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Sex Differences in the Psychometric Properties of the Pittsburgh Sleep Quality Index

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Abstract

Background: The Pittsburgh Sleep Quality Index (PSQI) is a well-known, validated, and reliable instrument used to measure the clinical construct of sleep quality. Little research has been done to measure its psychometric properties by sex. Previous researchers have established the validity of a three-factor structure, but it is unknown whether it applies to both men and women equally.
Materials and Methods: This study examined 198 participants; women ($n = 104$), men ($n = 94$) who were participants in the Diabetes Sleep Treatment Trial, an ongoing study examining the effect of continuous positive airway pressure on glycemic control in people with type 2 diabetes. A principal components analysis with varimax rotation, scree plots, parallel analysis, and Eigenvalues confidence intervals were all computed to determine factor structure using the seven components measured in the PSQI.
Results: Component one, a question about perceived sleep quality, loaded with ''sleep efficiency'' and ''sleep duration'' in men and with ''daytime dysfunction'' and ''sleep disturbances'' in women.
Conclusion: This study confirms a three-factor structure as previously suggested; however, ''perceived sleep quality'' may load differently depending on the sex being examined. This result suggests that men and women may interpret what is meant by ''overall sleep quality'' differently.

Keywords: sleep, diabetes, sex differences, Pittsburgh Sleep Quality Index

Introduction

While many people talk informally about how well they slept, the concept of what composes ''sleep quality'' is difficult to define and harder to measure because of its inherent subjective characteristics. Yet, poor sleep quality can be an important symptom of sleep disorders and is associated with mood disorders, anxiety and depression, and frequently accompanies serious medical illnesses.[1] The Pittsburgh Sleep Quality Index (PSQI)[1] was developed as a measure of sleep quality to determine when impaired sleep quality becomes pathological in nature and needs further evaluation, or to evaluate the response of treatment of sleep disorders. Since its inception, the PSQI has been accepted as the standard instrument to measure sleep quality with over 2272 citations listed in PubMed alone.

No factor analysis was conducted in the initial validation of the study as it was intended to determine the overall concept of sleep quality and to be used as a single global measure. Validation of the instrument was conducted by calculating validity, test-retest reliability, and internal homogeneity. Questions included in the PSQI were obtained from prior sleep instruments, clinical judgment and expertise, and were then honed by its use over 18 months. Overall the scale was found to do well in all three measures.[1]

Since the development of the PSQI, many researchers have conducted a factor analysis of the PSQI, arriving at a one, two, or three factor model depending on the characteristics of the sample population.[2] According to a recent systematic review of validation studies of the PSQI, in studies examining its factor structure, 8 out 11 studies reported that one factor was not adequate to represent overall sleep quality.[2] Perhaps the most well-known study was conducted in a sample of older adults (>60 years).[3] Cole et al.[3] proposed a three-factor structure consisting of (1) perceived sleep quality; (2) sleep efficiency; and (3) daily disturbance.

Given that there is broad evidence of sex differences in the effects of sex hormones on sleep mechanisms, as well as in circadian clock genes, respiratory function, and stress responses, it is likely that conceptual sleep quality is different in men and women. Premenopause, women have a later circadian rhythm than men. This may be a factor in women's greater propensity to insomnia.[4] Sleep debt also accumulates more quickly in women and it takes longer for women to recover.[4] Women who experience sleep debt may be at higher risk for cardiovascular or metabolic complications.[4] Data

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suggest that after menopause, women report worse sleep quality than men.[5] Women and men also report different functional outcomes from poor sleep quality including worse mood and lower daytime energy.[6] Research also suggests that women report, and possibly experience, different symptoms of impaired sleep.[7]

Because women's sleep differs substantially from men, Mallampalli and Carter[8] reporting from a roundtable of interdisciplinary experts at the Society for Women's Health in 2013, suggested that screening instruments be developed specific for sleep patterns in women. Toward this objective, an examination of the gendered patterns and perceptions of sleep was conducted in an established instrument, the PSQI, to see whether there might be an instance where there were sex differences in the perception of sleep quality.

Additionally, the effects of impaired sleep potentially complicate self-management behaviors, and contribute to increased risk and poorer outcomes in persons with type 2 diabetes. Poor sleep quality has been implicated in increased risk for type 2 diabetes.[9] Recent longitudinal data from the Nurses' Health Study confirm an association with measures of sleep quality including difficulty sleeping and short sleep duration and a risk for sleep apnea and type 2 diabetes in women.[10] One cross-sectional study suggested that daytime sleepiness has a greater effect on women's daytime energy than men's daytime energy, which may contribute to risk factors associated with type 2 diabetes.[6] Finally, women with type 2 diabetes suffer greater cardiovascular complications than men with type 2 diabetes suggesting this is a crucial area for study.[11]

There is a lack of consistency in the few studies that have examined sex differences in the PSQI.[2] While the concept of sleep quality is an accepted clinical construct and is a topic of much fascination in the average person's daily life and conversation, it is likely to be perceived differently by different individuals and within different populations. No known studies have examined a factor structure of the PSQI by sex. Due to the known sex differences in the mechanics of sleep and studies that suggest women report different symptoms of sleep impairment than men, it was hypothesized that men and women will report perceptual differences in sleep quality. The purpose of this study is to examine possible sex differences in the factor structure of the PSQI in a sample of people with type 2 diabetes who were recruited because of their self-appraised impaired sleep.

Materials and Methods

This study used a cross-sectional, descriptive design and was approved by the Institutional Review Board at the University of Pittsburgh. Data from the ongoing Diabetes Sleep Treatment Trial ([DSTT] PI: Chasens, R01 DK096028) were used to explore the sex differences in factor structure. The purpose of the DSTT is to examine the effects of continuous positive airway pressure (CPAP) treatment on glycemic control in people with obstructive sleep apnea (OSA) and type 2 diabetes. All participants were recruited from the community and were telephone screened before a baseline assessment. Potential participants were excluded from the studies if they had prior experience with CPAP, if they did not report type 2 diabetes, if daytime sleepiness was a safety issue, if they could not read English, or were not independently mobile.

Measures

Baseline profile. The baseline assessment included several sleep and diabetes-related questionnaires, including the PSQI and a demographic questionnaire, a clinical evaluation of height and weight to calculate body mass index, and a venipuncture to measure A1C level. Participant's sex was self-identified. Participants were given a home sleep device (ApneaLink Plus®) to wear the following night to evaluate them for OSA and measure its severity.

Pittsburgh Sleep Quality Index. The PSQI is a self-administered questionnaire that includes 19 questions that when scored, are separated into seven components. The components include (1) perceived sleep quality; (2) sleep latency (how long it takes to fall asleep); (3) sleep duration; (4) habitual sleep efficiency (how long a person is asleep in comparison to their time in bed); (5) sleep disturbances (*i.e.*, noise, temperature, pain, nocturia); (6) sleep medications; and (7) daytime dysfunction (sleepiness, concentration). The questions concerning trouble sleeping are answered via a Likert scale from ''not during the past month'' to ''three or more times a week'' or are written in; that is, ''when have you usually gone to bed at night?'' or ''how long has it usually taken you to fall asleep.'' The PSQI has reported good overall reliability (Cronbach's $\alpha = 0.83$) and validity (sensitivity 89.6% and specificity 86.5%).[1] A score greater than five indicates impaired sleep quality.

Data analysis

IBM SPSS statistics version 24.0 was used for all statistical analysis in this study. Significance was set at $p < 0.05$ for two-sided hypothesis testing. Descriptive statistics were used to describe demographic variables such as age, marital status, and global PSQI score, and were calculated as means and standard deviations. Univariate normality of each of the seven components of the PSQI was assessed using the Shapiro–Wilk test and a through examination of box-plots and histograms. Multivariate outliers were screened using the Mahalanobis distance technique.[12] Participants who did not complete the PSQI were removed from the study.

The Kaiser–Meyer–Olkin (KMO) and Bartlet's test statistics were computed to determine whether the total men's and women's samples were suitable for a factor analysis. Principal component analysis was used to see whether there were linear combinations of the components that correlated and accounted for maximum variance. Both Promax and Varimax rotations were employed to determine the best fit of components into factors. Eigenvalues, Eigenvalue confidence levels,[13] scree plots,[14] and parallel analysis[15] were used to identify latent factors in the total sample; men and women were analyzed separately. Based on sample size, the cut points for factor loadings may vary;[16] minimum factor loading at the preliminary interpretation was considered 0.32 based on best practice recommendations.[17] Reliability estimates were calculated using Cronbach's α, with results >0.80 considered ideal.[18] Inter-item correlations were evaluated and inter-item correlations >0.80 among the components were evaluated for possible redundancy.

Table 1. Demographic Variables

Variable	Female (n = 104) Mean ± SD or %	Male (n = 94) Mean ± SD or %	p
Age	55.3 (11.1)	58.5 (10.0)	0.036
White	48 (46.2%)	61 (65.6%)	0.006
Partnered	32 (30.8%)	42 (45.2%)	0.037
>High school	83 (80%)	65 (70%)	0.109
BMI	35.0 (7.0)	34.5 (6.4)	0.620
A1C	7.6 (2.0)	8.0 (1.6)	0.919
Total PSQI	10.5 (3.9)	9.5 (4.2)	0.084

BMI, body mass index; PSQI, Pittsburgh Sleep Quality Index; SD, standard deviation.

Results

At the time of this study, 199 participants completed the baseline assessments with the sample balanced by sex (Table 1). One participant did not complete the PSQI and was removed from this analysis making the total sample 198. The overall sample reported poor sleep quality (mean = 10.02). The means of all seven components measured in the PSQI per men and women can be found in Table 2. There were significant differences in the sample by sex in age, race, and marital/partnership status.

The Barlett's test of sphericity and the KMO statistic were assessed to determine whether the sample was appropriate for factor analysis. The KMO statistic exceeded 0.60 in all samples and the Bartlett's test of sphericity was significant ($p < 0.001$) in all samples meaning that the sample was appropriate for a factor analysis.[13]

Reliability and construct validity

For the sample of men, the PSQI demonstrated good internal consistency (Cronbach's $\alpha = 0.715$) meeting the minimum condition for good reliability; for women (Cronbach's $\alpha = 0.674$) and the total sample (Cronbach's $\alpha = 0.695$) approached good internal consistency. Inter-item correlation matrices show none of the components to be above 0.80 indicating little or no redundancy. Habitual sleep efficiency and sleep duration ($r = 0.608$) were more highly correlated in men than in women ($r = 0.363$). A Fishers r to z transformation confirmed this as a significant difference between men and women in this sample ($p < 0.05$). Additionally, sleep duration is much more highly correlated with perception of sleep quality in men ($r = 0.515$) than in women ($r = 0.245$). Sleeping medications were the least correlated with all the other components except for sleep latency and in many instances were not significant.

To ensure adequate differentiation and maximize factor loadings of the seven components, an orthogonal rotation (Varimax) was chosen to closely examine the factor structure. Using the principal components analysis (PCA) and varimax rotation, we determined a three-factor structure for both male and female samples (Table 4). We found similar results when comparing them to a Promax rotation. While the sample size was modest, factors loadings of >0.64 indicated potential latent variables. Factor one very clearly demonstrated a latent variable (Eigenvalue's 2.6–2.9) accounting for 37%–40% of the variance (Table 3).

An Eigenvalue of one is considered the cutoff for factor inclusion but may not be accurate approximately one-third of the time.[17] Therefore, it was less clear whether factors two and three were latent variables as their values, while greater than one, were not substantially greater than one (Table 4). Further analysis was conducted to determine whether they were additional factors. Scree plots, which look for natural breaks in data,[17] were examined and each confirmed the same three-factor structure in both men and women. In addition, parallel analysis, using randomly generated data, was conducted separately for men and women. In parallel analysis, any randomly generated Eigenvalues that are greater than Eigenvalues generated from the data indicate that the factor is not meaningful.[15] In this data, Eigenvalue means for men were greater than the randomly generated eigenvalues in factor's one and three thus corroborating these two factors in the sample of men. For women, only factor one generated a mean Eigenvalue greater than the randomly generated

Table 2. Comparison of the Mean Scores of Men and Women on the Seven Components of the Pittsburgh Sleep Quality Index

Components	What is your sex?	Mean	SD
PSQI component no. 1 score—Subjective sleep quality*	Male	1.44	0.79
	Female	1.68	0.75
PSQI component no. 2 score—Sleep latency	Male	1.48	1.05
	Female	1.73	1.01
PSQI component no. 3 score—Sleep duration	Male	1.52	1.16
	Female	1.59	1.11
PSQI component no. 4 score—Habitual sleep efficiency	Male	1.11	1.26
	Female	1.08	1.18
PSQI component no. 5 score—Sleep disturbances*	Male	1.87	0.62
	Female	2.09	0.58
PSQI component no. 6 score—Use of sleeping medications	Male	0.76	1.20
	Female	0.95	1.24
PSQI component no. 7 score—Daytime dysfunction	Male	1.24	0.73
	Female	1.38	0.71

*$p < 0.05$, All scores range 0–3. Subjective sleep quality (higher scores = worse sleep quality); sleep latency score (higher scores = longer to fall asleep and more often trouble falling asleep); sleep duration (higher score = shorter sleep duration); habitual sleep efficiency (higher score = worse sleep efficiency); sleep disturbances score (higher score = more disturbances); sleeping medications (higher score = more frequent use); daytime dysfunction (higher scores = more sleepiness and less ''enthusiasm to get things done'').

PSQI, Pittsburgh Sleep Quality Index.

Table 3. Principal Components Analysis, Total Variance for Women and Men

Components	Eigenvalues (Women)	% Variance (Women)	% Cumulative variance (Women)	Eigenvalues (Men)	% Variance (Men)	% Cumulative variance (Men)
Perception of sleep quality	2.631	37.581	37.581	2.818	40.252	40.252
Sleep latency	1.09	15.575	53.156	1.262	18.027	58.28
Sleep duration	1.044	14.919	68.075	1.108	15.831	74.111
Habitual sleep efficiency	0.816	11.651	79.726	0.595	8.498	82.609
Sleep disturbances	0.553	7.898	87.624	0.495	7.073	89.682
Use of sleeping medications	0.472	6.742	94.366	0.429	6.123	95.805
Daytime dysfunction	0.394	5.634	100	0.294	4.195	100

Eigenvalues. Because parallel analysis did not completely confirm a three-factor structure in men and women, we also investigated Eigenvalue confidence intervals.[13] This method only demonstrated one latent variable in both the male and female samples (factor one). Out of the four types of factor analysis we computed, PCA and scree plots confirmed a three-factor structure. Parallel analysis partially confirmed the factor structures found in the PCA, and Eigenvalue confidence intervals did not confirm a three-factor structure.

We then looked to the literature for suggestions for the best fit of factor structure for our data. Cole et al.[3] also found a three-factor structure in a sample of older adults very similar to our three-factor structure. In their analysis, the only difference in their factor structure from ours was that the perception of sleep quality loaded with sleep latency and sleeping medications. Since the three-factor structure is established from previous research, and our analysis suggested a very similar factor structure, we believe it to be the best fit for our data for both men and women. Table 4 summarizes the factor structure found in our data. Component one ''perceived sleep quality'' loaded with ''sleep duration'' and ''sleep efficiency'' in men and but in women ''perceived sleep quality'' loaded with ''nighttime disturbances'' and with ''daytime disturbances.'' Otherwise, in both men and women (1) ''sleep duration'' and ''habitual sleep efficiency''; (2) ''sleep latency'' and ''sleep medications''; and (3) ''sleep disturbances'' and ''daytime disturbances'' load similarly to form three factors.

Discussion

Our findings suggest a three-factor structure similar to the findings of Cole et al.[3] These findings suggest that women and men may perceive sleep quality differently in this sample of people with type 2 diabetes. In women, perceived sleep quality loaded with the components of sleep disturbances and daytime dysfunction. In men, perceived sleep quality loaded with sleep duration and habitual sleep efficiency. In both sexes, sleep latency loaded with perceived sleep quality (factor loadings >0.32) but was a less robust association for both. These findings suggest that women may equate sleep quality with disturbances of sleep (*e.g.*, baby crying, partner snoring) and its daytime effects such as sleepiness or poor concentration. Men may be more likely to equate sleep quality with sleep duration and sleep efficiency.

Cole et al.[3] described a similar factor structure for a sample of older adults, however, his participants were more likely to equate ''perception of sleep quality'' with sleep latency and the need to take sleeping medications. Cole et al.[3] named the factor that included the components of sleeping medications, sleep latency, and perception of sleep quality, ''perception of sleep quality.'' As the perception of sleep quality does not load with the same components in our sample, we do not believe that the ''perception of sleep quality'' carries the same meaning to our participants. However, our findings are otherwise like Cole et al.'s[3] findings. In summary, we suggest that the component, ''perception of sleep quality'' might load with different components depending on the population being studied; in our sample, it loads differently by sex.

It is unclear whether lifestyle and sociocultural factors associated with gender, or whether biological factors play a role in how sleep quality is perceived by men and women. If they define or perceive sleep quality differently, it might account for differences in symptom reports. According the general theory of sex differences put forth by Arnold,[19] sex

Table 4. Factor Loadings Using the Seven Components of the Pittsburgh Sleep Quality Index Based on a Principal Components Analysis and Varimax Rotation

	Factor 1		Factor 2		Factor 3	
	Men	Women	Men	Women	Men	Women
Perceived sleep quality	0.649	0.694				
Sleep latency	0.547	0.397			0.653	0.596
Sleep duration	0.849			0.866		
Habitual sleep efficiency	0.858			0.731		
Sleep disturbances		0.817	0.776			
Use of sleeping medications					0.923	0.903
Daytime dysfunction		0.740	0.863			

Only factor loadings >0.32 are listed.

differences may be expressed differently depending on age, levels of stress and health, environment, genetics, epigenetics, and various other influences that make it difficult to generalize beyond this sample. Therefore, it is unclear whether men and women without diabetes or with normal sleep would respond in a similar manner. For instance, recent research suggests that African Americans suffer worse sleep quality than Whites[20] and that older adults might perceive sleep quality differently.[3] Factors such as race, age, and marital/partnership status were not considered, and they may also affect one's perception of their sleep quality.

Conclusions

In summary, this study suggests that there may be different factor structures for men and women in the PSQI depending on the population being examined. This is the first known study to compare the sex differences in psychometric properties of the PSQI. Although both men and women had three-factor structure similar to each other and to that proposed by Cole et al.[3] the component of ''perception of sleep quality,'' in this sample appears to be interpreted differently by the sexes. This suggests that sleep, sex, and gender researchers need to recognize the possibility of perceptual differences in this concept between the sexes.

While this sex difference will not be found in every sample, even one instance of sex difference in the perception of subjective sleep quality challenges the assumption that men and women always perceive sleep quality alike. Researchers who use the PSQI in either describing the sample, or who are using sleep quality as a measurement of sleep impairment, should be careful to account for sex and gender differences in the perspectives of sleep quality. Finally, we suggest further examination of sex differences in the PSQI factor structure in samples of men and women with normal sleep and those with sleep disorders.

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Author Disclosure Statement

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