

ORIGINAL ARTICLE

Childhood Sleepwalking and Its Relationship to Daytime and Sleep Related Behaviors

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ABSTRACT

Objective: Sleepwalking is common in children, however, the relationship between sleepwalking, bedtime routine and daytime problems is poorly understood. We assessed the prevalence of parent reported sleepwalking in school children, and its relationship with broader sleep and daytime difficulties.

Methods: Parents of 1814 children aged 5 to 10 years reported on child sleepwalking, other sleep behavior, emotional and daytime behavioral functioning.

Results: Parents reported that 10.5% of children had sleepwalked in the previous week. There were no sex differences in sleepwalking prevalence, however middle children were reported to sleepwalk more than other children. Sleepwalking was associated with more problems of bedtime routine, bedtime anxiety, and daytime tiredness, as well as more sleep terrors, sleep talking, disordered sleep breathing symptoms, restless sleep and bruxism; however, these correlations were very small. Sleepwalkers also had significantly more emotional problems, conduct problems, and hyperactivity. Post hoc analyses showed that after controlling for sleep disordered breathing and sleep terrors, sleepwalking no longer contributed to the prediction of emotional, conduct, or hyperactivity problems, or morning tiredness. Results for the relationship between sleep instability and sleepwalking were mixed.

Conclusions: Frequent sleepwalking is common in children and is associated with a range of sleep and behavior problems. However, behavioral and emotional problems associated with sleepwalking are accounted for by comorbid sleep disorders. Risk for other sleep related problems and impact on daytime functioning in children who sleepwalk warrant assessment and treatment. Similarly, children presenting with behavioral concerns should be assessed for sleep problems.

Keywords: Sleepwalking, somnambulism, prevalence, behavior, sleep disorders, parasomnia

INTRODUCTION

Episodes of sleepwalking are relatively common in children and, while often harmless, have the potential to

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result in injury to the child and, on rarer occasions, to others. A systematic review of the prevalence of sleepwalking from 17 countries estimated that the rate of sleepwalking in children in the previous 12 months was 5.0% (95% CI 3.8–6.5), while the lifetime prevalence of sleepwalking was 6.9% (95% CI 4.6%–10.3%) (Stallman & Kohler, 2016). Sleepwalking in children has been associated with a range of sleep disorders including confusional arousals, rhythmic movement disorders, sleep disordered breathing, and sleep talking (Guilleminault et al., 2005; Neveus, Cnattingius, Olsson,

& Hetta, 2001). Abnormalities in sleep architecture have also been found in children who sleepwalk, including shortened sleep and less stable NREM sleep cycles (Guilleminault et al., 2005). Children who sleepwalk have also been found to be at a greater risk for behavioral and emotional problems. Smedje, Broman and Hetta (2001) report in elementary school aged children that sleepwalking was associated with hyperactivity, greater emotional symptoms and greater overall behavioral difficulties. Lehmkuhl, Wiater, Mitschke and Frike-Oerkermann (2008) report in 2–14 year old children that sleepwalking was associated with conduct and peer problems. Shang, Gau and Soong (2006) in their survey of 4–9 year olds report increased aggressive behaviour and somatic complaints and a higher frequency of problems with attention, delinquency, socialisation and thoughts. Sleepwalking in younger children has also been linked by several groups to separation anxiety (Petit, Touchette, Tremblay, Boivin, & Montplaisir, 2007; Steinsbekk & Wichstrom, 2015). To date, however, it is unclear whether the impact of sleepwalking on daytime functioning is a direct effect or secondary to other factors associated with disrupted sleep, such as shortened sleep and daytime sleepiness.

In adults, there is strong evidence of an association between sleepwalking and daytime sleepiness (Lopez, Jausent, & Dauvillier, 2014; Lopez et al., 2013; Montplaisir, Petit, Pilon, Mongrain, & Zadra, 2011; Oudiette et al., 2009), as well as other indicators of sleepiness such as fatigue (Lopez, Jausent, & Dauvillier, 2014; Lopez et al., 2013). The association between sleepwalking and daytime sleepiness has not been as well-explored in children. Neveus et al. (2001) report in children aged 6–11 years that sleepwalking was not a significant risk for daytime sleepiness, but was clearly associated with other parasomnias which were predictive of daytime sleepiness. As such, the impact of sleepwalking on daytime functioning may be indirectly mediated by its impact on other sleep disorders.

Factors that might precipitate sleepwalking in children are not well understood but sleep loss is thought to increase the risk (e.g. Perrault, Carrier, Desautels, Montplaisir, & Zadra, 2013). As a consequence, a

frequently recommended intervention for sleepwalking is to ensure that children both maintain a stable sleep routine and obtain maximal sleep (National Sleep Foundation, 2015; NHS, 2015; The Royal Children's Hospital Melbourne, 2015). In addition to minimizing sleepwalking, these recommendations would also be expected to remediate any daytime deficits associated with sleep loss. Biggs et al. (2011) found that children with unstable sleep routines (i.e. a greater difference in the timing of sleep on week versus weekend nights) had more problematic daytime behaviors and, moreover, that this association was stronger than that between sleep length and daytime functioning. These findings suggest that sleep routine stability may be more important than sleep length for optimal daytime functioning in children who sleepwalk, but this has yet to be examined.

Given the relatively high prevalence of sleepwalking in children, and the potential link to both sleep-related and daytime problems, understanding the risks and behaviors closely associated with sleepwalking in this age is important. Therefore the aims of this study were to assess the prevalence of parent reported sleepwalking in elementary school children and to explore the relationship between sleepwalking and daytime functioning and the possible influence of daytime sleepiness, sleep length and the presence of other sleep disorders on this relationship and conversely if the latter factors predict sleepwalking.

METHOD

Participants

Participants were parents of multi-stage stratified random sample of 1814 Australian elementary school children aged 5 to 10 years ($M = 7.7$, $SD = 1.7$ years; 48% female). There was no significant difference in the proportion of males and females at each year level $F(1, 1812) = .85$, $p = .36$. A large proportion of children reported on were the eldest child in the family (40.1%), followed by youngest (32%), middle (14.9%), or only child (12.9%). The majority of families were Caucasian (85%) with smaller percentages identifying as Asian (8.9%), African (1.4%), Indigenous (1%) and other or

unspecified (3.7%). Participants were included from all socioeconomic (SES) groups with 37.7% from low SES areas, 21.7% from mid SES areas, and 40.7% from high SES areas.

Measures

Sleep behavior and problems. The Pediatric Sleep Problem Survey Instrument (Biggs, Kennedy, Martin, van den Heuvel, & Lushington, 2012), a 26-item parent report omnibus pediatric sleep questionnaire, was used to assess sleep problems. Parents were asked to rate their child's sleep behavior on a 4-point scale: never (did not occur), rarely (occurred 1 time during the week), sometimes (occurred 2–4 times in the week), or usually (occurred 5 or more times in the week). The scale has six subscales: sleep routine, bedtime anxiety, morning tiredness, night arousals, sleep disordered breathing, and restless sleep. It also has individual items for sleep problems including: enuresis, sleepwalking, hyperhidrosis, and bruxism. Parents were asked to rate the frequency during the most recent typical school week and whether they considered each item a problem. The subscales had adequate internal consistency in this sample ($\alpha = .78, .80, .80, .66, .73, \text{ and } .63$ respectively). For analyses of those with and without sleep problems, the frequency ratings were collapsed to those who had the problem at least once during the week and those that did not.

Emotional and behavioral functioning. The 25-item Strengths and Difficulties Questionnaire (SDQ; Goodman, 1999) parent report measure assesses both a child's strengths and difficulties in functioning on a 3-point scale: not true, somewhat true, and certainly true. It has five subscales: emotional problems, conduct problems, hyperactivity, peer problems and prosocial behavior. These subscales have adequate internal validity in this sample ($\alpha = .69, .67, .79, .60 \text{ and } .74$ respectively).

Bedtime instability and length. Bedtime instability was assessed by calculating the difference in parent reported: a) bedtime on weekends and usual bedtime on school nights and b) usual sleep duration on weekends and school nights (Koch & Stiller, 2015).

Design

This study used a cross-sectional observational design.

Procedure

Ethics approval was provided by the Human Research Ethics Committees of the Women's and Children's Hospital, Adelaide, and the University of Adelaide. This study is part of a larger pediatric sleep study that is reported elsewhere (Biggs et al., 2012). It used a multi-stage stratified, random sampling design to randomly select schools from within three socio-economic levels (SES) based on the Australian Bureau of Statistics Socio-economic Indexes for Areas (SEIFA). This index, based on postcode, provides a summary score related to key variables including household income, education, occupation, and ethnicity. Twenty-three out of the 63 government (37%) and nine out of 20 non-government (45%) schools that were approached agreed to participate in the study. Questionnaires were distributed to 7186 students in grades 1 to 5 in these schools in the Adelaide metropolitan area. The questionnaire was distributed through schools to children to take home to their parents to complete as part of a pediatric sleep and health survey. A second distribution and newsletter reminders were sent four weeks after the initial distribution. Thirty-one of the original 1845 returned surveys did not complete the sleepwalking question and were excluded from the analyses. The response rate for the total sample was 25.2%, however the final sample is considered representative of the population sample and is described elsewhere (Biggs et al., 2012).

Statistical Analyses

Descriptive statistics were used to describe the prevalence of sleepwalking and whether parents perceived it to be a problem. A linear regression was used to determine the variance in frequency explained by sleepwalking being perceived a problem by parents. A chi-square analysis was used to explore the relationship between age and sleepwalking. A series of MANOVAs were used to evaluate whether sleepwalkers had greater bedtime problems, morning tiredness, comorbid sleep

problems, and daytime behavioral and emotional problems than children who did not sleepwalk. A sequential linear regression was used to examine the effect of sleepwalking on daytime behaviour after controlling for sleep disordered breathing and sleep terrors. Independent *t*-tests were used to identify whether sleepwalkers had greater sleep instability than non-sleepwalkers. A logistic regression was used to explore whether sleepwalking predicted other sleep problems.

RESULTS

One week period prevalence of sleepwalking

A total of 10.5% of parents reported that their child had sleepwalked at least once in the previous week [95% CI 9.09, 11.91; $N = 191$]. There were no sex differences in sleepwalking prevalence, however middle children were reported to sleepwalk more than their siblings $\chi^2(3, N = 1793) = 17.75, p < .001$. Figure 1 displays the percentage of children in each age group who were reported to have sleepwalked once in the previous week, 2–4 times during the week or 5+ times during the week. A chi-square test showed a significant relationship between age and sleepwalking, $\chi^2(5, N = 1814) = 18.38, p = .003$, with a greater proportion of nine-year-old

children in this sample sleepwalking compared to other ages.

Of the children who sleepwalked in the previous week, the majority had one episode (76.4%), 20.9% had two to four episodes, and 2.6% had more than five episodes. Of parents who reported their child sleepwalking in the previous week, 54.4% did not perceive sleepwalking to be a problem, 30.2% found it to be somewhat of a problem, and 10.7% reported it was a problem; 30 did not comment. While frequency of sleepwalking was significantly correlated with the extent parents perceived it to be a problem, perceived problem only accounted for a small amount of the variance ($R^2 = .07$).

Relationship between sleepwalking and other sleep problems

The percentage of sleepwalkers and non-sleepwalkers whose parents also reported other sleep related problems is shown in Table 1. A MANOVA was used to determine whether sleepwalkers were more likely to experience other sleep related problems than non-sleepwalkers. Compared with children who did not sleepwalk, sleepwalkers had significantly more sleep related problems, $F(10, 1626) = 14.26, p < .001$, Wilks' $\Lambda = .92$, partial $\eta^2 = .08$. Descriptive statistics and univariate

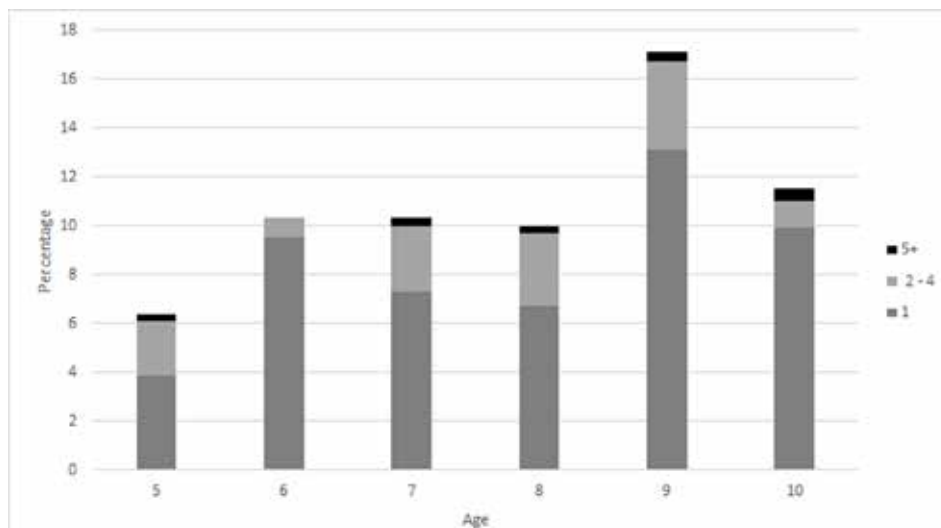


Figure 1: Histogram of the percentage of children who sleepwalked in the previous week in each age group. Columns have been stacked according to the frequency of sleepwalking (once, 2-4 times in the week or 5 or more times)

results using Bonferroni correction are shown in Table 2. These indicated that, compared with non-sleepwalkers, sleepwalkers were significantly more likely to also

experience problems with sleep routine, bedtime anxiety, restless sleep, morning tiredness, seeming tired all the time, sleep terrors, and bruxism. There was no significant difference between sleepwalkers and non-sleepwalkers for enuresis. The effect sizes for sleep talking, sleep terrors and restless sleep were large, while the remaining ones were small to moderate.

Table 1. Percentage of sleepwalking and non-sleepwalking children with sleep problems

	Non-sleepwalkers n = 1590	Sleepwalkers n = 187
	(%)	
Sleep subscales (%)		
Restless sleep	79.7	94.5
Morning tiredness	75.8	83.3
Bedtime Routine Problems	74.5	80.1
Disordered breathing	49.9	61.7
Bedtime anxiety	41.3	56.0
Individual items		
Sleep talking	52.7	79.4
Bruxism	23.6	36.2
Sleep terrors	7.8	26.6
Tired all the time	14.6	23.1
Enuresis	15.9	17.6

Note. Sleep problems are defined as occurring at least once during the previous week

The Phi coefficients with Bonferroni correction revealed that sleepwalking was significantly correlated with sleep talking, sleep terrors, restless sleep, bruxism, and bedtime anxiety (Table 3). The size of these associations however were small and accounted for less than 4% of the variance. A binomial logistic regression was used explore whether bedtime and other sleep problems predicted sleepwalking. After controlling for age and sex, the explained variation in sleepwalking based on this model was 1.6% (Nagelkerke $R^2 = .16$).

Table 2. The means, standard deviations for sleep problems, univariate F result and effect size

	Non-Sleepwalkers	Sleepwalkers	F df = 1729	d
	M (SD) n = 1553	M (SD) n = 178		
Bedtime anxiety	1.52 (2.62)	2.01 (2.80)	5.19*	.19
Bedtime routine problems	2.54 (2.94)	3.52 (3.55)	15.91***	.33
Morning tiredness	2.68 (2.59)	3.27 (2.70)	7.47**	.23
Sleep talking	.70 (.79)	1.38 (.95)	104.96***	.84
Sleep terrors	.09 (.33)	.32 (.63)	57.63***	.62
Sleep disordered breathing	1.41 (2.06)	2.15 (2.71)	17.88***	.35
Restless sleep	2.80 (2.39)	4.76 (2.86)	96.44***	.80
Enuresis	.28 (.74)	.29 (.76)	.01	.01
Bruxism	.41 (.82)	.62 (.97)	10.23**	.25
Tired all the time	.51 (.71)	.67 (.77)	7.31**	.22

*p < .01, **p < .01, *** p < .001

Note. d = .2 is small, d = .5 is medium effect, d = .8 is large effect

Table 3. Phi Coefficient Correlations between sleepwalking and other bedtime and sleep problems

Sleep problem	1	2	3	4	5	6	7	8	9
1. Sleepwalking	1								
2. Sleep talking	.16***	1							
3. Sleep terrors	.19***	.16***	1						
4. Disordered breathing	.07	.22***	.14***	1					
5. Restless sleep	.11***	.55***	.15***	.21***	1				
6. Enuresis	.01	.04	.07	.05	.05	1			
7. Bruxism	.09***	.19***	.11***	.15***	.14***	.06	1		
8. Bedtime anxiety	.09***	.16***	.19***	.12***	.16***	.10***	.16***	1	
9. Bedtime routine problems	.04	.11***	.11***	.09***	.16***	.05	.05	.20***	1

***p < .0007

Table 4. The means, standard deviations on the SDQ subscales, univariate F results and effect sizes

SDQ subscale	Non-Sleepwalkers	Sleepwalkers	F	d
	M (SD)	M (SD)	df = 1729	
Emotional problems	1.96 (2.01)	2.58 (2.19)	14.98***	.31
Conduct problems	1.72 (1.66)	2.11 (2.11)	8.20**	.23
Hyperactivity problems	3.69 (2.51)	4.13 (2.86)	4.81*	.17
Peer problems	1.57 (1.68)	1.74 (1.73)	1.62	-
Prosocial behaviour	7.95 (1.93)	7.97 (1.90)	.03	-

* $p < .01$, ** $p < .01$, *** $p < .001$

Note. $d = .2$ is small, $d = .5$ is medium effect

Behavioral and emotional functioning

A MANOVA was used to identify whether sleepwalking contributed to daytime behavioral and emotional problems. Compared with children who did not sleepwalk, sleepwalkers had significantly more behavioral and emotional problems, $F(5, 1708) = 4.14$, $p = .001$, Wilks' $\Lambda = .99$, partial $\eta^2 = .01$. The descriptive statistics, univariate analyses using Bonferroni correction and effects sizes are shown in Table 4. Sleepwalking children had more emotional problems, conduct problems, and hyperactivity but were not significantly different from non-sleepwalkers on peer problems and prosocial behavior. A post-hoc sequential linear regression showed that after controlling for sleep disordered breathing and sleep terrors, sleepwalking did not significantly contribute to the prediction of emotional, conduct, or hyperactivity problems, or morning tiredness ($\Delta R^2 < .01$).

Sleepwalking and bedtime stability

On average, children slept 10.55 hours ($SD = .66$) on school nights and 10.28 hours ($SD = .81$) on weekends. There was no significant difference between sleepwalkers and non-sleepwalkers for total sleep time, $t(1058) = 1.20$, $p = .23$. Differences between weekend usual bedtime and school day usual bedtime ranged from 1 to 3.92 hours. Sleepwalkers had significantly greater discrepancy in bedtimes ($M = .87$, $SD = .62$) than non-sleepwalkers ($M = .77$, $SD = .61$), $t(1747) = 2.08$, $p = .04$. However the effect size was very small, $d = .16$.

Differences in sleep duration between weekends and school days ranged from 0 to .3.5 hours, ($M = -.27$,

$SD = .71$). An independent t -test showed no significant difference between sleepwalkers and non-sleepwalkers on differences in sleep duration on weekends compared with school days, $t(995) = -.07$, $p = .95$.

DISCUSSION

This study explored the one week period prevalence rate of sleepwalking in Australian elementary children and investigated the relationship between sleepwalking and other behaviors. In contrast to most studies of childhood sleepwalking that assess sleepwalking behavior over long periods, for example, 3, 6, or 12 months, this study aimed to minimize error related to recall bias by using parent reports of sleepwalking in children in the most recent typical week, replicating Liu and Liu's (2003) study of Chinese elementary school children. The one week period prevalence rate of 10.5% in the current study of Australian children is slightly higher than Liu and Lui's 6% but similar to other studies that have measured current sleepwalking in children (e.g. Smedje et al., 2001; Wiechers et al., 2011).

Consistent with previous research (Gerd Lehmkuhl, Wiater, Mitschke, & Fricke-Oerkermann, 2008; Smedje et al., 2001), this study found a relationship between sleepwalking and emotional problems, conduct problems, and hyperactivity. Similar to previous studies with adults, but for the first time in children, this study found sleepwalking to also be associated with morning tiredness. However, these behavioral and emotional problems were accounted for by comorbid sleep breathing disorders and sleep terrors, rather than

sleepwalking per se. Notably, these were not controlled for in previous studies of relationships between sleepwalking and behavior. Sleepwalking therefore appears more as a behavior within the context of sleep rather than a disruption to sleep and does not then appear to impact on sleep quality directly. The findings further suggest that waking sleepwalkers as an attempt to minimize the behavior may actually cause daytime problems because of the greater disruption to NREM sleep. This warrants further research.

The comorbidity of sleep problems found in this study is consistent with previous research that has shown a relationship between sleepwalking and sleep disordered breathing (Guilleminault et al., 2005), sleep-talking (Neveus et al., 2001; Petit et al., 2007), sleep terrors (Petit et al., 2015; Petit et al., 2007), rhythmic movement disorder and confused arousals (Neveus et al., 2001). The question remains as to whether these behaviors represent discrete disorders or whether certain patterns of sleep behavior are a symptom of one (or more) underlying sleep disorders or neurophysiological processes. Our results show that while there is a statistically significant relationship between these problems, they have very little shared variance. Collectively, results of this and previous work lend some support support for the hypothesis that sleepwalking is a result of precipitant events and/or predisposition including alterations in arousal threshold and response (Zadra, Desautels, Petit, & Montplaisir, 2013). Further research using more objective assessments of sleep and neurophysiology is required to understand these mechanisms, particularly in children where the prevalence appears highest.

The prevalence of sleepwalking is regularly reported as higher in children compared with adults (Zadra & Pilon, 2011). This has led to an assumption that sleepwalking is in part a developmental phenomenon, and in many cases largely benign and unlikely to progress through to adulthood. However, results from this study and others suggest sleepwalking in children is associated in some way with significant sleep and daytime morbidity (Gerd Lehmkühl et al., 2008; Neveus et al., 2001; Smedje et al., 2001). More recently sleepwalking and other

parasomnias have been regarded as a disorder of sleep maturation, with a high proportion of children with parasomnias exhibiting a range of developmental comorbidities (Nevsimalova, Prihodova, Kemlink, & Skibova, 2013). Differences across ages within childhood have not been closely examined. Our data suggest the prevalence of sleepwalking is relatively stable across ages 5 to 10 years, with the exception of a spike observed at age 9 years. Developmentally there is no clear explanation for this finding, however a recent longitudinal study of sleep walking in children provides consistent evidence and described the overall prevalence to increase steadily from preschool through to a peak by age 10 years (no report was made at age 9), with a slight decrease by age 12–13 years (Petit et al., 2015). Further analyses of our data show the larger reported prevalence was predominantly due to the increased number of nine year old children reported to had sleepwalked only once in the last week. Despite the relatively large sample and even distribution of children across the represented ages, slight differences in the reporting of less frequent episodes could have led to the result. Further research is required to determine if this is a reliable feature of sleepwalking incidence during childhood, what factors may otherwise lead parents to report more less-frequent episodes at this age, and investigate other developmental factors such as the sleep maturation, pubertal onset, or measurement error whereby parents are less aware of nocturnal behavior in adolescents may also help to explain the pattern observed.

Finally, we found mixed results for the relationship between sleepwalking and sleep routine. There was a significant relationship between stability of bedtime routines between weekday and weekend periods, however this effect was very small. There was no significant difference between sleepwalkers and non-sleepwalkers on differences in sleep duration on weekends compared with school days. These results point to the need for more fine-tuned assessment of the night-to-night stability of sleep routine, which may help to clarify the relationship with sleepwalking, and better determine a basis for such an intervention approach.

The intriguing finding that middle children are more likely to sleepwalk than their siblings is not easily understood and warrants further investigation.

Limitations

The main limitation of this study is the response rate. However, the multi-stage stratified, random sampling design resulted in reasonable response rates from each SES category and across age ranges. The second limitation is that sleepwalking is difficult to assess in children because: 1) sleepwalking behaviors can include simple behaviors such as briefly getting out of bed but not leaving the bedroom, that typically go unobserved, 2) sleepwalking, a NREM parasomnia may be confused by parents with other nocturnal wandering behaviors such as confusional arousals or REM sleep behavior disorder, and 3) there has been no research to validate measures of sleepwalking apart from PSG. Despite these limitations, parent-report of recent period prevalence has some strengths for measuring young children as sleepwalking typically occurs in the first third of the night. As young children typically go to sleep before their parents, parents are more likely to observe nocturnal wandering at this time, which is more likely to

be sleepwalking. Parents are generally more attuned to noises in the bedroom of younger children and likely to investigate, increasing the likelihood of sleepwalking being observed. One week period prevalence minimizes recall bias associated with longer recall periods (Boschloo et al., 2013).

Conclusion and implications

Sleepwalking affects around one in 10 children at least weekly and is associated with poor sleep routines and bedtime anxiety. There is a high association between sleepwalking and sleep talking, night terrors and restless sleep. Behavioral and emotional problems commonly associated with sleepwalking are accounted for by these comorbid sleep disorders rather than sleepwalking per se. Risk for other sleep related problems and impact on daytime functioning in children who sleepwalk warrant assessment and treatment. Similarly, children presenting with behavioral concerns should be assessed for sleep problems. Sleepwalking appears to be fairly common and innocuous in school aged children, although further research is needed to understand the problems parents' perceive it causes, and it's interrelationship with other sleep and daytime behaviors.

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