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Convergent validity of actigraphy with polysomnography and parent-reports when measuring sleep in children with Down syndrome

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Abstract

Background—There is a need for rigorous measures of sleep in children with Down syndrome as sleep is a substantial problem in this population and there are barriers to obtaining the gold-standard polysomnography (PSG). PSG is cost-prohibitive when measuring treatment effects in some clinical trials and children with Down syndrome may not cooperate with undergoing a PSG. Minimal information is available on the validity of alternative methods of assessing sleep in children with Down syndrome, such as actigraphy and parent-ratings. Our study examined the concurrent and convergent validity of different measures of sleep, including PSG, actigraphy, and parent reports of sleep among children with Down syndrome.

Method—A clinic (n=27) and a community (n=47) sample of children with Down syndrome were examined. In clinic, children with Down syndrome wore an actigraph watch during a routine PSG. In the community, children with Down syndrome wore an actigraph watch for a week at home at night as part of a larger study on sleep and behaviour. Their parent completed ratings of the child's sleep during that same week.

Results—Actigraph watches demonstrated convergent validity with PSG when measuring a child with Down syndrome's total amount of sleep time, total wake time after sleep onset, and sleep period efficiency. In contrast, actigraph watches demonstrated poor correlations with parent reports of sleep, and with PSG when measuring the total time in bed and total wake episodes. Actigraphy, PSG, and parent ratings of sleep demonstrated poor concurrent validity with clinical diagnosis of obstructive sleep apnoea.

Conclusion—Our current data suggest that actigraph watches demonstrate convergent validity and are sensitive to measuring certain sleep constructs (duration, efficiency) in children with Down syndrome. However, parent-reports, such as the CSHQ, may be measuring other sleep constructs. These findings highlight the importance of selecting measures of sleep related to target concerns.

Keywords

Down syndrome; polysomnography; actigraphy; Children's Sleep Habits Questionnaire; sleep; children

Sleep problems are common in individuals with Down syndrome, with high rates of obstructive sleep apnoea (31–66%) and behavioural (52–69%) sleep problems (Carter, McCaughey, Annaz, & Hill, 2009; de Miguel-Diez, Villa-Asensi, & Alvarez-Sala, 2003; Esbensen & Hoffman, 2017a; Stebbens, Dennis, Samuels, Croft, & Southall, 1991). Behavioural sleep problems include problems that can be observed, such as bedtime resistance, sleep onset delay, sleep anxiety, night waking, and parasomnias (Stores & Stores, 2013). Interventions are available or being tested to support the sleep of children with Down syndrome. Bi-level and continuous Positive Airway Pressure (PAP) are common interventions used in the general population, but are less well tolerated among children with developmental disabilities (Shott, 2006). Surgical otolaryngology (adenoidectomy, tonsillectomy) are the primary intervention for obstructive sleep apnoea (OSA) in children with Down syndrome, with variable rates of success reported (Marcus et al., 2006; Merrell, 2007). Post-surgery, 48–63% of children continued to have an elevated frequency of apnoea, with an equal number of parents reporting to have observed apnoea in their child post-surgery (Merrell, 2007; Rosen, Lombardo, Skotko, & Davidson, 2011). Clinical trials of children with Down syndrome are currently underway to assess the clinical effectiveness of behavioural interventions and of hypoglossal nerve stimulators to support sleep. Given the prevalence of sleep problems and poor intervention outcomes, sleep is an important topic in the Down syndrome research and clinical community.

The importance of sleep in children with Down syndrome is recognised by the American Academy of Pediatrics, as the Committee on Genetics published the Health Supervision for Children with Down Syndrome. In this report, they recommend that all children receive a referral for an overnight diagnostic polysomnography (PSG; sleep study) by 4 years of age (Bull & Genetics, 2011). PSG is the gold standard for assessing sleep problems. Individuals with Down syndrome frequently demonstrate abnormal PSG with high sleep fragmentation (Levanon, Tarasiuk, & Tal, 1999; Trois et al., 2009). Although children diagnosed with sleep problems are receiving care consistent with the recommendations of this report, not all children are being screened (Esbensen, Beebe, Byars, & Hoffman, 2016). Only 48% of children seen at a large-scale paediatric centre had undergone PSG. However, there are several barriers to use of PSG in a clinical setting, as children may not cooperate with undergoing a sleep study (Skotko et al., 2017). Beyond barriers to completing PSG, regional barriers also exist. There is limited availability of PSG in some regions, or it would require an extensive drive and hotel stay for parents. Further, sleep is not observed in the child's natural environment, and for some families or research studies, undergoing a PSG is cost-prohibitive (Hyde et al., 2007). As not all children with Down syndrome will cooperate or be able to access PSG, the validity of other methods of assessing sleep warrants exploration.

Actigraphy is an alternative method of assessing sleep problems that has shown to be reliable with PSG in typically developing children with sleep disordered breathing (Hyde et al., 2007). Given the challenges of accessing PSG in research, the use of actigraphy to measure sleep among individuals with intellectual and developmental disabilities is becoming more common (Hare, Jones, & Evershed, 2006; van de Wouw, Evenhuis, & Echteld, 2012; van Dijk, Hilgenkamp, Evenhuis, & Echteld, 2012). However, the validity of actigraphy is undetermined in this population. A recent study of pre-schoolers with

developmental delays wearing actigraphs on their ankles suggested poor agreement with videosomnography (Sitnick, Goodlin-Jones, & Anders, 2008). Encouragingly, a small pilot study of older adults with intellectual disabilities wearing actigraphy watches suggested good sensitivity (i.e., detecting sleep), poor specificity (i.e., detecting awake), and adequate accuracy (i.e., overall agreement;) in measuring sleep parameters when compared with EEG sleep measurements (van de Wouw, Evenhuis, & Echteld, 2013). Given the variable performance of actigraphy in very young and very old populations of individuals with developmental disabilities, further assessments of the validity of actigraphy in measuring sleep in these age groups is needed, as well as preliminary assessment among school-age children. As actigraphy demonstrates validity in the general population when examining children with sleep disordered breathing, there is additional urgency to evaluate the use of actigraphy among school-age children with developmental disabilities who are more vulnerable to OSA, such as children with Down syndrome.

Parent report is another method of assessing sleep problems. Parent questionnaires about sleep behaviours provide input from a long-term observer regarding sleep hygiene, sleep anxiety, sleep behaviours such as restless movement, resisting bedtime and delayed sleep onset, and night-time waking (Beebe, 2012). While parent report measures of sleep demonstrate poor validity with PSG (Breslin et al., 2014), several parent-report measures of sleep demonstrate good psychometric properties and validity with other measures of sleep. The Children's Sleep Habits Questionnaire (CSHQ) was designed for use in paediatric populations under 10 years of age without intellectual disabilities (Owens, Spirito, & McGuinn, 2000). The CSHQ demonstrates strong psychometric properties and validity in identifying behavioural sleep problems in school-age children with Down syndrome ages 6–17 years (Esbensen & Hoffman, 2017a). In addition to acceptable internal consistency, the CSHQ demonstrates convergent validity with other behavioural measures of sleep and concurrent validity with clinical diagnoses of sleep disorders and use of PAP. Individual CSHQ subscales also demonstrate concurrent validity with reports from daily sleep diaries when measuring sleep onset, night waking, and daytime drowsiness. Further, the CSHQ demonstrates validity in other paediatric populations characterised by intellectual and developmental disabilities (Veatch et al., 2016). Among children with autism spectrum disorders, concurrent validity was established for the CSHQ subscales and actigraphy measures of sleep onset delay, night waking, and bedtime resistance. Parent reports of bed and wake times were also correlated with actigraphy-measured sleep duration. The Sleep Disturbances Scale for Children (SDSC) is another parent-reported measure of sleep that correlate with the CSHQ and demonstrates convergent and concurrent validity with sleep disorders, use of PAP, and reports from daily sleep diaries (Esbensen & Hoffman, 2017a). Thus, while parent-report measures may not correlate with PSG in assessing sleep duration or sleep apnoea, parents are validly reporting on other aspects of problematic sleep in children with Down syndrome or other developmental disabilities.

Despite the clinical importance of sleep problems in children with Down syndrome, minimal information is available on the validity of these alternative methods, specifically actigraphy, in assessing sleep in this population. The need for rigorous measures of sleep is significant as there are barriers to the gold-standard PSG, and use of PSG is cost-prohibitive when measuring treatment effects in some clinical trials. Given this need, in this study we examine

the concurrent and convergent validity of different measures of sleep, including PSG, actigraphy, and parent reports of sleep among children with Down syndrome. Regarding concurrent validity, given the concerns for sleep fragmentation in children with DS and OSA, we hypothesise that measures of sleep duration and quality as measured by PSG, actigraphy, and parent-report measures will be worse for children with diagnoses of OSA in comparison to children without OSA. Regarding convergent validity, we hypothesise that actigraphy and PSG will demonstrate correlations with respect to measures of time in bed, sleep duration, sleep onset-time, number of awakenings, and sleep efficiency. Further, we hypothesise that actigraphy and a parent-report sleep measure (CSHQ) will demonstrate correlations with respect to disrupted sleep.

Method

Participants

Two samples of children with Down syndrome were examined. In Study 1, 27 children undergoing routine PSG at a sleep clinic were consented to also wear an actigraphy watch. Children with Down syndrome ranged in age from 5 to 17 years of age ($M = 10.7$ years, $SD = 4.1$), were primarily male (67%) and Caucasian (78%). Most of these children (89%) were clinically diagnosed with a sleep disorder according to medical records. Diagnoses of OSA were confirmed in medical records. Other medical comorbidities reported include heart defects (48%), anxiety (15%) and attention deficit hyperactivity disorder (11%).

In Study 2, 47 children with Down syndrome and their parent participated in larger community-based studies on sleep and associated daytime behaviour and cognition. In this second study, children wore an actigraph watch and parents completed a rating scale on child sleep problems. Children with Down syndrome ranged in age from 6 to 17 years of age ($M = 10.9$ years, $SD = 3.1$), were primarily male (62%) and Caucasian (85%). Based on parent-reports and confirmed with medical records, 55% of these children were clinically diagnosed with a sleep disorder. Standard full scale IQ scores on the Kaufman Brief Intelligence Test-2 ranged from 40–65 ($M = 43.7$, $SD = 4.7$) (Kaufman, 2004). Standard scores on the Broad Index score of the Scales of Independent Behavior-Revised ranged from 0–93 ($M = 49.2$, $SD = 21.5$) (Bruininks, Woodcock, Weatherman, & Hill, 1996). Respondents were primarily mothers (93.3%).

Procedure

In Study 1, children with Down syndrome between the ages of 5 years 0 months and 17 years 11 months were recruited from existing patients being seen for a PSG within a paediatric sleep centre. The family was asked at their routine clinic visit if they would like to hear about the study and if they were interested in participating. The protocol was discussed and consent and assent were obtained. The children then slept overnight at the sleep lab, where a technician attached the child to the PSG and put the actigraph watch on simultaneously.

In Study 2, families of children with Down syndrome between the ages of 6 years 0 months and 17 years 11 months were recruited from the community. Parents provided information

on the child's demographics and completed behavioural rating forms. To measure sleep, parents completed a measure of behavioural sleep disturbances, the Children's Sleep Habits Questionnaire (CSHQ). For seven consecutive nights at home, children wore an actigraph watch while sleeping.

All study activities were approved and overseen by the Institutional Review Board at the medical centre.

Measures

Polysomnography—Children participated in a routine PSG in a paediatric medical centre. PSG utilised video-monitoring, EKG patches to monitor heart rate, motion belts around the chest, a nasal cannula for breathing, pulse oximetry on a finger or toe, a snore sensor (microphone), and EEG nodes to measure brain waves, and chin and eye muscle activity. Medical staff within the sleep centre provided summary sleep variables from the PSG to the research team. Variables extracted from PSG included total time in bed, total sleep time (minutes asleep after sleep onset), total wake time after sleep onset (WASO), sleep period time, total wake time, and total movement time.

Actigraphy—The Micro-mini Motionlogger Actigraph (Ambulatory Monitoring, Inc.) is a battery-operated device that closely resembles a watch and measures movement. The actigraph was placed on the non-dominant wrist of the participant 30 minutes before bedtime and removed from the wrist 30 minutes after rising in the morning. A validated sleep scoring algorithm was used to differentiate the movement data between sleep and wake states (*Micro-Mini Motionlogger Instruction Manual*, 2000; Sadeh, Sharkey, & Carskadon, 1994). Action-W2 software was used to analyse sleep parameters of sleep onset and offset after indicating the time the child went to bed, reported on a parent completed sleep diary. Variables extracted from actigraph watches included total time in bed, total sleep time, total WASO, total wake episodes, percent sleep efficiency, sleep latency, and activity index. Total wake episodes is the number of blocks of contiguous wake epochs (30 second intervals). Activity index is the percent of epochs with > 0 activity, which is a good indicator of restlessness. For Study 1, only one night of sleep data was extracted for the night the child slept in the sleep lab. For Study 2, the children wore the actigraph watch for 7 consecutive nights while sleeping. Variables extracted from actigraph watches were averaged over valid nights of data extraction. The majority of children demonstrated high compliance with wearing actigraphy watches, with 88% of children wearing the actigraph for 6 or 7 nights. The actigraphs were worn on average for 6.4 nights (SD = 1.2).

Parent-report of sleep—The Children's Sleep Habits Questionnaire (CSHQ) is a 33-item instrument screening for major childhood medical and behavioural sleep disorders over a typical week (Owens et al., 2000). Items are rated on a 3-point Likert type scale assessing frequency of sleep problems. The CSHQ provides scores for a total score and the following subscales: bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, night wakings, parasomnias, sleep disordered breathing, and daytime sleepiness. The CSHQ is demonstrated to be reliable and valid with children 6–17 years old with Down syndrome (Esbensen & Hoffman, 2017a).

Data Analysis

Preliminary analyses using t-tests and ANOVAs assessed for differences in demographics between participants in Studies 1 and 2. T-tests and ANOVAs were again used to assess for differences in sleep, as measured by actigraphy, between participants in Studies 1 and 2. Chi-square tests were used to compare differences in the rate of clinical diagnoses of obstructive sleep apnoea between Studies 1 and 2.

Preliminary analyses generated descriptive information on measures of sleep by PSG, actigraphy and parent-report CSHQ. Ratings of sleep on the CSHQ were evaluated based on cut-offs offered from the normative sample (Owens et al., 2000). Cut-offs were generated based on scores two standard deviations above the subscale or total mean generated in the normative sample.

To assess concurrent validity, t-tests were used to compare differences in rates of clinical diagnoses of sleep disorders across the different measures of sleep, from PSG (data from Study 1), actigraphy (data from Study 1 and 2), and CSHQ (data from Study 2).

To assess convergent validity, bivariate correlations were conducted between actigraphy and comparable PSG measures of sleep from Study 1, and with the subscale and total scores on the CSHQ from Study 2.

Results

Of the 27 participants in Study 1, usable data on PSG and actigraphy were available in 26 and 23 cases, respectively. PSG data was not available for one of the participants in Study 1 due to the patient room not being equipped with the appropriate software to analyse sleep log data. Actigraphy data was not available for one of the participants due to the watch not being put on the participant, and 3 actigraphs had technological errors when downloading the data in Study 1. Of the 47 participants in Study 2, 44 had usable actigraphy data. Technical errors contributed to lost data for 3 participants in Study 2. There were no significant differences in age, gender, or race among the children recruited for either Study 1 or 2.

Descriptive data for sleep, as measured by PSG and actigraphy, are presented in Table 1. On actigraphy measures of sleep, children in the clinic sample (Study 1) demonstrated poorer sleep in contrast to the community sample (Study 2). Children seen at the sleep centre were presenting with poor sleep efficiency [$t(65) = -2.20, p = .031$], a longer sleep latency [$t(65) = 3.68, p < .001$], more waking episodes [$t(65) = -2.51, p = .015$], and longer average duration of waking episodes [$t(65) = 4.06, p < .001$] than children in the community sample. In both the clinic and at home, children demonstrated a comparable sleep duration, similar WASO, and similar activity levels. Children in the clinic sample (88.9%) were more likely to be diagnosed with a comorbid OSA than children in the community sample (55.3%), $\chi^2(1) = 8.82, p = .003$.

Descriptive data for sleep, as measured by CSHQ, are presented in Table 2. Over 80% of the children with Down syndrome exceeded the cut-off for the total score on the CSHQ based

on the normative sample. Children with Down syndrome also exceeded the cut-off for the subscale scores. The percentage of children exceeding subscale cut-off scores ranged from 10% (Sleep Onset Delay) to 34% (Night Waking).

Concurrent validity

As shown in Table 3, children with Down syndrome with and without OSA did not demonstrate statistically significant differences in sleep duration or quality as measured with PSG, actigraphy, or CSHQ.

Convergent validity

As shown in Table 4, among children with Down syndrome in Study 1, the sleep measures from actigraph watches and PSG were significantly correlated when measuring total amount of sleep time ($r = .70, p < .001$), total WASO ($r = .49, p = .020$), and sleep efficiency ($r = .54, p = .008$). In this pilot sample, the sleep measures from actigraph watches and PGS were not correlated when measuring the total time in bed ($r = .24, p = .270$) or the total number of wake episodes ($r = .29, p = .219$). As shown in Table 5, among children with Down syndrome in Study 2, actigraph watches were not correlated to most parent reports of behavioural sleep concerns. Parasomnias, as measured by the CSHQ, were correlated with actigraphy measures of WASO ($r = .38, p = .014$) and the total number of wake episodes ($r = .31, p = .047$).

Discussion

The current study examined the concurrent and convergent validity of actigraphy as a measure of sleep among school-age children with Down syndrome, in comparison to PSG and parent-reports of sleep problems (CSHQ). Actigraph watches demonstrated convergent validity with PSG when measuring a child with Down syndrome's total amount of sleep time, total wake time after sleep onset, and sleep period efficiency. In contrast, actigraph watches demonstrated poor correlations with PSG when measuring the total time in bed and total wake episodes. The latter finding regarding wake episodes is consistent with the literature of actigraphy performing poorly in detecting night-time awakenings among older adults with intellectual disability (van de Wouw et al., 2012). Our current data suggest that actigraph watches are sensitive to measuring certain sleep constructs in children with Down syndrome, specifically total sleep time, wake after sleep onset and sleep efficiency.

Actigraphy was not related to parent reports of sleep. This finding is consistent with poor correlations between PSG and parent reports of sleep problems. Thus, while actigraphy and PSG demonstrate convergent validity in measuring certain sleep constructs (duration, efficiency), parent-reports, such as the CSHQ, may be measuring other sleep constructs. Specifically, the CSHQ may be measuring parent reports of behavioural sleep problems and not the amount or quality of sleep, thus explaining the poor convergent validity demonstrated in the current analyses (Esbensen & Hoffman, 2017). These findings have implications for the importance of supporting children with Down syndrome in complying with wearing actigraphs, such as having parents modelling also wearing watches, providing social stories, sensory desensitization, and use of positive reinforcement for wearing the

watch. Further, selection of sleep measures in future research should continue to consider the type of sleep problem targeted for study.

Actigraphy sleep quality variables were not related to clinical diagnoses of OSA in the current study. Further, no measures of sleep duration or quality, as measured by actigraphy watches, PSG, or parent-report, were significantly different across children with and without clinical diagnoses of OSA. This finding is not unexpected, as OSA is measured by Apnoea-Hypopnea Indices and not the duration of sleep. This finding is also not unexpected given the less reliable reports from parents in detecting obstructed breathing (Shott et al., 2006). Thus, for diagnosing OSA, PSG remains the gold standard. Interventions to improve OSA would benefit from sleep lab or in-home polysomnography measuring AHI levels, rather than using actigraphy.

Sleep was a common problem in both a clinical and community sample of children with Down syndrome, corroborating the literature that sleep is a major concern in this population. Children in our samples with Down syndrome were averaging 6.9 to 7.9 hours of sleep, which is less than the amount of sleep recommended for the age range of children sampled. Current paediatric recommendations are for 3 to 5 year olds to obtain 10 to 13 hours of sleep, 6 to 13 year olds to obtain 9 to 11 hours of sleep, and for 14 to 17 year olds to obtain 8 to 10 hours of sleep (Hirshkowitz et al., 2015). As expected, in a clinical setting, very few children were documented to achieve the recommended amount of sleep (3% when measuring sleep with PSG, 15% when measuring sleep with actigraphy). However, at home, only 24% of children were receiving the recommended amount of sleep. While sleeping in a clinic may be challenging for children with Down syndrome and children referred to clinic likely have presenting sleep problems, it appears that even at home children are not achieving the standard amount of recommended sleep. Thus, it appears that sleep is a significant concern for many children with Down syndrome, but not all.

In both clinic and at home, sleep efficiency was also very poor, with children with Down syndrome as a group averaging 76–85% depending on the method and location of measurement. Sleep efficiency of 85% is considered “good,” and below 74% as “not good” sleep quality (Ohayon et al., 2017). Thus, 34% of children in the current sample were exhibiting good sleep efficiency, 46% were exhibiting sleep efficiency between 75–84%, and 20% were exhibiting not good sleep efficiency. These children with below normal sleep efficiency are likely experiencing comorbid symptoms. There are significant implications for having poor sleep for children with Down syndrome, including poor behavioural regulation, worsening mood, and challenges with executive functioning (Esbensen & Hoffman, 2017b; Fallone, 2002). These behavioural and cognitive concerns highlight the need for sensitive and accessible measures for assessing sleep problems. Without accurate, accessible measures, it is difficult to identify and treat sleep problems in children with Down syndrome. If sleep difficulties continue, the physical and behavioural health of children with Down syndrome will likely be impacted.

Sleep in a clinic was slightly worse and more disrupted than at home. Specifically, sleep in a clinic was delayed, less efficient, and children experienced more and longer waking periods than in sleep at home. This finding is not unexpected. Measurement of sleep can be

impacted by the setting or environment, scoring variability between technicians, and challenges with assessing sleep on a single night rather than summarizing sleep over several nights (Reichert, Bloch, Cundiff, & Votteri, 2003). These challenges with using PSG, combined with the convergent validity with actigraphy, argue for using actigraphy in the home environment in sleep research to assess sleep duration and quality when wanting to maximise a natural sleeping environment. Not only will this method of measurement lead to valid data, it will also relieve stress and resources for clinics, families, and the children. Families may be more willing to agree to participate in sleep research when the burden of an overnight clinic visit is removed.

A strength of our study is that we examined the concurrent and convergent validity of actigraphy measures of sleep in both a clinic and a community setting with children with Down syndrome. However, this design is not without its limitations. The study design provides the opportunity for the clinic sample to over-represent sleep concerns and children who are able to comply with the sleep lab setting. The community sample may under-represent children with shorter sleep or fewer sleep problems, but over-represent children with behavioural concerns limiting participation in PSG.

Our findings contribute to understanding the measurement of sleep in Down syndrome, and have implications for selection of sleep measures in future studies of sleep in this paediatric population. Our findings are suggestive that future research studies involving children with Down syndrome can continue to use actigraph watches to measure the children's total amount of sleep time, total wake time after sleep onset, and sleep efficiency for more valid results, but not for diagnosing OSA. In order to assess for behavioural sleep difficulties, a parent report measure may still be appropriate. However, care in selection of sleep measures is warranted, particularly if targeting OSA.

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Table 1

Descriptive measure of sleep as measured by PSG and actigraphy.

	Study 1			Study 2		
	PSG (n=26)			Actigraphy (n=44)		
	M (SD)	Range		M (SD)	Range	
Measures similar across PSG and actigraphy						
Time in Bed (min)	532.4 (63.2)	426–688	577.6 (76.8)	423–742	569.4 (53.6)	365–667
Total Sleep Time (min)	414.4 (63.0)	272–557	446.4 (102.5)	261–685	469.4 (57.1)	333–586
Total Wake Time After Sleep Onset (min)	73.5 (48.6)	14–193	90.0 (55.7)	23–245	73.9 (44.8)	19–227
Total Wake Episodes (#)	27.7 (13.6)	9–69	14.6 (5.4)	4–28	18.7 (6.8)	6–39
Sleep Efficiency (%)	85.0 (9.5)	58–97	76.9 (11.6)	44–93	82.4 (8.3)	57–93
Measures exclusively available through actigraphy						
Sleep Latency (min)	-	-	38.6 (21.5)	0–87	21.6 (15.9)	3–84
Activity Index	-	-	38.4 (11.7)	24–71	34.5 (9.5)	15–63

Table 2

Frequency of sleep problems on Children's Sleep Habits Questionnaire – Study 2 (n=47).

CSHQ Subscales (range 1–3)	Mean (SD)	Percent over cut-off*
Bedtime Resistance	1.53 (.55)	34.0%
Sleep Onset Delay	1.36 (.67)	10.6%
Sleep Duration	1.41 (.55)	21.3%
Sleep Anxiety	1.48 (.49)	26.1%
Night Wakings	1.67 (.61)	34.8%
Parasomnias	1.35 (.26)	24.4%
Sleep Disordered Breathing	1.37 (.49)	31.1%
Daytime Sleepiness	1.61 (.38)	22.2%
Total Score	1.46 (.22)	84.4%

* Cut-off determined as scores two standard deviations above the mean of the normative sample (Esbensen & Hoffman, 2017a; Owens et al., 2000).

Table 3

Descriptive measure of sleep compared across clinical diagnoses of OSA.

Sleep measure	No OSA	OSA
	M (SD)	M (SD)
PSG (n=26, Study 1)	(n=13)	(n=13)
Time in Bed (min)	566.83 (15.78)	527.96 (65.81)
Total Sleep Time (min)	444.50 (37.95)	410.46 (65.06)
Total WASO (min)	81.33 (23.96)	72.45 (51.34)
Total Wake Episodes (#)	28.00 (4.58)	27.60 (14.57)
Sleep Efficiency (%)	84.53 (3.93)	85.05 (10.07)
Actigraphy (n=67, Study 1 & 2)	(n=22)	(n=45)
Time in Bed (min)	581.08 (47.37)	568.03 (68.19)
Total Sleep Time (min)	475.26 (54.84)	454.81 (83.94)
Total WASO (min)	78.73 (43.69)	79.79 (51.85)
Total Wake Episodes (#)	19.30 (6.70)	16.38 (6.46)
Sleep Efficiency (%)	81.91 (8.09)	79.81 (10.58)
CSHQ (n=47, Study 2)	(n=21)	(n=26)
Bedtime Resistance	1.56 (.55)	1.51 (.56)
Sleep Onset Delay	1.38 (.67)	1.35 (.69)
Sleep Duration	1.37 (.49)	1.45 (.60)
Sleep Anxiety	1.53 (.45)	1.43 (.52)
Night Wakings	1.78 (.53)	1.59 (.67)
Parasomnias	1.36 (.28)	1.34 (.25)
Sleep Disordered Breathing	1.22 (.31)	1.49 (.57)
Daytime Sleepiness	1.64 (.43)	1.58 (.35)
Total Score	1.48 (.22)	1.45 (.23)

Table 4

Correlations of actigraphy with PSG in a clinic sample – Study 1 (n=23).

	1	2	3	4	5	6	7	8	9
1 PSG - Time in Bed (min)	-								
2 PSG - Total Sleep Time (min)	.43*	-							
3 PSG - Total WASO (min)	0.07	-.63**	-						
4 PSG - Total Wake Episodes (#)	0.22	-0.03	0.05	-					
5 PSG - Sleep Efficiency (%)	0.02	.73**	-.99**	-0.04	-				
6 Actigraphy - Time in Bed (min)	.024	.54**	-.56**	-0.02	.59**	-			
7 Actigraphy - Total Sleep Time (min)	0.26	.70 **	-.67**	-0.19	.70**	.77**	-		
8 Actigraphy - Total WASO (min)	-0.01	-.48*	.49 *	0.19	-.53**	-0.01	-.59**	-	
9 Actigraphy - Total Wake Episodes (#)	0.12	0.01	-0.29	0.29	0.28	0.03	-0.12	0.18	-
10 Actigraphy - Sleep Efficiency (%)	0.17	.56**	-.53*	-0.21	.54 **	0.26	.79**	-.90**	-0.18

*
p < .05,

**
p < .01

Table 5

Correlations of actigraphy with CSHQ scores in a community sample – Study 2 (n=44).

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Actigraphy - Time in Bed (min)	-												
2 Actigraphy - Total Sleep Time (min)	.67**	-											
3 Actigraphy - Total WASO (min)	0.15	-.58**	-										
4 Actigraphy - Total Wake Episodes (#)	0.21	-0.05	.37**	-									
5 Actigraphy - Sleep Efficiency (%)	0.03	.74**	-.90**	-.24*	-								
6 CSHQ - Bedtime Resistance	0.00	-0.02	0.15	0.13	-0.02	-							
7 CSHQ - Sleep Onset Delay	0.00	-0.08	0.03	-0.19	-0.12	0.06	-						
8 CSHQ - Sleep Duration	0.02	-0.13	0.16	-0.12	-0.18	0.15	.39**	-					
9 CSHQ - Sleep Anxiety	-0.06	-0.04	0.09	0.06	-0.05	.64**	-0.08	0.13	-				
10 CSHQ - Night Wakings	0.05	0.08	0.06	0.02	0.08	.47**	-0.06	.40**	.43**	-			
11 CSHQ - Parasomnias	-0.09	-0.23	.38*	.31*	-0.29	.29*	0.22	.53**	.39**	.42**	-		
12 CSHQ - Sleep Disordered Breathing	-0.24	-0.11	-0.13	-0.25	0.05	-0.14	-0.08	0.21	0.02	-0.02	0.17	-	
13 CSHQ - Daytime Sleepiness	0.10	0.16	-0.08	-0.00	0.16	-0.18	-0.04	-0.00	-0.24	0.09	-0.02	0.21	-
14 CSHQ - Total Score	0.01	-0.05	0.20	0.07	-0.09	.64**	0.20	.57**	.54**	.72**	.74**	0.29	0.26

*
p < .05,**
p < .01