# Validation of a 3-Factor Scoring Model for the Pittsburgh Sleep Quality Index in Older Adults

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**Study Objectives:** The Pittsburgh Sleep Quality Index (PSQI) is widely used to assess subjective sleep disturbances in psychiatric, medical, and healthy adult and older adult populations. Yet, validation of the PSQI single-factor scoring has not been carried out.

**Design:** The PSQI was administered as a self-report questionnaire. Using a cross-validation approach, scores from the PSQI were analyzed with exploratory and confirmatory factor analyses.

**Setting:** San Diego, Denver, and Los Angeles community-based clinics.

**Participants:** Community-dwelling depressed and nondepressed adults older that 60 years of age (N = 417)

**Measurements and Results:** Results yielded a 3-factor scoring model that obtained a measure of perfect fit and was significantly better fitted than either the original single-factor model or a 2-factor model. Components of the 3 factors were characterized by the descriptors sleep efficiency, perceived sleep quality, and daily disturbances.

**Conclusions:** These findings validate the factor structure of the PSQI and demonstrate that a 3-factor score should be used to assess disturbances in three separate factors of subjective sleep reports.

**Keywords:** Sleep quality, latent analysis, confirmatory factor analysis, PSQI

**Citation:** Cole JC; Motivala SJ; Buysse DJ et al. Validation of a 3-factor scoring model for the pittsburgh sleep quality index in older adults. *SLEEP* 2006;29(1): 112-116.

## INTRODUCTION

SLEEP DISTURBANCE IS PREVALENT IN OLDER ADULTS, WITH MORE THAN 30% OF ELDERLY REPORTING IMPAIRED SLEEP QUALITY AND CHRONIC DIFFICULTIES with sleep performance, ranging from long latency periods before falling asleep and frequent awakenings at night to difficulties returning to sleep upon awakening.[1] Such disturbances of sleep impact daytime functioning, reduce quality of life, and are reported to lead to declines in heath status[2] and increases in all-cause mortality.[3]

The Pittsburgh Sleep Quality Index (PSQI) is a widely used 19-item self-report questionnaire that measures sleep disturbances.[4-7] Seven clinically derived domains of sleep difficulties, including sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction are assessed by the PSQI. Together, these sleep domains are scored as a single factor or PSQI Sleep Quality. Whereas many psychometric aspects of the PSQI have been examined and found to be appropriate, including internal consistency,[4,6] concurrent validity,[5,6] and discriminative validity,[5,6] the scoring validity of the PSQI has not been statistically examined. Given that efficacy of a scoring system is an essential aspect of validity,[8] it is important to know whether a single summed total score, as is presently used in single-factor scoring of the PSQI, best captures the multidimensional nature of sleep disturbance as indexed by the PSQI.

In this study, we examined the factor structure of the PSQI score using a cross-validation approach. An exploratory factor analysis (EFA) was followed by a confirmatory factor analysis (CFA) to ascertain the replicability of the factor structure in a second independent sample. Furthermore, the CFA compared the structure obtained through EFA with other logical structures for the PSQI, namely, the single-factor model. PSQI scores were measured in a sample of community-dwelling depressed and nondepressed older adults. This population provides an ideal sample in which to conduct initial factorial examination because of the full range of PSQI scores found in older adults, as well as the high prevalence of sleep disturbances in nondepressed as well as depressed elderly persons.[1,9,10]

## METHODS

### Participants

The Depression Substudy of the Veterans Affairs Cooperatives Trial #403, Shingles Prevention Study, provided the data presented in this article. The Shingles Prevention Study is a double-blind, placebo-controlled, multicenter, efficacy trial to determine whether vaccination with live-attenuated Oka/Merck varicella vaccine decreases the incidence and/or severity of herpes zoster and its complications in adults 60 years of age and older over the course of 2-year longitudinal follow-up.[11] Community-dwelling older adults (veterans and nonveterans) were recruited using general media publicity, letters of invitation, advertising, and interactions with local referral groups. The Depression Substudy identified subjects from 3 sites: University of Colorado; University of California, San Diego (UCSD) and San Diego Veterans Affairs Healthcare Center; and University of California, Los An-

**Disclosure Statement**

This was not an industry supported study. Dr. Cole has worked as a senior consultant for QualityMetric and is the president of Consulting Measurement Group. Dr. Buysse is a consultant for Actelion, Cephalon, Eli Lilly, Merck, Neurocrine, Pfizer, Respironics, Sanofi-Synthelabo, Servier, Sepracor, and Takeda. Dr. Levin has received research support from GlaxoSmithKline; and shares authorship of a pediatric text for McGraw Hill. Drs. Irwin, Motivala, and Oxman have indicated no financial conflicts of interest.

**Submitted for publication June 2005**
**Accepted for publication August 2005**

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geles (UCLA). All procedures were approved by the institutional review boards of the University of Colorado, UCSD, and UCLA. A total of 2858 subjects entering the Shingles Prevention Study underwent screening for entry into the Depression Substudy. Depression screening included completion of an abbreviated version of the Centers for Epidemiological Study of Depression scale[12] and answering 2 questions as to whether they had a prior episode of depression or had been treated for a depression. Persons who scored above the previously validated Centers for Epidemiological Study of Depression scale score for depression[12] or answered affirmatively for having had or received treatment for a depression were interviewed using the Structured Clinical Interview for Diagnostic and Statistical Manual—IV diagnosis (n = 212).[13] In addition, a sample of age- and sex-comparable participants who did not meet depression-screening criteria were interviewed (n = 219). As part of the Depression Substudy, questionnaire data on sleep quality, depressive symptom severity, and health functioning were obtained along with blood samples for assessment of varicella zoster virus immunity, to be reported elsewhere. Participants then received either varicella vaccine or placebo as previously reported. [11]

Of the 431 older adults who were enrolled into the Depression Substudy, 14 subjects were excluded due to current or lifetime history of alcohol dependence or other Axis I psychiatric disorders. The final sample included 417 participants, including 67 persons with current depressive disorder, 143 individuals with depressive disorder in full remission, and 207 persons who were never mentally ill. Women comprised 55.2% of the sample, and participants were predominately Caucasian (97.1%). The sample ranged in age from 60 to 95 years, with a mean of 68.90 years (SD = 6.34 years).

### Measures

The PSQI, administered by questionnaire, includes 19 items that measure self-reported sleep disturbances, including hours of sleep, ratings for frequency of problematic sleeping behaviors, and subjective sleep quality. Items are measured on either an open-ended format (such as regular bedtime) or a 5-point Likert scale (with varying anchors depending on the questions). According to the scoring guidelines provided by Buysse et al,[4] the 19 items are recoded with various algorithms to comprise 7 sleep components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications, and daytime dysfunction. The PSQI has favorable psychometric properties, with internal consistency reliability ranging from .80[6] to .83,[4] test-retest reliability from .85 [4] to .87,[5] convergent validity with other self-report measures of sleep[6] and sleep logs,[5] and good sensitivity and specificity for identifying those with or without sleep impairments using a PSQI total score cutoff of 5.0 or more.

### Data Analysis

Data were entered and cross-checked by research assistants with ample data-entry experience. PSQI item responses were scored into 7 different components, which had small amounts of missing data, with no more than 5.5% missing data for any composite. A single-point multiple imputation procedure for missing data replacement[14] was conducted for the missing points. PSQI component descriptive statistics are in Table 1 for each group in the cross validation.

**Table 1**—Pittsburgh Sleep Quality Index Component Correlations and Descriptive Statistics

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Exploratory Factor Analysis Sample** | | | | | | | |
| 1. Subjective sleep quality | — | .51 | .35 | .49 | .41 | .29 | .39 |
| 2. Sleep latency | | — | .26 | .45 | .32 | .32 | .16 |
| 3. Sleep duration | | | — | .60 | .10 | .04 | .04 |
| 4. Habitual sleep efficiency | | | | — | .22 | .29 | .11 |
| 5. Sleep disturbances | | | | | — | .12 | .28 |
| 6. Use of sleep medications | | | | | | — | .17 |
| 7. Daytime dysfunction | | | | | | | — |
| Mean | 0.74 | 0.76 | 0.41 | 0.58 | 1.22 | 0.65 | 0.70 |
| SD | 0.73 | 0.87 | 0.68 | 0.89 | 0.52 | 1.08 | 0.65 |
| **Confirmatory Factor Analysis Sample** | | | | | | | |
| 1. Subjective sleep quality | — | .59 | .56 | .66 | .46 | .39 | .38 |
| 2. Sleep latency | | — | .40 | .52 | .34 | .37 | .21 |
| 3. Sleep duration | | | — | .69 | .11 | .20 | .27 |
| 4. Habitual sleep efficiency | | | | — | .25 | .31 | .25 |
| 5. Sleep disturbances | | | | | — | .16 | .35 |
| 6. Use of sleep medications | | | | | | — | .14 |
| 7. Daytime dysfunction | | | | | | | — |
| Mean | 0.71 | 0.68 | 0.52 | 0.53 | 1.25 | 0.57 | 0.65 |
| SD | 0.76 | 0.86 | 0.81 | 0.87 | 0.62 | 1.04 | 0.76 |

Correlations provided for descriptive purposes and were, therefore, not analyzed for significance. All data were based upon multiple imputation data replacement database.

A cross-validation approach was undertaken to assess the factor structure of the PSQI.[15] Given the nature of the variant and nonlinear transformations from item responses into component scores, factor analysis was conducted on the component scores. After randomly splitting the sample into 2 independent subsamples, 1 subsample was analyzed with EFA (EFA sample n = 207: current depressive disorder n = 36; depressive disorder in full remission, n = 78; never mentally ill, n = 93) followed by CFA on the second subsample (CFA sample of n = 210: current depressive disorder n = 31; depressive disorder in full remission, n = 65; never mentally ill, n = 114)

In the EFA subsample, principal components analysis was employed to determine the number of factors to retain for the EFA based on criteria from Preacher and MacCallum.[16] Subsequently, EFA was carried out using maximum likelihood estimation extraction and direct oblimin rotation. Factor loadings (i.e., the correlation between each PSQI component to each factor) were evaluated against criteria from Comrey and Lee[17]: .71 or greater signifies excellent loadings, .63 to .70 are very good; .55 to .62 are good; .45 to .54 are fair; and .32 to .44 are deemed poor, while any values lower than .32 are discarded.

Once the EFA was completed, a CFA was undertaken in the CFA sample to test the replicability of the EFA results. Models of the latent structure should be more than well-fitted; they should also be better fitting than other logical structures or models.[18] Therefore, along with the results from the EFA, the CFA examined the single-factor scoring model utilized by the PSQI manual; in the single-factor model, all 7 components load on a single PSQI score. The resultant models were analyzed to determine the degree to which each model fit with the CFA subgroup data. Maximum likelihood extraction was carried out on the covariance matrix, and multivariate nonnormality was smoothed over using bootstrapping.[19,20] Per the recommendations of Schumacker and

**Table 2**—Factor Matrix for the 2-Factor Solutions

| Pittsburgh Sleep Quality Index Component | Sleep Efficiency | Perceived Sleep Quality |
|---|---|---|
| Subjective sleep quality | .15[f] | .77[a] |
| Sleep latency | .23[e] | .50[d] |
| Sleep duration | .60[c] | .09[f] |
| Habitual sleep efficiency | .86[a] | .18[f] |
| Sleep disturbances | -.04[f] | .53[d] |
| Use of sleep medications | .14[f] | .31[f] |
| Daytime dysfunction | -.15[f] | .55[c] |
| Percentage of total variance, % | 39.9 | 17.4 |

Factor analysis conducted with maximum likelihood estimate extraction and direct oblimin rotation. a = excellent loading, b = very good loading, c = good loading, d = fair loading, e = poor loading, f = loading too low to interpret. Interfactor correlation = .33.

Lomax,[21] multiple fit indexes were used to determine adequate model fit: goodness of fit and adjusted goodness of fit at .90 or higher,[22] comparative fit index at .95 or higher,[23] and root mean squared error of approximation (RMSEA) at .06 or lower.[24] More information on these different measures of fit can be found in other applied research.[25,26] Finally, the models were compared to each other to determine which best fit the data. Three statistics were used to make these comparisons: $\Delta\chi^2$,[27] overlap in the RMSEA confidence intervals,[28] and the Bayesian information criterion,[29] for which differences of 10 or more provides near-conclusive evidence that the model with the lower value is better fitted.[29] A model was determined to be significantly better fitted than another model if at least 2 of the 3 criteria for significant differences were met. It should be noted that subgroup (e.g., depressed, history of depression, and controls) comparisons were not conducted, as Byrne[30] has noted that a model should be validated on a general sample before multigroup latent analyses can be conducted.

## RESULTS

PSQI total scores for the 417 participants ranged from 0 to 18, with a mean of 4.98 (SD = 3.63). Table 1 provides the mean scores, SDs, ranges, and intercorrelations for each of the 7 components of the PSQI for the EFA and CFA samples separately. Correlations among many of the components were small to large,[31] ranging from the low .10s to the mid .60s. Each of the 7 PSQI component scores ranges from 0 to 3, with the means and SDs between 0.5 and 1.0 for most components.

### Exploratory Factor Analysis

An EFA was performed on a randomly assigned sample to provide an exploratory analysis of the PSQI latent structure. EFA results are displayed in Table 2, where each component is given a loading value. Two factors were identified. Factor 1 was labeled Sleep Efficiency, given the strong loadings from the PSQI components habitual sleep efficiency (.86) and sleep duration (.60). Factor 2 was labeled Perceived Sleep Quality, given the strong loadings from subjective sleep quality (.77) and daytime dysfunction (.55). Six of the 7 components had excellent to fair loadings. Use of sleeping medications showed similarly poor loading on both factors, although, for modeling purposes, this component was determined to be on its most-fitted factor, Perceived Sleep Quality (.31). Additionally, Table 2 shows that 39.9% of the variance was accounted for by the factor Sleep Efficiency, and 17.4 % of the variance was accounted for by the second factor, Perceived Sleep Quality. Finally, there was a medium-sized effect[31] for the correlation between the 2 factors (r = .33).

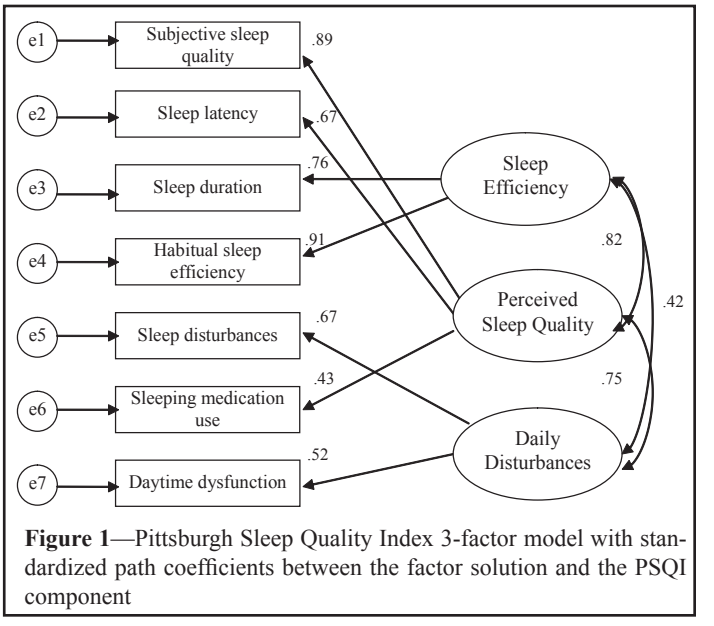


**Figure 1**—Pittsburgh Sleep Quality Index 3-factor model with standardized path coefficients between the factor solution and the PSQI component

### Confirmatory Factor Analysis

Based on the EFA, the CFA was run on the 2-factor solution on the other random half of the sample. In addition, a CFA was performed using the original PSQI single-factor model. Fit statistics for the single-factor model were insufficient for all but goodness of fit. However, fit statistics for the 2-factor model were more impressive, with all fit indexes revealing sufficient fit except for RMSEA (which was .09). Poor RMSEA suggests that either too many paths or too few latent variables are present in the model. Finally, the 2-factor model was significantly better fitted than the single-factor model according to study criteria (on $\Delta\chi^2$ and Bayesian information criterion difference but not on RMSEA difference).

The 2-factor model was examined further, given its insufficient RMSEA yet sufficient fit of all other fit indexes. Lagrange modifications indexes (which are used to test if any unmodeled paths will have a marked improvement on mode fit[21]) indicated that there was an unmodeled but marked relationship between the PSQI components of daytime dysfunction and sleep disturbance. The modification index indicated that addressing this relationship would improve fit with a reduced $\chi^2$ from between 33% and 50%.

Based on the modification index, a 3-factor model was developed and tested as shown in Figure 1, with inclusion of a new factor labeled Daily Disturbances. The 3-factor model met all 4 fit criteria and was significantly better fitted than either the single-factor model or the 2-factor model. Indeed, this model obtained the status of perfect fit, a noteworthy classification for models that have an RMSEA lower bound of 0. Moreover, to ensure that the 3-factor model was not sample specific, it was also tested using CFA on the original EFA subsample. Again, results were excellent for the 3-factor model, and it was not significantly different on any model comparison criteria than when tested on the CFA sample. Moreover, the relationship of each PSQI component score to its respective factor in the 3-factor model was significant

and large, ranging from the standardized path coefficients of .43 (sleeping medication use to Perceived Sleep Quality) to .91 (habitual sleep efficiency to Sleep Efficiency). Correlations between the factors ranged from .42 (medium large effect) to .82 (very large effect).

## DISCUSSION

Based on the original clinical formulation of the PSQI, Buysse et al[4] suggested that the 7 components of the PSQI be combined into a single factor, or the PSQI Total Score. The present findings represent the first empirical examination of the PSQI scoring system and demonstrate that a 3-factor model is statistically favored over a single score. In the single-factor model, the average standardized loading of individual components was .63, whereas, in the 3-factor model, this jumped to .73. These findings indicate that the 3-factor model provides a scoring system that is more reflective of how people respond to the PSQI. In addition, with the 3-factor model, each PSQI component has a critical role in determining the factor score, which means that the PSQI can assess severity of sleep impairment in each of 3 separate domains.

The present findings suggest the potential benefit of altering scoring of the PSQI from a single unitary index of sleep quality to a 3-dimensional assessment of sleep disturbance with scoring of the 3 factors: Sleep Efficiency, Perceived Sleep Quality, and Daily Disturbances. Without such changes in scoring, clinicians may miss significant sleep impairment that might only reside on 1 of the 3 PSQI factors. In other words, relying solely on the total score might not identify disturbances in 1 dimension or factor of the PSQI. Moreover, the 3-factor score has the benefit of obtaining varied assessment of the sleep problems from a single questionnaire. Knowing more about the type and nature of sleep problems is necessary to guide the selection of treatment.[32,33] Despite these assets, recommendation to change the scoring of the PSQI requires caution, as these findings were generated using a sample that was composed exclusively of depressed and nondepressed older adults. Hence, these data may not generalize to middle-aged adults or other clinical samples. Moreover, future studies are needed to address whether these 3 factors have clinical utility in identifying persons with and without insomnia.

Both the 2- and 3-factor models suggest subtle distinctions in the relationships between sleep difficulties. For example, 2 prominent sleep complaints in older adults—sleep duration and latency—loaded on separate factors. Furthermore, the PSQI components of sleep latency and sleeping medication use were more closely associated with Perceived Sleep Quality than were measures of sleep duration or habitual sleep efficiency. In addition, future studies are needed to define the factor-score cutpoint that will optimally identify sleep impairment.

One general limitation to the current study is the matter of assumed structural invariance. Structural invariance exists when the factor structure of a model remains constant between different groups. Herein, structural invariance was assumed for sex, depression group (current depressive disorder, depressive disorder in remission, and never mentally ill), and age cohort (all participants were over 60 years of age). Given that different scoring procedures do not exist for any subgroups on the PSQI,[4] the assumption of invariance is consistent with the PSQI scoring system. Nevertheless, future investigation of the PSQI could benefit from multigroup CFA.

In summary, this study provides the first examination of the factor structure of the PSQI—a crucial aspect of validity. Three factors—Sleep Efficiency, Perceived Sleep Quality, and Daily Disturbances—are derived from the PSQI. Although these factors require further validation, especially in other populations, multidimensional 3-factor scoring of the PSQI is favored over the single-factor PSQI total score.

## ACKNOWLEDGEMENTS

This work was supported in part by grants MH55253, T32-MH19925, AG18367. The authors thank Jessica Lee for her assisting in preparation of the manuscript.

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