

Title Page

Title: CFA of the SDSC in a Paediatric Clinical Sample

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AM, CP, and RSB developed the concept and designed the study being reported. MM, and AM are both PhD students at the University of Western Australia and collected the data under the supervision of CP and DMB. AM performed statistical analyses on all samples, interpreted data, and drafted the manuscript. RSB provided statistical expertise and CP provided clinical expertise and primary liaison with the health department clinic. Both CP, RSB, and DMB supervised development of work, helped in data interpretation and drafting parts of the manuscript. All authors evaluated and edited the manuscript.

Summary

The Sleep Disturbance Scale for Children (SDSC) was developed as a parent-report measure to screen for sleep disturbances within the preceding 6 months. Notably, the scale was developed using a sample of typically developing children and children with sleep disorders. The aim of this study was to factor analyse the SDSC using a clinical sample of children with a range of neuropsychological conditions and comorbidities and determine whether the original 6-factor structure was retained. 416 children aged 5-17 were assessed at the Neurosciences Unit (Perth, Western Australia) as part of routine, clinical neuropsychological assessment. Parents and guardians also completed the SDSC to rate their child's sleep. Confirmatory factor analysis of the original SDSC model (Bruni et al., 1996) revealed less than ideal fit. Three adjustments were made to the model based on factor loadings and modification indices. The sleep hyperhidrosis factor (including items 9 and 16) along with item 10 was removed, leaving a 5-factor SDSC model. The 5-factor model (SDSC-R) was factor analysed and examination of model fit statistics indicated that this new model produced good fit. Additional analyses revealed that older children had greater difficulty falling and staying asleep and with daytime sleepiness. However, no significant differences were observed across gender, diagnosis, or socioeconomic status. The results of this study suggest that the SDSC-R may be a more appropriate measure when assessing clinical samples. However, further research is required to validate the SDSC-R against objective measures of sleep and to determine appropriate T-score cut-offs.

Confirmatory Factor Analysis of the Sleep Disturbance Scale for Children (SDSC) in a Clinical Sample of Children and Adolescents

Introduction

Sleep disorders, including snoring, bedwetting, nightmares or night terrors, sleepwalking, sleep talking, and bruxism are frequently reported in children and adolescents (Ferreira et al., 2009). Importantly, sleep disturbances can affect children's behavioural, cognitive, and physical functioning (Saffari et al., 2014), leading to poor physical and mental health, academic difficulties, alcohol use, emotional and behavioural problems, and accidents or injuries (Huang et al., 2014). Further, a number of psychiatric symptoms, including anxiety, hyperactivity, depression, and externalising problems, have been linked to sleep difficulties (Paavonen et al., 2009). As the consequences of inadequate sleep in young people are often chronic and can have significant implications (Ferreira et al., 2009), early diagnosis is essential to facilitate access to treatment (Saffari et al., 2014). The most comprehensive diagnostic technique, polysomnography (PSG), is a type of sleep study involving the continuous and simultaneous recording of cardiopulmonary, physiological, and neurophysiological parameters whilst an individual sleeps (Jafari & Mohsenin, 2010). Although PSG is widely regarded as the gold standard for diagnosing sleep disorders (Ferreira et al., 2009), it is costly and time consuming. As a result, questionnaires have been developed as a means of assessing sleep in children and adolescents (Huang et al., 2014).

With numerous sleep questionnaires currently available, Spruyt and Gozal (2011) have raised concerns regarding the availability and use of sleep tools that have not been adequately developed or validated. Accordingly, they outlined 11 essential steps for developing and evaluating sleep assessment tools including: "1. Purpose; 2. Research Question; 3. Response Format; 4. Generation of Items; 5. Pilot; 6. Item-analyses and non-response analyses; 7. Structure; 8. Reliability; 9. Validity; 10. Confirmatory analyses; and 11. Standardisation and norms development" (p. 20). Of the questionnaires designed to assess sleep disorders in young people, the Sleep Disturbance Scale for Children (SDSC; Bruni et al., 1996) is among the few that meet these requirements (Spruyt & Gozal, 2011).

The SDSC is a short, parent-report measure used to screen for sleep disturbances in children within the preceding 6 months. The SDSC was developed using a sample of typically

developing children ($N = 1157$) and children with sleep disorders ($N = 147$) aged 6.5-15.3 years and was designed to categorise sleep disorders frequently reported in children (Bruni et al., 1996). The SDSC provides a total sleep score and six subscales: sleep breathing disorders; disorders of excessive somnolence; difficulty in initiating and maintaining sleep; sleep-wake transition disorders; disorders of arousal; and, sleep hyperhidrosis (night sweats) (Bruni et al., 1996). While originally published in English, the SDSC has since been translated into Brazilian Portuguese, Chinese, and Persian and validated as a useful screening tool for sleep disorders in these samples (Ferreira et al., 2009; Huang et al., 2014; Saffari et al., 2014).

Although the SDSC was developed using typically developing children and children with sleep disorders, it has been used to assess sleep in various clinical populations including children with neurological conditions (Cohen et al., 2013), obese adolescents (Cortese et al., 2007), young people with juvenile idiopathic arthritis (Khubchandani et al., 2011), children with cerebral palsy (Romeo et al., 2014), and children with Rolandic epilepsy (Samaitienė et al., 2013). However, to date, no research has examined the factor structure of the SDSC in a combined, heterogeneous sample of children and adolescents (5-18 years) with a range of neuropsychological conditions and comorbidities. As it is possible that the factor structure of the SDSC in a clinical sample (with neuropsychological diagnoses) will differ from that found in a typically developing or sleep disordered sample, the aim of the current study was to factor analyse the SDSC in a large clinical sample and determine whether the original 6-factor structure was retained.

Methods

SDSC data were collected by Psychology staff at the Neurosciences Unit (North Metropolitan Area Health Service – Mental Health), Perth, Western Australia as part of routine, clinical neuropsychological assessment of children presenting to the paediatric programme with a range of neuropsychological and neurological conditions. The study was approved by the Human Research Ethics Committees of the North Metropolitan Area Health Service – Mental Health, and the University of Western Australia.

Participants

Between July 2011 and September 2014, 416 children aged 9.62 ± 3.20 years (5-17 years) were assessed: 38% female and 62% male. The SDSC questionnaires were completed by the parents/guardians of children who were assessed at the Neurosciences Unit (NSU). The legal guardians gave written, informed consent for these clinical data to be used for research purposes.

These children presented with a range of conditions including congenital malformation of the brain, mild cognitive disorder, birth complications, cancer, epilepsy, acquired brain injury/infection, motor disorders (cerebral palsy, hemiplegia), specific and pervasive developmental disorders (PDD), foetal alcohol spectrum disorders (FASD), attention deficit hyperactivity disorder (ADHD), chromosomal abnormalities, and other medical or psychological factors. The most common condition in our sample was neurodevelopmental disorders (i.e., ADHD, FASD, and PDD) accounting for 24.5%, followed by motor disorders and other medical conditions at 14.2%. Additionally, 53% of the sample had a comorbid secondary diagnosis and 20% had a concurrent mental health diagnosis.

Questionnaire

The SDSC is a 26-item scale in which informants' report their child's sleep habits over the past six months. Question 1 asks "How many hours of sleep does your child get on most nights" with responses ranging from 1 ("9-11 hours") to 5 ("less than 5 hours"). Question 2 asks "How long after going to bed does your child usually fall asleep" with responses ranging from 1 ("less than 15") to 5 ("more than 60"). The scale response options for the remaining questions, e.g., Question 13 "the child has difficulty in breathing during the night", range from 1 ("Never") to 5 ("Always (daily)"). Scores are tallied to provide a total sleep score, as well as a score for each of the 6 sleep disorder subscales: sleep breathing disorders (3 items); disorders of excessive somnolence (5 items); difficulty in initiating and maintaining sleep (7 items); sleep-wake transition disorders (6 items); disorders of arousal (3 items); and, sleep hyperhidrosis (night sweats; 2 items).

Raw scores are converted to T scores, with a T score >70 (>95th percentile) indicative of a clinically significant sleep problem. The SDSC total score has good internal consistency (Cronbach's alpha: $\alpha = .79$ for typical children; and $\alpha = .71$ for children with sleep disorders, and exhibits good test-retest reliability ($r = .71$) (Bruni et al., 1996). Finally, Bruni et al. reported acceptable sensitivity (.89) and specificity (.74) in distinguishing between the control group and the children with sleep disorders in their sample.

Data Analysis Plan

Initial data screening and descriptive analyses were performed using SPSS 22.0 for Windows. Data were screened for missing values using Little's MCAR test. Data were not missing completely at random, $\chi^2(1317) = 1572.26, p < .001$. However, analyses of missing data

patterns revealed the data were missing at random. Additionally, fewer than 5% (1.78%) of total values were missing, which according to previous literature, can be considered inconsequential (Schafer, 1999). As Mplus uses all available data to estimate the model (using full information maximum likelihood), no transformations were performed prior to running the confirmatory factor analysis.

Further analysis of the data revealed that the items were both skewed and kurtotic. According to Cunningham (2010), where there are 5 or fewer responses to a scale and data depart from normality, the data should be treated as ordinal. Consequently, the weighted least squares means and variance adjusted (WLSMV) estimator was used to analyse the data in Mplus.

The factor structure of the SDSC was analysed in Mplus version 7.3 for Windows. Model fit was evaluated using chi-square and the incremental model fit indices including Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker/Lewis Index (TLI), and Weighted Root Mean Square Residual (WRMR). To evaluate model fit, we used conventions provided by Hu and Bentler (1999) which are widely used and accepted (Barrett, 2007). According to Hu and Bentler, a cut-off value close to .95 for the CFI and TLI, and a cut-off value $\leq .05$ (or 90% confidence intervals that cross .05) for RMSEA indicate 'relatively good' fit between the observed data and the hypothesised model. Given the known sensitivity of chi-square to sample size (Hooper, Coughlan, & Mullen, 2008), chi-square adjusted for degrees of freedom was calculated, where reasonable fit is indicated when the value is ≤ 3 (Hu and Bentler, 1999). Individual items were allowed to load freely on their specified factor and the factor variances were set to unity (1.0).

Modification indices (MI) were also examined as they provide more precise information regarding model misfit than standard goodness of fit measures (Brown, 2006). As recommended by Wang and Wang (2012), items with the highest MI (>10) were examined and, provided there was a conceptual, practical or theoretical reason for doing so, we adjusted the model and removed those items.

For invariance testing, measures of statistical significance were replaced with calculations of effect size (practical significance). This method was used due to the sensitivity of χ^2 to large samples and the likelihood of finding non-equivalence where there is equivalence when dealing with large samples. Effect size calculations (by item) were generated by Mean and Covariance Structure Analysis (MACS) using a program freely available on the internet

(dMACS; see Nye and Drasgow, 2011). Effect size was evaluated using Cohen's (2013) guidelines: .20 = small, .50 = medium, .80 = large. However, these values are an approximate measure of practical significance and, therefore, should be interpreted within the context of the measure (Cohen, 2013).

Finally, correlation analysis and multivariate analysis of variance (MANOVA) were used to examine the relationship between the SDSC subscales and demographic variables (age, gender, diagnosis, and socioeconomic status (SES)). Mother's highest level of education was used as an estimate of SES (Braveman et al., 2005).

Results

Factor Structure

The confirmatory factor analysis of the original SDSC model (Bruni et al., 1996) revealed less than ideal fit (see Table 1). Although the adjusted chi square statistic was adequate, RMSEA, CFI, and TLI were all beyond recommended cut-off values. These results suggest that the original 6-factor model of the SDSC does not adequately represent the sleep patterns or problems reported in our paediatric clinical sample.

Three adjustments were made to the SDSC model based on factor loadings and modification indices. The factor loading of Item 9 ("The child sweats excessively while falling asleep") exceeded 1 (Item 9 by sleep hyperhidrosis (SH) = 1.004) and, given the very high correlation of Item 9 with the only other item (Item 16; "The child sweats excessively during the night") in the SH factor (Item 9 with Item 16, $r^2 = .81$), the factor (including Items 9 and 16) was removed. Due to the similarity in the wording of these two items, it is possible that parents were responding the same way to both items, resulting in the high correlation.

The model was run again with the remaining 5-factors. Examination of model results and modification indices suggested that Item 10 ("The child wakes up more than twice per night") was loading across multiple SDSC factors. Additionally, the factor loading (.38) was below the recommended cut off of $\geq .40$ (Stevens, 1992), and the variance explained (0.14) was below the recommended cut-off of $\geq .20$ (Hooper et al., 2008). Accordingly, Item 10 was removed from

further analyses. The final, 5-factor CFA (Figure 1) was re-run (see Table 1 for Item statistics) revealing good fit (Table 2).¹

Invariance Testing

In order to examine the effect of demographics (age and gender) on SDSC model fit, age was divided at the median into younger (5 to 8) and older (9 to 17) age groups. Gender was split into females and males, represented by 0 and 1, respectively. After re-running the five-factor CFA and individually setting each item for each factor to unity, Items 4, 12, 14, 20, and 23 were selected as the referent items for each factor. Referent items are those items whose factor loadings differed the least across the two samples, thus exhibiting the greatest equivalence (Nye & Drasgow, 2011). Identification of appropriate indicator items is particularly important when determining whether a scale functions in the same way across multiple samples (Brown, 2006). The factor loadings of the abovementioned referent items were then set to unity for subsequent analyses and factor variances were freed.

Separate invariance tests were conducted comparing males and females, and comparing the younger and older age groups. Examination of the model fit statistics indicated that, although all invariance tests were approaching the suggested cut-offs for fit indices, χ^2 was significant for all invariance tests (see Table 3). Measures of effect size (by item) ranged from small to large for both gender (0.03 – 4.18) and age (0.02 - 1.32)². However, according to Nye and Drasgow (2011) these results are at the scale level and should be interpreted relative to the number of items multiplied by the number of response options. Using these conventions, the effect sizes due to differential item functioning (DIF) were relatively small (age = 0.01 - 0.03³; gender = 0 – 0.14) (see Table 4). As the SDSC is most commonly used as a screening tool and the practical

¹ Cronbach's alpha for each factor was calculated using the raw item scores: DIMS ($\alpha = .796$); SBD ($\alpha = .575$); DoA ($\alpha = .671$); SWTD ($\alpha = .676$); DOES ($\alpha = .792$); Total Score ($\alpha = .849$). These values should be interpreted with caution, as they include the error variance which has been excluded from the CFA (Muthen (2006).

² As requested by a reviewer of an earlier draft of this paper, invariance testing by age-group was also conducted dividing the sample into children 5 to 12 years ($N = 327$) and 13 to 17 years ($N = 89$), given that sleep patterns change with age (Jenni & Carskadon, 2005). The scale was not invariant for age (fit indices for invariance tests are given in Table S1). However, measures of effect size (by item) were substantively similar to those from the median split age-group comparisons, ranging from small to large (0.03 – 0.93).

³ Likewise, DIF effects relative to the number of items multiplied by the number of response options for age divided 5 to 12 years and 13 to 17 years were very small (0 – 0.05) (see Table S2).

significance (effect size for all items) was small, the SDSC can be considered to be age and gender invariant.

Demographic Analyses

Age was examined as a predictor of SDSC subscale factor scores. Older age was associated with greater difficulties in initiating and maintaining sleep (DIMS), $r = .21, p < .001$; fewer disorders of arousal (DOA), $r = -.13, p = .040$; and greater daytime sleepiness (DOES), $r = .28, p < .001$. All other correlations were not significant.

There were no differences on SDSC subscale scores for gender, $F(5, 410) = 0.90, p = .483$; diagnosis, $F(5, 391) = 0.90, p = .479$; or SES, $F(5, 304) = 1.169, p = .325$.

Discussion

CFA properties

The aim of this study was to examine the factor structure of the SDSC in a clinical sample of young people and determine whether the original 6-factor structure was retained. Although the SDSC was developed using a non-clinical sample and a separate sample of children with sleep disorders, it has subsequently been used to screen for sleep disturbances in a range of clinical populations (Cohen et al., 2013; Samaitienè et al., 2013). Therefore, it is important that the scales' psychometric properties, particularly in relation to clinical samples, are thoroughly evaluated. To the best of our knowledge, this is the first study to explore the factor structure of the SDSC in a clinical sample of children and adolescents with a range of neuropsychological conditions.

The results showed that the original 6-factor model of the SDSC did not present adequate fit for our paediatric clinical sample. Minor problems with the original factor structure may have contributed to the inadequate model fit. Items 9, 10, and 16 were all identified as potentially problematic items contributing to model misfit. Items 9 and 16, comprising the sleep hyperhidrosis (SH) factor were highly correlated and the loading of item 9 on the SH factor was greater than one. Further, according to Tabachnick and Fidell (2012), a factor should be defined by at least 3 variables. Therefore, the SH factor was removed from further analyses.

Additionally, a number of problems were identified with item 10. This item had a low loading on the difficulties in initiating and maintaining sleep (DIMS) factor to which it was proposed to belong, and examination of the modification indices suggested there were potential cross-loadings.

One possible explanation for item 10 cross-loading onto additional factors is the wording. Item 10 states “The child wakes up more than twice per night”. Although this item was proposed to load onto the DIMS factor, intuitively, it could also load onto disorders of arousal, sleep wake transition disorders, and disorders of excessive somnolence. For example, if the child wakes up more than twice per night it is possible that they will exhibit excessive daytime somnolence; or they may have awoken as a result of a nightmare (disorders of arousal) or difficulty breathing (sleep breathing disorders). As a result of the lack of discrimination with item 10, it was removed from subsequent analyses.

The resultant 5-factor SDSC (SDSC-R) provided good fit to the data. To validate the SDSC-R, invariance analyses were conducted to examine whether the same construct (in this case, sleep disturbances) were being measured across gender and age groups. Invariance analysis revealed that the scale was invariant for males and females and that any age invariance was minimal, suggesting the SDSC-R is valid and equivalent across gender and age.

Age Differences

Parents reported that older children had greater difficulty falling and staying asleep (DIMS) and with daytime sleepiness. This is consistent with studies that report a shift from ‘morningness’ to ‘eveningness’ as children progress through adolescence (Crowley et al., 2014). As would be expected, items regarding parasomnias, such as sleepwalking and nightmares (disorders of arousal), were more strongly endorsed for younger children (Davis et al., 2004). According to Davis et al., parasomnias typically subside as the child matures and are common in children aged 3 to 8 years.

Gender, Diagnosis, and Socioeconomic Status

No significant gender differences were observed across the SDSC factors. This finding is unsurprising considering the literature reporting on the effects of gender on sleep disturbance in children is largely inconsistent. For example, previous studies have reported more sleep problems in males than females (Shang et al., 2006), greater sleep disturbances in females (Wang et al., 2013), and no differences in sleep disturbances between the sexes (Nevés et al., 2001). Differences in the findings across these studies may be due to sample characteristics or differences in methodologies, including varying sleep measures (i.e., the Children’s Sleep Habits questionnaire in Wang et al.’s study). The current results, however, are consistent with Nevés et al. who also found no gender differences.

Similarly to gender, there were no differences in the SDSC factor scores based on the child's primary diagnosis. According to previous literature, children who have been diagnosed with physical, psychological, and neurodevelopmental disorders are at an increased risk of experiencing sleep disturbance (Stores, 1999). However, no literature has been identified comparing the sleep disturbance experienced across these various diagnoses. Consequently, further research in sleep disturbance patterns in different disorders is warranted.

Finally, no significant SES differences were observed across the SDSC factors. This finding is in contrast to previous studies which have reported greater rates of sleep disturbance in children who come from low SES families (Doku et al., 2013; El-Sheikh et al., 2010). It may be that other factors such as household income, in addition to mother's highest level of education, are required to form a more reliable estimate of SES. However, information regarding income was unavailable in this dataset.

In summary, the 6-factor SDSC did not provide good fit for the current, paediatric clinical sample, which suggests that the scale is not ideal for use in all clinical samples in its original form. However, the minor modifications, including the removal of three items and 1 factor, produced acceptable model fit. This revised 5-factor SDSC was equivalent across age and gender. It may be that the SDSC-R is a more appropriate measure to screen for sleep disturbances in young people with neuropsychological conditions.⁴ However, further research is needed to validate the SDSC-R against objective measures of sleep such as actigraphy or PSG and to determine what scores (using T score cut-offs) constitute disturbed sleep using this revised scale.

⁴ To facilitate this process, we have provided an excel spreadsheet that will calculate the child's score using the factor scores obtained in this study.

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