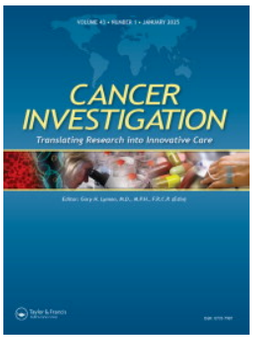

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The Pittsburgh Sleep Quality Index (PSQI) Applied to Cancer Patients: Psychometric Properties and Factors Affecting Sleep Quality

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ABSTRACT

Objective: Cancer patients frequently report sleep problems. The Pittsburgh Sleep Quality Index (PSQI) is a 19-item instrument for assessing sleep problems. The main objective of this study was to analyze the usefulness of the PSQI in oncological research.

Methods: A sample of 1,733 cancer patients with mixed diagnoses were included. In addition to the PSQI, the following questionnaires were adopted: the Insomnia Severity Index (ISI), the Jenkins Sleep Scale (JSS) and the sleep scale of the EORTC QLQ-SURV100.

Results: The internal consistency of the PSQI was $\alpha = 0.79$. Of the PSQI subscales, the subjective sleep quality correlated most strongly with the other sleep instruments (r between 0.68 and 0.77). In total, 69.2% of the sample were poor sleepers; the effect size of the difference between the PSQI total scores of the patients and a general population sample was $d = 0.83$. Female patients experienced more sleep problems than male patients ($d = -0.49$), and younger patients (<60 years) reported more sleep problems than older patients (≥60 years) ($d = 0.21$).

Conclusions: The PSQI can be recommended for use in clinical practice since its sub-dimensions provide detailed information on the sleep situation of cancer patients.

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Sleep quality; insomnia; cancer; PSQI; reliability; validity

Introduction

The WHO estimated that there were 19.3 million cases of newly diagnosed cancer and about 10 million cancer-related deaths worldwide in 2020, and that the number of new cases will increase over the next two decades (1). Globally there is an about 20% chance of developing a cancer disease over a lifetime (before the age of 75 years), and the chance of dying from a cancer disease is about 10% (2).

Sleep disturbances belong to the symptoms most frequently reported by cancer patients. In recent years, multiple studies have investigated the frequency of such sleep problems, several systematic review articles have been published (3–5), and an umbrella review has summarized the results of multiple review articles (6). A recent meta-analysis (3) found an overall prevalence of sleep disorders of 60.7%, based on 160 single studies. There was a great heterogeneity among these studies, with prevalence estimates ranging from 15% to 100%. Furthermore, sleep problems do not disappear after completion of cancer treatment, and the frequency of sleep problems of cancer survivors remains high (7).

In a study comparing cancer patients with the general population, sleep problems were found to have the second largest detrimental effect on quality of life of cancer patients after fatigue (8).

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Sleep problems are associated with low quality of life (9, 10), fatigue (11), depression (12), reduced work activity (13), poor healing (14), and even mortality (15).

Multiple instruments have been developed and used for measuring sleep problems. A review article on sleep problems in cancer patients reported 33 different measurement tools for sleep problems in the 254 studies underlying the review. The Pittsburgh Sleep Quality Index PSQI (16) is the most frequently used questionnaire for assessing sleep quality (14). It comprises 19 items that are assigned to seven subscales. Other multi-item instruments measure sleep problems or insomnia without considering subscales, such as the Insomnia Severity Index ISI (17) or the Jenkins Sleep Scale JSS (18).

There are also instruments for measuring quality of life, mental health, or depression, which include one sleep-related item, e.g. the EORTC QLQ-C30 (19), the PHQ-9 (20), and the GHQ-12 (21). An analysis of multiple samples of German cancer patients using the one-item sleep scale of the EORTC QLQ-C30, for example, confirmed that the sleep quality of cancer patients was worse than that of the general population (9).

What has not been investigated so far is the question of which components of sleep quality are especially reduced in cancer patients, and to what degree a consideration of the different components of sleep disturbances provides a more comprehensive view of cancer patients' sleep problems than the information obtained with single-scales measures. This might help decide under which conditions a short instrument for measuring sleep quality in cancer patients is sufficient and whether a consideration of different components of sleep problems might help to develop interventions aimed at improving sleep quality. In this study, we compare the PSQI and its seven components with other one-dimensional sleep scales in a large sample of cancer patients.

The aims of this study were (a) to test psychometric properties of the PSQI, including comparisons with other sleep scales, (b) to test which components of sleep quality are more and which are less affected by a cancer disease in comparison to the general population, and (c) to explore to what degree the different components of the PSQI help understanding the effects of sociodemographic and clinical factors on sleep quality.

Methods

Sample of cancer patients

The cancer patients were recruited in an oncological rehabilitation clinic in Germany, between July 2022 and June 2023. In Germany, cancer patients are generally offered the opportunity to participate in a rehabilitation program to help restore their physical and psychosocial functioning upon cancer treatment completion. Patients participate in physical fitness exercises, physiotherapy, relaxation techniques, and counseling concerning occupational and nutritional behavior, tailored to their specific individual needs.

Inclusion criteria were: confirmed cancer diagnosis, age 18 years and above, absence of severe cognitive impairment, and sufficient command of the German language. The Ethics Committee of the Medical Faculty of the University of Leipzig approved the study (approval number: 513/21-ek). Informed consent was obtained from the participants after they were given a full explanation of the purpose and nature of the data collection and storage. A total of 2,250 consecutive patients were asked to participate, and 1,733 (77%) of them agreed to take part in the study and to complete the questionnaires.

Instruments

The Pittsburgh Sleep Quality Index (PSQI) (16) was developed by Buysse and colleagues in 1989. It consists of 19 items and seven sub-domains of sleep difficulties: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. All subscales range from 0 to 3. A global score of overall sleep quality can be calculated by adding up the subscales, resulting in a total score ranging from 0 to 21. High values indicate severe sleep problems, and a total score above 5 is generally used to indicate poor sleep, though several authors recommend other optimal cutoff scores (22). According to the generally used cutoff (above 5), 32% of the Austrian general population (23), 35.9% of the German

general population (24), and 39% of the general population of Hong Kong (25) are poor sleepers. The PSQI has been translated into many languages and is applicable to an age range from children (25) to persons above 100 years of age (26). The PSQI has been shown to be a suitable instrument for measuring sleep problems in cancer patients (27–29). Multiple studies have tested psychometric properties of the PSQI: internal consistency (30), test-retest reliability (31), and validity (32–34). Many examinations have been performed to test the dimensional structure of the PSQI. The results were mixed; a systematic review article (35) analyzed the results of 45 studies and found that the optimal number of factors ranged from 1 to 3. The reliability of the PSQI proved to be sufficient but not optimal, with α coefficients of 0.81 and 0.77 (27), 0.75 (33), 0.71 (36), 0.68 (26).

In addition to the PSQI, the following sleep-related questionnaires were used:

ISI: The Insomnia Severity Index (17) is a seven-item instrument for measuring insomnia.

JSS: The Jenkins Sleep Scale (18) comprises four items for measuring sleep quality.

EORTC QLQ-C30: The EORTC QLQ-C30 (19) is a 30-item instrument for assessing quality of life in cancer patients. One of its scales is the single-item sleep quality scale.

EORTC QLQ-SURV100: The EORTC QLQ-SURV100 (37) is an instrument for measuring quality of life in cancer survivors. One of its scales is the four-item sleep scale.

One of the questions of the PSQI is: "How satisfied are you with your current sleep quality?" We added the question "How satisfied were you with your sleep quality before the tumor diagnosis?", with the same four response categories as in the PSQI.

In addition to the above-mentioned questionnaires, we recorded sociodemographic and clinical data based on self-report and medical charts.

Statistical methods

Reliability in terms of internal consistency was expressed in terms of Cronbach's α coefficient, based on the seven subscales of the PSQI. Correlations between the subscales and with other sleep-related scales were calculated as Pearson correlations to indicate convergent validity. Effect sizes were calculated using Cohen's *d*, relating the mean score differences to the pooled standard deviation. The statistical significance of group differences (e.g. sex, age groups) was tested with *t*-tests for independent samples. In the case of more than two groups (tumor types), ANOVAs were calculated to test group differences, and the Eta^2 coefficient was used to characterize the amount of group variability. All calculations were performed with SPSS version 27.

Results

Sample characteristics

A total of 1,733 cancer patients were included in the study. The mean age was 56.0 years ($SD = 14.5$ years), and 59.5% of the participants were women (see Table 1).

Psychometric properties of the PSQI

Table 2 presents scale and subscale characteristics of the PSQI. The PSQI global score had the following characteristics: *M*: 8.31, *SD*: 4.18, skewness: 0.464, and kurtosis: −0.530. The subscale mean scores were between 0.32 (sleep medication use) and 1.55 (subjective sleep quality). The (part-whole corrected) subscale-test-correlations (r_{it}) ranged from 0.29 (sleep medication) to 0.70 (subjective sleep quality). Reliability in terms of Cronbach's α was 0.79, McDonald's ω was 0.81. Table 2 also shows the α coefficients when single subscales were deleted. Deleting the sleep medication subscale would have led to a slight increase of the α coefficient from 0.79 to 0.80.

Correlations with other sleep scales are shown in the lower part of Table 2. The correlations between the PSQI total score and the four additional sleep scales were between 0.72 and 0.81, indicating convergent validity. The Insomnia Severity Index ISI reached the highest correlation with the PSQI total score ($r = 0.81$). Regarding the seven subscales of the PSQI, the correlations between the first subscale (subjective sleep quality) and the other scales were highest, with coefficients

Table 1. Sociodemographic and clinical characteristics of the sample ($n = 1{,}733$).

	n	%
Sex		
Male	702	40.5
Female	1,031	59.5
Age group		
18–39 years	254	14.7
40–49 years	276	15.9
50–59 years	417	24.1
60–69 years	464	26.8
≥70 years	322	18.6
Education[a]		
Elementary school (8–9 years)	356	20.6
Junior high school (10 years)	527	30.5
High school/university (≥11 years)	830	48.1
No formal qualification	13	0.8
Employment status[a]		
Employed	996	57.7
Unemployed	63	3.7
Retired	589	34.1
Other	78	4.5
Tumor localization		
Breast	560	32.3
Prostate	309	17.8
Gastrointestinal tract	290	16.7
Hematological	202	11.7
Female genital organs	108	6.2
Urinary tract	87	5.0
Melanoma	49	2.8
Thyroid / endocrine glands	38	2.2
Male genital organs	29	1.7
Others	61	3.5
Time since diagnosis		
≤6 months	549	31.7
7 months–≤12 months	513	29.6
13 months–≤24 months	358	20.7
>24 months	313	18.1
Treatment		
Cancer-related medication[a]		
No	1366	79.2
Yes	358	20.8
Surgery[a]		
No	177	10.2
Yes	1556	89.8
Chemotherapy[a]		
No	882	51.1
Yes	843	48.9
Radio therapy[a]		
No	952	55.0
Yes	779	45.0
Hormone therapy[a]		
No	1247	72.5
Yes	473	27.5
Antibody therapy[a]		
No	1452	84.7
Yes	262	15.3

[a]Missing data not reported.

between 0.68 and 0.77, and the correlations with subscale 6 (sleep medication) were lowest.

Comparison between cancer patients and the general population

The comparison between the PSQI subscale mean scores of the cancer patients with those of the general population is illustrated by Figure 1. The general population scores were taken from a large general population study ($n = 9{,}284$) conducted in Germany (24). The mean age of this general population sample was 56.3 years ($SD = 12.4$ years), and the proportion of women was 52.4% (24).

In all subscales, sleep problems of the cancer patients were markedly higher than those of the general population; the highest effect size was obtained for the subscale sleep disturbances. The effect size of the total PSQI score was $d = 0.90$. Of the 1,733 cancer patients, 1,199 (69.2%) were poor sleepers using the usual cutoff (sum score >5), while the proportion of poor sleepers in the general population sample was 36% (24).

Concerning the recalled sleep quality during the time before diagnosis, the mean score of the question "How was your sleep quality before your cancer diagnosis?" was 0.96 (SD = 0.71). Since low scores in this scale indicate good sleep, this mean score indicates a markedly better recalled sleep quality than the patients' mean score of the corresponding subscale 1 (actual subjective sleep quality; $M = 1.55$), but also an even higher sleep quality than that of the general population ($M = 1.14$, see Figure 1).

Effects of sex, age, and clinical variables on sleep quality

Table 3 shows PSQI mean scores, broken down by sociodemographic and clinical variables. Tumor groups were restricted to the five groups with at least 100 patients each, and treatment groups were restricted to those with at least 30% of the patients receiving that type of treatment.

Women reported more sleep problems than men on all of the seven subscales; the highest effect sizes were found for daytime dysfunction. The effect size of the sum score showed a coefficient of nearly half a standard deviation ($d = 0.49$).

Younger patients experienced more sleep problems than older ones in six of the seven subscales, with the highest difference on the first subscale (subjective sleep quality). The effect size of the total score was $d = -0.21$.

Physical functioning, as measured with the EORTC QLQ-C30, was negatively correlated with the PSQI total score ($r = -0.41$, $p < 0.001$).

Table 2. Subscale characteristics and correlations with other sleep-related questionnaires.

	Subjective sleep quality	Sleep latency	Duration of sleep	Sleep efficiency	Sleep disturbances	Sleep medication use	Daytime dysfunction	Global score
Mean	1.55	1.53	0.86	1.32	1.35	0.32	1.38	8.31
(*SD*)	(0.72)	(1.06)	(0.98)	(1.17)	(0.53)	(0.82)	(0.83)	(4.18)
r_{it}	0.70	0.56	0.67	0.67	0.46	0.29	0.40	
α del[a]	0.74	0.76	0.73	0.73	0.78	0.80	0.79	$\alpha = 0.79$
Correlations with other sleep scales								
ISI	0.77	0.56	0.60	0.59	0.55	0.26	0.55	0.81
JSS	0.69	0.53	0.51	0.53	0.52	0.21	0.47	0.72
SURV-100-sleep	0.68	0.58	0.57	0.58	0.47	0.28	0.38	0.75
C30-sleep	0.70	0.51	0.56	0.58	0.47	0.28	0.40	0.74

r_{it}: part-whole-corrected test-item correlation; [a]α if item is deleted.

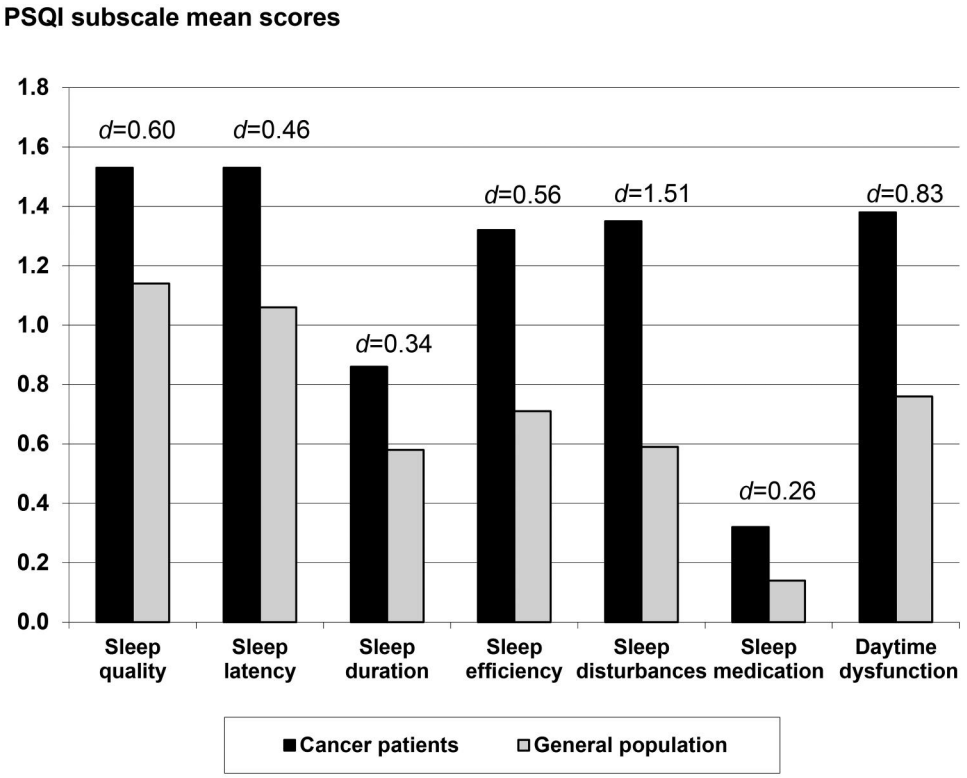

Figure 1. PSQI subscale mean scores of the cancer patients and the general population.

Among the cancer groups, the most severe sleep problems were reported by patients with breast cancer ($M = 9.06$) and cancer of the female genital organs ($M = 9.33$), while prostate cancer patients experienced the least sleep problems ($M = 6.82$). The comparison of the seven subscales shows that daytime dysfunction was associated with the largest tumor group differences, and the only subscale with no significant group differences was sleep medication.

While surgery and chemotherapy had no substantial effect on sleep quality, patients receiving radiation therapy reported more sleep problems than those without radiation therapy in six out of the seven subscales. The highest group difference ($d = 0.27$) was found for the subscale sleep disturbances.

Discussion

The first research question concerned the psychometric properties of the PSQI. As in other studies, the reliability (Cronbach's α) was acceptable (0.79) and slightly higher than in most other examinations (26, 27, 33, 36, 38), which reported coefficients between 0.68 and 0.81. However, it was lower than the α coefficient typically reached with other instruments that are not composed of

Table 3. PSQI mean scores, stratified by sociodemographic and clinical variables.

		Subjective sleep quality	Sleep latency	Duration of sleep	Sleep efficiency	Sleep disturbances	Sleep medication use	Daytime dysfunction	Sum score
All patients	*M*	1.53	1.53	0.86	1.32	1.35	0.32	1.38	8.31
	(SD)	(0.72)	(1.06)	(0.98)	(1.17)	(0.53)	(0.82)	(0.83)	(4.18)
Sex									
Male	*M*	1.37	1.27	0.74	1.12	1.21	0.27	1.12	7.12
	(SD)	(0.70)	(1.01)	(0.93)	(1.14)	(0.49)	(0.77)	(0.75)	(3.96)
Female	*M*	1.66	1.70	0.95	1.45	1.44	0.35	1.56	9.12
	(SD	(0.71)	(1.06)	(1.00)	(1.16)	(0.54)	(0.85)	(0.84)	(4.14)
d		0.41	0.42	0.22	0.29	0.45	0.10	0.55	0.49
p		***	***	***	***	***		***	***
Age group									
<60 years	*M*	1.65	1.60	0.93	1.35	1.40	0.28	1.49	8.70
	(SD)	(0.73)	(1.08)	(1.00)	(1.17)	(0.54)	(0.77)	(0.85)	(4.22)
≥60 years	*M*	1.42	1.44	0.78	1.27	1.29	0.37	1.26	7.83
	(SD)	(0.69)	(1.03)	(0.95)	(1.16)	(0.52)	(0.87)	(0.80)	(4.09)
d		−0.32	−0.15	−0.15	−0.07	−0.21	0.11	−0.28	−0.21
p		***	**	**		***	*	***	***
Tumor class									
Breast	*M*	1.68	1.72	0.96	1.43	1.48	0.30	1.50	9.06
	(SD)	(0.72)	(1.04)	(1.00)	(1.16)	(0.55)	(0.78)	(0.85)	(4.17)
Prostate	*M*	1.31	1.21	0.70	1.08	1.22	0.29	1.00	6.82
	(SD)	(0.66)	(0.99)	(0.92)	(1.13)	(0.49)	(0.80)	(0.71)	(3.92)
Digestive organs	*M*	1.46	1.42	0.87	1.26	1.30	0.31	1.34	7.97
	(SD)	(0.72)	(1.02)	(0.99)	(1.16)	(0.52)	(0.83)	(0.81)	(4.02)
Hematological	*M*	1.58	1.57	0.81	1.32	1.32	0.39	1.52	8.50
	(SD)	(0.71)	(1.12)	(0.93)	(1.17)	(0.52)	(0.90)	(0.79)	(4.05)
Female genital organs	*M*	1.67	1.66	1.12	1.62	1.34	0.34	1.58	9.33
	(SD)	(0.67)	(1.13)	(1.08)	(1.16)	(0.50)	(0.89)	(0.81)	(4.30)
Eta^2		.040	.034	.015	.018	.037	.002	.060	.045
F		15.39	12.93	5.39	6.66	14.06	0.58	23.33	17.30
P		***	***	***	***	***		***	***
Time since diagnosis									
≤12 months	*M*	1.51	1.50	0.82	1.29	1.35	0.32	1.33	8.11
	(SD)	(0.72)	(1.03)	(0.98)	(1.16)	(0.52)	(0.82)	(0.83)	(4.18)
>12 months	*M*	1.60	1.58	0.93	1.36	1.35	0.32	1.47	8.61
	(SD)	(0.72)	(1.11)	(0.97)	(1.17)	(0.55)	(0.81)	(0.83)	(4.17)
d		−0.13	−0.07	−0.11	−0.06	0.00	0.00	−0.17	−0.12
p		*		*				***	*
Treatment									
Cancer medication									
No	*M*	1.53	1.51	0.87	1.31	1.33	0.33	1.35	8.23
	(SD)	(0.73)	(1.08)	(0.99)	(1.17)	(0.51)	(0.83)	(0.83)	(4.20)
Yes	*M*	1.59	1.59	0.86	1.33	1.44	0.28	1.48	8.57
	(SD)	(0.68)	(1.01)	(0.96)	(1.18)	(0.58)	(0.79)	(0.84)	(4.13)
d		0.09	0.08	−0.01	0.02	0.20	−0.06	0.16	0.08
p						***		*	
Surgery									
No	*M*	1.58	1.46	0.81	1.39	1.34	0.43	1.48	8.51
	(SD)	(0.70)	(1.13)	(0.94)	(1.21)	(0.53)	(0.95)	(0.85)	(4.24)
Yes	*M*	1.54	1.54	0.87	1.31	1.35	0.31	1.37	8.28
	(SD)	(0.72)	(1.06)	(0.98)	(1.16)	(0.53)	(0.80)	(0.83)	(4.18)
d		−0.06	0.07	0.06	−0.07	0.02	−0.14	−0.13	−0.05
p							*		
Chemotherapy									
No	*M*	1.52	1.52	0.84	1.26	1.34	0.33	1.31	8.12
	(SD)	(0.73)	(1.03)	(0.97)	(1.17)	(0.53)	(0.83)	(0.82)	(4.22)
Yes	*M*	1.58	1.53	0.88	1.37	1.36	0.31	1.46	8.49
	(SD)	(0.71)	(1.10)	(0.98)	(1.16)	(0.53)	(0.81)	(0.84)	(4.15)
d		0.08	0.01	0.04	0.09	0.04	−0.02	0.18	0.09
p								***	
Radiation therapy									
No	*M*	1.48	1.45	0.80	1.25	1.29	0.35	1.32	7.93
	(SD)	(0.71)	(1.04)	(0.95)	(1.17)	(0.50)	(0.86)	(0.81)	(4.14)
Yes	*M*	1.62	1.62	0.94	1.40	1.43	0.29	1.46	8.76
	(SD)	(0.72)	(1.08)	(1.01)	(1.16)	(0.55)	(0.77)	(0.86)	(4.19)
d		0.20	0.16	0.14	0.13	0.27	−0.07	0.17	0.20
p		***	***	**	**	***		***	***

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; *d*: effect size; Eta^2: effect size; *F*: test statistic, *p*: significance level.

subdimensions such as the ISI (e.g. $\alpha = 0.90$ (17) and $\alpha = 0.92$ (39)) or the JSS (e.g. $\alpha = 0.84$ (40) and $\alpha = 0.86$ (41)). We believe that the suboptimal α coefficient of the PSQI is due to the fact that the seven subdimensions of the PSQI represent different components of sleep quality in terms of content, and not simply the combination of a true score (representing sleep quality in general) and an error score. In our study, we did not test whether a one-, two-, or three-dimensional structure would have best represented the data. Even if such an analysis had shown that a three-factorial structure had better fit indices than a one-dimensional structure, this would have no consequences for the application of the PSQI with its subscales and total scores. Despite the fact that the majority of CFA studies supported two- or three-dimensional structures (35), it is useful to maintain the usual sum score or the seven single components, but not partial scores in between, resulting from two- or three-factorial solutions. Therefore, we think that further investigations of the prognostic validity of the PSQI are useful, while further CFA studies on the internal structure of the questionnaire are not.

From a statistical point of view, the coefficient of "α if item deleted" (Table 2) indicates that the subscale sleep medication could be removed without a reduction in reliability. However, to make the results comparable with those of other studies, the PSQI should not be changed, and information on drug use can give physicians additional information on their patients' situation.

The correlations of the PSQI sum score with the other four sleep scales ranged from 0.72 to 0.81, indicating convergent validity. This is comparable with the results of other studies, e.g. $r = 0.79$ (42) and $r = 0.84$ (43) for the correlation between the PSQI and the ISI. Of the seven PSQI subscales, the first one (subjective sleep quality) was most strongly correlated with the other sleep scales in each case; however, for each of the four additional sleep scales (ISI, JSS, SURV-100-sleep and C30-sleep) the correlations with the PSQI sum score were higher than those with the first PSQI subscale. This means that subjective sleep quality as assessed in subscale one is central to the concept covered by the PSQI, but adding the other dimensions increases the measurement precision. Despite the suboptimal internal consistency of the PSQI, the validity of the PSQI sum score is high.

When compared with the general population, the sleep quality of the cancer patients was poor. Among the patients, 69.2% were poor sleepers, which is in line with the results of a recent meta-analysis (3). The effect size of the difference in the PSQI sum scores between cancer patients and the general population was $d = 0.90$, which is nearly one standard deviation. This is even somewhat larger than the effect size ($d = 0.80$) reported in another study where sleep quality was measured with the single-item sleep scale of the EORTC QLQ-C30 (8). The larger effect size in our study may be due to the higher reliability of the PSQI in comparison with the single-item sleep scale of the EORTC QLQ-C30.

When looking at the seven subscales, all subscales showed greater sleep problems in the patients' group in comparison with the general population, and the most notable differences were found for sleep disturbances and daytime dysfunction – two aspects of sleep quality that are not generally incorporated in other questionnaires on sleep quality. It may be a matter of debate whether it is appropriate to consider daytime sleepiness or daytime dysfunction a component of sleep quality. Daytime dysfunction is strongly associated with fatigue (44), which is also markedly increased in cancer patients (45). Because of the option of giving healthcare providers additional information on the sleep situation in a broader sense, we believe that maintaining daytime dysfunction in this assessment instrument is appropriate.

The recalled sleep quality of the patients from the time before diagnosis was even better than that reported by the general population. This can be due to response shift (46–48), a change in the frames of reference due to adaptation processes. Experiencing severe sleep problems in the context of the cancer disease may have resulted in considering previously assessed normal sleep as good sleep. This would suggest that the differences in sleep quality between cancer patients and the general population, as shown in Figure 1, still underestimate the true differences because the changes in the reference frame contribute to an underestimation of the true changes.

Female cancer patients reported significantly more sleep problems than male patients. This sex difference is a general finding that is observed in the general population as well as in particular disease groups. The effect size of this sex difference in our study was nearly half a standard deviation ($d = 0.49$). In the general population, this effect size is weaker ($d = 0.35$ (24)) which means that experiencing a cancer diagnosis further widens this sex difference, and that female cancer patients require special attention by health care providers.

Though sleep problems generally increase with increasing age in the general population (24, 49), the cancer patients showed an opposite trend: Patients older than 60 years of age reported fewer sleep problems than their younger counterparts ($d = -0.21$ for the total score), which is also in line with other studies (50). Among the subscales, subjective sleep quality ($d = -0.31$) contributed most strongly to this age difference. The use of sleep medication was the only subscale with higher levels in the younger age group. This may be explained by the fact that younger patients perceive the change in sleep quality from pre-diagnosis times to the situation in the clinic more intensively compared to older patients, and that this stronger change motivated them to use sleep medication as a means to overcome the sleep problems.

The comparison of the tumor classes showed highest scores for breast cancer patients and patients with cancer of female genital organs, and lowest scores for prostate cancer patients. Breast cancer and prostate cancer are confounded with sex, and it is difficult to decide to what degree these scores are due to the sex or to specific aspects of the disease. Prostate cancer patients, when compared with other cancer types, generally report low detriments in quality of life, low levels of mental distress, and relatively good sleep (8). Since the focus of this paper is on the specific subscales of the PSQI, it is interesting to note that only one subscale (sleep medication) showed no significant differences between the cancer groups, and that the most pronounced group differences were found for daytime dysfunction and the sum score.

Looking more closely at the subscales of the PSQI, the following conclusions can be drawn: The subjective sleep quality subscale corresponds most closely to what other sleep scales contain: the subjective assessment of sleep quality and, related to this, subjective satisfaction with sleep. This is reflected in the high correlations between this PSQI subscale and the other instruments.

The sleep medication subscale occupies a special position: in all areas, it shows the lowest correlations and mean score differences. It is the only behavioral item in the PSQI. Thus, sleep medication use seems to depend less on sleep quality itself and more on the general tendency to take medication. Because there is a strong association between supportive care needs and satisfaction with sleep in cancer patients (51), and because some patients have little familiarity with the option of sleep medication, healthcare providers should inform patients about sleep medication options. Even though the sleep medication subscale is relatively independent of the other subscales of the PSQI and thus actually lowers its reliability slightly, the subscale should be retained because of its independent insight value.

The subscale of daytime dysfunction also plays a distinct role. It is not included in the other sleep instruments such as ISI and JSS and focuses less on sleep itself than on the consequences of poor sleep. This is expressed statistically in a relatively low part-whole correlation with the PSQI overall scale and in lower correlations with the other sleep questionnaires. Daytime dysfunction and fatigue are closely related, and both are strongly elevated in cancer patients, which is also reflected in the relatively large differences between cancer patients and the general population in this subscale ($d = 0.60$). Although this subscale also contributes little to the reliability of the PSQI, it provides additional relevant information for the practitioner.

For epidemiological studies in which global sleep quality is to be assessed in an effective manner with a short instrument, questionnaires with fewer items, such as the ISI and the JSS, seem more appropriate. However, when a more detailed analysis of sleep problems is sought, the PSQI with its multiple facets proves to be well suited despite (or perhaps because of) its suboptimal internal consistency and its questionable dimensional structure (35).

The various components of sleep quality as mapped by the PSQI also provide entry points for interventions to improve sleep quality (52, 53). The literature generally describes relatively

weak relationships between subjective sleep quality and objective sleep parameters (54, 55). The PSQI components of sleep duration, sleep latency, and sleep efficiency can in principle also be assessed with objective methods and thus offer starting points for clarifying the associations between subjectively estimated sleep quality and objective parameters in more detail.

Some limitations of the study should be mentioned. The cancer patients were treated in a rehabilitation clinic, and this sample might, therefore, not be entirely representative of all cancer patients. Patients in a good state of health (rehabilitation program not necessary) and patients in a poor state of health (too weak to participate) may be underrepresented. We only assessed sleep quality in terms of subjective assessments; results obtained by objective measures such as polysomnography or wearables may differ from these subjective results.

For some comparisons, the potential prognostic factors of sleep problems are confounded, e.g. tumor type, sex, and age. The PSQI scores were not normally distributed, so some of the statistical tests are not completely accurate. Concerning the psychometric structure of the PSQI, we did not analyze complex models such as item response theory models, and we did not perform confirmatory factor analyses since we believe that the identification of a two- or three-dimensional substructure of the PSQI does not provide relevant information that is of value for researchers or health care providers.

Conclusions

The study confirmed severe sleep problems in cancer patients. Female patients are especially affected by sleep problems and deserve special attention. While the PSQI is more time-consuming than shorter sleep quality questionnaires, it provides relevant information for healthcare practitioners in addition to the assessment of global sleep quality.

Disclosure statement

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