Examination of Sleep Health dimensions and their associations with perceived stress and health in a UK sample

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Abstract

Background: Sleep health is a relatively new multidimensional concept, however there is no consensus on its underlying dimensions. A previous study examined potential indicators of sleep health using an aggregated sleep health measure. However, the psychometric properties of which are yet to be determined. . The primary aim of the current study was to assess the factor structure, reliability and validity of this measure A secondary aim was to explore the relationships between sleep health and perceived stress, in addition to physical and mental health **Methods**: A cross-sectional online survey was conducted with 257 adults from the UK aged 18-65 years (78.4% female, mean age=29.39 [*SD*=11.37]). Participants completed 13 Sleep health items, the Pittsburgh Sleep Quality Inventory, Insomnia Severity Scale, Epworth Sleepiness Scale, Perceived Stress Scale and SF-12 Health Survey. **Results:** The measure exhibited good internal consistency (α=.785) and construct validity as determined by associations with existing sleep measures. Principle components analysis was conducted and four factors emerged; sleep quality (α=.818), sleep adaptability (α=.917), sleep wellness (α=.621) and daytime functioning (α=.582). Adaptability (β=-241) was strongest predictor of perceived stress, and daytime functioning was strongest predictor of physical (β =.322) and mental health (β =.312). **Conclusions:** Sleep health is a multidimensional construct comprising four distinct but related dimensions. The importance of sleep health in terms of lower perceived stress and better mental and physical health is highlighted.

Introduction

Sleep is vital to health and wellbeing (1), and the optimal performance of many biological (2,3), cognitive, and emotional processes (4). Recently, interest in the relationship between sleep and both physical and mental health has increased (5,6). Indeed, epidemiological and population health studies and research on the pathophysiology of disordered sleep, (7,8) have clarified associated health outcomes and provided insight into potential vulnerability factors. However, an emphasis on disordered sleep has left the determinants of, and benefits associated with good-sleep somewhat overlooked (9,10). This emphasis on the 'abnormal', potentially limits our understanding of what is considered 'good' healthy sleep from a public health standpoint.

Whilst guidelines on 'normal' sleep, with respect to duration and quality, have only recently have been outlined (11,12), consensus regrading which dimensions of good sleep health remain undetermined. The term Sleep Health was initially outlined by Buysee (9), prior to the published guidelines on recommended sleep duration and quality. It was suggested that sleep health was likely to be a multidimensional construct considering the positive attributes of sleep, as opposed to the absence of sleep disturbance. To that end five subjective dimensions were proposed: satisfaction, alertness, timing, efficiency and duration. Subsequently a five-item scale which examined each dimension was proposed, but not psychometrically tested. Buysse (9) also suggested that sleep adaptability (ability to sleep under challenge) and sleep variability (regularity in sleep schedules) should also be included.

The Sleep Health Index (SHI), a more comprehensive and psychometrically tested measure of sleep health has recently been developed (10). Items developed by a team of experts were factor analysed resulting in 12 items across three dimensions; sleep quality, sleep duration and disordered sleep. However, only three dimensions may seem too few, particularly in comparison to the five of the SATED.

The dimensional structures of the two scales appear to be juxtaposed. The satisfaction, alertness and efficiency dimensions of the SATED are similar to those included in the SHIs sleep quality dimension; and the duration and timing items of the SATED are similar to those of the SHI sleep duration dimension. However, the SATED does not consider sleep disorders or sleep deficit, and the SHI does not assess adaptability. Therefore, examination of the dimensional structure of sleep health using items incorporating elements of both, with the addition of adaptability, may overcome these inconsistencies.

To fully examine sleep health dimensions, aspects of both the SHI and SATED should be included to gauge all relevant aspects of sleep health. Further, a measure of this nature would be beneficial public health research, particularly in examination of psychological, behavioural and health outcomes. Indeed, a recent study used an aggregate measure of sleep health [Masked-for-review] with items from validated sleep-related questionnaires. Specifically, potential subjective and objective indicators of declining sleep health, were examined. However, the study utilised only a small sample of normal-sleepers.

As the concept of sleep health is relatively new, exploring associations with other psychological and health related variables is relevant to public health. Subjectively increased stress and poor health are intrinsically linked with disturbed sleep (13, 14). Further, Knutson and colleagues (10) found that overall sleep health was largely predicted by perceived stress, and physical health to be a significant predictor of sleep quality. However, the contribution of sleep adaptability was not considered, which seems particularly important with regards to stress and health and will therefore be examined in the current study

Aims and objectives

The purpose of the current study was two-fold. The primary aim was to determine the underlying dimensions of sleep health, using both the SHI and SATED. This was achieved utilising appropriate items from established validated sleep questionnaires. The secondary aim was to examine the associations between each dimension and perceived stress, physical and mental health, to exemplify the importance of considering sleep health in a public health context.

Method

Participants

A non-experimental survey design with 257 adults aged between 18 and 65 years (78.4% female, mean age = 29.39 [SD= 11.37]) from the UK, was employed.

Participants were recruited via opportunity (snowball) sampling using recommended online platforms (15) including dedicated participation sites, social media, university mailing lists, and student participation pools (however, was not restricted to students). The study was also advertised within [masked-for-review] University. As the study was advertised online, the number of individuals who could have taken part was not recorded.Ethical approval was gained from the institutional ethics board prior to the study commencement. All participants provided informed consent and accessed the survey via URL

Measures

Sleep health

In light of the suggested dimensions of sleep health as suggested by Buysse (9) and Knutson (10), a measure was created using items from the following reliable sleep measures (internal consistency reported); Pittsburgh Sleep Quality Index (PSQI[α=0.83]; 16) Insomnia Severity Index (ISI[α=0.78] 17) Morningness Eveningness Questionnaire (MEQ[α=0.86]; 18)Ford Insomnia Response to Stress Test (FIRST[α=0.83]; 19), and Sleep Preoccupation Scale (SPS[α=0.91]; 20). Respondents were required to consider their sleep, behaviours, thoughts and feelings over the previous month using the original scale's answer format of each item.

Items conceptually similar to those on the SHI (10) assessed perceived sleep quality, negative impact, and daytime sleepiness. Two items similar to those on the SATED assessed sleep satisfaction and sleep efficiency (benchmarked against NSF's age-appropriate criteria.) Total sleep time (also scored against the NSF's age criteria) was a measure of sleep duration, and assessments of perceived sleep deficit (difference between ideal and actual sleep schedule) and sleep variability (difference between work night and non-work night bedtime) were also included.

Further, items gauged diagnoses of a sleep disorder; communication with a medical professional about a sleep problem, and use of sleep medication. Finally, a proxy measure of sleep adaptability was also included. Two items from the FIRST (19) examining the likelihood of a daytime or an evening event impacting the quality of sleep.

All thirteen items were scored on numerical scales such that higher scores indicated better sleep health. For an overview of the questions and how they correspond with each SHI and SATED dimension, see Appendix 1.

Pittsburgh Sleep Quality Index

The PSQI (16) is a 19-item measure used to assess sleep problems over the previous month. Responses are on a 4-point likert scale between 0- 3. The scale covers sleep quality, latency, duration, efficiency, disturbances, use of medication, and daytime dysfunction. The subscales are summed to provide a total score ranging between 0-21 with higher scores indicating more sleep problems.

Insomnia Severity Index

The ISI (17) is a seven-item self-report measure providing a brief tool for the clinical evaluation of insomnia. The scale is scored on a 5-point Likert scale (0-4). Scores range from 0-20 and higher scores indicate increased insomnia severity.

The Epworth Sleepiness Scale

The Epworth Sleepiness Scale (ESS[α=0.88]; 21) is an eight-item questionnaire measuring daytime sleepiness. Participants indicate on a 0-3 scale likelihood they will dozein particular situations. Higher scores indicate higher risk of dozing with scores ranging between 0-24.

SF-12 Health Survey

The SF-12 is a multidimensional generic measure of physical and mental health and quality of life, and short form of the SF-36, a standardized questionnaire used to assess patient health (22). The SF-12 contains 12 items s from the SF-36. and produces two summary scores relating to physical and mental health r (PCS[α=0.89] and MCS[α=0.76]). These summary scores were originally estimated using a weighted formula on factor weights obtained from PCA, in relation to the SF 36. However, recently this method has been criticised and raw score summations now recommended (23) and implemented here. Range of total scores were 6-20 (PCS) and 6-27 (MCS) with higher scores indicating better physical or mental health.

Perceived Stress Scale

The Perceived Stress Scale (PSS-10[α=0.83]; 24) assessed stress levels. The 10-item scale assesses respondent's experience of stressful situations in the past month on a 5-point Likert scale (0-4). Four items are reverse scored. Scores range from 0-40, and higher scores indicating greater stress.

Treatment of Data

All participants completed the sleep health questions, PSQI, ISI, and ESS. Five data sets were missing for the PSS, and 14 for the SATED and SF-12. Individual missing values (0.8% for sleep health items) were managed using mean substitution in line with similar methods used in various questionnaire-based studies (25).

For the regression models, a power analysis was conducted using G*Power indicating a sample size of n=125 would result in adequate power (0.803) for a small effect.

All statistical analyses were conducted using IBM SPSS-24. Firstly, the internal consistency of the sleep health items was assessed using Cronbach's alpha. Pearson's bivariate correlations with the existing sleep measures (i.e. SATED, PSQI, ISI and ESS) were then conducted to assess overall construct validity. Partially following recommendations by Hinkin (26), Principal Components Analysis [PCA] with Varimax Rotation and Kaiser Normalization, was then conducted on the sleep health data. PCA was chosen in order to achieve an accurate, lower-dimensional representation of sleep health but with minimal loss of information regarding what constitutes the construct.

The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis was good (according to Hutcheson and Sofroniou, (27) (KMO = .774) and Bartlett's test of Sphericity a showed a significant result (BS (78) = 1065.263, p<.001) indicating the data was suitable for PCA. The 13 sleep health items were entered into the analysis and factor loadings greater than .35 were considered significant, in line with recommendations for sample sizes over 250 (28). Factors with eigenvalues above 1.00 were extracted in line with Kaiser's (29) criterion.

The internal consistency of each factor, inter-scale correlations and relationships with the SATED dimensions were then examined. Gender differences were assessed with independent samples t-test and Pearson's correlations assessed the relationship with age. Finally, hierarchical multiple regression analyses (enter method) were implemented (controlling for age and gender in step 1) with the sleep health dimensions as predictors and the PSS, MCS and PCS as outcomes (in 3 models).

Results

Scale reliability and validity

Cronbach's alpha indicated good internal consistency for the full scale (α =.785). Item-total statistics indicated all 13 items could be retained. With respect to construct validity, a positive correlation was demonstrated with the SATED (r =.657, p<.001) and negative correlations were observed with the PSQI (r= -.867, p<.001),ISI (r= -.792, p<.001) and ESS (r=-368, p<.001).

Sleep health factor structure

The factor loadings are presented in table 1. Four dimensions were extracted and accounted for 62.55% of the overall variance.

[Table-1-here]

Cronbach's alpha for the dimensions were; 'Sleep quality' (5 items) α=.827, 'Sleep Adaptability' (2 items), α=.914, 'Sleep wellness' (4 items) α=.621, and 'Daytime Function' (2 items), α=.582.

Bivariate correlations between the factors showed negligible to low positive correlations (r = .00 -.30) between 'Sleep Quality' and the other three factors, and between 'Sleep Wellness' and 'Daytime Function', indicating little evidence of collinearity (see table 2). Therefore, all dimensions were included in the regression analyses.

[Table-2-here]

SATED comparisons

Table 3 shows the relationships between the dimensions and each SATED domain 'sleep quality' showed a strong (>.70) positive correlation with total SATED scores, moderate (.50- .70) correlations with the satisfaction and duration dimensions, and low (.30 - .50) correlations with the efficiency, alertness and timing dimensions. 'Adaptability showed a significant but small correlation with total SATED scores in addition to the satisfaction, efficiency and duration dimensions but was not significantly correlated with alertness or timing. Sleep wellness showed small but significant positive correlations with total SATED scores and each of the SATED dimensions with the exception of timing. Daytime function showed low correlations with total SATED scores and each SATED dimension, again with the exception of timing.

[Table-3-here]

Demographics

Total sleep health was not significantly correlated with age (r=-20, p=.746), neither was sleep quality (r=-090, p=.149) or adaptability (r=.018, p=.772). Age was negatively correlated with sleep wellness (r=-.218, p<.001) and positively correlated with daytime function (r=.234, p<.001). With regards to gender, males (M=24.94, SD=5.29) scored significantly higher than females (M=21.55, *SD*=5.90) on total sleep health [$t(252)=3.742, p<.001$]. Males also scored higher on each separate factor ($p<.05$), with the exception of sleep wellness ($p=.092$).

Perceived stress and health

Total sleep health was significantly negatively correlated with PSS scores ($r=-.406$, $p<.001$) and positively correlated with both the PCS ($r=.362$, $p<.001$) and MCS ($r=.548$, $p<.001$).

As observed in table 4, the model including age and sex as predictors of PSS scores was significant [$F(2,248)=8.420, p=<.001$] at step 1 predicting 6.4% of the variance. The addition of sleep health dimensions was also significant at step 2 [$F(6,244)=13.806, p<.001$] predicting an additional 19.0% of the variance. Age, sleep quality, sleep adaptability and daytime function were significant predictors in the final model, with sleep adaptability the strongest predictor ($\beta=-.241$) followed by daytime function ($\beta=-.231$).

For PCS scores, the model at step 1 was not significant [$F(2,239)=1.323$, $p=.268$]. However, the addition of the sleep health dimensions was significant at step 2 [$F(6,235)=9.913$, $p<.001$] predicting an extra 19.1% of the variance. Only sleep wellness and daytime function were significant predictors in the final model, with daytime function as the strongest predictor ($\beta=.322$).

The regression model at step 1 for MCS scores was significant [$F(2,239)=10.943, p<.001$], predicting 6.4% of the variance. The addition of the sleep health dimensions to the model was also significant at step 2 [$F(6,235)=27.947$, $p<.001$] predicting an additional 33.3% of the variance. Age, sleep quality, sleep adaptability and daytime function were significant predictors in the final model The strongest predictors were daytime function ($\beta=.312$) and sleep quality ($\beta=.289$)(See table 4).

[Table-4-here]

Discussion

Main findings

An aggregate measure of sleep health was devised using a comprehensive range of items pertaining to sleep health, and total scores correlated positively with the SATED indicating good construct validity. Negative relationships were also evident with the PSQI (Buysse et al., 1989), ISI (17) and ESS (21) signifying the scale measured positive aspects of healthy sleep as intended.

The PCA indicated four clear dimensions; sleep quality, sleep adaptability, sleep wellness and daytime function. As sleep health should emulate the benefits of good healthy sleep (9,10), the dimensions were labelled positively. The Internal reliability of each dimension was acceptable with the exception of daytime functioning (<.60). However, as a relationship was observed between total sleep health and levels of sleepiness (21), and aspects of sleep-related daily functioning are included on previous scales (i.e. negative impact, [SHI] and alertness [SATED]), daytime function was retained. Sleep wellness also exhibited a lower alpha level (<.70). It can be argued that consideration of sleep disorder is vital in sleep health assessment (10), yet, it is also purported that sleep health is not simply the absence of sleep problems (9). Therefore, in a population of 'good sleepers' this dimension could be dropped and more emphasis placed on vulnerability.

What is already known

Good-sleep and its effect on daily life can play a positive role in physical and mental health (30) However, the majority of previous research focuses on the links between poor sleep and negative outcomes rather than the benefits of good sleep. For example; sleep problems have been found to moderate the relationship between stressful events and depression (31) and links between poor sleep quality and anger, tension and fatigue (32) have been observed.

What this study adds

In addition to the dimensional structure of sleep health, the importance of sleep adaptability as a sleep health characteristic has been exemplified. This was particularly evident in relation to lower perceived stress and better mental health, and highlights the advantage of assessing sleep health in this way, over existing sleep quality measures in isolation. Further, the importance of daytime function in the determination of better health is highlighted. Daytime function had the second largest association with perceived stress, and strongest association with both mental and physical health. However, as questions included in the SF-12 (22) gauge health related quality of life, this does makes sense. Finally, sleep quality had the second largest association with mental health, further supporting the specific link between good sleep and better mental health (32).

Contrary to expectation, better sleep wellness was not related to levels of stress or either physical or mental health. As the presence of sleep disorders (e.g. insomnia) can have an adverse effect on psychological and physical health (36) this finding is surprising. However, it could be argued that the absence of disordered sleep (and relevant treatment-seeking) does not improve stress and health, in the same way that disordered sleep may increase stress levels and worsen health. Further, as sleep disorders tend to become more prevalent in older adults (33), and as age was controlled in the current study, this may account for the lack of relationships observed.

Limitations

Firstly, due to the cross-sectional design, the direction of causality cannot be reliably inferred. IT is likely that the relationships observed are bi-directional due to the evidence of sleep affecting health and vice versa (e.g. 34-36). Secondly, using items from several scales could also be considered a limitation. However, aggregate multidimensional measures have previously been implemented successfully in this way (6). All questions were self-administered, leading to the usual self-report concerns. Further, other factors such as socioeconomic and educational status could have influenced these findings, however were not examined in the scope of the current study. Finally, the current sample was largely comprised of white females. However, although females do tend to report more sleep problems (36), there is no reason to believe that the clustering of these items may differentiate between genders.

Conclusions

In summary, the current study proposes that sleep health comprises of the four distinct but related dimensions of sleep quality, sleep adaptability, sleep wellness and daytime function. Aspects of sleep health are shown to have consequences for stress, in addition to both physical and mental health. This tool could be helpful for researchers aiming to provide insight into specific aspects of sleep health (other than simply sleep quality) and tailor interventions aimed at improving the concept, in a public health capacity.

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