast and prostate cancer patients

Subscales of QoL	**Pittsburgh Sleep Quality Index (PSQI)**					**Actigraphy (ACT)**				
	Long Sleepers		**Short Sleepers**			**Long Sleepers**		**Short Sleepers**		
BC (PSQI<7.15; ACT<5.97)**	**n=8**		**n=8**			**n=9**		**n=7**		
PC (PSQI<7.5; ACT<4.6)**	**n= 9**		**n =6**			**n=7**		**n=8**		
	Mean	**SD**	**Mean**	**SD**	**P-value**	**Mean**	**SD**	**Mean**	**SD**	**P-value**
Breast cancer										
Nausea and Vomiting	12.50	24.80	4.17	7.72	**0.035***	-	-	-	-	-
Constipation	0.00	0.00	8.33	15.43	**0.000**	-	-	-	-	-
Diarrhea	4.17	11.79	20.83	16.67	**0.016***	3.71	11.11	23.81	25.19	**0.019***
Emotional Functioning	-	-	-	-	-	94.44	8.33	80.95	26.66	**0.004***
Dyspnoea	-	-	-	-	-	3.71	11.11	19.05	37.79	**0.029***
Appetite Loss	-	-	-	-	-	3.70	11.11	14.29	26.24	**0.030***
Financial Difficulties	-	-	-	-	-	3.71	11.11	33.33	47.14	**0.002***
Prostate cancer										
Nausea and Vomiting	12.50	24.80	4.17	7.72	**0.035***	2.38	6.29	2.38	0.00	**0.023***
Insomnia	25.00	23.57	4.17	11.79	**0.050***	-	-	-	-	-
Constipation	0.00	0.00	8.33	15.43	**0.000***	-	-	-	-	-
Diarrhea	4.17	11.79	20.83	24.80	**0.016***	4.76	12.59	0.00	0.00	**0.023***
Appetite Loss	-	-	-	-	-	19.05	17.82	0.00	0.00	**0.000***
Financial Difficulties	-	-	-	-	-	14.29	26.23	4.17	11.79	**0.048***

*Difference between long and short sleepers significant at the 5%, level respectively**;** PC-prostate cancer; BC- breast cancer
**Fulfilling this criterion refers to short sleepers

For prostate cancer patients, the sleep quality measured using actigraphy device reported an influence on nausea and vomiting, appetite loss and diarrhea, while PSQI measurements determined the influence only for constipation. Sleep duration as measured by the actigraphy device influenced nausea, vomiting, appetite loss, diarrhea and financial difficulties. On the other hand, PSQI measure showed an influence of sleep duration for the QoL subscales of nausea and vomiting, insomnia, constipation and diarrhea. Overall, good sleepers and long sleepers assessed using actigraphy showed poorer quality of life. It's possible that prostate cancer survivors were still at risk of experiencing insomnia symptoms prior to treatment, or that they had sleeping issues before their diagnosis. According to one study [22], half of prostate cancer survivors who met the requirements for chronic insomnia syndrome had sleep problems before their cancer diagnosis.

Our study indicates that PSQI could be a better measure for sleep quality while actigraphy device could be better measure for sleep duration, while relating to the QoL subscales. For prostate cancer, actigraphy measures were more useful to relate sleep quality to the QoL, while combined measures were useful when relating sleep duration with QoL. Thus, our study suggests that both, subjective and objective measures are useful to determine the influence of sleep on QoL of cancer patients. As sleep disruption is prevalent among breast and prostate cancer patients, early evaluation and tailored intervention to improve sleep quality becomes necessary for better quality of life**.**

The strengths of the current study include objective as well as subjective measurements of sleep among cancer patients. This study is one of its kind as there has been limited research assessing the influence of QoL domains in sleep quality and sleep duration among prostate cancer patients. In addition, there has been limited or no study so far on quality of sleep in prostate cancer in Taiwan.

Although our study had interesting findings, there were some limitations. The low number of participants increased the possibility of missing data. Some devices malfunctioned which further led to incoherent data. Also, the device was used for a short duration. A longer duration could have ensured efficient data collection and improvement in the observed results. Lastly, a participant who was awake but not moving could have been wrongly detected as sleeping by the actigraphy device. Future studies could include a large number of participants for a longer duration.

Conclusions

This study findings indicates the influence of sleep (duration and quality) on QoL. Poor sleep has lower the quality of life among breast and prostate cancer patients Thus, this study suggests a need to assess sleep disturbance and appropriate treatment plan for better cancer patient management.

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