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ORIGINAL ARTICLE

Structural and construct validity of the Czech version of the Pittsburgh Sleep Quality Index in chronic insomnia

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Abstract

OBJECTIVES: The Pittsburgh Sleep Quality Index (PSQI) is one of the widely used and recommended measures of assessing sleep quality in chronic insomnia; however certain psychometric properties of the questionnaire are still unknown in this group of patients. The present study aimed to examine the internal consistency, and structural and convergent validity of the Czech version of the PSQI in chronic insomnia patients. The usefulness of the standard and alternative scoring systems was also investigated in relation to symptoms of sleepiness, insomnia, depression, and anxiety.

METHODS: In our study, 105 participants filled out a series of questionnaires including PSQI, Insomnia Severity Index (ISI), Epworth Sleepiness Scale (ESS), and Beck Depression and Anxiety Inventories (BDI, BAI).

RESULTS: The internal consistency of the questionnaire using Cronbach's alpha was 0.608. A series of confirmatory factor analyses revealed adequate fit for three structures. A three-factor model descriptively stood out among the rest but subsequent correlational analyses did not provide sufficient support for accepting an alternative scoring model.

CONCLUSIONS: The results highlight the issue of structural variance of the PSQI and in chronic insomnia point to the important role of the PSQI components of daytime dysfunction and sleep disturbances in showing comorbid symptoms with daytime sleepiness and psychopathology.

Abbreviations:

PSQI	- Pittsburgh Sleep Quality Index
ISI	- Insomnia Severity Index
ESS	- Epworth Sleepiness Scale
BDI	- Beck Depression Inventory
BAI	- Beck Anxiety Inventory
ICD-10	- International Statistical Classification of Diseases and Related Health Problems, 10th Revision
SD	- standard deviation
DWLS	- diagonally weighted least squares estimator
χ^2	- chi-squared test
GFI	- goodness of fit index
CFI	- comparative fit index,
TLI	- Tucker-Lewis index
RMSEA	- root mean square error of approximation
95% CI	- 95% confidence interval
SRMR	- standardized root mean square residual
rs	- Spearman's inter-correlations
N	- number of subjects
α	- Cronbach's alpha

INTRODUCTION

Insomnia in its chronic form affects millions of people worldwide, and it is estimated that 6–10% of population would meet criteria for the disorder (Ohayon 2002). Adequate and convenient screening by practitioners and specialists is therefore warranted. One of the tools that is most frequently and widely used to measure sleep and insomnia symptoms is the Pittsburgh Sleep Quality Index (PSQI).

In the insomnia population, there have been only a handful studies that validated the measure (Backhaus *et al.* 2002; Buysse *et al.* 1989; Sohn *et al.* 2012; Doi *et al.* 2000). These studies performed various reliability and validity analyses, but were limited by either small sample sizes or focus on other aspects of the PSQI validity such as discriminative, construct, sensitivity and specificity. The degree to which the PSQI is a valid measure in psychometric domains such as internal consistency, convergent, and structural validity in chronic insomnia, is still unknown.

In other than insomnia populations, the internal consistency of the PSQI was reported both within and between groups generally in the satisfactory or high range of 0.70 to 0.83 (Buysse *et al.* 1989; Carpenter & Andrykowski 1998; Rener-Sitar *et al.* 2014; Skouteris *et al.* 2009). The construct validity including convergent validity has also been investigated, the PSQI total score correlated with other measures of sleep quality (Aloba *et al.* 2007; Backhaus *et al.* 2002; Spira *et al.* 2012), as well as depression, tension/anxiety, and confusion (Carpenter & Andrykowski 1998; Casement *et al.* 2012; Skouteris *et al.* 2009; Spira *et al.* 2012). The data on the internal consistency and construct validity in specifically chronic insomnia is still lacking.

Studies on structural validity of the PSQI recently pointed out to its multidimensional nature and thus questioned the standard scoring as represented by global score (Casement *et al.* 2012; Gelaye *et al.* 2014; Nicassio *et al.* 2014). It is therefore important to verify the alternative scoring systems represented by individual factor scores because they may improve the sensitivity of the instrument (Magee *et al.* 2008), may better reflect individual's responses to the PSQI (Cole *et al.* 2006), and may provide crucial information about highly comorbid psychopathology (Babson *et al.* 2012). Establishing the usefulness of different scoring systems has therefore important clinical relevance in chronic insomnia population where using PSQI is recommended (Buysse *et al.* 2006).

The aim of the study was twofold: 1) to investigate the internal consistency, structural and convergent validity of the Czech version of the PSQI in a specifically sleep disordered sample of chronic insomnia patients, and 2) to assess the usefulness of the standard and alternative scoring systems by comparing them to measures of sleepiness, insomnia, and psychopathology.

MATERIALS AND METHODS

Participants

Participants included in the study were outpatients of the sleep laboratory at the Prague Psychiatric Centre in 2012–2014. As a part of the participants' clinical examination by the centre's attending physicians, questionnaire data for sleep quality, daily sleepiness, insomnia severity, and depressive and anxiety symptom severity were obtained along with polysomnography. Patients were retrospectively enrolled in the study if they: 1) were aged 18 or older, 2) were diagnosed with nonorganic insomnia according to ICD-10 (WHO 2008), and 3) did not suffer any comorbid psychiatric, neurological, or sleep disorder at the time of insomnia diagnosis. From a total of 217 patients with insomnia symptoms, 105 adults (48 males and 57 females) aged 18 to 86 years (mean=44.5, SD=14.24) were included. The reduction in number of participants allowed us to have a heterogeneous sample of chronic insomnia patients. All participants continued to use their habitual medication including antidepressants (tricyclic, sedative, 3rd–5th generation), benzodiazepines, antipsychotics, melatonin, and antihistamines. The study was approved by the ethical committee of the National Institute of Mental Health in the Czech Republic.

Measures

The *Pittsburgh Sleep Quality Index (PSQI)* was developed to measure the quantitative and subjective aspects of sleep quality and includes 7 components (subscales): subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction (Buysse *et al.* 1989). The questionnaire is widely used in the Czech context, however no study has yet validated it.

The *Epworth Sleepiness Scale (ESS)* is a self-administered questionnaire that subjectively assesses the daytime sleepiness in eight everyday situations of relative inactivity (Johns 1991). The Czech version of the scale has only recently shown good internal consistency and test-retest reliability (Schalek *et al.* 2015). The *Insomnia Severity Index (ISI)* was designed as a brief screening measure for insomnia symptoms and an outcome measure in treatment research (Bastien *et al.* 2001). The index has not yet been validated in Czech language.

The short version of *Beck Depression Inventory (BDI)* includes 13 items that subjectively measure the intensity of depression in psychiatric and normal populations (Beck & Beck 1972). The *Beck Anxiety Inventory (BAI)* was developed to measure severity of anxiety in psychiatric populations (Beck *et al.* 1988). Although widely used, neither of the Beck inventories has been validated in the Czech Republic. The questions in both inventories that could have potentially reflected sleep disturbances ("I get too tired to do anything", "Inability to rest") were excluded from analyses in order to avoid inflating correlations.

Statistical analyses

Firstly, the descriptive statistics and correlations between the PSQI, its components and other measures were examined. Spearman correlations were performed due to ordinal nature of the PSQI. Secondly, the internal consistency of the PSQI using Cronbach's alpha and item-total correlations of the seven subscales was computed. Based on previously reported structures of the PSQI, a series of 11 confirmatory factor analyses was then conducted to assess the structural validity of the questionnaire (Aloba *et al.* 2007; Burkhalter *et al.* 2011; Buysse *et al.* 2008; Buysse *et al.* 1989; Cole *et al.* 2006; Gelaye *et al.* 2014; Hita-Contreras *et al.* 2014; Koh *et al.* 2015; Kotronoulas *et al.* 2011; Sohn *et al.* 2012). The diagonally weighted least squares (DWLS) estimator was used to assess the model parameters. To assess fitted model, chi-squared test (χ^2) and multiple fit indices were used: goodness of fit index (GFI), comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA) along with 95% confidence interval (95% CI), and standardized root mean square residual (SRMR). Fitted model was considered good if indices reached statistically insignificant and lower χ^2, GFI was >0.90, CFI ≥0.95, TLI ≥0.95, RMSEA ≤0.05 (≤0.08 adequate fit), and SRMR ≤0.08 (Hooper *et al.* 2008). The good/adequate nested models were then compared against one another based on the χ^2 difference tests. The most parsimonious model was then considered as a better alternative. Additionally, simple comparisons of χ^2 were also used in non-nested models with adequate fit – a model was considered to be better fitted if it had lower χ^2. To determine the usefulness of standard and alternative scoring systems, the convergent validity of the PSQI was finally examined via bivariate correlation analyses of the PSQI global score, PSQI factor scores, and total scores on measures of sleepiness, insomnia severity, depression, and anxiety.

RESULTS

Sample characteristics – descriptive statistics

Table 1 provides the descriptive statistics for the PSQI global score, seven PSQI components, and measures of insomnia, sleepiness and psychopathology, as well as the Spearman's inter-correlations (r_s) of the PSQI. Using the recommended cutoff score of 5 for the global PSQI score, 92.4% of the participants had poor sleep quality.

Internal consistency – Cronbach's alpha

Overall, the questionnaire reached the borderline criterion (α=0.608) where internal consistency may be put in question (George & Mallery 2003). Three components did not correlate well with the questionnaire overall: sleep disturbances (r=0.103), use of sleep medications (r=0.256), daytime dysfunction (r=0.270). They were however not removed from the analyses as their deletion would not result in increasing the instrument's reliability. Deletion of components of sleep disturbances and use of sleep medications would improve the reliability but not sufficiently (α=0.621 and α=0.616, respectively). Given little benefit of exclusion of any item, and bearing in mind the potential loss of information if an item was deleted, all components were included in further confirmatory analyses.

Tab. 1. Pittsburgh Sleep Quality Index (PSQI) descriptive statistics and Spearman's component correlations, descriptive statistics on assessment instruments and their Spearman's component correlations.

	N	Mean	SD	1	2	3	4	5	6	7	8
1. Subjective sleep quality	105	1.85	0.77	–	0.23*	0.37**	0.29**	0.19	–0.06	0.27**	0.48**
2. Sleep latency	104	2.08	0.98		–	0.25*	0.45**	0.12	0.31**	0.13	0.63**
3. Sleep duration	103	1.76	1.10			–	0.49**	0.08	0.06	0.19	0.66**
4. Habitual sleep efficiency	98	1.28	1.17				–	0.10	0.20*	0.05	0.73**
5. Sleep disturbances	103	1.41	0.55					–	–0.06	0.37**	0.22*
6. Use of sleep medications	105	1.91	1.35						–	0.12	0.49**
7. Daytime dysfunction	102	1.33	0.65							–	0.41**
8. PSQI global score	105	11.41	3.67								–
ESS	105	9.09	4.67	–0.06	–0.12	–0.02	0.03	0.27**	–0.11	0.39**	
ISI	104	17.01	4.38	0.36**	0.45**	0.24*	0.32**	0.20	0.19	0.16	
BDI	101	5.74	4.33	0.20	0.07	0.19	0.10	0.40**	–0.02	0.30**	
BAI	104	9.06	6.98	0.06	0.18	0.03	0.10	0.38**	0.05	0.20*	

ESS = Epworth sleepiness scale; ISI = Insomnia Severity Index; BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory;
* = correlation statistically significant at p=0.05 (two-tailed); ** = correlation statistically significant at p=0.01 (two-tailed)

Structural validity – confirmatory factor analyses (CFA)

A series of 11 confirmatory factor analyses was conducted to investigate the structural validity of the PSQI. Table 2 presents the goodness-of-fit indices for all models including one-, two-, and three-factor solutions. Models 4, 8, 9, and 11 did not converge. The original scoring system (Buysse *et al.* 1989) as represented in the Model 1 indicated a poor fit with the data except one fit index. Models 5, 7, and 10 respectively based on studies by Sohn *et al.* (2012), Cole *et al.* (2006), and Gelaye *et al.* (2014) encompassing two- and three-factor structures showed adequate model fit indices. The statistical comparison of the nested models (Models 7, 10) and Model 5 was subsequently conducted.

Tab. 2. The χ^2 test and goodness-of-fit indices including one-, two-, and three-factor models of the PSQI.

	χ^2	df	*p*	GFI	CFI	TLI	RMSEA	95% CI	SRMR
Model 1	26.572	14	0.022	0.969	0.867	0.801	0.099	0.037–0.156	0.102
Model 2	24.835	13	0.024	0.971	0.875	0.798	0.099	0.035–0.158	0.099
Model 3	26.436	13	0.015	0.969	0.858	0.771	0.106	0.045–0.164	0.101
Model 4	–								
Model 5	16.534	13	0.221	0.981	0.963	0.940	0.054	0.000–0.123	0.078
Model 6	24.819	12	0.016	0.971	0.864	0.763	0.108	0.045–0.168	0.099
Model 7	14.806	11	0.192	0.983	0.960	0.923	0.061	0.000–0.134	0.076
Model 8	–								
Model 9	–								
Model 10	15.991	11	0.141	0.981	0.947	0.899	0.070	0.000–0.140	0.079
Model 11	–								

χ^2 = chi-squared test; df = degrees of freedom; *p* = *p*-value; GFI = goodness of fit index, CFI = comparative fit index, TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation; 95% CI = 95% confidence interval; SRMR = standardized root mean square residual

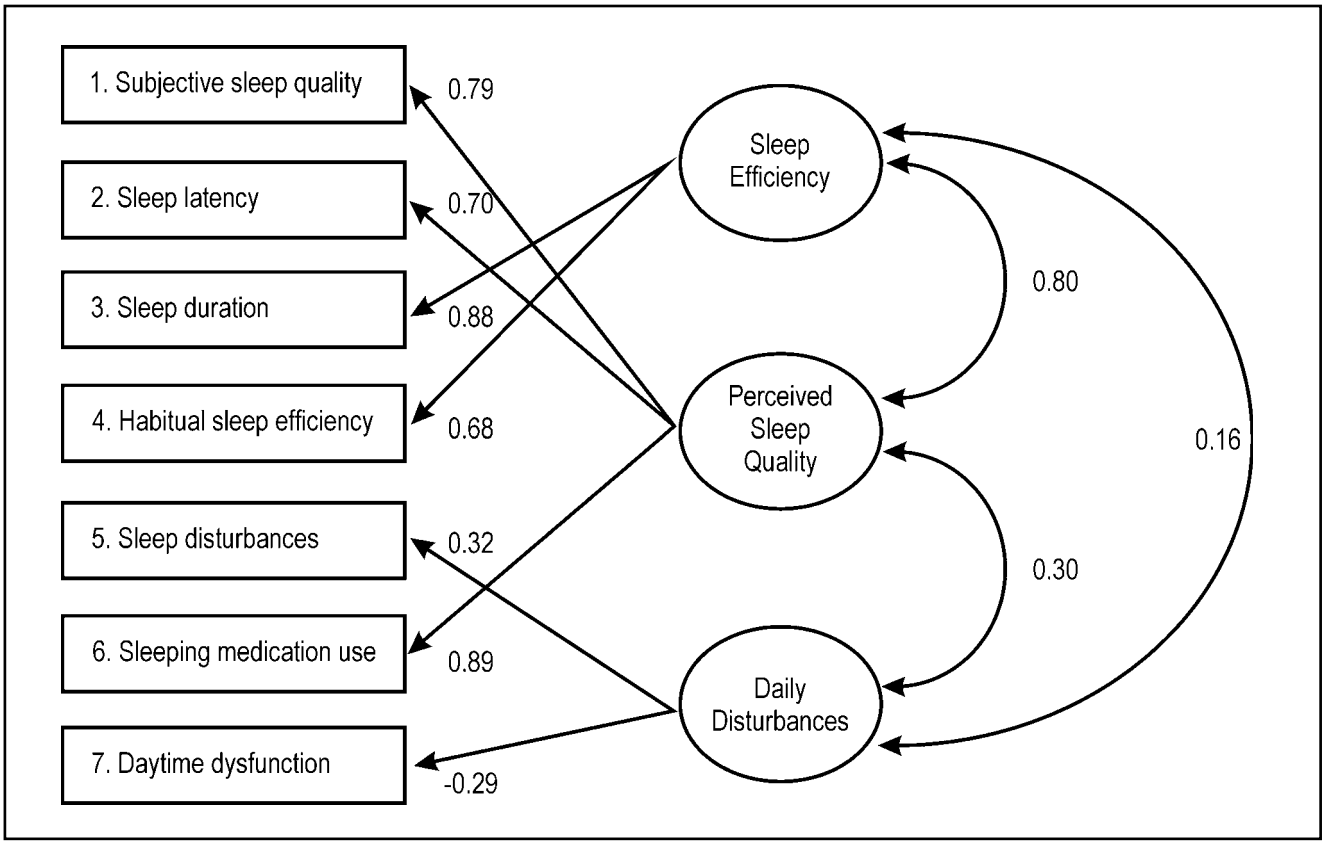

Fig. 1. Three-factor model 7 as originally proposed by Cole *et al.* (2006) with standardized path coefficients between factor solution and the PSQI components.

The χ^2 difference tests of the nested models revealed that Model 5 was not significantly different from the more parsimonious models 7 and 10 ($\Delta\chi^2(2)=1.728$, $p>0.05$; $\Delta\chi^2(2)=0.543$, $p>0.05$ respectively). Simple comparison of the magnitudes of χ^2 in non-nested models (Model 7, 10) were more in favor of Model 7 as proposed by Cole *et al.* (2006), and other investigators (Casement *et al.* 2012; Mariman *et al.* 2012). The factors of the Model 7 were named according to Cole *et al.* (2006): Sleep Efficiency, Perceived Sleep Quality, and Daily Disturbances (Figure 1).

Convergent validity – correlation analyses

Correlations between the PSQI factor scores of Model 7, PSQI global score and related measures of insomnia, sleepiness and psychopathology are presented in Table 3. To assess whether the correlations between factors and the PSQI global scores were significantly different, tests for the equality of dependent correlations were conducted. Correlations between the factor Daily Disturbances and ISI, BDI, and BAI scores, and the global score and ISI, BDI, and BAI scores did not differ significantly (z=–1.81–1.86, all $p\geq0.05$).

DISCUSSION

The present study examined the internal consistency and structural validity of the Czech version of the Pittsburgh Sleep Quality Index in a sample of chronic insomnia patients. As such, it is the first study to assess the instrument structure in solely sleep disordered population and the first study examining the validity of the PSQI in the Czech context. The usefulness of a standard and alternative scoring system as found in the structural analyses was also assessed using convergent validity analyses with measures of daytime sleepiness, insomnia symptoms, and psychopathology (depression, anxiety).

Firstly, it is of note that more than 7% of participants scored below the cutoff point for decreased sleep quality despite being diagnosed with insomnia. It is currently unclear whether the finding is due to the specifics of the sample, insomnia criteria, cultural differences or other present factors, however it may overall question the sensitivity of the instrument in chronic insomnia patients and deserves further investigation. Secondly, the reliability analysis suggested marginally acceptable level of internal consistency. Specifically, sleep disturbances, use of sleeping medications, and daytime disturbance components had low correlations with the questionnaire overall but their deletion did not result in notable improvement of internal consistency. This may be due to the inherent characteristics of the chronic insomnia sample and may suggest the three components do not consistently reflect the construct of sleep quality in chronic insomnia. Findings are comparable to other investigations that also reported Cronbach's alpha of 0.60–0.70 (Koh *et al.* 2015; Magee *et al.* 2008; Spira *et al.* 2012) and also found the same three components at least somewhat problematic (Babson *et al.* 2012; Cole *et al.* 2006; Doi *et al.* 2000).

Our results of the series of confirmatory factor analyses point to the PSQI being a multidimensional instrument. Our findings are consistent with growing number of studies which point to the multifactorial nature of the PSQI (Aloba *et al.* 2007; Babson *et al.* 2012; Casement *et al.* 2012; Cole *et al.* 2006; Gelaye *et al.* 2014; Jomeen & Martin 2007; Koh *et al.* 2015; Magee *et al.* 2008; Nicassio *et al.* 2014; Tomfohr *et al.* 2013). Three models with both two- and three-factor solutions showed adequate fit with the data but a model originally proposed by Cole *et al.* (2006) descriptively stood out among the other two as the most acceptable model in our sample of chronic insomnia patients. In this model, the PSQI consisted of three factors: Perceived Sleep Quality, Sleep Efficiency, and Daily Disturbances.

We also found evidence for the potentially important role of the components of daytime dysfunction and sleep disturbances in structural validity of the PSQI. The measures of sleepiness and psychopathology were significantly correlated with the Daily Disturbances factor, more so than with the PSQI global score. This result highlights a closer relationship between the PSQI components of daytime dysfunction and sleep disturbances and symptoms of daytime sleepiness, depression, and anxiety. These findings were similarly reported elsewhere (Babson *et al.* 2012; Dietch *et al.* 2016; Jomeen & Martin 2007) and support the notion that various sleep symptoms may differentially relate to psychological symptoms. Our results suggest that any clinician whose insomnia patient scores high on either

Tab. 3. Bivariate correlations between PSQI factor scores of Model 7, PSQI global score, and measures of insomnia, sleepiness and psychopathology.

	Perceived Sleep Quality	Sleep Efficiency	Daily Disturbances	PSQI global score
ESS	–0.145	0.030	0.453**	0.047
ISI	0.437**	0.279**	0.209**	0.454**
BDI	0.109	0.199	0.521**	0.292**
BAI	0.190	0.099	0.443**	0.276**

ESS = Epworth sleepiness scale; ISI = Insomnia Severity Index; BDI = Beck Depression Inventory; BAI = Beck Anxiety Inventory;
** = correlation statistically significant at p=0.01 (two-tailed)

daytime dysfunction or sleep disturbances components should consider possible comorbid symptoms of daytime sleepiness and psychopathology.

Disentangling the relations between sleep quality and psychopathology may importantly inform both prevention and treatment. Future studies should therefore expand on the issue of interrelatedness between daytime dysfunction and sleep disturbances and psychopathology. For example, it would be beneficial to assess dissociation, psychoticism, or posttraumatic stress in order to determine the relation between sleep quality and these psychopathologies.

Another main result of the present study concerns the issue of structural variance. It appears that the PSQI is multidimensional; however the more important question is whether the stability of the structure holds in different populations and is found feasible clinically. Mollayeva *et al.* (2015) found the structure of the PSQI inconstant and naturally variant. Our findings confirmed the PSQI total score had convergent validity and the global scoring was found useful. Thus, they showed the limited utility of the alternative scoring which is in line with other studies that found the PSQI to be a multidimensional instrument but its alternative scoring was not useful (Casement *et al.* 2012; Ho & Fong 2014; Mollayeva *et al.* 2015).

One of the limitations of our study includes restricted generalizability of our findings with regards to scoring recommendations to other populations. Our results may be constrained to the population of people with chronic insomnia and to the cultural and societal context of the Czech Republic as the psychometric characteristics of the PSQI previously varied in different languages and countries (Doi *et al.* 2000; Gelaye *et al.* 2014; Koh *et al.* 2015; Kotronoulas *et al.* 2011; Sohn *et al.* 2012). Although having a relatively low number of participants for the purposes of factor analyses, a strength of our study is the inclusion of a heterogeneous sample of chronic insomnia patients with no comorbidities as confirmed by attending physicians and all-night polysomnography.

To conclude, the present study provides evidence for possible acceptance of more than one differing structures of the PSQI in chronic insomnia. Caution must therefore be taken with regard to accepting any alternative scoring systems. Nevertheless, this study brings important new insights into the reliability and validity of the Czech version of the PSQI, and into the comprehensive assessment of sleep quality in chronic insomnia. Clinicians are recommended to pay particular attention to the PSQI components of daytime dysfunction or sleep disturbances as these may point to comorbid symptoms of daytime sleepiness and psychopathology.

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