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Original Article

# Factor structure of the Chinese version of the Pittsburgh Sleep Quality Index in breast cancer patients

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ABSTRACT

*Objective:* The Pittsburgh Sleep Quality Index (PSQI) is used extensively to assess subjective sleep disturbance in cancer populations. Although previous studies on the PSQI suggested a better fit for a two- or three-factor model than the original one-factor model, none accounted for the indicator-specific effect between sleep duration and habitual sleep efficiency. This study evaluated the PSQI's dimensionality and its convergent validity with cancer-related psychopathological states in female breast cancer patients.

*Methods:* The PSQI was administered to 197 women with breast cancer. Confirmatory factor analysis examined the relative fit of one-, two-, three-, and revised one-factor models. The PSQI's convergent validity was evaluated via bivariate correlations between the PSQI factor scores and measures of anxiety, depression, fatigue, pain, and quality of life.

*Results:* Confirmatory factor analyses showed an adequate fit for the revised one-factor model with the PSQI global score as the overall index of sleep disturbance. Although the revised one- and two-factor solutions showed statistically equivalent model fits, the one-factor model was selected due to utility reasons. The severity of sleep dysfunction that the PSQI global score represented was positively correlated with anxiety, depression, fatigue, pain, and reduced quality of life.

*Conclusion:* The results support the PSQI's original unidimensional structure, demonstrating that the PSQI global score is a valid and parsimonious measure for assessing and screening sleep dysfunction in cancer patients.



## 1. Introduction

Sleep disturbance is prevalent in cancer patients, with common symptoms including long latency periods before falling asleep, frequent nocturnal awakenings, and impaired sleep quality [1]. Sleep deprivation has been associated with decreased physical and mental well-being such as greater fatigue, pain, anxiety, depression, and reduced quality of life [2–4]. The Pittsburgh Sleep Quality Index (PSQI) is a widely used 19-item self-report instrument that assesses sleep disturbances [5]. The PSQI determines respondents' usual bed and wake times, the number of actual hours slept, time taken to fall asleep, and asks other Likert-type questions. These items are then used to assess seven clinical components of sleep difficulty: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleep medication, and daytime dysfunction.

Validation studies have shown that the PDQI has adequate psychometric properties in terms of reliability, construct validity, and concurrent validity in clinical populations such as depressed patients [6,7], insomniacs [8], and cancer patients [9–11]. According to the developers of the PSQI [5], the scale allows researchers to determine sleep dysfunction over a one-month period via the computation of a simple, global score that reflects the severity of sleep disturbance. Although the developers' proposed a unidimensional structure, studies assessing its factorial validity have had inconsistent results. Some validation studies have indicated that the PSQI might be better represented by a two- [9,10,12] or three-factor [6,13,14] model, rather than the original one-factor structure.

Given the broad use of the PSQI as a sleep measure in clinical trials and research among cancer patients, uncovering its underlying factor structure is essential for a precise assessment of sleep disturbance. Although most validation studies favor a multidimensional scoring system over a single global score, there is no consensus

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about the best representation of the factor structure. Interestingly, the intrinsic overlapping natures of the components of sleep duration and habitual sleep efficiency have largely been overlooked in these studies. Sleep duration refers to the number of actual hours slept, whereas habitual sleep efficiency indicates the ratio of the number of actual hours slept to the total number of hours spent in bed. As both components are derived from the same item, the two components are expected to show an indicator-specific effect, in which they will share a specific variance and will be more highly correlated with each other than with other indicators [15]. To our knowledge, existing psychometric studies on the PSQI have yet to adjust for this indicator-specific effect in their analyses. Failure to take this effect into account might produce imprecise representations of the underlying factor structure [16].

Our objective was to investigate the factor structure of the PSQI using data from a sample of breast cancer patients over a three-week interval. Three previously reported factor structures – the one-, two-, and three-factor models – were evaluated through a series of confirmatory factor analyses (CFAs). In this study, an additional one-factor model with a residual covariance between sleep duration and habitual sleep efficiency was specified. The factor models were compared according to their relative model fit [17]. It would be theoretically meaningful to evaluate whether PSQI factor scores offer an incremental value beyond the global score. The convergent validity of the PSQI factor models was examined by exploring the associations between the PSQI factor scores and observed measures on cancer-related psychopathological states, namely, anxiety, depression, fatigue, pain, and quality of life. A moderate degree of association between PSQI factor scores and the psychopathological states was expected.

## 2. Methods

### 2.1. Participants

This study evaluated the psychometric properties of the PSQI through a secondary data analysis of a clinical trial of dance/movement therapy for cancer treatment-related symptoms. Participants of this study were recruited from three community cancer support centres in Hong Kong using a prospective and consecutive sampling design. Breast cancer patients, who were able to understand, read, and write Chinese and were in Stage I, II or III of the disease, were identified and invited to join the study via mail. The invitation letter clearly stated the purpose and procedures of the study and the potential benefits and risks. A total of 197 female breast cancer patients participated in the study and attended a briefing session where details of the study were delivered and informed consent and baseline data were solicited. The participants were involved in the dance/movement programme, which was a form of palliative treatment for cancer treatment-related symptoms. The participants had a mean age of 49.4 years (SD: 8.0) and an average time since diagnosis of 23.2 months (SD: 7.5). More than half of the sample were married (64.5%) and had had primary or secondary education (65.5%). The majority of the participants had received lumpectomy (56.4%) and chemotherapy (78.1%) and was undergoing adjuvant radiotherapy treatment (70.1%). The questionnaire data on anxiety, depression, sleep quality, fatigue, pain, and quality of life were obtained from the participants at baseline (Time 1). A subsample of 184 participants completed a follow-up assessment three weeks later (Time 2). All of the procedures were approved by the institutional review board of The University of Hong Kong.

### 2.2. Measures

The Chinese Pittsburgh Sleep Quality Index is a 19-item self-report instrument for assessing sleep disturbance over the month before questionnaire administration [5,12]. Seven component scores – subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleep medication, and daytime dysfunction – are computed from the items. The scores for these components range from 0 (no difficulty) to 3 (severe difficulty) and are summed to produce a global measure of sleep disturbance, with a higher score denoting poorer sleep quality (range: 0–21). Previous validation studies [11,18] have suggested a cut-off of the global score at $\geqslant 8$ for the presence of sleep disturbance in cancer patients. In the present study, the PSQI had a Cronbach's $\alpha$ of 0.79 at both Times 1 and 2, indicating acceptable levels of reliability. The PSQI displayed good test–retest reliability ($r = 0.79$, $P < 0.01$) over the three-week interval.

Anxiety and depression were measured using the Chinese Hospital Anxiety and Depression Scale [19]. This is a 14-item instrument that assesses the severity of anxiety and depressive symptoms using a four-point response format. The total score for anxiety (seven items) and depression (seven items) combined ranges from 0 to 21, with a higher score denoting worse status. In the present study, the Cronbach's $\alpha$ was 0.85 for anxiety and 0.82 for depression at both Times 1 and 2. The Brief Fatigue Inventory [20] was used to assess fatigue symptoms. This is a nine-item instrument that measures the severity and interference of fatigue symptoms using an 11-point response format. The average score of the nine items is used as the total scale score, with a higher score denoting greater fatigue. In our study, the Cronbach's $\alpha$ for the scale was 0.95 at Time 1 and 0.96 at Time 2.

The Brief Pain Inventory [21] was used to assess the pain symptoms. This is an 11-item instrument that measures the severity and interference of the pain symptoms using an 11-point response format. The total score for pain severity (four items) and pain interference (seven items) ranges from 0 to 10, with a higher score denoting worse status. In our study, the Cronbach's $\alpha$ was 0.96 for pain severity and 0.95 for pain interference at both Times 1 and 2. Quality of life was assessed using the Functional Assessment of Cancer Therapy – Breast scale [22]. This is a 36-item instrument that measures quality of life in breast cancer patients in physical, social, emotional, functional, and breast cancer specific domains using a five-point format. The total score for quality of life ranges from 0 to 144, with a higher score denoting a better quality of life. In our study, the Cronbach's $\alpha$ for the scale was 0.91 at Time 1 and 0.97 at Time 2.

### 2.3. Statistical analyses

Preliminary analysis of the attrition rate showed that the dropouts ($n = 13$) and non-dropouts ($n = 184$) did not differ significantly on any of the demographic characteristics or PSQI component scores at baseline. A CFA was performed in Mplus version 7.11 [23] on the seven PSQI component scores using the robust maximum likelihood estimator. Missing data for PSQI item responses were minimal, with no more than 2.5% of the data missing for any component scores at Time 1 and Time 2. Therefore, missing data were handled with full information maximum likelihood under the missing at random assumption [24].

Four CFA models were specified for Time 1 and Time 2 data: the original one-factor model [5], a two-factor model [12], a three-factor model [6], and a revised one-factor model. The one-factor model specified all of the seven components as indicators of a single factor of sleep disturbance. In the two-factor model, the components of subjective sleep quality, sleep latency, sleep medication, sleep disturbances, and daytime dysfunction were reflective indicators of the sleep quality factor, whereas sleep duration and habitual sleep efficiency were reflective indicators of the sleep efficiency factor. In the three-factor model, the components of subjective sleep quality, sleep latency, and sleep medication were reflective

indicators of the sleep quality factor; the components of sleep disturbances and daytime dysfunction were indicators of the daily disturbances factor; and the components of sleep duration and habitual sleep efficiency were indicators of the sleep efficiency factor. The revised one-factor model included a residual covariance for sleep duration and habitual sleep efficiency. All four models specified that each component should load on one factor only.

The model fit was assessed based on the following criteria on the fit indices [25]: insignificant $\chi^2$-test statistic; comparative fit index (CFI) $\geqslant$0.95; Tucker–Lewis index (TLI) $\geqslant$0.95; root mean square error of approximation (RMSEA) $\leqslant$0.06; and standardized root mean square residual (SRMR) $\leqslant$0.08. The model selection was based on the $\chi^2$-test statistic, Bayesian information criterion (BIC), and theoretical considerations. The BIC takes model parsimony into account by imposing penalties on the number of free parameters estimated and adjustments for sample size [26]. A lower BIC indicates a better fit with greater model parsimony.

The convergent validity of the PSQI was examined through bivariate correlation analyses of the PSQI factor scores and six observed scores on anxiety, depression, fatigue, pain severity, pain interference, and quality of life. The PSQI factor scores were derived from the best-fitting factor model, as suggested by the CFA results. For instance, the sum of all of the PSQI component scores composed the standard PSQI global score. The statistical significance level was set at 0.05. To account for the inflation of type I error due to multiple comparisons, Bonferroni adjustment was made to control the overall type I error rate at 0.05 by multiplying each *P*-value by a factor of six [27].

## 3. Results

### 3.1. Descriptive statistics

The PSQI global score had a mean of 7.59 (SD: 4.12) at Time 1 and 7.38 (SD: 4.15) at Time 2. Using the cut-off PSQI score of $\geqslant$8, 46.0% and 39.5% of the participants reported sleep problems at Time 1 and Time 2, respectively. Table 1 presents the mean scores, SDs, and intercorrelations for the seven PSQI components at Time 1 and Time 2, separately. At Time 1, the mean component scores ranged from the lowest, 0.37 for the sleep medication, to the highest, 1.65 for sleep latency. At Time 2, the mean component scores ranged from the lowest, 0.28 for the sleep medication, to the highest, 1.56 for sleep disturbances. Although most of the correlations among the seven components were moderate ($r$ = 0.25–0.53), sleep medications had weaker correlations with the other components ($r$ = 0.14–0.32). A notable exception was the expected strong correlation between sleep duration and habitual sleep efficiency ($r$ = 0.76 at Time 1 and 0.78 at Time 2).

**Table 1**
Descriptive statistics of PSQI components at Time 1 and Time 2.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1. Subjective sleep quality | | 0.53 | 0.53 | 0.52 | 0.49 | 0.27 | 0.47 |
| 2. Sleep latency | 0.42 | | 0.32 | 0.38 | 0.39 | 0.14 | 0.31 |
| 3. Sleep duration | 0.45 | 0.30 | | 0.76 | 0.33 | 0.30 | 0.27 |
| 4. Habitual sleep efficiency | 0.47 | 0.41 | 0.78 | | 0.34 | 0.30 | 0.25 |
| 5. Sleep disturbances | 0.49 | 0.30 | 0.30 | 0.34 | | 0.19 | 0.46 |
| 6. Sleep medications | 0.23 | 0.19 | 0.16 | 0.15 | 0.24 | | 0.29 |
| 7. Daytime dysfunction | 0.49 | 0.32 | 0.27 | 0.25 | 0.49 | 0.32 | |
| Time 1 mean | 1.36 | 1.65 | 0.76 | 1.03 | 1.50 | 0.37 | 1.00 |
| Time 1 SD | 0.75 | 0.91 | 0.95 | 1.13 | 0.59 | 0.88 | 0.88 |
| Time 2 mean | 1.33 | 1.54 | 0.75 | 1.06 | 1.56 | 0.28 | 0.96 |
| Time 2 SD | 0.78 | 0.93 | 1.00 | 1.14 | 0.61 | 0.84 | 0.86 |

PSQI, Pittsburgh Sleep Quality Index.
Correlations for Time 1 ($n$ = 197) and Time 2 ($n$ = 184) are displayed on the upper and lower diagonals. All correlations are statistically significant ($P$ < 0.05).

### 3.2. Factorial validity

Table 2 presents the goodness-of-fit indices for the one-, two-, three-, and revised one-factor models of the PSQI at Times 1 and 2. The one-factor model provided a poor fit to the data at Times 1 and 2 (significant $\chi^2$: CFI <0.80, TLI <0.70, RMSEA >0.15). The revised one-factor model provided an adequate fit to the data at Times 1 and 2 (insignificant $\chi^2$: CFI and TLI >0.95; RMSEA and SRMR <0.06). The revised one-factor model provided a significantly better fit than the original one-factor model in terms of $\chi^2$ difference and a substantially smaller BIC. The residual correlation between sleep duration and habitual sleep efficiency was strong ($r$ = 0.63 at Time 1; 0.70 at Time 2; $P$ < 0.05). The standardized parameter estimates for the revised one-factor model are displayed in Fig. 1. The factor loadings were statistically significant and ranged from 0.36 (sleep medication) to 0.84 (subjective sleep quality).

The two-factor model produced a model fit equivalent to the revised one-factor model. The correlation between the sleep quality factor and sleep efficiency factor was 0.69 at Time 1 and 0.60 at Time 2. The three-factor model produced a good model fit to the data at Time 1 and Time 2 (insignificant $\chi^2$: CFI and TLI >0.99; RMSEA and SRMR <0.04) and provided a significantly smaller $\chi^2$-statistic than the other models. Nevertheless, the sleep quality factor and daily disturbance factor exhibited an extremely high correlation in this model ($r$ = 0.85 at Time 1; $r$ = 0.93 at Time 2), indicating that these two factors were not well distinguished. This unacceptable discriminant validity together with the higher BIC suggested the possibility of overfitting and model redundancy.

### 3.3. Convergent validity

Table 3 presents the correlations between the PSQI factor scores and validating measures at Times 1 and 2. The PSQI global score was positively correlated with anxiety, depression, fatigue, pain severity, and pain interference ($r$ = 0.31–0.50 at Time 1; $r$ = 0.35–0.53 at Time 2; $P$ < 0.05), and negatively associated with quality of life ($r$ = −0.54 at Time 1; $r$ = −0.57 at Time 2; $P$ < 0.05). The sleep quality factor showed similar correlations with anxiety, depression, fatigue, pain severity, pain interference ($r$ = 0.36–0.55 at Time 1; $r$ = 0.40–0.58 at Time 2; $P$ < 0.05) and quality of life ($r$ = −0.58 at Time 1; $r$ = −0.59 at Time 2; $P$ < 0.05). However, the sleep efficiency factor was not significantly correlated with fatigue and pain severity ($r$ = 0.13–0.16 at Time 1; $r$ = 0.17–0.20 at Time 2; $P$ > 0.05). It had substantially smaller correlations with anxiety, depression, pain interference, and quality of life than the PSQI global score.

## 4. Discussion

This study examined various PSQI factor structures in a sample of breast cancer patients, where the relative fit of the one-, two-, and three-factor models was compared. The three-factor model [6] provided a good fit to the data. However, an extraordinarily strong correlation ($r$ = 0.93) was found between the sleep quality and daily disturbance factors. This finding is in line with previous factor analytic results [6,12,14] and points to the model's poor discriminant validity. In addition, the high BIC of the three-factor model compared to the two-factor model, despite its significantly lower $\chi^2$-value, suggests the possibility of model overfit. A follow-up analysis of a second-order factor model that took account of the high inter-factor correlations resulted in Heywood cases, suggesting that the second-order common factor is mis-specified. Given the potential of model redundancy and factor multicollinearity, the three-factor structure of the PSQI was not supported.

The original one-factor model proposed by Buysse et al. [5] provided a poor model fit to the data at Times 1 and 2. However, the

**Table 2**
Goodness-of-fit indices for the factor models of PSQI.

| Time | Model | $\chi^2$ | df | CFI | TLI | RMSEA | SRMR | BIC |
|---|---|---|---|---|---|---|---|---|
| T1 | 1-factor | 102.0* | 14 | 0.771 | 0.657 | 0.179 | 0.077 | 3184.5 |
| | Revised 1-factor | 21.4 | 13 | 0.978 | 0.965 | 0.057 | 0.042 | 3117.3 |
| | 2-factor | 21.4 | 13 | 0.978 | 0.965 | 0.057 | 0.042 | 3117.3 |
| | 3-factor | 12.6 | 11 | 0.996 | 0.992 | 0.027 | 0.031 | 3117.8 |
| T2 | 1-factor | 121.5* | 14 | 0.702 | 0.553 | 0.204 | 0.099 | 3048.4 |
| | Revised 1-factor | 20.1 | 13 | 0.980 | 0.968 | 0.055 | 0.040 | 2969.2 |
| | 2-factor | 20.1 | 13 | 0.980 | 0.968 | 0.055 | 0.040 | 2969.2 |
| | 3-factor | 12.2 | 11 | 0.997 | 0.994 | 0.024 | 0.030 | 2971.0 |

PSQI, Pittsburgh Sleep Quality Index; CFI, comparative fit index; TLI, Tucker–Lewis index; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual; BIC, Bayesian information criterion.
The revised 1-factor model added a residual covariance for sleep duration and habitual sleep efficiency.
* $P < 0.05$.

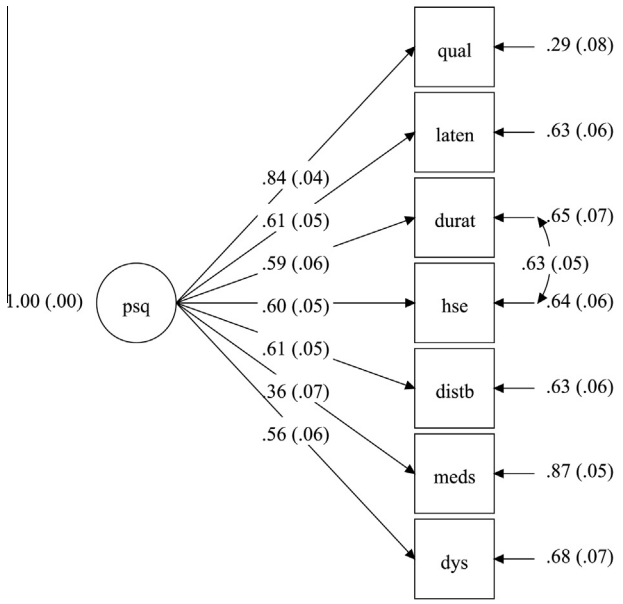


**Fig. 1.** The revised one-factor model of the Pittsburgh Sleep Quality Index with an indicator-specific effect between sleep duration and habitual sleep efficiency. Circle represents the latent variable; squares represent the seven components (from the top: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleep medication, and daytime dysfunction).

components of sleep duration and habitual sleep efficiency showed a strong correlation in Time 1 ($r = 0.76$) and Time 2 ($r = 0.78$) compared to other intercomponent correlations ($r = 0.14$–$0.53$). This correlation pattern is consistent with the correlation matrix of previous studies [6,10,12] where the two components showed a similarly strong correlation ($r = 0.69$–$0.76$). As both components were derived from the same item on the number of actual hours slept, it is justifiable to take the indicator-specific effect into account to enable a proper analysis of the factor structure. In this case, the standard CFA model with uncorrelated residual variables was too restrictive. Given the much-improved model fit for the revised one-factor model, it is credible that the omission of the indicator-specific covariance between the two overlapping components contributed to the poor model fit in the original one-factor model. In future factor analysis of the PSQI, researchers should account for the indicator-specific effect between sleep duration and habitual sleep efficiency.

Despite the overall acceptable fit of the revised one-factor model, the sleep medication indicator showed the lowest mean and a low factor loading ($\lambda = 0.36$ and 0.35 at Time 1 and 2, respectively). This finding, which is compatible with results of previous studies [6,12,14], reflects an avoidance of pharmacological interventions in sleep problems due to side-effects or the availability of behavioural interventions. Future studies should elucidate the role of this component in assessing sleep disturbances in other sampling contexts.

The revised one-factor model and the two-factor model were statistically equivalent. The latter provided exactly the same model fit and was indistinguishable from the former on a statistical basis. We attempted to differentiate the two models on a practical basis by examining the convergent validity of the PSQI scores of the two models. As expected, the PSQI global score was moderately and positively associated with anxiety, depression, pain, fatigue, and reduced quality of life. Although comparable correlations were found for the sleep quality factor, the sleep efficiency factor was weakly or not significantly associated with cancer-related psychopathological states. That the PSQI global score was at least as good as the two PQSI factor scores at predicting the psychopathological states appears to imply that the two-factor PSQI scoring model has little incremental predictive value over the PSQI global score. Given the practical complexities of scoring and interpreting two PSQI factor scores, the clinical utility of the two-factor model seems dubious.

There are several limitations to this study. First, its results were generated using an exclusive sample of breast cancer patients. Although the revised one-factor model fitted the data well and

**Table 3**
Correlations between PSQI factor scores and validating measures.

| Variables | Time 1 PSQI | | | Time 2 PSQI | | |
|---|---|---|---|---|---|---|
| | Global score | Sleep quality | Sleep efficiency | Global score | Sleep quality | Sleep efficiency |
| Anxiety | 0.50* | 0.55* | 0.30* | 0.53* | 0.58* | 0.29* |
| Depression | 0.34* | 0.38* | 0.18 | 0.50* | 0.50* | 0.32* |
| Fatigue | 0.34* | 0.41* | 0.13 | 0.45* | 0.53* | 0.20 |
| Pain severity | 0.31* | 0.36* | 0.16 | 0.35* | 0.40* | 0.17 |
| Pain interference | 0.45* | 0.50* | 0.26* | 0.49* | 0.53* | 0.26* |
| Quality of life | −0.54* | −0.58* | −0.32* | −0.57* | −0.59* | −0.34* |

PSQI, Pittsburgh Sleep Quality Index.
Values represent Pearson correlation coefficients.
* $P < 0.05$ with Bonferroni correction for multiple comparisons.

remained stable over a three-week interval, these results may not generalize to other populations. Future studies should attempt to replicate the current findings and further examine the clinical utility of the two-factor model in identifying sleep dysfunction in other clinical samples and cultural contexts. Next, the convergent validity of the PSQI might be inflated by the common method variance that was present in self-report data. Future research should incorporate structural interviews or clinical assessments as alternative assessment methods of sleep dysfunction.

In conclusion, this study is the first to account for the indicator-specific effect between sleep duration and habitual sleep efficiency in the evaluation of the factor structure of the PSQI. The present study demonstrated an adequate fit for the one-factor structure for the PSQI. The PSQI was found to be a precise and psychometrically valid instrument that allows a straightforward global scoring for screening of sleep dysfunction in cancer patients. It is recommended that researchers and clinicians continue to use the PSQI global score rather than the two-factor scoring system to identify clinically significant sleep disturbance.

## Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2013.10.019

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