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Estimating Child Sleep From Parent Report of Time in Bed: Development and Evaluation of Adjustment Approaches

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Abstract

Objective To develop and evaluate adjustment factors to convert parent-reported time in bed to an estimate of child sleep time consistent with objective measurement. **Methods** A community sample of 217 children aged 4–9 years (mean age = 6.6 years) wore actigraph wristwatches to objectively measure sleep for 7 days while parents completed reports of child sleep each night. After examining the moderators of the discrepancy between parent reports and actigraphy, 3 adjustment factors were evaluated. **Results** Parent report of child sleep overestimated nightly sleep duration by ~24 min per night relative to actigraphy. Child age, gender, and sleep quality all had small or nonsignificant associations with correspondence between parent report and actigraph. Empirically derived adjustment factors significantly reduced the discrepancy between parent report and objective measurement. **Conclusions** Simple adjustment factors can enhance the correspondence and utility of parent reports of child sleep duration for clinical and research purposes.

Keywords: actigraphy, adjustment, child sleep, correspondence, parent report

Introduction

Sleep is increasingly recognized as a factor that impacts children's cognitive, behavioral, and physical health functioning (Gregory & Sadeh, 2012; Smaldone, Honig, & Byrne, 2007; Vriend et al., 2013). With this recognition has come a heightened interest in the clinical usefulness of various methods for assessing child sleep. Although the validity of certain objective measures (e.g., overnight polysomnography [PSG], actigraphy) is well established, commonly used subjective measures of child sleep appear to produce discrepant estimates (Dayyat, Spruyt, Molfese, & Gozal, 2011; Iwasaki et al., 2010; Short, Gradisar, Lack, Wright, & Chatburn, 2013; Tikotzky & Sadeh, 2001), potentially limiting their clinical utility. Despite consistent findings that subjective reports of child sleep diverge from more validated objective methods, no studies have examined the possibility of systematically adjusting subjective reports of child sleep, even with the availability of simple methods for adjustment in the broader pediatric health literature (Modi, Guilfoyle, Morita, & Glauser, 2011; Wu, Pai, Gray, Denson, & Hommel, 2013). Such research could greatly enhance the utility of common parent-reported sleep data by giving researchers and clinicians tools for improving the correspondence of these reports with objective estimates of sleep time.

Objective methods, including overnight PSG and actigraphy, are typically recommended over subjective measures of child sleep (e.g., parent reports; Lam, Mahone, Mason, & Scharf, 2011). However, objective methods may not be feasible in all situations. PSG is typically considered the "gold standard" in the assessment of sleep quality; however, its cost and inability to capture sleep duration patterns at home are important limitations. Actigraph accelerometers, which measure sleep by detecting periods of movement and inactivity, have been touted as a less expensive option for objectively measuring child sleep (particularly sleep duration), with the advantage of being able to unobtrusively capture sleep patterns over extended periods (e.g., several days or weeks) in the child's natural setting (Sadeh, 2008). Although less expensive than overnight PSG, actigraph wristwatches still cost several hundred dollars or more per device and often require an additional $100 every year in device maintenance (e.g., batteries, computer software; Meltzer, Montgomery-Downs, Insana, & Walsh, 2012), which represents a significant investment for many clinical providers. Further, providers are unlikely to recoup these costs through billing, and broken equipment needs to be replaced periodically, making cost a meaningful obstacle to objective sleep measurement in many clinical settings. The decision to purchase the equipment may be particularly difficult for clinicians who consider sleep assessment to be a relevant, but not necessarily central, aspect of their practice. For example, sleep problems are known to be comorbid with a variety of chronic pediatric medical (e.g., chronic pain, asthma; Lewin & Dahl, 1999; Sadeh, Horowitz, Wolach-Benodis, & Wolach, 1998) and mental health problems (e.g., anxiety, attention deficit hyperactivity disorder, depression; Alfano, Ginsburg, & Kingery, 2007; Cortese, Faraone, Konofal, & Lecendreux, 2009; Ivanenko, Crabtree, & Gozal, 2005), and comprehensive assessments of these conditions would often benefit from some assessment of sleep as an issue that could be exacerbating the primary condition. In these situations, objective sleep assessment may not be a viable option, and other methods for collecting relevant information about child sleep are needed.

One alternative to objective sleep measurement is the use of parent proxy report for basic information about a child's sleep, particularly nightly sleep duration. Although asking parents to report on their child's "average" or "typical" sleep has shown important limitations (Iwasaki et al., 2010; Werner et al., 2008), parent reports of specific bed times and wake times each day for a particular assessment window (often a couple days to a week) may be a more promising data collection method. Such assessments are inexpensive, minimally demanding on parent reporters, and provide information regarding child time in bed for each day. Given their low cost and minimal burden, parent reports of child sleep times represent a commonly used method of assessment in clinical settings (Iwasaki et al., 2010; Sadeh, 2008; Werner et al., 2008).

Despite well-documented issues with correspondence to objective measures, it may be possible to enhance parent report of child sleep through systematic adjustment. Rather than dismiss parent reports as too inaccurate to be useful, knowledge of the pattern of discrepancy between parent reports and objective measures could allow for a standard adjustment to convert parent report to an estimate of child sleep time more in line with objective methods. Sleep research with young children shows a high bivariate correlation between parent report and actigraphy for key sleep parameters (e.g., >.80 for sleep onset, wake time, and total sleep time; Tikotzky & Sadeh, 2001), suggesting that, although important discrepancies exist, these discrepancies tend to be systematic. Data-driven approaches for adjusting subjective report information are available and have been applied to other areas of pediatric health, most notably in the medication adherence literature (Modi et al., 2011; Wu et al., 2013). However, we are aware of no studies examining the application of such adjustment procedures to parent reports of child sleep. Given the importance of pediatric sleep, the convenience and ubiquity of parent reports in this area, and the documented discrepancies between these reports and objective methods, an adjustment factor for subjective reports of child sleep could have considerable clinical and research value.

As a precursor to developing any adjustment approaches, it is important to first understand the pattern of discrepancy between parent report of child sleep and objective measurement. However, research rigorously examining the moderators of this discrepancy has been limited. Numerous studies have documented discrepancies between parent report and objective measures of child sleep, with findings generally indicating a tendency for parents to overestimate child sleep in comparison with actigraphy. Specifically, parents tend to report earlier sleep onset times and later wake times compared with actigraph measurements, combining to result in average overestimates of total sleep time ranging from 30 to 45 min per night (Dayyat et al., 2011; Iwasaki et al., 2010; Short et al. 2013; Tikotzky & Sadeh, 2001; Werner et al., 2008). However, very few studies have examined moderators of parental correspondence with objective measurement regarding child sleep times, and the scant research in this area has notable limitations. Werner and colleagues (2008) examined child sex, age, and family socioeconomic status as possible moderators, but none of these factors were significantly associated with correspondence.

Although a potentially helpful first examination of the moderators of correspondence, the Werner study was limited by a relatively small sample size (N = 50) and simple regression analyses, limiting the power to find significant moderator effects. A more powerful approach would be to examine possible moderators within a larger sample using a multilevel modeling framework in which each day is considered an observation nested within an individual. Previous research has not examined the correspondence between parent report and actigraphy with such methods, and this approach would dramatically improve our ability to detect significant moderators of correspondence, which, in turn, would inform the interpretation of these reports. Most importantly, such a rigorous analysis of the patterns of discrepancy would inform the development of empirically derived and clinically relevant adjustment factors. If clinically meaningful differences in discrepancy exist across demographic categories (e.g., boys vs. girls, older vs. younger children) or sleep quality, then such factors would need to be incorporated into any adjustment formula. On the other hand, if patterns of discrepancy are relatively consistent across these categories, a simpler and more universal adjustment calculation could be developed. Age and sex were chosen as variables of interest because they have been highlighted in previous research (e.g., Werner et al., 2008), and because studies suggest important differences in sleep patterns across sex (Sadeh, Raviv, & Gruber, 2000) and development (Montgomery-Downs, O'Brien, Gulliver, & Gozal, 2006). Further, age and sex are readily available demographic variables in any clinical setting, so if they exert an important influence on discrepancy, they can be easily accounted for in clinician-friendly adjustment factors. We also added a measure of good versus poor sleep quality as a potential moderating variable because previous research has not examined this factor and poor sleep quality may exacerbate the discrepancy between parent report and actigraphy.

Given the centrality of parent reports of child sleep in typical clinical settings, and the absence of existing adjustment approaches for these reports, the current study focused on developing and testing adjustment approaches for converting parent-reported time in bed to an estimate of child sleep corresponding with actigraphy. To inform the development of the adjustment factors, we first examined potential moderators of discrepancy using a multilevel analytic framework. The main analyses then focused on testing the utility of three adjustments for parent report of child sleep. Specifically, we evaluated (a) a simple 30-min adjustment to parent reports (based on previous research reporting overestimates of child sleep relative to actigraphy); (b) a regression-based adjustment; and (c) a half-sample adjustment. We hypothesized that the various adjustments would all improve the correspondence of parent-reported child sleep, reducing the discrepancy between these reports and actigraphic measurement. If effective, these adjustment factors could substantially improve the utility of basic parent report data, both clinically and in research. Empirically derived adjustments could enable clinicians to quickly transform parent reports into estimates of child sleep time more in line with objective methods, which, in turn, could be considered in assessment and treatment planning. The adjustments could also be useful in research studies in which objective measurement of sleep is not feasible but reasonable estimates of child sleep are needed.

Method

Participants and Procedure

The sample included 217 children aged 4–9 years ($M = 6.60$, $SD = 1.18$) and 52.5% were female. The majority of children were White, non-Hispanic (84.8%), with the remaining identifying as African American (10.1%), Hispanic (1.4%), or other (3.6%). The ethnic breakdown of the sample reflected the broader demographics of the community from which it was drawn, with no significant differences in the percentage of White or ethnic minority individuals between the sample and Census data for the recruited zip codes ($p > .05$).

This study was approved by the University of Louisville Human Research Committee and is part of a larger investigation examining the effects of sleep restriction and extension on cognitive and neurophysiological processes in preschool and school-age children. Recruitment of school-age children was conducted in eight schools (six public, two parochial) located in Louisville, KY. Flyers describing the study and consent forms were sent home with 306 children, and 204 completed forms were returned (66.7%). Recruitment of preschool children was through targeted advertisements in local newspapers and resulted in an additional 17 children, bringing the total to 221. All 221 children with parental consent were then screened for eligibility. Exclusion criteria for the larger study included previous diagnosis of a chronic medical condition, obesity, or frequent snoring (all assessed by parent report on a brief questionnaire), significant behavioral/emotional problems [assessed by parent report on the Child Behavior Checklist (Achenbach & Rescorla, 2001) and a follow-up interview with a clinical psychologist for children rated in the clinically significant range for any broadband scales], and IQ below 70 (assessed by a standardized picture vocabulary test). Four children were excluded, all for clinically significant behavioral problems, resulting in a final sample of 217.

The actigraphy and sleep log data used for the current study were collected during the 7-day baseline period of the larger study, in which participants were instructed to maintain their normal sleep schedule and avoid psychoactive substances, medications, and naps. Actigraphy and parent-reported sleep logs were collected at the end of the baseline period. Adherence rates to actigraphy and sleep logs were good, with 86.2% (*N* = 187) and 84.0% (*N* = 178) of children having complete actigraphy and sleep log data, respectively. Among those with missing data, 53% (*N* = 16) had completely missing actigraphy data and 58% (*N* = 20) had completely missing sleep log data. Among those with partially missing data, the mean number of days missed was 1.25 (*SD* = 0.45) for actigraphy and 1.22 (*SD* = 0.43) for sleep logs. All participants with partially missing actigraphy or sleep log data had at least 4 days of data. Participating families who completed all study procedures (including overnight PSG, a multiweek sleep protocol, and several lab tasks) were given compensation of $125 at the end of the study.

Measures

Actigraphy

The Actiwatch (MiniMitter Actiwatch®-64 Co, Inc, 1998–2003, version 3.4) is a small watchlike device that records motor activity via an accelerometer that monitors both speed and degree of motion. The Actiware-Sleep software uses a weighted moving average algorithm (Oakley, 1997), such that activity counts are recorded for each 1-min epoch and are modified by how much activity occurred in the surrounding 4 min to yield a total activity count. The default threshold sensitivity value (TSV) was used and is defined as 40 activity counts within an epoch. Thus, the total activity count for each 1-min epoch is then compared with the TSV. If the total activity count for the measured epoch is greater than the TSV (i.e., 40), then the period is scored as a waking period. In contrast, if the total activity count for the measured epoch is less than the TSV (i.e., 40), the period is scored as sleep. Assumed sleep time represents the amount of time between sleep start and sleep end. Sleep start and sleep end were determined automatically as the first 10-min period in which no more than one epoch was scored as mobile, and likewise for the last 10-min period, respectively. Parents were instructed to have their children wear the device continuously throughout the day on the non-dominant wrist, except when at risk of getting the device wet. When the device was taken off, the parent was to indicate on the sleep log when the actigraph was removed and why (e.g., "went to the pool from 1:00 p.m. to 3:00 p.m."). Children were monitored for 7 days.

Sleep Log

Parents recorded the bed time and wake time of their children each day for 7 days. Total time in bed was calculated by summing the minutes between the recorded bed time and wake time. Given the evidence demonstrating the limitations of parental accuracy with regard to night awakenings (Iwasaki et al., 2010), as well as the extra demands made on parents in collecting such reports, parents were not asked to record night awakenings. Thus, parent-reported time in bed was compared with actigraphy-determined assumed sleep time.

Sleep Quality

Sleep quality was defined according to criteria set forth by Sadeh and colleagues (2000). Poor sleepers were identified by either (a) having a sleep percentage <90% based on polysomnographic (PSG) recording or (b) having three or more night awakenings during the PSG recording (with each night awakening lasting at least 5 min). Sleep quality was defined using PSG parameters rather than actigraphy parameters (e.g., sleep efficiency), given that PSG is generally regarded as the gold standard for capturing parameters related to sleep quality (Kushida et al., 2005). Fifty children (23.0%) of the children whose sleep pattern was measured met these criteria and thus were classified as poor sleepers.

Statistical Analyses

The analyses consisted of two parts. In the first part, multilevel modeling was used to examine the overall pattern of discrepancies between parent-reported child sleep and actigraphy, with particular attention to the association between selected child characteristics (i.e., age, gender, sleep quality) and the correspondence of parent reports with objective measurement. The second set of analyses then tested the utility of three adjustment approaches in improving correspondence between parent report and actigraphy.

Parameters of interest included parent-reported time in bed and actigraphy-determined assumed sleep. Discrepancy variables were created by subtracting actigraphy-determined assumed sleep from parent-reported time in bed for different sampling frames (1 day, 2 days, 3 days … 7 days). Multilevel models were then estimated to examine the overall pattern of, and individual differences in, discrepancies between parent report and actigraphy data. Change was specified as a function of the sampling frame length. Restricted maximum likelihood was used to report model parameters and to assess the significance of random effects. A major advantage of multilevel analysis is that all available data are incorporated into the analysis, including data from children who had some missing actigraphy and/or sleep log data. All analyses were conducted using SAS PROC MIXED software (version 9.3, SAS Institute, Cary, NC).

Three adjustment methods were applied to the parent report time in bed to determine their utility in making parent reports more correspondent with actigraphy-determined assumed sleep. First, a simple adjustment factor that consisted of subtracting 30 min from all parents' time in bed reports was conducted, given the consistent findings in existing literature indicating that parents overestimate their children's sleep time by about this amount (Dayyat et al., 2011; Werner et al., 2008). Second, adjustment factors commonly used in the pediatric health literature were used, including a regression-based approach and a half-sample adjustment factor (Wu et al., 2013). The regression-based approach consisted of regressing parent report time in bed (the independent variable) onto actigraphy-determined assumed sleep time (the dependent variable). The intercept and slope term from this analysis formed an equation to adjust parent-reported time in bed (i.e., slope term × parent-reported time in bed + intercept). The half-sample adjustment factor was obtained by randomly splitting the sample in half and then dividing the actigraphy-determined assumed sleep time values by parent report time in bed values for the participants in the first half of the sample. The average of the divided values was the adjustment factor, which was then applied to the second half of the sample by multiplying it with the parent-reported time in bed.

The adjustment analyses yield three different adjusted parent reports, which were then subtracted from the actigraphy-determined assumed sleep time to create three adjusted discrepancy variables. The absolute values of the three adjusted parent report discrepancy variables were then calculated so that over- and under-adjustments did not "wash" each other out (which would give the illusion of greater correspondence in group-level analyses). That is, absolute values of discrepancies preserve key information about the extent to which the adjustment "missed" perfect correspondence. Paired sample t-tests were conducted between the absolute values of the three adjusted discrepancy values to determine which adjustment method resulted in the greatest correspondence between parent report and actigraphy.

Results

Descriptive Results

Overall, parents reported an average of 607.19 (SD = 38.26) min (i.e., ≈10 hr and 7 min) per night for child time in bed. Assumed sleep as assessed by actigraphy indicated children sleeping an average of 583.05 (SD =58.30) min (i.e., ≈9 hr and 43 min) per night. On average, therefore, parent reports overestimated child nightly sleep time by 24.14 min (SD = 22.59) in comparison with actigraphy.

Multilevel Modeling Results: Unconditional Model

A piece-wise model of change was the most accurate and parsimonious model for these data, with change described by a significant and positive random linear slope from day 1 to day 3 (p < .0001) and a significant negative random quadratic slope from day 3 to day 7 (p < .0001) (Figure 1). Though pair-wise t-tests indicate that the 7-day sampling frame yielded the highest correspondence between parent report and actigraphy (Table I), the differences between the 4-, 5-, 6-, and 7-day sampling frames were minimal (<6 min). Given the negligible

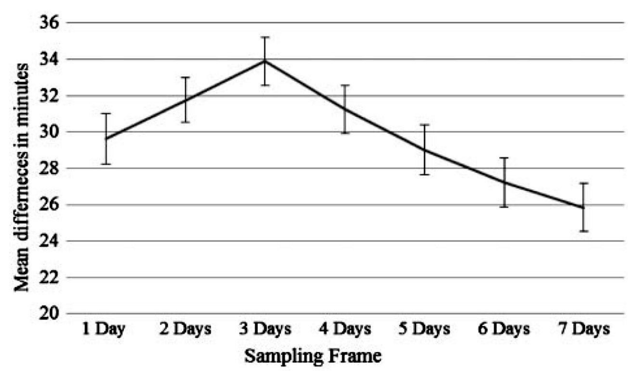

Figure 1. Final piecewise model for the discrepancy between parent report and actigraphy-determined assumed sleep time as assessed using a 7-day sampling frame.

Table I. Model-Predicted Comparison of Sampling Frame Performance

	Mean difference	df	t	p
Assumed sleep				
7 days vs. 1 day	−7.14	178	−2.59	.01
7 days vs. 2 days	−9.26	177	−3.58	.0004
7 days vs. 3 days	−11.39	177	−4.48	<.0001
7 days vs. 4 days	−5.40	177	−7.86	<.0001
7 days vs. 5 days	−3.18	167	−5.23	<.0001
7 days vs. 6 days	−1.38	162	−3.36	.001

differences, the 4-, 5-, 6-, and 7-day frames are considered to have similar performance from a practical clinical perspective.

Multilevel Modeling Results: Conditional Models

Conditional models were estimated to examine the effects of child age, gender, and sleep quality on the discrepancy between parent-reported time in bed and actigraphy-determined assumed sleep. Child age was the only statistically significant predictor of the discrepancy between parent-reported and actigraphy-determined assumed sleep ($b = -.17$, $p = .03$), but the effect size was small (pseudo-$R^2 = .03$). Neither gender nor child sleep quality was a significant predictor of discrepancy.

The differences between moderately (>30 min) or extremely (>60 min) discrepant parent reports and minimally discrepant parent reports (<30 min) were also examined. Results indicated that 35.7% of the sample (N = 58) had moderately discrepant parent reports and only 3.0% (N = 4) children had extremely discrepant parent reports. However, age, gender, and sleep quality did not differentiate those children with moderately and extremely discrepant reports from those with minimally discrepant parent reports (data not shown).

Adjustment Factors

A one-sample t-test comparing the *absolute value* of the difference between unadjusted parent report of time in bed and actigraphy-assumed sleep time to a test value of 0 indicated that the mean difference (in either direction) between the two methods was 24.14 min, $t(167) = 19.12$, $p < .001$ (Table II). This analysis indicates that parent reports are significantly discrepant from actigraphy, warranting an examination of the utility of adjustment factors.

As described above, the 30-min adjustment factor consisted of simply subtracting 30 min from parent reports of time in bed: Adjusted assumed sleep = (parent report time in bed) − 30. The regression adjustment method resulted in a regression equation (consisting of an intercept and slope) for adjusting parent-reported time in bed: Adjusted parent report = 42.63 + [0.89 × (parent report time in bed)]. The final adjustment method (half sample) involved calculating an adjustment factor based on the first half of the sample, resulting in a factor of .96 [i.e., adjusted parent report = .96 × (parent-reported time in bed)]. See Table II for descriptions of the discrepancies between parent report and actigraphy for each of the adjustment methods.

A series of paired-samples t-tests were conducted using absolute values of discrepancies to compare the performance of the various adjustment methods to each other. Results indicated that both the regression and half-sample adjustments performed slightly better than the 30-min adjustment [$t(167) = -3.291$, $p = .001$ ($M = -1.618$, $SD = 6.37$) for regression; $t(84) = -2.15$, $p = .034$ ($M = -1.35$, $SD = 5.76$) for half-sample values]; however, the average differences were <2 min in both cases. The regression and half-sample values did not significantly differ from each other [$t(84) = 1.17$, $p = .246$ ($M = .340$, $SD = 2.67$)].

Discussion

This study reports on the development and evaluation of adjustment approaches for parent report of child sleep duration. As a precursor to the adjustment analyses, we examined potential moderators of the discrepancy between parent report and actigraphy, finding that selected demographic and clinical factors had minimal impact on discrepancy. Although child age was a *statistically* significant predictor of parental discrepancy (likely due to the large number of observations), the effect size for this variable was extremely small (pseudo-$R^2 = .03$), suggesting its effect was *clinically* negligible. Our findings showing that age and sex do not substantively affect the correspondence between parent-reported time in bed and actigraphic estimates of sleep period replicate Werner et al.'s (2008) findings, but in a much larger and better-powered sample. Given the lack of meaningful moderators to consider, we were able to proceed in developing and testing simple adjustment

Table II. Comparison and Utility of Adjustment Methods

Adjustment Method	Mean discrepancy of parent report vs. actigraphy (min)	% of moderate discrepancy (>30 min)	% of extreme discrepancy (>60 min)	% of parental overestimates	% of parental underestimates
Unadjusted	24.14	35.7	3.0	94.6	5.4
30 min	15.00	8.3[a]	0.0	35.7	64.3
Regression	13.38	5.4[b]	0.0	48.2	51.8
Half sample	14.14	5.9[c]	0.0	45.9	54.1

factors that could be applied to all parent reports, regardless of child age, sex, or sleep quality. The results indicate that all three options for "adjusting" parent reports resulted in improved correspondence with objectively measured child sleep, making them potentially viable tools in clinical and research settings. These findings are consistent with previous pediatric health literature demonstrating the utility of empirically derived adjustment factors for parent reports of key pediatric health behaviors (e.g., medication adherence; Modi et al., 2011; Wu et al., 2013) and suggest that the correspondence of parent report of child sleep with objective measurement can be significantly enhanced through systematic adjustment.

A comparison between the three adjustment factors indicated that the regression and half-sample approaches performed slightly better than the simple 30-min factor in adjusting parent reports. However, it is worth noting that the differences between the approaches were small, with <2 min separating the performance of the different approaches. Practically, these differences are not meaningful and the performance of the three factors can be viewed as similar. All of the approaches converted parent-reported time in bed to estimates of child sleep and, therefore, could be valuable in clinical and research contexts. Although all of the approaches are simple to calculate, the 30-min approach is the simplest and, consequently, perhaps the best candidate for a "rule of thumb" adjustment to apply in clinical settings.

In addition to results indicating that the adjustment factors improved correspondence with objective measurement *on average*, our analysis of moderate and extreme discrepancy also demonstrates the utility of the adjustment factors. Each adjustment yielded a dramatic reduction in moderate (>30 min) discrepancies and eliminated extreme (>60 min) discrepancies in parent reports. Given that parent reports may overestimate child sleep, potentially masking an important sleep issue, proper adjustment can convert these reports into estimates of child sleep that are more useful to clinicians in identifying sleep problems in need of intervention.

In addition to the novel findings discussed above, it is worth noting two other findings that replicate previous research. First, our results are consistent with literature suggesting that parent reports systematically overestimate child sleep relative to actigraphy (Dayyat et al., 2011; Werner et al., 2008). Interestingly, this finding also reflects a more general tendency for parent report of child health variables to diverge from objective measurements. For example, both parent reports of child weight (Lundahl, Kidwell, & Nelson, 2014) and child medication adherence (Wu et al., 2013) also show patterns of significant divergence from objective measurement, suggesting that perhaps parent report of sleep is not fundamentally different in this regard. Second, we found that a sampling frame of at least 4 days yielded better correspondence, which is consistent with previous research (Acebo et al., 1999) recommending at least a 4- or 5-day period when assessing child sleep.

Limitations and Future Directions

Although the current study makes new clinically relevant contributions to the child sleep measurement literature, some limitations should be noted. First, this study only examined issues of sleep duration. Parent reports of child sleep times have little to say about the *quality* of child sleep (Sadeh, 2008), and other more objective measures (such as overnight PSG) are much better suited to address issues of sleep quality. Despite this notable limitation, considerable research suggests that sleep duration has an important effect on cognitive, behavioral, and physical functioning (Smaldone et al., 2007; Vriend et al., 2013), making it a highly relevant area for assessment. Second, this study used an extremely simple parent report of child sleep—including only bed time and wake time for each night—which limited our evaluation to time in bed. More detailed parent-reported logs, including estimates of time awake in bed (e.g., nocturnal awakenings, sleep latency) are sometimes used in clinical settings; however, alternative adjustment procedures would be needed specifically for converting such reports to more closely correspond with objective measurement. From a practical clinical perspective, the simple report format used in this study may be a particularly appealing option for collecting data with minimal burden on parents, and then these reports can be quickly converted into useful estimates of child sleep.

Third, the current sample had limited ethnic diversity. Future studies should replicate our findings in more diverse samples so that the results can be generalized cross-culturally with confidence. Fourth, this study did not examine weekdays versus weekend, which previous studies have found moderates the correspondence of parent report for child sleep (Iwasaki et al., 2010; Tremaine, Dorrian, & Blunden, 2010). Finally, the current study used a healthy sample of children in a limited age range. The results should be replicated both in older children and in clinical samples, in which different adjustment factors may be generated. In addition to replicating the results of this study in different populations, future research should examine the utility of the adjustment factors in clinical practice. Specifically, research is needed to determine whether adjusted parent reports of child sleep provide sensitive and specific information that can be useful in identifying problematic sleep patterns in need of intervention.

Clinical and Research Implications

Despite the limitations noted above, the current study has important clinical and research implications. Clinically, the adjustment factors allow clinicians to quickly transform parent reports of time in bed into estimates of child sleep that are more like what one would obtain from actigraphy. The resulting estimates then may be more sensitive to identifying children with suboptimal sleep in need of intervention. Research shows that even a difference of ~30 min of sleep can have a significant effect on child neurobehavioral functioning (Gruber et al., 2011; Sadeh, Gruber, & Raviv, 2003), so an adjustment of 30 min could be clinically meaningful.

In terms of research, the adjustment factors may increase power for detecting significant relationships between child sleep duration and other variables of interest, when parent reports are used. Notably, researchers who are unable to use objective sleep measures in their research for various reasons (e.g., cost, study design) may benefit from collecting and adjusting parent report data of child sleep. With the increasing recognition that sleep impacts a variety of health and psychosocial outcomes, the adjustment approaches may help increase the feasibility of incorporating low-cost and low-burden estimates of child sleep duration into pediatric research. Researchers may prefer the more empirically derived regression and half-sample adjustments because of their slightly better performance, although any of the factors evaluated in this study have the potential to be useful. Also, the current study's findings regarding improved parental correspondence with longer assessment periods could have important implications for measuring sleep in research. As suggested by Stremler and colleagues (2013), longer sampling windows for parent tracking of sleep may improve both the quality of reports and potentially change the target behavior over time through the effects of close monitoring.

Conclusions

Parent reports of child sleep have major advantages in terms of cost and convenience. Using the adjustment approaches developed in this study, simple parent reports can be converted to estimates of child sleep roughly in line with actigraphy. As recommended by Sadeh (2008), multimethod assessment of child sleep—including both subjective and objective measures—is ideal. However, when objective measures are not feasible, our results suggest that simple empirically derived adjustment factors can be applied to make parent reports a more valuable source of information.

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