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ORIGINAL ARTICLE

Structure validity of the Pittsburgh Sleep Quality Index in renal transplant recipients: A confirmatory factor analysis

Hanna BURKHALTER,[1] Susan M SEREIKA,[2] Sandra ENGBERG,[3] Anna WIRZ-JUSTICE,[4] Jürg STEIGER[5] and Sabina DE GEEST[1]

[1]Institute of Nursing Science, University of Basel, [4]Center for Chronobiology, Psychiatric University Clinic, and [5]Division of Transplant Immunology and Nephrology, University Hospital Basel, Basel, Switzerland; and [2]Departments of Heath and Community Systems and Biostatistics, School of Nursing and Graduate School of Public Health, and [3]Department of Health Promotion & Development, School of Nursing, University of Pittsburgh, PA, USA

Abstract

The primary aim of this study was to fit and test the hypothesized three-factor model of the Pittsburgh Sleep Quality Index (PSQI) reported by Cole (2006) in renal transplant (RTx) recipients. We conducted a cross-sectional descriptive study using a convenience sample of home-dwelling RTx recipients, transplanted 6 months to 5 years prior to initiation of the study. Of the 135 RTx patients meeting the inclusion criteria, 29% were women with a mean age of 52 years (SD: 12; range: 21 to 76). The PSQI and a structured demographic questionnaire were mailed to the patients' homes. We conducted a confirmatory factor analysis to fit and test a single-factor model proposed by Buysse (1989) as well as the Cole (2006) three-factor model. Confirmatory factor analysis provided weak empirical support for the three-factor model ($\chi^2 = 16.555$, d.f. = 8, $P < 0.0351$; RMSEA = 0.089; WRMR = 0.492; CFI = 0.983). *Post hoc* exploration of the three-factor model indicated the inclusion of an additional path from sleep-medication items to the factor of sleep efficiency, which demonstrated an improved fit ($\chi^2 = 11.850$, d.f. = 8, $P = 0.408$; RMSEA = 0.060; WRMR = 0.384; CFI = 0.992). Confirmatory factor analysis suggests that the three-factor model of the PSQI has a better fit than the original one-factor model, and the additional pathway may improve its fit. The three-factor model with the additional path should be tested in a new sample before use in RTx recipients.

Key words: confirmatory factor analysis, daytime disturbances, renal transplantation, sleep efficiency, sleep quality.

INTRODUCTION

Renal transplant (RTx) recipients are chronically ill patients confronted with side effects of the immunosuppressive regimen, which causes significant co-morbidity, including cardiovascular complications,[1] *de novo* malignancies,[2] and infections.[3] It has also become clear that sleep–wake disregulation leads to insomnia and/or excessive daytime sleepiness.[4] The detrimental effects of sleep–wake disregulation have been well documented in healthy patients and include metabolic derangements,[5] cardiovascular disease,[6] coronary artery calcification,[7] depression,[8] chronic inflammation[9] and an increase in mortality.[10] In the chronically ill, for example in heart-failure patients, daytime sleepiness is associated with poor self-care[11,12] and in dialysis patients poor sleep quality is associated with increased mortality.[13] In RTx

Correspondence: Dr Sabina De Geest, Institute of Nursing Science, University of Basel, Bernoullistrasse 28, CH-4056 Basel, Switzerland. Email: sabina.degeest@unibas.ch

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recipients sleep impairments are associated with a decreased emotional state,[14] increased psychological problems, co-morbidities,[15] and decreased quality of life.[15–17]

The Pittsburgh Sleep Quality Index (PSQI) is a widely used 19-item self-report questionnaire that measures sleep disturbances. Seven clinically derived domains of sleep difficulties are assessed by the PSQI. Together, these sleep domains are scored as a single factor named Sleep Quality (SQ). Psychometric properties of the PSQI have been examined and found to be appropriate in relation to internal consistency,[18,19] concurrent validity[19,20] and discriminative validity[19,20] in healthy and ill populations.

Cole *et al*. (2006)[21] examined the factor structure of the PSQI using a cross-validation approach. An exploratory factor analysis in community-dwelling depressed and non-depressed older adults was followed by a confirmatory factor analysis to ascertain the reproducibility of the factor structure. They identified and confirmed a three-factor structure of the PSQI (based on the confirmatory factor analysis, all fit indices were good) and recommended that this model be used to document disturbances in three separate factors of subjective sleep: (i) perceived SQ (ii) daytime disturbances and (iii) sleep efficiency. Another study with Nigerian students[22] confirmed Cole's findings.

In previous studies, the prevalence of poor SQ in RTx recipients assessed with the Pittsburgh Sleep Quality Index (PSQI) ranged from 30% to 62%.[14,15,23] Despite its use in this population, the PSQI has not been validated in RTx recipients.

It is likely that the one-factor model of Buysse (1989)[18] will not fully capture the multidimensional nature of sleep disturbance in RTx recipients. We hypothesize that a three-factor model similar to Cole's model will better represent the sleep disturbances in this population. Our rationale for this belief is the reported high prevalence of depression and anxiety among RTx recipients. A quarter of RTx recipients have depression (prevalence ranging from 5%[24] to 25%[25]) or anxiety (prevalence ranging from 15%[25] to 70%[26]). Fear of losing the transplanted kidney through rejection is a common source of anxiety. While we expect the factor structure in our population to be similar to that reported by Cole *et al*., the way that sleep drugs relate to other items may differ because the utilization of these agents in the RTx population is likely to differ from their use in the population Cole studied. Some sleep drugs interfere with immunosuppressants,[27] so clinicians may be less likely to prescribe them for these patients than for other patient groups.

This study aims to assess whether the one-factor model proposed conceptually by Buysse[18] or the three-factor model identified by Cole[21] best captures the multidimensional nature of sleep disturbance in RTx recipients.

METHODS

Participants

This study used a cross-sectional descriptive design in a single RTx center. A convenience sample of 217 community-dwelling adult RTx recipients who received renal transplants at the University Hospital in Basel, Switzerland were included. The inclusion criteria were: (i) first RTx, (ii) between 6 months and 5 years post transplant, (iii) ability to understand and read German, (iv) more than eighteen years of age and willing to provide written informed consent. Patients were excluded if they had had a combined transplant, lacked mental clarity based on their clinician's appraisal, or could not read the questions.

Measures

Demographic and clinical data

Basic demographic data (i.e. age [years] and gender [male/female]) were retrieved from medical files in the University Hospital in Basel, Switzerland and from a structured self-report questionnaire developed for the Swiss Transplant Cohort Study (STCS). Sociodemographic variables included highest completed level of education (no completed school, mandatory school, apprenticeship, general qualification for University entrance, higher professional education, higher technical or commercial school, university, other); current occupation or last professional position (self-employed, working in a relative's firm or business, apprentice/trainee, director/manager, middle/lower management, employee, househusband/-wife, student, other); working capacity (percentage of time worked for pay during the past 6 months); marital status (single, married/living together, widow[er], divorced/separated); and monthly income in Swiss francs (CHF) (1 CHF = 0.90 USD): <4500; 4501 to 6000; 6001 to 9000 and >9001).

Pittsburgh Sleep Quality Index

The PSQI consists of 19 self-rated questions and five questions rated by the bed partner or roommate. The latter five questions are used for clinical information only and are not included in the scoring of the PSQI. The 19 self-rated questions assess a wide variety of factors and are grouped into seven component scores, each weighted equally on a 0–3 scale. According to the scoring guidelines provided by Buysse *et al*. (1989), the 19 items are analyzed to yield 7 sleep components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction. The seven component scores are then summed to yield a global PSQI score, which ranges from 0 to 21. Higher scores indicate poorer SQ.[18]

The PSQI has shown favorable psychometric properties in previous research with internal consistency coefficients ranging from 0.80[19] to 0.83[18] and test–retest correlation coefficients from 0.85[18] to 0.87[20] in healthy, depressive, insomnia, cancer and transplant populations. Convergent validity has been established with other self-report measures of sleep[19] and sleep logs.[20] A total PSQI score of 5 or more showed good sensitivity and specificity for the identification of poor versus good SQ when tested against polysomnography.[20] Backhaus *et al*.[20] reported a Cronbach's α of 0.85, a test–retest reliability coefficient of 0.87, a sensitivity ranging from 80% to 100% and a specificity ranging from 80 to 83% in German patients with primary insomnia.

Data collection

The study received the approval of the Ethics Committee of Basel. The subjects signed an informed consent form prior to participation. Data were de-identified and stored in an anonymous electronic database. Questionnaires were placed in a locked cabinet for security. Data collection took place from September 2008 to November 2008. Addresses and telephone numbers of all patients who fulfilled the eligibility criteria were extracted from the University Hospital in Basel database, and eligible patients received a short letter describing the purpose of the study. If a patient was willing to participate in the study he/she signed the written informed consent form (two copies, one for the patient and one for the researcher) and filled out the questionnaires. All questionnaires had a unique identifier that allowed identification of patients by the investigator. Patients sent the completed questionnaires back in a pre-stamped, pre-addressed envelope. Patients who had not returned their questionnaires after 30 days received a mailed reminder to complete the questionnaires. Those who did not respond within 10 days received a reminder telephone call. If the completed questionnaires were not returned after the telephone call, the patient was considered a non-responder.

Data management and analysis

Data were entered twice in the data management package SPSS and checked for inconsistencies between the entries. All discrepancies were compared with the original data and corrected.

Exploratory and descriptive data analyses were performed using SPSS software version 14.0 (SPSS, Inc., Chicago, IL, USA). Exploratory analyses entailed screening for univariate and multivariate outliers and the evaluation of missing data in terms of the amount and pattern of missingness. Missing data analysis examined the variables of the education, profession, work capacity, marital status, socioeconomic status and PSQI in terms of missingness and the observed values of these variables. Little's MCAR test was used to assess whether the missingness was completely at random (MCAR).[28] For Little's MCAR test, a non-significant finding provides some support for the MCAR assumption and that a listwise deletion approach may be reasonable. Descriptive statistics were calculated as frequencies (%) for categorical variables, while continuous interval or ratio scaled variables were summarized using means and standard deviations (or medians and inter-quartile ranges (IQR), respectively, if data were non-normally distributed and/or extreme values were present). Group-comparative statistics (two-sample *t*-test for approximately normally distributed interval- or ratio-scaled subject descriptors, Mann-Whitney *U*-test for ordinal scaled or non-normally distributed interval- or ratio-scaled variables, and chi-square tests of independence for nominally scaled characteristics) were used to compare the subgroups of responders and non-responders and subjects and dropouts. All tests of hypotheses were two-tailed and the level of significance was set at 0.05.

Confirmatory factor analysis (CFA) was conducted using Mplus (version 5.21, 2007 Muthen & Muthen) on the seven component scores, given the different scaling and non-linear transformation from item responses into component scores. Through CFA we analyzed the single-factor scoring model originally proposed by the

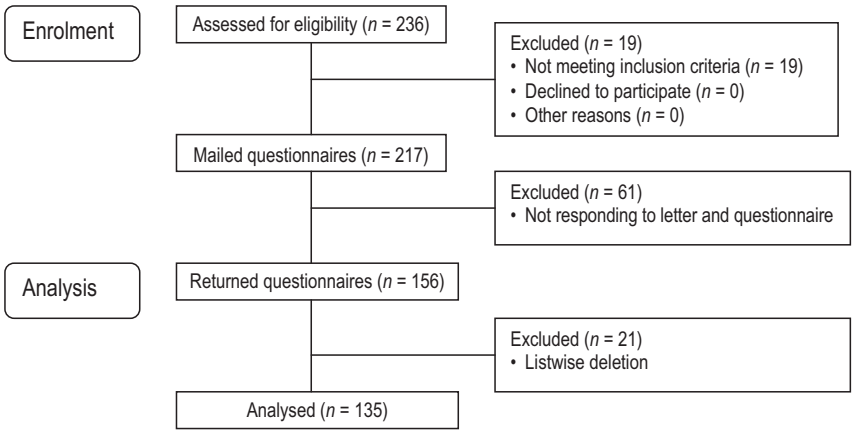

Figure 1 Flow diagram of the sample.

developer of the scale.[18] We also analyzed the three-factor model suggested by Cole.[21] Multiple fit indices were used to determine adequate model fit:[29] comparative fit index (CFI); weighted root mean square residual (WRMR); and root mean squared error of approximation (RMSEA). Finally the models were compared to each other by delta chi-squared ($\Delta\chi^2$) statistics to determine which best fit the data. The cutoffs suggesting good fit are: RMSEA < 0.05 (0.05 < RMSEA < 0.08 indicates adequate model fit; RMSEA ≥ 0.08 suggests poor model fit); CFI close to 1 (CFI > 0.95 indicates good fit); and WRMR value less than 0.90. A significant chi-square indicates lack of satisfactory model fit. That is, the chi-square test statistic used in modeling fitting is a "goodness of fit" measure in that a finding of statistical significance means the estimated covariance/correlation structure based on the model is significantly different from the observed covariance/correlation matrix.[30,31] Modification indices are generated by the software package; they are data-driven indicators of changes to the model that are likely to improve model fit.

RESULTS

The sample flow is shown in Figure 1. Out of the 217 eligible patients, 156 (72%) returned the questionnaire packets. Of these, only 135 (68%) fully completed the PSQI. Non-respondents ($n = 61$; 28%) were significantly older than respondents ($t = 2.9$, d.f. = 214, $P = 0.004$).

There were no significant differences in the patients who did not completely fill out the PSQI ($n = 21$) and those who did ($n = 135$). Therefore we chose a listwise deletion and had a 13% sample drop-out rate. The Little's MCAR test ($\chi^2 = 42.455$, d.f. = 45 $P = 0.580$), demonstrated that the missingness of data was completely at random, further supporting the decision to include only those subjects who completely filled out the PSQI.

The sample ($N = 135$) included 94 men (70%) and 41 women (30%) with a median age of 52 years (IQR: 19). Median time since transplantation was 2 years (IQR: 3). Nineteen percent of the subjects ($N = 14$) had more than one co-morbidity. A third ($N = 45$) were unemployed, while two-thirds ($N = 89$) were married or living with a significant other. The PSQI global score for the 135 subjects ranged from 1 to 19, with a median of 5 (IQR:5). Using the recommended cutoff point of 5, 47.4% (N = 64) of the subjects reported poor SQ. Table 1 displays the descriptive statistics for the seven PSQI components and the correlations between the components. Each of the scores ranged from 0 to 3. The lowest inter-component correlation was between "the use of sleep medication" and "sleep duration" (r = 0.14) and the highest correlation was between "sleep efficiency" and "sleep duration" (r = 0.73).

The fit statistics for the single-factor model proposed by Buysse[18] universally indicated a poor fit with the data ($\chi^2 = 51.850$, $P < 0.0001$; RMSEA = 0.188; WRMR = 1.024; CFI = 0.915). We also fitted the hypothesized three-factor model published by Cole[21] and Aloba.[22] The three-factor model, displayed in Figure 2, also demonstrated poor fit, but to a lesser extent that the original one-factor model ($\chi^2 = 16.555$; $P < 0.0351$; RMSEA = 0.089; WRMR = 0.492; CFI = 0.983). The relationship of each PSQI component score to its corresponding factor was significant and large ranging from standardized path coefficients of 0.56 (daytime disturbances to daytime function factor) to 0.99 (habitual sleep

Table 1 PSQI component correlations and descriptive statistics

	1	2	3	4	5	6	7
1. Subjective sleep quality	1						
2. Sleep latency	0.55	1					
3. Sleep duration	0.53	0.44	1				
4. Habitual sleep efficiency	0.56	0.44	0.73	1			
5. Sleep disturbances	0.52	0.43	0.19	0.35	1		
6. Use of sleep medications	0.42	0.40	0.14	0.30	0.32	1	
7. Daytime disturbances	0.36	0.22	0.18	0.28	0.41	0.21	1
Mean	0.96	1.16	0.55	0.74	1.26	0.33	1.01
Standard deviation	0.72	0.96	0.87	1.01	0.59	0.85	0.86
Median	1	1	0	0	1	0	1
IQR	0–1	0–2	0–1	0–1	1–2	0–0	0–1

Correlations of the seven components of the PSQI, provided for descriptive purposes.

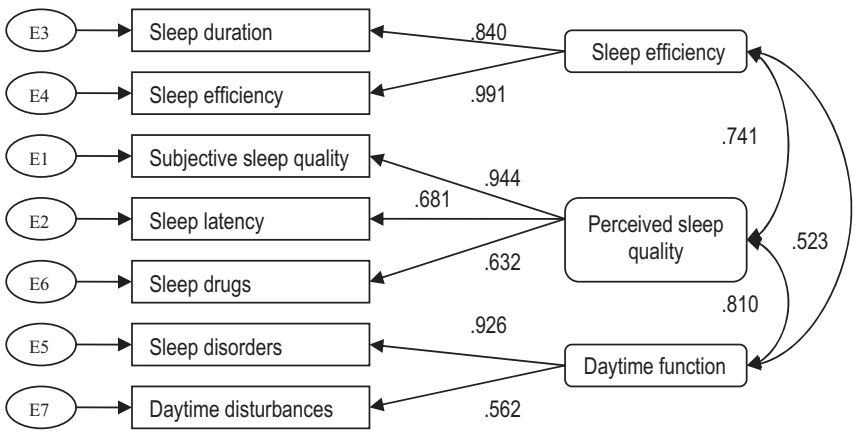

Figure 2 Three-factor model on the sample having complete PSQI data ($n = 135$).

efficiency to sleep efficiency factor). The correlation between the factors ranged from 0.52 (medium-large effect) to 0.81 (large effect).[32]

Model modification indices for the three-factor model pointed to some sources of poor fit, specifically the possible cross-loading of the sleep drugs component on the sleep efficiency factor($\Delta\chi^2 = 6.646$ improvement). The three-factor model with the additional path from the sleep efficency factor to sleep drugs component showed very good fit based on all fit indices ($\chi^2 = 11.850$, $P = 0.408$; RMSEA = 0.060; WRMR = 0.384; CFI = 0.992) (Fig. 3 and Table 2). The relationship between each PSQI component score and its corresponding factor was significant and large ranging from the standardized path coefficients of $\beta = 0.51$ (sleep efficiency factor to sleep drugs component) to 1.088 (perceived sleep quality factor to sleep drugs component). The correlation between the factors ranged from 0.53 (medium-large effect) to 0.80 (large effect).

DISCUSSION

This study is the first to assess the PSQI factor scoring structure in the RTx population. A three-factor scoring model is favored over a single score. Congruent with previous research, we showed that the three-factor model showed good fit criteria, aside from RMSEA, chi-square and a possible cross-loading indicated by the modification indices. For this reason we continued the modeling and added a path from sleep drugs to the sleep efficency factor. The model with the modified path showed very good fit criteria.

The three-factor scoring model shows that "perceived sleep quality", "daytime disturbances" and

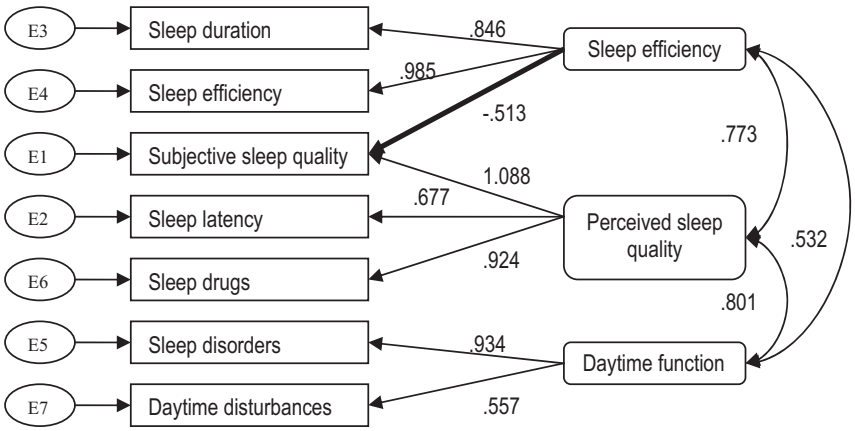

Figure 3 Three-factor model with additional path, suggested from modification indices.

Table 2 Fit statistics of the three models

Model	d.f.	Number of free parameters	χ^2 (*P*-value)	RMSEA	WRMR	CFI
1-Factor	9	28	51.850 ($P < 0.000$)	0.188	1.024	0.915
3-Factor†	8	31	16.555 ($P = 0.035$)	0.089	0.492	0.983
3-Factor‡	8	31	11.850 ($P = 0.041$)	0.060	0.384	0.992

†Best model, except for RMSEA; ‡Modification indices. CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation; WRMR, Weighted Root Mean Square Residual d.f. = Degrees of freedom. χ^2 = Chi-square goodness-of-fit statistic.

"sleep efficiency" are three correlated concepts that cover patients' sleep experience. Our findings are consistent with the study of Cole *et al*. (2006)[21] and the study of Aloba *et al*. (2007)[22] in that the three-factor model was a better fit than a single-factor model. We did not, however, find fit indices as good as those found by Cole. This could be related to the use of different analysis approaches as well as differences in samples. We had skewed data and used a statistical program for the CFA that can handle ordinal data. Further, our sample has completely different characteristics: they live with a new organ, take a lot of medication and continue to fear organ rejection or loss.

The addition of a path predicting sleep medication from the sleep efficiency factor significantly improves the model. The sleep medication component is correlated with the factors of perceived sleep quality and sleep efficiency. The component of sleep medication is based on only one item asking "During the past month, how often have you taken medicine (Prescribed or 'over the counter') to help you sleep (Not during the Past month/ Less than once a week/ Once or twice a week/ Three or more times a week)?". When subjects in our study took sleep medications more frequently, they perceived a decrease in the quality of their sleep ($\beta = 1088$). In contrast their perceived sleep efficiency improved ($\beta = 0.51$). The meaning of these results is not clear: it could be that sleep induced by medication is not the same as natural sleep and thus perceived differently. We suggest clarifying them in a further study. The model modification was *post hoc* and may have capitalized on chance. Ideally these results should be cross-validated with a new sample.

This study has several limitations. First, the data were collected anonymously. Consequently it was not possible to call the patient to obtain missing data. Second, a larger sample size (>200) would have increased the precision of the estimators from the CFA (e.g. factor loadings, factor correlations, etc.) and hence ultimately the stability of the estimators further validating the three-factor model. Third, our sample consisted of patients who were 6 months to 5 years post-transplant. In the first year following transplantation a number of predisposing (e.g. corticosteroid drugs) and precipitating factors (e.g. anxiety, stress) can increase the risk of poor sleep. After the first year there are fewer precipitating factors, but there is the risk that sleep disturbances during the first year continue. A larger sample would have permitted us to do a stratified analysis. Lastly, this study was cross-sectional and does not

provide any information on the persistence of the three-factor structure over time.

CONCLUSION

Confirmatory factor analysis suggests that the three-factor model of the PSQI may hold promise for the subjective assessment of SQ in RTx recipients. Further confirmatory work is needed to investigate the three-factor model with the additional path.

TRANSPARENCY DECLARATION

The authors have had no involvement, financial interests or arrangements, any other financial connections, or other situations, direct or indirect, that might raise the question of bias in the work reported.

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