Support Care Cancer (2017) 25:3059–3066
DOI 10.1007/s00520-017-3713-9

ORIGINAL ARTICLE

Reliability and validity of the Pittsburgh Sleep Quality Index in breast cancer patients

Filipa Fontes[1] · **Marta Gonçalves**[1,2] · **Susana Maia**[2] · **Susana Pereira**[1,3] · **Milton Severo**[1,4] · **Nuno Lunet**[1,4]

Received: 28 November 2016 / Accepted: 17 April 2017 / Published online: 28 April 2017

Abstract
Purpose We aimed to assess the factor structure, internal consistency, test-retest reliability, and construct validity of the European Portuguese version of the Pittsburgh Sleep Quality Index (PSQI) in breast cancer patients.
Methods This study was based on a cohort of breast cancer patients, among whom the PSQI was used to measure sleep quality three years after cancer diagnosis ($N = 474$). A sample of 62 participants underwent additional PSQI testing, wore a wrist actigraph for five consecutive days, and was reevaluated with the PSQI after one month. A confirmatory factor analysis, considering the components suggested by the principal component analysis (PCA), was performed to determine model fit. To evaluate internal consistency and test-retest reliability, Cronbach's alpha and intraclass correlation coefficient (ICC) were calculated, respectively. To assess construct validity, Spearman's correlation coefficients were computed between PSQI scores and actigraphy measures and other theoretical related constructs.
Results PCA suggested one or two components. The latter showed better fit to the data, though the two factors were strongly correlated ($r = 0.76$) and internal consistency was not satisfactory for one of the factors. Regarding the one-factor model, internal consistency (Cronbach's alpha = 0.70) and test-retest reliability (ICC = 0.76) were adequate. Sleep duration, habitual sleep efficiency, and sleep disturbance dimensions were significantly correlated with the corresponding actigraphy measures; the PSQI global score derived from the one-factor model was more strongly correlated with subjective sleep complaints ($r \geq 0.60$).
Conclusions The unidimensional construct of the European Portuguese version of the PSQI showed adequate reliability and validity among breast cancer patients.

Keywords Actigraphy · Breast neoplasms · Principal component analysis · Psychometrics · Sleep

✉ Nuno Lunet
nlunet@med.up.pt

[1] ISPUP – EPIUnit, Universidade do Porto, Rua das Taipas, 4050-600 Porto, Portugal

[2] Centro de Medicina do Sono – Hospital CUF Porto, Estrada da Circunvalação, 4100-180 Porto, Portugal

[3] Instituto Português de Oncologia do Porto, Rua Dr. António Bernardino de Almeida, 4200-075 Porto, Portugal

[4] Departamento de Ciências da Saúde Pública e Forenses e Educação Médica, Faculdade de Medicina, Universidade do Porto, Al. Prof Hernâni Monteiro, 4200-319 Porto, Portugal

Introduction

Sleep complaints have been reported to affect up to 65% of breast cancer patients [1–3], being more frequent than in patients with other oncological diseases [4, 5] or in the general population [6, 7]. Among breast cancer patients, poor sleep quality was shown to be an important contributor to low health-related quality of life (QoL) [3, 8] and to be correlated with other physical and psychological outcomes, including fatigue [9], anxiety, and depression [10].

The Pittsburgh Sleep Quality Index (PSQI) is a self-administered questionnaire to assess sleep quality [11], commonly used among breast cancer patients. A systematic review on the psychometric properties of this instrument showed that it has good internal consistency for within- and between-group comparisons, but there was scarce information on test-retest reliability [12]. However, the correlation between PSQI scores and the corresponding measures derived from polysomnography or actigraphy were generally poor

[12]. Furthermore, previous studies in different populations have shown that the PSQI might be better represented by a two- or a three-factor model [13–16], rather than the original one-factor structure; studies among breast cancer patients yielded inconsistent results [14, 17]. Otte el al. [14] reported that a two-factor model had a better fit than the original one-factor or a three-factor solution. Their study yielded a "sleep efficiency" factor composed by the sleep duration and habitual sleep efficiency components and a "perceived sleep quality" factor, with the remaining PSQI components. On the contrary, Ho et al. [17] described that a revised one-factor model, with a residual covariance between sleep duration and habitual sleep efficiency, was the best solution, supporting the original unidimensional structure of the PSQI.

Two studies evaluated the psychometric properties of the PSQI in Portuguese populations [18, 19]; one reported preliminary data from a sample of undergraduates and master degree students [19], and the other evaluated a sample of community-dwelling adults [18], yielding values of internal consistency for the unidimensional solution (Cronbach's alpha) of 0.65 and 0.70, respectively. However, the factor structure of the PSQI or its test-reliability was not addressed in any of these previous studies, and none of them investigated its construct validity using an objective measure of sleep (e.g., actigraphy or polysomnography). Therefore, we aimed to assess the factor structure, internal consistency, test-retest reliability, and construct validity of the European Portuguese version of the PSQI, in breast cancer patients, three years after cancer diagnosis.

Methods

Participants

Participants were breast cancer patients enrolled in 2012 in a prospective cohort study designed to assess neurological complications and patient reported outcomes related with cancer and its treatment, among women with newly diagnosed breast cancer. The study protocol has been described in detail elsewhere [20]. Briefly, patients proposed for surgery were consecutively recruited among those admitted to the Breast Clinic of the Portuguese Institute of Oncology of Porto (IPO-Porto). We excluded women treated with chemotherapy and/or radiotherapy in the chest or axillary areas for other primary cancer, those who had received any treatment for breast cancer before, and those considered less likely to be able to cooperate due to cognitive impairment (score lower than 17, or lower than 16 for women over 65 years, in the Montreal Cognitive Assessment [21]).

The present investigation was based on data from 474 women evaluated three years after breast cancer diagnosis (T_0) and on data derived from evaluations in two later moments (T_1 and T_2) of a convenience sample ($N = 62$) of these participants, selected mostly among those living closer to IPO-Porto (Fig. 1).

At T_0, socio-demographic data were collected using a structured questionnaire and clinical records were reviewed for cancer stage and breast cancer treatments. Sleep quality was evaluated using the PSQI [11]. Anxiety and depression were measured through the Hospital Anxiety and Depression scale [22]. QoL was assessed using the questionnaire of the European Organization for the Research and Treatment of Cancer [23]; for the purposes of the present analysis, the global health status/QoL, insomnia and fatigue subscales were used to address overall QoL, subjective sleep complaints and fatigue, respectively. In the global health status/QoL subscale, higher scores represent better QoL, while in the remaining subscales or instruments, higher scores correspond to worse outcomes.

At T_1, a sample of 62 participants underwent additional PSQI evaluation and were invited to wear a wrist actigraph for five consecutive days. After one month (T_2), these patients were contacted by phone to be reevaluated with the PSQI (Fig. 1).

Sleep measures

Pittsburgh Sleep Quality Index

The PSQI was designed to measure sleep quality over a one-month interval. It includes 19 self-rated questions that generate seven component scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. Component scores (range 0 to 3) are summed to provide a global sleep quality score (range 0 to 21); a score greater than five indicates poor sleep quality [11]. For the present study, we used a previously published European Portuguese version of the PSQI [24].

Actigraphy

Participants were asked to use an actigraph (Actiwatch 2; Phillips Respironic, USA) for five consecutive days, always including three weekdays and the weekend, with the instruction to remove it only for swimming. The Actiwatch 2 actigraph is a wrist monitor that includes an accelerometer to measure movement activity and a photometer to measure light exposure; the latter is used to assist in the interpretation of movement activity. Epochs of one-min light exposure and movement were transferred to a computer and analyzed using the Actiware-Sleep 5.0 analysis software (Phillips Respironic, USA). For a more accurate interpretation of the movement activity, participants fulfilled a sleep diary while wearing the actigraph and were asked to keep record of any period in

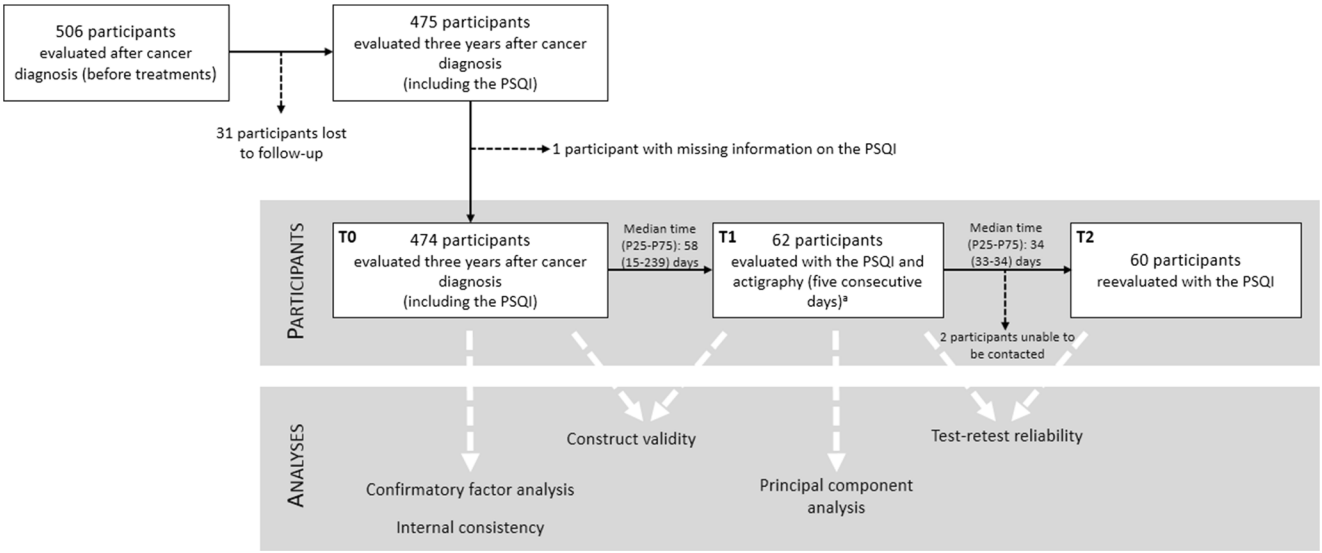

Fig. 1 Diagram describing the number of patients in each of the evaluations performed. *PSQI* Pittsburgh Sleep Quality Index, *P25* percentile 25, *P75* percentile 75. Data on actigraphy is only available for 61 patients, because one patient refused to use it because she felt it worsened her sleep quality (*superscript letter a*)

which it was removed. For the purpose of the present analysis, averages of four actigraphy sleep parameters were computed: sleep latency (time until falling asleep), total sleep time (actual sleep time), sleep efficiency (percent of time in bed spent sleeping), and wake time after sleep onset (WASO, total amount of time awake during the night after falling asleep).

The Actiwatch 2 actigraph was previously used in validation studies in other populations (e.g., adult volunteers free of sleep disorders [25], adult patients with low back pain [26], children and adolescents scheduled for a clinical evaluation of sleep [27]). The agreement with results from polysomnography was shown to be close to 90% [25–27].

Statistical analysis

Sample characteristics are presented as counts and proportions for categorical variables, mean and standard deviation (SD) for quantitative variables with approximately symmetrical distributions, and median and percentile 25 and 75 (P25-P75) for quantitative variables with markedly asymmetrical distributions.

Participants selected for actigraphy were compared with the remaining cohort, regarding socio-demographic and clinical characteristics, using the Mann-Whitney or the chi-square tests, as applicable.

Principal component analysis (PCA) was performed using data from T_1; confirmatory factor analysis (CFA) and internal consistency analysis were performed using data from T_0; construct validity was assessed through data retrieved at T_0 (PSQI measures, sleep complaints, fatigue, anxiety, depression, and global health status/QoL) and T_1 (actigraphy measures of sleep latency, total sleep time, sleep efficiency and WASO); and test-retest reliability was evaluated using data both from T_1 and T_2, as depicted in Fig. 1.

A PCA was performed using the seven PSQI component scores, to understand the underlying structure of the PSQI. The acceleration factor and the optimal coordinate index were assessed to determine the number of components to retain [28]. The PSQI components with absolute factor loading of 0.40 or higher were interpreted as having a meaningful contribution to the corresponding underlying factor.

A CFA was performed to assess model fit of the factor structure obtained from the PCA. It was evaluated using the chi-square goodness of fit test (χ^2), the chi-square per degree of freedom ($\chi^2/_{df}$), the standardized root mean squared residual (SRMR), the root mean square error of approximation (RMSEA), the comparative fit index (CFI) and the Tucker-Lewis index (TLI). Commonly used guidelines suggest SRMR at 0.08 or lower, RMSEA at 0.07 or lower, CFI and TLI at 0.95 or greater and non-significant values of χ^2 or $\chi^2/_{df}$ between 2 and 3 to be considered adequate model fit [29].

To evaluate the internal consistency, we calculated Cronbach's alpha and to further assess component internal consistency, we computed the corrected item-total correlation. To assess test-retest reliability, the intraclass correlation coefficients (ICCs) were computed using a two-way mixed effects model, treating the cases as a random factor, for each of the seven components of the PSQI, for each factor, and for the global score.

In order to assess construct validity, Spearman's correlation coefficients were computed between PSQI-derived scores and actigraphy corresponding measures and other theoretically related constructs, namely sleep complaints, fatigue, anxiety, depression, and global health status/QoL.

Table 1 Principal component analysis of the Pittsburgh Sleep Quality Index (PSQI), considering the one-component and the two-component model ($N = 62$)

PSQI components	One-component model	Two-component model[a]	
		PC1	PC2
Subjective sleep quality	0.79	0.67	0.42
Sleep latency	0.60	0.45	0.40
Sleep duration	0.62	0.82	−0.16
Habitual sleep efficiency	0.78	0.85	0.10
Sleep disturbance	0.67	0.41	0.60
Use of sleep medication	0.20	−0.22	0.73
Daytime dysfunction	0.46	0.15	0.64
% of explained variance	0.38	0.33	0.24
% of explained cumulative variance	0.38	0.33	0.57

PC principal component, *PSQI* Pittsburgh Sleep Quality Index

[a] Varimax with Kaiser Normalization rotation method. PSQI components presenting factor loadings of 0.40 or higher with both PC were assumed to contribute to the PC with the highest factor loading

Statistical analyses were conducted using STATA®, version 11.2 (StataCorp, College Station, TX, USA) and R, version 3.0.1 (R Core Team, Vienna, Austria).

Results

Participants' characteristics

At T_0, participants had a mean (SD) age of 57.9 (10.8) years and a median (P25–P75) of 6 (4–11) years of schooling. A total of 6.5% had non-invasive breast cancer (ductal carcinoma in situ). Among the remaining patients, most were at stage I (47.3%) and II (30.8%), whereas just over 15% were more advanced (stage III, 14.8%; stage IV, 0.6%). Nearly half of the women were submitted to mastectomy (49.6%) and one third underwent axillary lymph node dissection (34.2%). At T_0, the mean (SD) PSQI score was 7.3 (4.3) and 61.4% of the participants presented poor sleep quality.

Participants included in the T_1 sample were significantly younger than the remaining cohort (median: 55.2 vs. 58.5, $P = 0.018$) and presented a lower proportion of poor sleep quality at T_0 (50.0 vs. 63.1%, $P = 0.048$), but there were no significant differences regarding education (median 6 vs. 6 schooling years, $P = 0.458$) and cancer stage (stage 0/I 56.4 vs. 53.5%, $P = 0.665$).

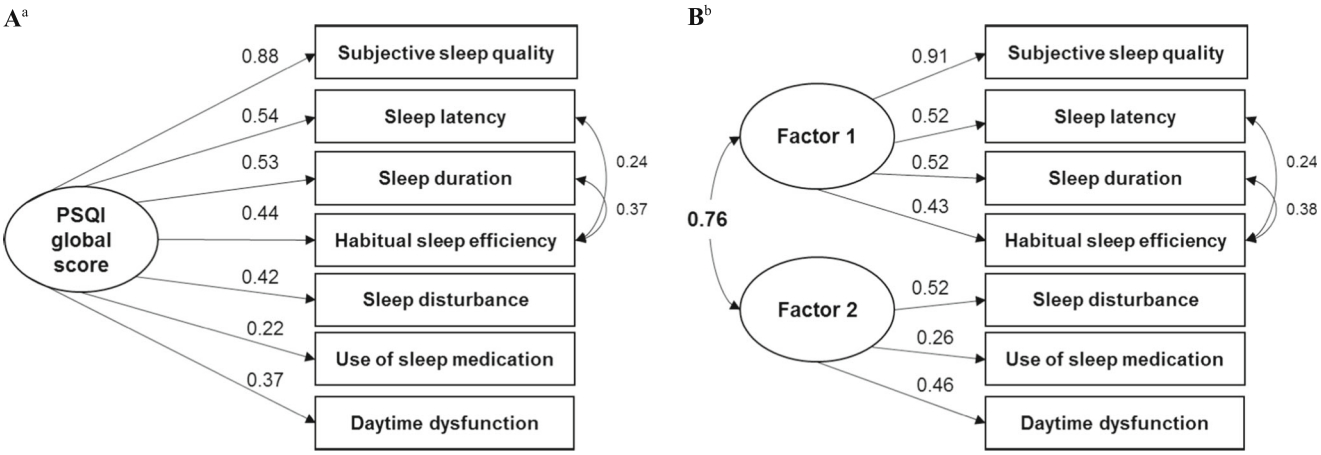

Fig. 2 Confirmatory factor analysis for the **a** one-factor and **b** two-factor models of the Pittsburgh Sleep Quality Index (PSQI) in breast cancer patients ($N = 474$). *CFI* comparative fit index, PSQI Pittsburgh Sleep Quality Index, *RMSEA* root mean square error of approximation, *SRMR* standardized root mean squared residual, *TLI* Tucker-Lewis index. *Ovals* identify latent variables. *Rectangles* represent the PSQI measured items. *Single-headed arrows* represent loadings between each PSQI component and the underlying factor. *Double-headed arrows* represent correlations between PSQI items or between factors, as applicable. $\chi^2 = 38.3$ ($df = 12$), p value < 0.005; $\chi^2/_{df} = 3.2$; SRMR = 0.04; RMSEA = 0.07; CFI = 0.97; TLI = 0.94 (*superscript letter a*). $\chi^2 = 30.0$ ($df = 11$), p value < 0.005; $\chi^2/_{df} = 2.7$; SRMR = 0.04; RMSEA = 0.06; CFI = 0.98; TLI = 0.95 (*superscript letter b*)

Table 2 Item-total correlation with total score ($N = 474$)

PSQI components	Corrected item-total correlation			Cronbach's alpha if item deleted		
	One-factor model	Two-factor model		One-factor model	Two-factor model	
		Factor 1	Factor 2		Factor 1	Factor 2
Subjective sleep quality	0.62	0.60		0.63	0.73	
Sleep latency	0.50	0.49		0.64	0.78	
Sleep duration	0.49	0.60		0.65	0.72	
Habitual sleep efficiency	0.62	0.70		0.60	0.66	
Sleep disturbances	0.34		0.20	0.69		0.20
Use of sleep medication	0.22		0.16	0.75		0.38
Daytime dysfunction	0.27		0.21	0.70		0.14
Cronbach's alpha				0.70	0.78	0.28

Principal component analysis

Using the acceleration factor and the optimal coordinate index as the extraction criterion for components, one or two components, which accounted for a total of 38% or 57% of the variance, respectively, were identified in the PCA (Table 1). In the one-component solution, the use of sleep medication PSQI component did not reliably load into the principal component (PC) (absolute factor loading <0.40). In the two-component solution, all the PSQI components have a meaningful contribution on the corresponding PC; the PC1 includes subjective sleep quality, sleep latency, sleep duration, and habitual sleep efficiency; and the PC2 includes sleep disturbance, use of sleep medication, and daytime dysfunction.

Table 3 Test-retest reliability for the seven Pittsburgh Sleep Quality Index (PSQI) components, and for the one-factor and the two-factor models ($N = 60$)

PSQI components	ICC[a] (95%CI)
Subjective sleep quality	0.64 (0.46–0.77)
Sleep latency	0.56 (0.36–0.71)
Sleep duration	0.59 (0.40–0.73)
Habitual sleep efficiency	0.56 (0.36–0.71)
Sleep disturbance	0.46 (0.23–0.64)
Use of sleep medication	0.89 (0.82–0.93)
Daytime dysfunction	0.66 (0.48–0.78)
Factor 1 (two-factor model)	0.69 (0.53–0.80)
Factor 2 (two-factor model)	0.79 (0.67–0.87)
PSQI global score (one-factor model)	0.76 (0.62–0.85)

PSQI Pittsburgh Sleep Quality Index

[a] Intraclass correlation coefficients (ICCs) using an absolute agreement and single measures definition and two-way mixed effects model

Confirmatory factor analysis

The CFA for the one-factor and two-factor models of the PSQI are depicted in Fig. 2. In both solutions, the examination of modification indices suggested that habitual sleep efficiency was correlated with sleep duration and sleep latency components. The two-factor model seems to provide a better fit than the original one-factor model, as established by smaller values of $\chi^2/_{df}$ (2.7 vs. 3.2) and higher values of TLI (0.95 versus 0.94). In the former the correlation between each PSQI component and the underlying factor ranged from 0.22 to 0.88 and in the latter from 0.43 to 0.91 in factor 1 and 0.26 to 0.52 in factor 2. In the two-factor model, the correlation between factor 1 and factor 2 was high (0.76).

Score reliability

When considering all of the seven components together (one-factor solution), the corrected item-total correlation ranged from 0.22 to 0.62; the overall Cronbach's alpha was 0.70 and increased to 0.75 when the use of use of sleep medication component was omitted (Table 2). Considering the two-factor solution, internal consistency was adequate for factor 1 but not satisfactory for factor 2 (Cronbach's alpha 0.78 vs. 0.28). The corrected item-total correlation ranged from 0.49 to 0.70 in factor 1 and from 0.16 to 0.21 in factor 2; removal of the use of sleep medication component from factor 2 increased Cronbach's alpha to 0.38 (Table 2).

Test-retest reliability is described in Table 3. The within-subject reliability was high for the use of sleep medication PSQI component, for factor 2, and for the PSQI global score derived from the one-factor model, and moderate for each of the remaining individual components.

Table 4 Spearman's *rho* correlations of Pittsburgh Sleep Quality Index (PSQI) global and component scores with actigraphy measures and with other theoretical related constructs

PSQI components	Actigraphy ($N = 61$)				Theoretical related constructs ($N = 474$)				
	Sleep latency	Total sleep time	Sleep efficiency	WASO	Sleep complaints	Fatigue	Anxiety	Depression	Global health status/QoL
Sleep latency	0.11	0.15	0.05	0.00	0.45*	0.18*	0.24*	0.19*	−0.23*
Sleep duration	0.09	−0.41*	−0.30*	0.06	0.42*	0.05	0.13*	0.09*	−0.12*
Habitual sleep efficiency	0.24	−0.07	−0.31*	0.27*	0.48*	0.14*	0.17*	0.16*	−0.22*
Sleep disturbance	0.09	0.12	−0.18	0.39*	0.32*	0.24*	0.23*	0.18*	−0.18*
Factor 1 (two-factor model)	0.16	−0.05	−0.15	0.16	0.61*	0.22*	0.28*	0.24*	−0.31*
Factor 2 (two-factor model)	−0.01	0.25	−0.01	0.22	0.35*	0.35*	0.42*	0.45*	−0.44*
PSQI Global score (one-factor model)	0.10	0.07	−0.09	0.17	0.62*	0.32*	0.39*	0.37*	−0.42*

Higher scores of the PSQI components and of the PSQI global score correspond to worse outcomes, e.g., higher sleep latency, less sleep duration, less habitual sleep efficiency, higher sleep disturbance, and worse sleep quality, as applicable. Higher scores of sleep latency and WASO actigraphy measures correspond to a worse outcome, e.g., higher sleep latency and higher time awake after sleep onset, respectively; higher scores of total sleep time and sleep efficiency actigraphy measures correspond to higher sleep time and higher sleep efficiency. Higher scores of sleep complaints, anxiety, depression, and fatigue correspond to a worse outcome; higher scores of global health status/QoL represent better QoL

PSQI Pittsburgh Sleep Quality Index, *QoL* quality of life, *WASO* wake-up after sleep onset

*Correlation is significant at the 0.05 level

Score validity

Correlations between the PSQI scores and actigraphy measures and other theoretical related constructs are reported in Table 4. All of the specific actigraphy measures, except sleep latency, were significantly correlated with the corresponding PSQI scores ($r \geq |0.30|$). Greater WASO and sleep efficiency evaluated with the actigraphy were significantly associated with lower sleep efficiency and greater sleep duration, respectively, measured by the PSQI. Statistically significant correlations were found between almost all of the theoretical related constructs and measures derived from the PSQI. The strongest associations were found between sleep complaints and both factor 1 and PSQI global score ($r \geq 0.60$).

Discussion

This study shows that a one-factor model has adequate internal consistency for within- and between-group comparisons (Cronbach's alpha = 0.70) and test-retest reliability (ICC = 0.76) [30]. Although a two-factor model (factor 1 including subjective sleep quality, sleep latency, sleep duration, and habitual sleep efficiency; factor 2 including sleep disturbance, use of sleep medication, and daytime dysfunction) had a better fit, the internal consistency was not satisfactory for factor 2 (Cronbach's alpha = 0.28).

To our knowledge, only two studies have addressed the factor structure of the PSQI among breast cancer patients [14, 17]. One study suggested that a two-factor model better fit the data than the original solution, yielding a "sleep efficiency" factor composed by the sleep duration and habitual sleep efficiency components and a "perceived sleep quality" factor, with the remaining components [14]. The other study supports the unidimensional structure of the PSQI, while assuming a residual covariance between sleep duration and habitual sleep efficiency [17]. In both studies, conclusions resulted from CFA using a predefined factor structure and the authors did not access the reliability of their factor solution, which precludes direct comparisons with our findings.

In accordance with previous assessments of test-retest reliability using a similar time interval between evaluations [16, 31, 32], we showed that the PSQI global score presented a good degree of agreement. Furthermore, factor 2 also presented an ICC equal or above 0.70, which may be interpreted as corresponding to a good stability over the one-month period between evaluations [30]. Among the PSQI components, sleep disturbance presented the lowest agreement between the two evaluations, which may, at least in part, result from real changes in this sleep parameter, even in such a short period, in breast cancer patients.

In our study, despite measures of sleep duration, habitual sleep efficiency, and sleep disturbance correlated significantly with the corresponding variables obtained from actigraphy, we did not find a statistically significant or meaningful correlation between objective and subjective measures of sleep latency. In the present study, participants were asked to a keep record of the time when they got into bed and the actigraphy device that we used contains a photometer to measure light exposure, which is useful for determining the time at which

the lights were turned off. However, the low accuracy of self-reports may, at least in part, contribute to the underestimation of the correlation between the two measures. The difficulty in determining sleep onset latency accurately has been reported before [33].

When the PSQI was developed, the authors acknowledged that the clinical construct of sleep quality is a "complex phenomenon that is difficult to define and measure objectively" and stated that despite including quantitative aspects of sleep, as well as purely subjective aspects, such as "depth" or "restfulness" of sleep, the exact elements that compose sleep quality, and their relative importance can vary between individuals [11]. Therefore, it is reasonable to expect that the PSQI performs differently in distinct settings or populations. Our findings are consistent with other studies that have found the PSQI global score to be more highly correlated with psychological status than objective ones, such as those derived from actigraphy [34–36]. In our study, the PSQI global score correlated significantly with fatigue, anxiety, depression, global health status/QoL, and especially with sleep complaints. This suggests that, among breast cancer patients, the PSQI scores may be more strongly correlated with self-perceived sleep quality than with objective measures of sleep quality.

In addition to providing setting-specific data, our study adds to previous research in the Portuguese population, the evaluation of PSQI test-retest reliability and its construct validity using an objective sleep measure; the present study also contributes to the characterization of the PSQI factor structure and also for the measurement of its reliability and validity among breast cancer patients. However, some limitations need to be addressed. Our objective measure of sleep is a proxy measurement, as polysomnography is still considered the gold standard; nevertheless, previous studies have shown an agreement between the two methods close to 90% [25–27]. Also, the time period measured by the PSQI and that measured by actigraphy were different; the PSQI was based on the month prior to its completion and the actigraphy was performed in the five days after PSQI testing, which may contribute to underestimate the correlations between objective and subjective sleep measures. Finally, data were collected mainly in early stage breast cancer patients, thus we cannot generalize our results to women with more advanced disease and to earlier periods after diagnosis.

In conclusion, our study provides additional evidence for the good psychometric properties of the one-factor structure of the European Portuguese version of the PSQI in breast cancer patients. Despite the two-factor solution has demonstrated better fit to the data, the unidimensional construct has adequate reliability and validity, and the parsimonious solution may be used, both in clinical practice and research, to identify "good" and "poor" sleepers. An inexpensive and easy to administer psychometrically robust instrument to evaluate sleep quality, such as the PSQI, can help clinicians to comprehensively address the effect of sleep problems on the well-being of breast cancer patients, as well as to provide them with high quality care.

Compliance with ethical standards

Funding This study was funded by FEDER through the Operational Programme Competitiveness and Internationalization (POCI-01-0145-FEDER-016867) and national funding from the Foundation for Science and Technology (FCT) (Portuguese Ministry of Science, Technology and Higher Education) (PTDC/DTP-EPI/7283/2014) under the Unidade de Investigação em Epidemiologia - Instituto de Saúde Pública da Universidade do Porto (EPIUnit) (POCI-01-0145-FEDER-006862; Ref.UID/DTP/04750/2013); the PhD Grant SFRH/BD/92630/2013 (Filipa Fontes) co-funded by the FCT and the POPH/FSE Program.

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval The study was approved by the Ethics Committee of the Portuguese Institute of Oncology of Porto (Ref. CES 99/2014 and CES 201/2015) and by the Portuguese Data Protection Authority (Ref. 8601/2014). All participants provided written informed consent.

References

1. Otte JL, Carpenter JS, Russell KM, Bigatti S, Champion VL (2010) Prevalence, severity, and correlates of sleep-wake disturbances in long-term breast cancer survivors. J Pain Symptom Manag 39:535–547
2. Desai K, Mao JJ, Su I et al (2013) Prevalence and risk factors for insomnia among breast cancer patients on aromatase inhibitors. Support Care Cancer 21:43–51
3. Fortner BV, Stepanski EJ, Wang SC, Kasprowicz S, Durrence HH (2002) Sleep and quality of life in breast cancer patients. J Pain Symptom Manag 24:471–480
4. Savard J, Villa J, Ivers H, Simard S, Morin CM (2009) Prevalence, natural course, and risk factors of insomnia comorbid with cancer over a 2-month period. J Clin Oncol 27:5233–5239
5. Davidson JR, MacLean AW, Brundage MD, Schulze K (2002) Sleep disturbance in cancer patients. Soc Sci Med 54:1309–1321
6. Carpenter JS, Elam JL, Ridner SH et al (2004) Sleep, fatigue, and depressive symptoms in breast cancer survivors and matched healthy women experiencing hot flashes. Oncol Nurs Forum 31: 591–5598
7. Carlson LE, Campbell TS, Garland SN, Grossman P (2007) Associations among salivary cortisol, melatonin, catecholamines, sleep quality and stress in women with breast cancer and healthy controls. J Behav Med 30:45–58
8. Liu L, Fiorentino L, Rissling M et al (2013) Decreased health-related quality of life in women with breast cancer is associated with poor sleep. Behav Sleep Med 11:189–206
9. Roscoe JA, Kaufman ME, Matteson-Rusby SE et al (2007) Cancer-related fatigue and sleep disorders. Oncologist 12(Suppl 1):35–42
10. Sanford SD, Beaumont JL, Butt Z et al (2014) Prospective longitudinal evaluation of a symptom cluster in breast cancer. J Pain Symptom Manag 47:721–730

11. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ (1989) The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res 28:193–213
12. Mollayeva T, Thurairajah P, Burton K et al (2016) The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: a systematic review and meta-analysis. Sleep Med Rev 25:52–73
13. Nicassio PM, Ormseth SR, Custodio MK et al (2014) Confirmatory factor analysis of the Pittsburgh Sleep Quality Index in rheumatoid arthritis patients. Behav Sleep Med 12:1–12
14. Otte JL, Rand KL, Carpenter JS, Russell KM, Champion VL (2013) Factor analysis of the Pittsburgh Sleep Quality Index in breast cancer survivors. J Pain Symptom Manag 45:620–627
15. Tomfohr LM, Schweizer CA, Dimsdale JE, Loredo JS (2013) Psychometric characteristics of the Pittsburgh Sleep Quality Index in English speaking non-Hispanic whites and English and Spanish speaking Hispanics of Mexican descent. J Clin Sleep Med 9:61–66
16. Kotronoulas GC, Papadopoulou CN, Papapetrou A, Patiraki E (2011) Psychometric evaluation and feasibility of the Greek Pittsburgh Sleep Quality Index (GR-PSQI) in patients with cancer receiving chemotherapy. Support Care Cancer 19:1831–1840
17. Ho RT, Fong TC (2014) Factor structure of the Chinese version of the Pittsburgh sleep quality index in breast cancer patients. Sleep Med 15:565–569
18. Del Rio Joao KA, Becker NB, de Neves JS, Isabel Santos Martins R (2017) Validation of the Portuguese version of the Pittsburgh Sleep Quality Index (PSQI-PT). Psychiatry Res 247:225–229
19. Marques D, Gomes AA, Meiavia A et al (2013) Reliability and initial validation of the Pittsburgh Sleep Quality Index, European Portuguese version: a preliminary study in a sample of higher education students. Sleep Medicine 14:e140
20. Pereira S, Fontes F, Sonin T et al (2014) Neurological complications of breast cancer: study protocol of a prospective cohort study. BMJ Open 4:e006301
21. Freitas S, Simoes MR, Alves L, Santana I (2011) Montreal Cognitive Assessment (MoCA): normative study for the Portuguese population. J Clin Exp Neuropsychol 33:989–996
22. Zigmond AS, Snaith RP (1983) The hospital anxiety and depression scale. Acta Psychiatr Scand 67:361–370
23. Aaronson NK, Ahmedzai S, Bergman B et al (1993) The European Organization for Research and Treatment of Cancer QLQ-C30: a quality-of-life instrument for use in international clinical trials in oncology. J Natl Cancer Inst 85:365–376
24. Paiva T, Penzel T. (2011) [Centro de Medicina do Sono: Manual Prático]. Lidel, Lisboa
25. O'Hare E, Flanagan D, Penzel T et al (2015) A comparison of radio-frequency biomotion sensors and actigraphy versus polysomnography for the assessment of sleep in normal subjects. Sleep Breath 19:91–98
26. Alsaadi SM, McAuley JH, Hush JM et al (2014) Assessing sleep disturbance in low back pain: the validity of portable instruments. PLoS One 9:e95824
27. Meltzer LJ, Walsh CM, Peightal AA (2015) Comparison of actigraphy immobility rules with polysomnographic sleep onset latency in children and adolescents. Sleep Breath 19:1415–1423
28. Raîche G, Walls TA, Magis D, Riopel M, Blais J-G (2013) Non-graphical solutions for Cattell's scree test. Methodology 9:23–29
29. Hooper D, Coughlan J, Mullen M (2008) Structural equation modelling: guidelines for determining model fit. Electronic Journal of Business Research Methods 6:53–60
30. Nunnally J, Bernstein L (1994) Psychometric theory. McGraw-Hill Higher, New York
31. Rener-Sitar K, John MT, Bandyopadhyay D, Howell MJ, Schiffman EL (2014) Exploration of dimensionality and psychometric properties of the Pittsburgh Sleep Quality Index in cases with temporomandibular disorders. Health Qual Life Outcomes 12:10
32. Sitasuwan T, Bussaratid S, Ruttanaumpawan P, Chotinaiwattarakul W (2014) Reliability and validity of the Thai version of the Pittsburgh Sleep Quality Index. J Med Assoc Thail 97(Suppl 3): S57–S67
33. Ancoli-Israel S, Cole R, Alessi C et al (2003) The role of actigraphy in the study of sleep and circadian rhythms. Sleep 26:342–392
34. Grandner MA, Kripke DF, Yoon IY, Youngstedt SD (2006) Criterion validity of the Pittsburgh Sleep Quality Index: investigation in a non-clinical sample. Sleep Biol Rhythms 4:129–139
35. Spira AP, Beaudreau SA, Stone KL et al (2012) Reliability and validity of the Pittsburgh Sleep Quality Index and the Epworth Sleepiness Scale in older men. J Gerontol A Biol Sci Med Sci 67: 433–439
36. Beaudreau SA, Spira AP, Stewart A et al (2012) Validation of the Pittsburgh Sleep Quality Index and the Epworth Sleepiness Scale in older black and white women. Sleep Med 13:36–42