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Recommended Citation

Storfer-Isser, A., Lebourgeois, M., Harsh, J., Tompsett, C., Redline, S. (2013). Psychometric Properties of the Adolescent Sleep Hygiene Scale. *Journal of Sleep Research, 22*(6), 707-716.
Available at: https://aquila.usm.edu/fac_pubs/20264

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NIH Public Access
Author Manuscript
J Sleep Res. Author manuscript; available in PMC 2014 December 01.

Published in final edited form as:
J Sleep Res. 2013 December ; 22(6): . doi:10.1111/jsr.12059.

Psychometric Properties of the Adolescent Sleep Hygiene Scale (ASHS)

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Summary

This study evaluated the psychometric properties of the Adolescent Sleep Hygiene Scale (ASHS), a self-report measure assessing sleep practices theoretically important for optimal sleep. Data were collected on a community sample of 514 adolescents (16-19 years; 17.7±0.4 years; 50% female) participating in the late adolescent examination of a longitudinal study on sleep and health. Self-reports of sleep hygiene and daytime sleepiness, caretaker-reports of behavior, and sleep-wake estimation on weekdays from wrist actigraphy were collected. Confirmatory factor analysis indicated the empirical and conceptually-based factor structure was similar for 6 of the 8 proposed sleep hygiene domains. Internal consistency of the revised scale (ASHSr) was α=0.84; subscale alphas were: physiological: α=0.60; behavioral arousal: α=0.62; cognitive/emotional: α=0.81; sleep environment: α=0.61; sleep stability: α=0.68; daytime sleep: α=0.78 α = 0.50. Sleep hygiene scores were positively associated with sleep duration (r=.16) and sleep efficiency (r=.12), and negatively correlated with daytime sleepiness (r=-.26). Results of extreme-groups analyses comparing ASHSr scores in the lowest and highest quintile provided further evidence for concurrent validity. Correlations between sleep hygiene scores and caretaker reports of school competence, internalizing, and externalizing behaviors provided support for convergent validity. These findings indicate that the ASHSr has satisfactory psychometric properties for a research instrument and is a useful research tool for assessing sleep hygiene in adolescents.

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Conflicts of interest: All authors have declared no conflicts of interest.

Author contributions: A.S.I.: Data analysis and interpretation of the results, drafting and revising the manuscript; M.K.L, J.H., C.J.T.: Interpretation of the results, critical revisions to the manuscript; S.R.: Conception and design, acquisition of data, interpretation of the results, critical revisions to the manuscript

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Keywords

adolescence; confirmatory factor analysis; pediatric sleep questionnaire; psychometrics; sleep hygiene

Introduction

Sleep is a basic need that may be particularly important during periods of rapid growth and development. An established literature shows that adolescents experience maturational changes in their sleep biology, including a circadian phase delay and a slowing of the accumulation of sleep homeostatic pressure across the waking day (Carskadon, 2011). In combination with psychosocial factors (i.e., early school start times, shifts in roles and responsibilities during the teenage years) (Carskadon, 2011; LeBourgeois *et al.*, 2005) and behavioral practices (i.e., later bedtime, increased technology use, screen time, and social engagement in the evening) (Carskadon, 2002), adolescents' sleep may suffer in a number of ways, including short sleep duration (National Sleep Foundation, 2006, 2011), shifts in sleep/wake patterns (Hagenauer *et al.*, 2009; National Sleep Foundation, 2006), decreased sleep quality (Roberts *et al.,* 2002), and differences in sleep duration on weekends versus weekdays (National Sleep Foundation, 2006; Russo *et al.,* 2007). Thus, the adolescent years represent a window of sleep vulnerability due to the interaction of multiple biological and social factors.

Inadequate sleep is common among adolescents (National Sleep Foundation, 2006; Smaldone *et al.*, 2007). Over 60% of American high school students are getting less than the minimum recommendation of 8 hours of sleep on school nights, and nearly one in four (39%) report experiencing excessive daytime sleepiness at least several days per week (National Sleep Foundation, 2006). Almost half (45%) of 11- to 17- year-old adolescents reported a sleep problem occurring at least a few nights a week, including difficulty initiating sleep, maintaining sleep, and early awakening (National Sleep Foundation, 2006). Insufficient sleep duration and/or poor sleep quality among adolescents is associated with problems with academic performance (Dewald *et al.*, 2010), psychosocial functioning (Dahl and Lewin, 2002; Smaldone *et al.*, 2007), obesity (Cappuccio *et al.*, 2008), prehypertension (Javaheri *et al.*, 2008), and motor vehicle accidents (Pizza *et al.*, 2010).

Sleep hygiene practices, defined as "behavioral practices that promote good sleep quality, adequate sleep duration, and full daytime alertness" (LeBourgeois *et al.*, 2005) may be targets for intervention. Sleep hygiene is viewed as multidimensional with implications for the timing of sleep and wake periods, the quality of the sleep environment, and for behavioral, emotional, and physiological readiness for sleep with the approach of bedtime. Few studies have examined adolescent sleep hygiene practices and sleep outcomes. In studies of college students, sleep hygiene has been reported to be associated with sleep quality (Brown *et al.*, 2002; Mastin *et al.*, 2006) and daytime sleepiness (Mastin *et al.*, 2006). It may be that some sleep hygiene practices have a greater impact on sleep quality and duration than others, as indicated by variable empirical support for specific sleep hygiene recommendations (Malone, 2011). For instance, refraining from using electronic devices at bedtime has been reported as beneficial (Calamaro *et al.,* 2009), while evidence to support the recommendations of avoiding evening exercise and abstaining from lengthy daytime naps is limited (Malone, 2011; Stepanski & Wyatt, 2003). The mixed findings underscore the need to empirically evaluate sleep hygiene recommendations.

The Adolescent Sleep Hygiene Scale (ASHS) is a self-report questionnaire specifically designed to assess theoretically-based sleep hygiene domains thought to influence the sleep

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quality and quantity of youth aged ≥ 12 years (LeBourgeois *et al.*, 2005): physiological (e.g., evening caffeine consumption); cognitive (e.g., thinking about things that need to be done at bedtime); emotional (e.g., going to bed feeling upset); sleep environment (e.g., falling asleep with the lights on); sleep stability (e.g., different bedtime/wake time pattern on weekdays and weekends); substance use (e.g., evening alcohol use); daytime sleep (e.g., napping); and having a bedtime routine (LeBourgeois *et al.*, 2005). Although this instrument was recently rated "approaching well established" in terms of its evidence-based assessment criteria (Lewandowski *et al.*, 2011), further investigation of the psychometric properties of the ASHS is needed (Lewandowski *et al.*, 2011; Spruyt and Gozal, 2011), especially with older adolescents. Additionally, examining associations of each sleep hygiene domain with measures of sleep quality and quantity will help to evaluate sleep hygiene recommendations. The objectives of this study were to assess the validity and reliability of the ASHS measures by examining: 1) the factor structure of the ASHS; 2) the internal consistency reliability for ASHS subscales and the entire ASHS; 3) the concurrent validity of the ASHS with objective measures of sleep quality and sleep duration as well as subjective daytime sleepiness; 4) the convergent validity of the ASHS with behavioral outcomes.

Method

Participants

The sample was comprised of adolescents participating in the late adolescent examination of the Cleveland Children's Sleep and Health Study, a longitudinal, community-based urban cohort study designed to evaluate sleep measures and health outcomes in children born full-term and pre-term. Details about recruitment and the study design are reported elsewhere (Javaheri *et al.*, 2008). In brief, all 907 children that participated in the middle childhood examination at age 8-11 were eligible to participate in this wave of data collection; participants were between 16-19 years of age at the late adolescent examination. A total of 517 adolescents were studied, of which 514 were included in these analyses (n=3 participants did not complete the ASHS). The mean age of participants was 17.7 years (SD=0.4). Almost half (49%) of the sample was male; nearly 60% were Caucasian, 36% were African-American, and 43% were born <37 weeks gestational age.

Protocol

As previously described (Javaheri *et al.*, 2008), adolescents completed the ASHS along with sleep and health questionnaires in person between April 2006 and April 2010 at a dedicated clinical research facility when free of acute illness. Participants were asked to wear a wrist actigraph and complete a daily sleep log for 5-7 consecutive 24-hour periods during the week after their assessment at the clinical research facility. Written consent and/or assent were obtained from the study participants as well as their parent/legal guardian. The protocol for the late adolescent examination was approved by University Hospitals of Cleveland Institutional Review Board.

Measurements

Adolescent Sleep Hygiene Scale (ASHS)—The ASHS is a 32-item self-report measure used to assess adolescent sleep hygiene (LeBourgeois *et al.*, 2005). The ASHS includes 4 qualitative items to ascertain usual bedtime and wake time on weekdays and weekends, and 28 quantitative items that are used to calculate 9 subscale scores: physiological (5 items), cognitive (6 items), emotional (3 items), sleep environment (4 items), daytime sleep (1 item), substances (2 items), sleep stability (4 items), bedtime routine (1 item) and bed sharing (2 items). Based upon comments from adolescents participating in our prior study (LeBourgeois et al., 2005), a few minor changes were made to the ASHS: one item was added to the daytime sleep factor (*"After 6pm in the evening, I*

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take a nap"); one item was added to the sleep stability factor ("I fall asleep in one place and then move to another place during the night"); and the bed/bedroom sharing factor and the two items that comprise it were omitted. Using a 6-point ordinal rating scale ranging from 1=*never* to 6=*always*, adolescents indicated how often each item occurred during the past month. All but one of the items is reverse-coded, with higher scores indicating better sleep hygiene. Each subscale score is calculated by taking the average of the items comprising that subscale, and the mean of the subscale scores is used to create the total sleep hygiene score. The ASHS measure and scoring instructions can be found in Table 1 or downloaded from http://sleep.colorado.edu/measures.

Actigraphy—Actigraphy data were collected using the Octagonal Sleep Watch 2.01 (Ambulatory Monitoring Inc, Ardsley, NY) worn on the non-dominant wrist for 5-7 consecutive 24-hour periods. The data were digitized in 1-minute epochs and scored using the Action-W analysis software (Ambulatory Monitoring Inc, Ardsley, NY) using the Time-Above-Threshold algorithm, which has been validated in adolescent populations (Johnson *et al.*, 2007). Daily sleep logs were used to identify sleep intervals to be scored using actigraphy. Time of actigraphy-watch removal/non-wear and naps were also noted and used to annotate the actigraphy record. In the event that a sleep log was not completed, actigraphy signals were used per se to mark the sleep period. Mean weekday sleep measures were calculated for participants with at least three weekdays (Sunday – Thursday) of actigraphy data (n=360). Variability in sleep duration was calculated using the coefficient of variation for nightly sleep duration. The first of three consecutive epochs of actigraphic sleep at the beginning of the scoring interval was used to define sleep onset, and sleep onset latency was calculated as the interval from bedtime (from the daily sleep log) to the first epoch of actigraphic sleep. Wake after sleep onset was defined as the number of minutes scored as wake during the sleep period. Sleep efficiency was calculated as the percentage of sleep time during the sleep period (the interval from sleep onset to the terminal awakening). Sleep mid-point, a measure reflecting the phase of the sleep period, was defined as the clock time half way between sleep onset time and the time of the terminal awakening.

Daytime Sleepiness—Self-reported daytime sleepiness was measured with a pediatric modification of the Epworth Sleepiness Scale (ESS) (Johns, 1992). Using a 4-point ordinal response scale, adolescents rated how likely they were to doze in 8 different situations, with higher scores indicating greater daytime sleepiness. The last item, "in a car while stopped for a few minutes in traffic" was replaced with "doing homework or taking a test". Internal consistency of the ESS was α = .73.

Behavioral Measures—Parents completed the Child Behavioral Check List (CBCL) to assess child and adolescent behavior (Achenbach and Rescorla, 2001). Raw subscale scores and composite scale scores were calculated and converted to age- and sex-adjusted t-scores (M=50; SD=10) using published norms constructed from population-based samples (Achenbach and Rescorla, 2001). Three summary scales were included in the present study: internalizing behaviors (withdrawn, anxiety/depression and somatic complaints), externalizing behaviors (delinquent and aggressive), and school competency.

Statistical Analyses

First-order confirmatory factor analyses (CFAs) were used to examine the factor structure of the ASHS using LISREL version 8.8 (Scientific Software International, Lincolnwood, IL). Robust maximum likelihood estimation using the sample variance-covariance matrix as well as the asymptotic covariance matrix was used for all CFAs to account for the skewed distribution of the responses on several of the ASHS items. All covariances among the latent constructs were estimated, and measurement errors among the observed variables were

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assumed to be uncorrelated. The initial model was based on the theoretical structure of the ASHS (LeBourgeois *et al*., 2005). Model re-specification included removing items with standardized factor loadings below 0.30 (e.g., the variable accounted for <10% of the variance in the latent factor), and the incremental effect of each change was examined by refitting the model upon making a single change. After identifying a model consisting of items with adequate factor loadings, inter-factor correlations were examined to assess factor redundancy. Model adequacy was assessed using the Satorra-Bentler scaled χ^2 (SBχ^2), Root Mean Square Error of Approximation (RMSEA) point estimate and 90% confidence interval (90% CI), the Tucker-Lewis Index (TLI), and Standardized Root Mean Square Residual (SRMR). Rules of thumb were used to facilitate the interpretation of approximate fit statistics (Hu and Bentler, 1999): RMSEA point estimate below .08, lower and upper bounds of the 90% CI below .05 and .10, and TLI ≥ 0.90, and SRMR ≤ 0.08 were considered indications of adequate model fit. Additionally, second-order CFAs were estimated to evaluate whether an overarching sleep hygiene factor explained the variance in the sleep hygiene subscales.

The results of the confirmatory factor analyses were used to create subscale scores as well as a total score (total ASHSr). Internal consistency reliability for each ASHSr subscale was examined using Cronbach α. Pearson and Spearman correlations were used to assess concurrent validity with actigraphy-based sleep variables and daytime sleepiness (ESS), while correlations with behavioral outcomes (CBCL) were used to assess convergent validity. To further assess validity, the top and bottom sample-based quintiles of the total ASHSr score were used to categorize adolescents as having good or poor sleep hygiene, respectively. Between group comparisons on actigraphy-based sleep outcomes, daytime sleepiness, and behavioral measures were examined using the two-sample t-test for normally distributed measures and the Wilcoxon rank-sum test for non-normally distributed measures. Statistical significance was set at .05 and no adjustments were made for multiple comparisons. SAS version 9.2 (SAS Institute, Cary, NC) was used for these analyses.

Results

Descriptive Statistics for the ASHS

The means and standard deviations for the 28 quantitative ASHS items are shown in Table 1. The most highly endorsed items were: “On weekends, I stay up more than 1 hour past my usual bedtime” (M = 3.9, SD = 1.5); “During the hour before bedtime, I do things that make me feel very awake (e.g., playing video games, watching TV, talking on the telephone)” (M = 3.8, SD = 1.5); and “I use my bed for things other than sleep (e.g., talking on the telephone, watching TV, playing video games, doing homework)” (M = 3.8, SD = 1.7). The two least endorsed items were those from the substance use scale, with over 80% of adolescents reporting never using tobacco or consuming alcohol after 6 pm.

Confirmatory Factor Analyses (CFA)

The first CFA model, which was based on the theoretical structure of the ASHS, included 8 latent constructs and 28 items. An admissible solution was not obtained, most likely due to the markedly skewed distributions of the two substance use items. After excluding the substances factor and the two items that comprise it, the 7-factor, 26-item model converged but did not have minimally adequate fit (SBχ^2 = 1110, df = 279, p < .001; RMSEA = .076; TLI = .89; SRMR = .098). Examination of the results suggested three areas of model misspecification. First, one item on the sleep stability subscale (“During the school week, I ‘sleep in’ more than 1 hour past my usual wake time”) had a low standardized factor loading (Λ = .26). This was not surprising given that school start times are fixed and adolescents may be unable to ‘sleep in’ more than an hour on school days. Second, although the bedtime

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routine factor was moderately correlated with the cognitive factor (Ψ = -.19), it had very low correlations with the other 6 factors (Ψ's ranged from -.08 to .02), suggesting poor convergent validity. Third, the inter-factor correlation between the cognitive and the emotional factors was high (Ψ = .84), indicating overlapping constructs. The model was therefore re-specified after omitting the one item with a low factor loading, excluding the bedtime routine item and factor, and combining the cognitive and emotional factors into a single factor. This 5-factor, 24-item model did not provide an adequate fit to the data (SBχ^2 = 1018, *df* = 242, $p < .001$; RMSEA = .079; TLI = .89; SRMR = .100). Inspection of the results showed that three items from the cognitive factor had low standardized factor loadings on the combined cognitive-emotional factor; those three items were conceptually similar, and assessed cognitively-stimulating and non-emotive behaviors. Thus, the model was re-estimated with those three items loading on a new "behavioral arousal" factor, while the other 6 items from the cognitive and emotional factors loading on a cognitive/emotional factor. This revised factor structure for this 6-factor, 24-item model provided an adequate fit to the data (Figure 1). Although the Satorra-Bentler χ^2 was statistically significant (SBχ^2 = 768, *df* = 237, $p<.001$), the approximate fit statistics indicated adequate model fit (RMSEA = .066, 90% CI: .061, .071; TLI = .93; SRMR = .085). The standardized factor loadings were acceptable, ranging from .36 to .98 (Table 1). Internal consistency reliability for the total ASHSr was high (α = .84), and reliability on the ASHSr subscales ranged from α = .60 (physiological) to α = .81 (cognitive-emotional) (Table 2). The inter-factor correlations indicated acceptable convergent and divergent validity, with correlations ranging from Ψ = .15 for the sleep stability and daytime sleep factors to Ψ = .64 for the physiological and sleep environment factors (Table 2).

A second-order CFA was estimated to examine the extent to which an overarching sleep hygiene construct explained the variance in each of the 6 ASHSr factors. The model fit statistics for the second-order CFA were satisfactory (SBχ^2 = 776, *df* = 246, $p < .001$; RMSEA = .065; 90% CI: .060, .070; TLI = .94; SRMR = .087). The γ coefficients ranged from γ = .36 (sleep stability factor) to γ = .87 (physiological) (Table 2), indicating that the sleep hygiene construct explained 13% of the variance in sleep stability factor and 76% of the variance in the physiological factor. Standardized factor loadings (Λ) for each item, which are shown in Figure 1, are consistent with those obtained from the first-order factor analysis (Table 1).

Concurrent Validity

The results of the confirmatory factor analyses were used to create a total score for the revised 24-item ASHS (ASHSr) as well as subscale scores. Higher total sleep hygiene scores (total ASHSr) were associated with longer sleep duration (r = .16), less night-to-night variability in sleep duration (r = -.21), higher sleep efficiency (r = .12), an earlier bedtime (r = .17) and mid-sleep time (r = -.13), shorter sleep onset latency (r = .14) and less daytime sleepiness (r = -.26) (all p-values < .05; see Table 3). The physiological, daytime sleep, and sleep environment subscales were the most consistently correlated with the sleep outcome measures (Table 3). For example, scores on the physiological and sleep environment subscales were positively correlated with sleep efficiency (r = .18 and r = .17) and negatively correlated with time awake after sleep onset (r = -.17 and r = -.16) and variability in sleep duration (r's = -.21). Higher scores on the daytime sleep subscale were associated with longer and less variable sleep duration (r = .13 and r = -.22), an earlier bedtime (r = -.15), and less daytime sleepiness (r =-.31).

The quintiles of the sample distribution of the total ASHSr score were used in an extreme-groups analysis to compare adolescents with poor sleep hygiene (ASHSr score ≤ 3.8) vs. good sleep hygiene (ASHSr score ≥ 4.9). Consistent with expectations, adolescents in the highest quintile of sleep hygiene values slept longer had an earlier bedtime and mid-sleep

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time, shorter sleep onset latency, and less daytime sleepiness compared to adolescents in the lowest quintile (Table 4). Sleep efficiency, wake after sleep onset, and wake time did not differ between groups.

Convergent Validity

The total ASHSr score and most of the ASHSr subscales were correlated with behavioral problems and school competency (Table 3). The total score, physiological and daytime sleep subscale scores had the strongest correlations with school competency (r's ranging from .20 - .25). The sleep environment subscale was also related to internalizing and externalizing behaviors (r's = -.22), while the cognitive-emotional scale was correlated with internalizing behaviors (r = -.24). Furthermore, adolescents in the highest quintile of sleep hygiene values had lower internalizing and externalizing behavior scores and greater school competence scores compared to adolescents with sleep hygiene values in the lowest quintile (Table 4).

Discussion

Evidence-based assessment of the psychometric properties of available pediatric sleep instruments is needed (Lewandowski *et al.*, 2011; Spruyt and Gozal, 2011). The current study examined the factor structure, internal consistency reliability and concurrent validity of the ASHS using a community-based urban sample of 16-19 year old adolescents. The empirical factor structure of the revised 24-item scale (ASHSr) is largely consistent with the theoretically-based structure initially proposed (LeBourgeois *et al.*, 2005), with the exceptions that the cognitive and emotional domains were combined into one factor and a new behavioral arousal construct was identified. Internal consistency reliability of the ASHSr as well as concurrent validity with objective measures of sleep and convergent validity with behavioral outcomes indicate that the ASHSr has satisfactory psychometric properties for a research instrument to assess adolescent sleep hygiene.

Sleep hygiene was modestly correlated with objective measures of sleep quality and duration in our study, which is consistent with previous findings (Brick *et al.*, 2010; Brown *et al.*, 2002; Mastin *et al.*, 2006). Our results suggest that sleep hygiene may have a small but important role in explaining the variance in sleep outcomes. Targeting healthy sleep hygiene practices has the potential to positively affect adolescents' sleep (Brown *et al.*, 2002). A school-based sleep hygiene program was successful at decreasing adolescents' sleep latency and improving the regularity of the adolescents' bedtime, although daytime sleepiness and sleep quality did not change (de Sousa *et al.*, 2007). Furthermore, concise and focused behavioral sleep interventions have been efficacious in improving sleep habits and pro-social behavior over a 12-month period among children entering the school system (Quach *et al.*, 2011), and better sleep hygiene practices were related to better sleep among youth under 11 years of age (Mindell *et al.*, 2009). In the research context, the ASHSr may be a valuable tool for tracking the efficacy of such prevention/intervention programs targeting sleep promotion among adolescents.

Adolescents with better sleep hygiene practices slept about 30 minutes longer than adolescents with the poorest sleep hygiene practices, indicating a moderate effect size (Cohen's D = .48). Prior research has shown that this magnitude of change in sleep duration may be beneficial. For example, Sadeh and colleagues found increasing sleep duration by 35 minutes was associated with improved neurobehavioral functioning in school-aged children (Sadeh *et al.*, 2004), and Owens and colleagues reported that extending sleep duration by 45 minutes on school days was associated with better alertness, health, and mood in high-school students (Owens *et al.*, 2010). Additionally, in our study, adolescents with poor sleep hygiene had significantly lower school competency scores and significantly higher behavioral problem scores, which is also consistent with the extant literature regarding the

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association of poor sleep quality/insufficient sleep duration with lower academic performance (Dewald *et al.*, 2010) and psychosocial functioning (Dahl and Lewin, 2002; Smaldone *et al.*, 2007).

A strength of the current study is that we empirically examined theoretically important but understudied sleep hygiene domains such as daytime sleep (Malone, 2011; Stepanski & Wyatt, 2003) with sleep duration and quality outcomes. Daytime sleep was weakly correlated with sleep duration and was not associated with measures of sleep quality. It may be that adolescents with insufficient nocturnal sleep compensate by napping during the day. Further research is needed to examine this speculation and to evaluate whether the recommendation to avoid daytime naps is warranted.

Our findings indicate that cognitive/emotional arousal is a single factor that is distinct from behavioral arousal. The cognitive/emotional subscale assesses rumination behaviors and negative emotional states at bedtime, while the behavioral arousal ASHS subscale measures activating behaviors prior to bedtime (i.e., using the phone, playing video games and watching TV). Interestingly, neither the cognitive-emotional nor the behavioral arousal subscales were associated with sleep efficiency, although more behavioral arousal was associated with decreased sleep duration. However, limiting the use of electronic devices prior to bedtime runs counter to the lifestyle of many adolescents (Malone, 2011). Results from a recent poll on sleep and technology use found that more than half (56%) of 13-18 year olds reported sending, receiving or reading text messages almost every night during the hour before bedtime, and 28% reported having cell phone nearby with the ringer turned on while sleeping (National Sleep Foundation, 2011).

Our results suggest that the sleep environment (e.g., falling asleep while watching TV; sleeping in a room that is too hot or cold) may be a particularly important aspect of sleep hygiene. Lower scores on this subscale were associated with lower sleep efficiency, more time awake after sleep onset, greater daytime sleepiness, more behavioral problems, and lower school competency. These findings are consistent with those reported by Noland and colleagues, whereby high school students commonly reported that environmental factors such as watching television, improper bedroom temperature, and excessive noise were barriers to their getting adequate sleep (Noland *et al.*, 2009).

Adolescents with higher ASHSr sleep stability subscale scores, as indicated by more regular bedtimes and wake times, had an earlier bedtime and mid-sleep time, shorter sleep onset latency, and less daytime sleepiness. These results are consistent with previous findings that adolescents with set parent-determined bedtimes had an earlier bedtime, longer sleep duration, and were more awake during the day compared to adolescents without parent-set bedtimes (Short *et al.*, 2011). Although the ASHSr sleep stability subscale was not correlated with parent-reported school competency in the current study, a prior study found that inconsistent sleep/wake schedules were associated with lower academic performance (Wolfson and Carskadon, 2003). Moreover, greater variability in nocturnal sleep duration and shorter sleep duration were associated with markers of metabolic dysfunction among 4-10 year old children (Spruyt *et al.*, 2011), further underscoring the potential importance of maintaining a consistent sleep schedule.

A limitation of our study is that a lack of variability in the responses for the items measuring alcohol and tobacco use after 6:00 in the evening prohibited their inclusion in the factor analysis. The low sample prevalence of evening alcohol and tobacco use in the current study is consistent with findings from a recent survey of the sleep habits of high school students (Noland *et al.*, 2009) as well as national trends among American teenagers (Johnston *et al.*, 2012). Alcohol and tobacco use are theoretically important aspects of sleep hygiene, as empirical evidence from polysomnography data shows that alcohol use before bedtime alters sleep architecture (Arnedt *et al.*, 2011), and that smokers have greater sleep impairments relative to non-smokers (Zhang *et al.*, 2006). Thus, it is recommended that the alcohol and tobacco use items be retained on the ASHSr, although these two items were not included in the total ASHSr score.

The results of our study need to be interpreted in light of several limitations. First, the ASHSr factor structure consists of both exploratory and confirmatory analyses. Future research is needed to examine the revised factor structure using confirmatory methods, including re-examining the substances scale. Second, we did not explore potential moderators of the relation of sleep hygiene scores and sleep outcomes. An area for future research is to investigate if the association of sleep hygiene practices and sleep quality or behavioral outcomes varies by demographic characteristics (e.g., sex, socioeconomic status, etc.) or personality traits such as extraversion/introversion (Malone, 2011). Third, additional work is needed to understand the relation of sleep hygiene with subjective measures of sleep quality, as this was not assessed in the current study. Fourth, our findings are from a community-based sample; subsequent studies are needed to examine the ASHSr in adolescent populations with sleep disorders such as sleep apnea, insomnia, delayed sleep phase syndrome, and restless leg syndrome, and the utility of the ASHSr in a clinical context has yet to be explored. Finally, further research is needed to assess predictive validity of the ASHSr as well as other forms of reliability (e.g., test-rest reliability).

Acknowledgments

This work was supported by NIH grants: NIH HL07567, HL60957, UL1-RR024989, and 1U54CA116867

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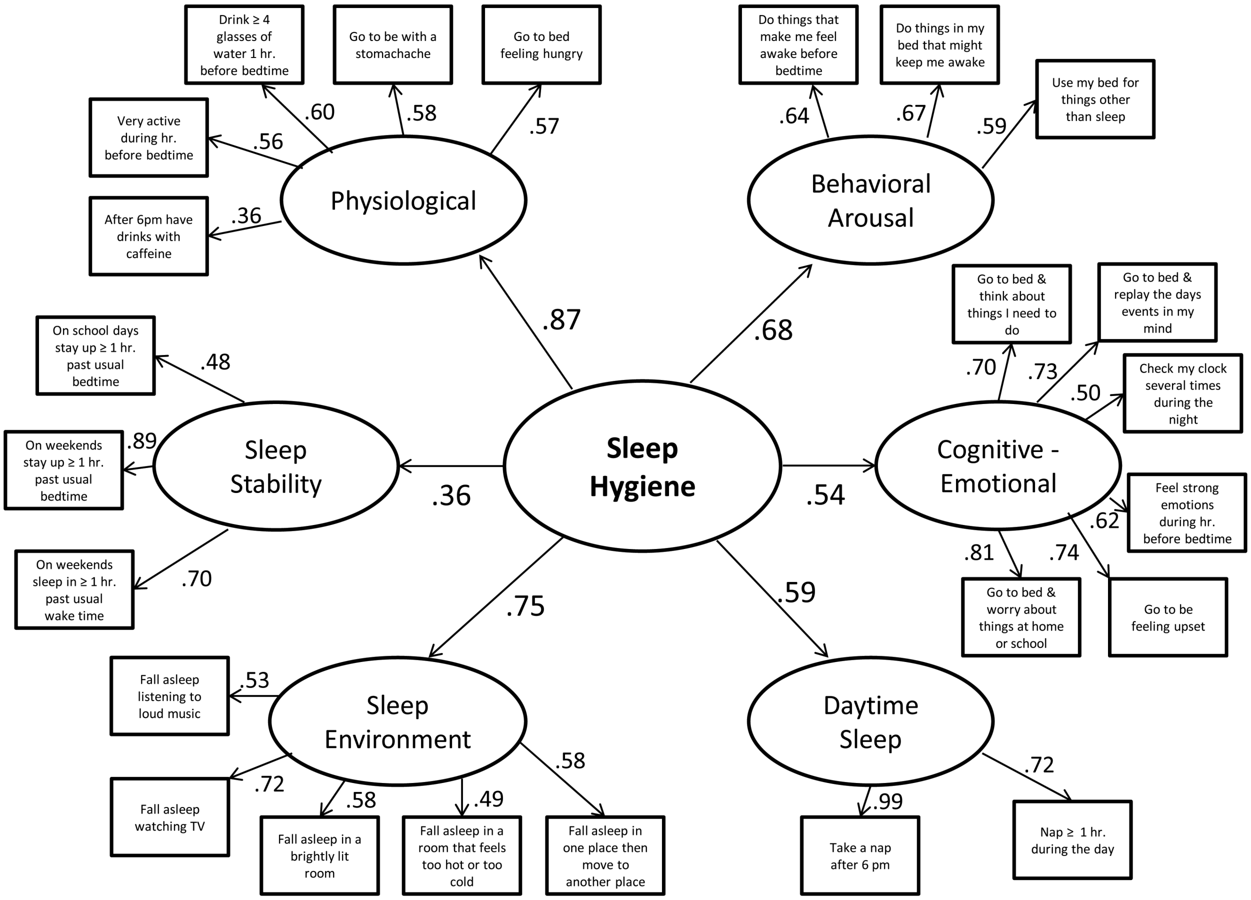

Figure 1.

Factor Structure of the Revised 24-item Adolescent Sleep Hygiene Scale (ASHSr) and Factor Loadings from the Second-Order Factor Analysis

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Table 1

Descriptive Statistics and Standardized Factor Loadings (Λ) from the First-Order Factor Analysis of the Original 28-Item Adolescent Sleep Hygiene Scale (ASHS)

Item	*M*	*SD*	*Λ*
Physiological Factor			
After 6:00 pm, I have drinks with caffeine (e.g., cola, pop, root beer, iced tea, coffee)	2.9	1.4	.36
During the hour before bedtime, I am very active (e.g., playing outside, running, wrestling)	2.5	1.6	.56
During the hour before bedtime, I drink > 4 glasses of water (or some other liquid)	2.7	1.7	.60
I go to bed with a stomachache	1.5	0.8	.58
I go to bed feeling hungry	1.9	1.1	.57
Behavioral Arousal Factor			
During the hour before bedtime, I do things that make me feel very awake (e.g., playing video games, watching TV, talking on the telephone)	3.8	1.5	.64
I go to bed and do things in my bed that keep me awake (e.g., watching TV, reading)	3.1	1.6	.67
I use my bed for things other than sleep (e.g., talking on the telephone, watching TV, playing video games, doing homework)	3.8	1.7	.59
Cognitive/Emotional Factor			
I go to bed and think about things I need to do[†]	3.5	1.4	.70
I go to bed and replay the day's events over and over in my mind[†]	2.8	1.4	.73
I check my clock several times during the night[†]	2.5	1.5	.50
During the 1 hour before bedtime, things happen that make me feel strong emotions (sadness, anger, excitement)[‡]	2.5	1.3	.62
I go to bed feeling upset[‡]	2.0	1.1	.74
I go to bed and worry about things happening at home or at school[‡]	2.5	1.3	.81
Sleep Environment Factor			
I fall asleep while listening to loud music	1.7	1.2	.53
I fall asleep while watching TV	2.6	1.6	.72
I fall asleep in a brightly lit room (e.g., the overhead light is on)	1.5	0.9	.58
I fall asleep in a room that feels too hot or too cold	2.2	1.3	.49
I fall asleep in one place and then move to another place during the night[*]	1.7	1.2	.58
Sleep Stability Factor			
During the school week, I stay up more than 1 hour past my usual bedtime	3.1	1.3	.48
During the school week, I sleep in more than 1 hour past my usual wake time[**]	1.7	1.1	n/a
On weekends, I stay up more than 1 hour past my usual bedtime	3.9	1.5	.89
On weekends, I sleep in more than 1 hour past my usual wake time	3.5	1.5	.70
Daytime Sleep Factor			
During the day, I take a nap that lasts > 1 hour	2.5	1.3	.72
After 6:00 pm, I take a nap[*]	2.0	1.2	.99
Substances Factor			
After 6:00 pm, I smoke or chew tobacco	1.4	1.1	n/a
After 6:00 pm, I drink beer (or other drinks with alcohol)	1.2	0.6	n/a
Bedtime Routine			

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Item	*M*	*SD*	*Λ*
I use a bedtime routine (e.g., bathing, brushing teeth, reading)***	3.6	1.8	n/a

Response choices were on a 6-point ordinal scale: 1 = *Never (0%)*; 2 = *Once in awhile (20%)*; 3 = *sometimes (40%)*; 4 = *quite often (60%)*; 5 = *frequently, if not always (80%)*; 6 = *always (100%)*.

Scoring: Each subscale score is calculated by taking the average of the items comprising that subscale, and the mean of the subscale scores is used to create the revised 24-item total sleep hygiene score (total ASHSr).

* Note: Item was added after the scale was published in 2005.

† Loaded on the cognitive scale in the original version.

‡ Loaded on the emotional scale in the original version.

** This item was omitted due to a low factor loading on the sleep stability scale

*** Item is not reverse-coded

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Table 2

Inter-Factor Correlations (Ψ) from the First-Order Factor Analysis and Factor Loadings (γ) from the Second-Order Factor Analysis of the Revised 24-Item Adolescent Sleep Hygiene Scale (ASHSr)*

	1	2	3	4	5	6
1 Physiological (α = .60)	1					
2 Behavioral Arousal (α = .62)	.54	1				
3 Cognitive / Emotional (α = .81)	.52	.37	1			
4 Sleep Environment (α = .61)	.64	.60	.35	1		
5 Sleep Stability (α = .68)	.32	.29	.23	.26	1	
6 Daytime Sleep (α = .78)	.55	.36	.29	.44	.15	1
Higher order factor loadings (γ)	.87	.68	.54	.75	.36	.58

*All inter-factor correlations are statistically significant at $p < .01$.

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Table 3

Assessment of Concurrent and Convergent Validity of the ASHSr[1]

	Total ASHSr	Physiological	Cognitive Emotion	Behavior Arousal	Sleep Environ	Sleep Stability	Daytime Sleep
Actigraphy-Based Weekday Sleep Measures							
Sleep duration	.16†	.09	.07	.13*	.10	.07	.13*
Variability in sleep duration	-.21‡	-.12‡	-.08	-.12*	-.21‡	-.06	-.22‡
Sleep efficiency	.12*	.18‡	.01	.03	.17‡	.01	.08
Mid-sleep	-.13*	-.08	-.10*	-.07	-.01	-.10*	-.09
Bedtime	-.17‡	-.08	-.11*	-.11*	-.03	-.12*	-.15‡
Wake time	-.06	-.05	-.07	-.02	.05	-.06	-.03
Sleep onset latency	-.14†	-.14†	-.10*	-.07	-.09	-.13*	-.07
Wake after sleep onset	-.10	-.17†	-.01	-.01	-.16†	.01	-.06
Daytime Sleepiness							
Epworth sleepiness scale[a]	-.26‡	-.10*	-.23‡	-.09*	-.21‡	-.11*	-.31‡
CBCL Behavioral Measures							
School competency[b]	.25‡	.22‡	.11*	.14†	.18‡	.07	.20‡
Internalizing behaviors[c]	-.18‡	-.12*	-.24‡	-.01	-.22‡	-.04	-.13†
Externalizing behaviors[c]	-.18‡	-.17‡	-.15†	-.04	-.22‡	-.06	-.10*

[1] Pearson correlations shown for normally distributed measures; Spearman reported for non-normally distributed variables

* p < .05

† p < .01

‡ p < .001

[a] Higher scores indicate more sleepiness

[b] Higher scores indicate greater competence

[c] Higher scores indicate more problems

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Table 4

Variations in Sleep Measures, Daytime Sleepiness and Behavior by Poor and Good Adolescent Sleep Hygiene Scores (ASHSr)

	Poor Sleep Hygiene	Good Sleep Hygiene	*p*-value
Actigraphy-Based Weekday Sleep Measures	N=73	N=69	
Sleep duration (min)	433 ± 78	466 ± 59	.005
Variability in sleep duration	17.8 (10.0, 25.0)	9.3 (5.8, 12.3)	<.001
Sleep efficiency	96.4 (92.9, 97.9)	97.3 (94.7, 98.0)	.10
Mid-sleep	4:23 ± 1:29	3:52 ± 1:14	.03
Bedtime	00:16 (23:19, 01:09)	23:35 (23:00, 00:17)	.005
Wake time	7:40 (6:53, 9:27)	7:43 (6:52, 8:47)	.34
Sleep onset latency (min)	14.0 (6.3, 19.2)	7.8 (4.0, 14.6)	.02
Wake after sleep onset (min)	16.4 (10.0, 33.8)	14.0 (8.4, 24.4)	.16
Daytime Sleepiness	N=106	N=98	
Epworth sleepiness scale[a]	8 (5, 12)	5 (3, 8)	<.001
CBCL Behavioral Measures	N=100	N=90	
School competency[b]	42.0 ± 12.7	50.5 ± 10.7	<.001
Internalizing behaviors[c]	50.4 ± 11.0	44.7 ± 9.6	<.001
Externalizing behaviors[c]	50.1 ± 10.8	44.5 ± 9.4	<.001

Mean ± SD shown for normally distributed measures; median (25^{th}, 75^{th} percentiles) shown for non-normally distributed measures.

Poor sleep hygiene: total ASHSr score ≤ 3.8 (lowest quintile)

Good sleep hygiene: total ASHSr score ≥ 4.9 (highest quintile)

[a]Higher scores indicate more sleepiness

[b]Higher scores indicate greater competence

[c]Higher scores indicate more problems