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Sleep problems and language development in toddlers with Williams syndrome

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ABSTRACT

Sleep and related maternal beliefs were assessed in a narrow age range of 18 children with Williams syndrome (WS) and 18 typically developing (TD) children. WS is a rare genetic disorder characterised by a complex physical, cognitive and behavioural phenotype. High prevalence of sleep difficulties in older children and adults with WS have been reported. Parents completed 6 questionnaires: the Brief Infant Sleep Questionnaire, Infant Sleep Vignettes Interpretation Scale, Pittsburgh Sleep Quality Index of Parents, Child Behaviour Checklist, MacArthur Communicative Development Inventory for Infants – Words and Gestures, and the Major (ICD-10) Depression Inventory. Compared to TD children, those with WS had shorter night sleep, more night wakings and wakefulness according to parental report. Regression analyses revealed that a proportion of the variance in language development scores in WS children could be explained by night sleep duration. Compared to control parents, the mothers of the WS group were more likely to describe their child's sleep as problematic and had higher rates of involvement with child sleep, yet they had a lesser tendency to interpret sleep problems as signs of distress and a greater tendency to emphasise limit setting. Approximately half of both groups of mothers experienced poor sleep quality. This was also related to maternal mood, and night wakefulness in the children with WS. This is the first study to quantify sleep difficulties in young children with WS in a narrow age range using maternal report. The possible negative effects on maternal sleep and mood, and the link between night sleep and language development in young children with WS, requires further detailed investigation.

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1. Introduction

Sufficient sleep is defined as an amount that is conducive to effective social and neuropsychological functioning and is important to healthy development in children (Dahl, 1999; Hill, Hogan, & Karmiloff-Smith, 2007). There is an extensive body of evidence demonstrating that insufficient sleep interferes with higher cognitive functioning (e.g., Randazzo, Muehlbach, Schweitzer, & Walsh, 1998; Walker & Stickgold, 2006), and contributes to child behavioural problems (e.g., Sadeh, Gruber, & Raviv, 2002). There have been fewer studies examining the effects of sleep quality in typically developing (TD) infants and

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toddlers but mounting evidence suggests that insufficient sleep, and frequent night wakings in the early years are associated with a variety of short- and long-term negative outcomes such as lower performance in language and spatial tasks, higher levels of impulsivity and hyperactivity (Dearing, McCartney, Marshall, & Warner, 2001; Touchette et al., 2007), larger weight for length (Tikotzky et al., 2010), lower scores on measures of mental and motor development (Dearing et al., 2001; Freudigman & Thoman, 1993; Scher, 2005).

Estimates of sleep difficulties amongst TD infants and toddlers in Australia, UK, US, Canada, and a number of Asian countries suggest that 20–50% of parents report some degree of difficulty with their child's sleep, posing a large cost to health services (e.g., Armstrong, Quinn, & Dadds, 1994; Hiscock & Wake, 2001; Johnson, 1991; Martin, Hiscock, Hardy, Davey, & Wake, 2007; Mindell, Sadeh, Wiegand, How, & Goh, 2010), and reports of associated negative mental and physical health for parents (e.g., Martin et al., 2007). Early sleep problems are often presumed to be temporary however, this is typically not the case, and may persist into childhood (Touchette et al., 2007; Zuckerman, Stevenson, & Bailey, 1987). Touchette et al. (2005) found that a third of infants who were sleeping less than 6 h per night at 5 and 17 months, continued to have this problem at 29 months. Even when insufficient sleep at 2.5 years increased to sufficient levels by 3.5 years, lower scores on a spatial task, and higher scores on a hyperactivity–impulsivity measure were found at age 6 compared to those sleeping more than 10 h a night. This is of particular concern not only for TD children, but also those with developmental disorders as sleep problems may compound their existing cognitive and behavioural difficulties, and they are inherently more vulnerable to sleep difficulties (Bartlett, Rooney, & Spedding, 1985; Lancioni, O'Reilly, & Basili, 1999).

The main aim of the current study was to investigate sleep in toddlers with WS. To date, there appear to be no published studies providing quantifiable reports investigating sleep specifically in toddlers with this rare developmental disorder. WS is caused by a hemizygous microdeletion of some 28 genes on chromosome 7q11.23 (Tassabehji, 2003). The incidence of WS is approximately 1 in 20,000 live births (Morris, Demsey, Leonard, Dilts, & Blackburn, 1988). The main cognitive characteristics of WS include overall IQ scores between 55 and 69 (Mervis et al., 2000; Searcy et al., 2004), a 'hyper-social' personality profile, relatively good face recognition and language skills, and poor visuo-spatial skills (Annaz, Karmiloff-Smith, Johnson, & Thomas, 2009; Donnai & Karmiloff-Smith, 2000).

Studies examining sleep in individuals with WS indicate that sleep is problematic for this population. Annaz and colleagues (2011) reported that 97% of school-aged children with WS experienced bedtime resistance, sleep anxiety, night wakings, and daytime sleepiness. More recently, actigraphy measures revealed that, compared to TD children and children with Down syndrome, children with WS (age range: 6–12 years) had significantly longer sleep latencies as well as parental reports of bed-wetting and body pains (Ashworth, Hill, Karmiloff-Smith, & Dimitriou, 2013). A large proportion of adolescents and adults (age range: 17–35 years) with WS are also reported to experience daytime sleepiness, nocturnal leg discomfort, and fragmented sleep as measured by actigraphy (Goldman, Malow, Newman, Roof, & Dykens, 2009). Polysomnography studies have demonstrated differences in sleep architecture between TD and WS children. Arens et al. (1998) found that children with WS spent double the amount of time awake after sleep onset, more time in stages 3 and 4 (slow wave sleep), and less in stages 1 and 2. Reduced sleep efficiency (sleep onset to offset time as a proportion of time in bed), and REM sleep, as well as increased slow wave sleep, respiratory-related arousal, and restlessness have been seen in studies with children (age range: 2–18 years, Mason et al., 2011), and adolescents and adults (age range: 14–29 years, Bódizs, Gombos, & Kovács, 2012; Gombos, Bódizs, & Kovács, 2011).

Due to the mounting evidence seen in children and adults with WS, Annaz, Hill, Ashworth, Holley, and Karmiloff-Smith (2011) argued that sleep difficulties should be considered one of the defining symptoms of WS, a sentiment also shared by some clinical professionals. The ages of the participants in the studies reviewed above were wide in range, and there appear to be no studies investigating sleep specifically in WS in the first few years of life. Investigating sleep in the early years is essential as it is unclear if sleep problems are a phenotypic characteristic of WS (Bódizs et al., 2012) or whether sleep difficulties develop as a result of other domain specific factors associated with WS such as issues with attention (e.g., Scerif, Cornish, Wilding, Driver, & Karmiloff-Smith, 2004), hypersociability or behavioural problems (Bódizs et al., 2012; Mason et al., 2011).

Sleep involves finely tuned multidimensional processes such as psychological processes, biochemistry, genetics, and responses to external environmental cues (Hill, 2011). Therefore multiple types of regulation may affect the complex sleep-wake system, which consequently may impact on waking life and family functioning. Sleep problems in early childhood may have a negative impact on multiple factors such as behaviour, cognition, language, and health of a child (e.g., Dearing et al., 2001; Scher, 2005; Tikotzky et al., 2010; Touchette et al., 2007). Furthermore, parental involvement may contribute to infant sleep disturbances and infants' abilities to self-sooth (Sadeh, Flint-Ofir, Tirosh, & Tikotzky, 2007). This may particularly be the case in primary caregivers of children with developmental disorders (e.g., Meltzer, 2008) as they may be at increased risk of associated stress, and experience more parental anxiety. There may be bidirectional effects where sleep difficulties in children or parents may impact on each other (e.g., Meltzer & Mindell, 2007; Wayte, McCaughey, Holley, Annaz, & Hill, 2012). Therefore, in the current study, a range factors were explored in six questionnaires assessing child sleep, parental cognition in relation to early child sleep, maternal sleep, and mood measures. The main goals of the study were: (i) to compare sleep in TD toddlers and those with WS from a narrow age range, using parental reports; (ii) to explore the relationships between sleep and behaviour and language outcomes; and (iii) to examine the relationships between child sleep and related maternal beliefs, maternal sleep, and maternal mood.

2. Method

2.1. Participants

Twenty-eight parents of toddlers with WS were contacted through the Williams Syndrome Foundation, UK database (88% of children up to 48 months of age registered). Fourteen parents of WS children (10 female, 4 male) returned the completed questionnaires. A further 4 parents were interviewed by telephone for the Brief Infant Sleep Questionnaire (BISQ, Sadeh, 2004). The parents of 18 TD children (12 female, 6 male) also completed the questionnaires (4 of whom only completed the BISQ). The TD children were individually age matched to the children with WS. The paired participants differed in age on average by 8.33 days (SD = 5.36, range 4–22 days, see Table 1). There were no significant differences in chronological age between the paired children (*M* difference 0.12 m, SD = 0.31 m, $t(17) = 1.56$, $p = .14$, $d = 0.01$). Sixty-one percent of the participants (11 pairs) were also matched on gender. All of the participants were born full-term apart from one in each group. *A priori* chi-square analyses revealed that the two groups did not differ on gender ($\chi^2(1) = 0.47$, $p = .49$), ethnicity ($\chi^2(3) = 6.00$, $p = .11$), maternal education ($\chi^2(3) = 5.01$, $p = .15$), and parental occupation ($\chi^2(2) = 0.80$, $p = .67$). There was a difference in relation to breast feeding as more of the TD toddlers had been breastfed (WS: 57%, TD: 100%; $\chi^2(1) = 7.64$, $p = .006$), and for a longer time (WS, *M* months: 4.25 months, SD: 6.61; TD, *M* months: 9.14, SD: 6.52; $t(13) = 2.19$, $p = .047$, $d = 0.74$).

Children with WS had been diagnosed clinically, as well as by means of the *fluorescence in situ hybridisation* (FISH) genetic test for deletion of one copy of the Elastin gene. All individuals had normal or corrected-to-normal vision. Parents were asked about their child's current and past health issues, medication use, and diet. Note that none of the children had any formal diagnosis of a sleep disorder, although one child with WS had been prescribed melatonin for sleep difficulties. The study was approved by the Williams Syndrome Foundation, UK and Middlesex University Ethics Committee, and written consent was provided from all of the parents.

2.2. Sleep-related questionnaires

1. *Brief Infant Sleep Questionnaire* (BISQ, Sadeh, 2004). Based on parental reports, this questionnaire provides information on sleep and the circumstances surrounding sleep, such as duration (night and day), number and duration of night wakings, settling time, sleep latency, sleep location (e.g., own bed, parent's bed), position (e.g., prone, supine, side), conditions surrounding sleep onset, and parents' perception of their child's sleep quality. It has been found to correlate positively with sleep diaries and actigraphy (Sadeh, 2004).

2. *Infant Sleep Vignettes Interpretation Scale* (ISVIS, Sadeh et al., 2007) examines parental underlying beliefs about infant sleep, and has been found to be predictive of infants' night wakings (Tikotzky & Sadeh, 2009). Fourteen brief vignettes of infant and toddler sleep scenarios are presented and caregivers are asked to rate three questions on a 6-point scale. The three questions are aimed at gauging parents' beliefs about the degree of parental involvement required, limit setting, and the extent to which a given sleep issue is related to child temperament. Note, the ISVIS largely refers to infants and toddlers up to 24 months of age but due to the low general functioning of the WS group, it was deemed useful to use materials that would cover their level of functioning.

3. *Pittsburgh Sleep Quality Index of Parents* (PSQIP, Buysse, Reynolds III, Monk, Berman, & Kupfer, 1989) explores adults' sleep with questions rated on a 4-point scale and yields seven component scores as well as a global score. It is reported to have a sensitivity of 0.90 and specificity of 0.87 in the detection of sleep disturbances (Buysse et al., 1989). It generates a maximum difficulty score of 21 and a score above 5 indicates poor sleep quality.

4. *Child Behaviour Checklist* 1.5–5 (CBCL 1.5–5, Achenbach & Rescorla, 2000) is a widely used questionnaire completed by parents with 99 questions rated on a 3-point scale. The questions yield scores on 7 sub-scales (Emotionally Reactive, Anxious/Depressed, Somatic Complaints, Withdrawn, Sleep Problems, Attention Problems, Aggressive Behaviour, & Other) for 1.5 to 5-year-old children. These scores are compared to norms that correspond to normal, borderline (93rd–97th percentiles) and clinical ranges (scores above the 97th percentile).

5. *MacArthur Communicative Development Inventory for Infants* (*MCDI*) – *Words and Gestures* (Fenson et al., 1993) is a standardised measure of language development, suitable for 8- to 30-month-olds. It is based on parental reports of infants' and toddlers' receptive language and their production of gestures, words and sentences. Sleep and daytime napping in

Table 1
Age in Months for the Child Measures: BISQ, ISVIS, CBCL, MCDI.

Age Months		*n*	*M*	SD	Range
BISQ only					
	Williams	18	30.43	9.53	15.40–48.20
	Typically developing	18	30.31	9.44	15.57–47.47
All child measures					
	Williams	14	31.67	9.58	18.50–48.20
	Typically developing	14	31.55	9.50	18.03–47.47

infancy have been found to correlate with later scores on language development (Dearing et al., 2001; Touchette et al., 2007) and language learning (Gómez, Bootzin, & Nadel, 2006).

6. *Major* (*ICD*-10) *Depression Inventory* (MDI, Bech, Rasmussen, Raabæk Olsen, Noerholm, & Abildgaard, 2001) is a short questionnaire with items rated on 6-point Likert scales. The questions are aimed at reflecting moderate to severe symptoms of depression listed in the Diagnostic and Statistical Manual of Mental Disorders-IV (DSM-IV) and the International Classification of Diseases (ICD-10). It has a sensitivity of 0.86–0.92 and specificity of 0.82–0.86 in the diagnosis of clinical depression. Total scores equate to clinical symptoms as follows: 'mild depression' (20–24), 'moderate' (25–29) or 'severe' (30+).

3. Results

Data were analysed using IBM SPSS for Windows, Version 20 (SPSS Inc., Chicago, IL). Data were screened for outliers using *z*-scores, and Cook's distances. Age-matched analyses (paired *t*-tests, logistic regressions) were performed with the continuous data between the WS and TD groups for the BISQ, ISVIS, PSQIP, and MDI. The categorical variables of the BISQ were analysed using chi-square, and the logistic regression analyses were based on whether the children with WS experienced a given characteristic compared to their age-matched TD pair. Some of the BISQ variables, as based on the grouped data (as opposed to the age-matched analyses), were not normally distributed. Therefore, Kendall's τ correlations were performed (due to the small sample sizes) and the variables in the hierarchical multiple regression analyses were log transformed.

1. *BISQ* According to parental reports, the children with WS had significantly shorter night sleep duration ($t(17) = 3.21$, $p = .005$, $d = 0.99$), had significantly more night wakings ($t(17) = 2.22$, $p = .04$, $d = 0.83$), longer night wakefulness ($t(17) = 3.14$, $p = .006$, $d = 1.02$), took longer to settle ($t(16) = 2.79$, $p = .01$, $d = 0.90$) and fell asleep later at night ($t(17) = 2.20$, $p = 04$, $d = 0.61$), compared to age-matched TD children (Table 2). There were no significant differences in daytime sleep duration ($t(14) = 0.93$, $p = .37$, $d = 0.44$).

For the categorical variables, the options for a number of the items were dichotimised due to the sample sizes (e.g., sleep with a parent or not; sleep as a small or serious problem versus not at all; falling asleep alone or with a parent, see Sadeh, 2004). Group comparisons using chi-square and logistic regression analyses revealed that significantly more children with WS slept with a parent ($\chi^2(1) = 4.43$, $p = .035$) and more mothers from the WS group reported that their child had a small or serious sleep problem ($\chi^2(1) = 10.6$, $p = .001$), which was also reflected in a high odds ratio (see Table 3). That is, parents of children with WS were 21 times more likely to describe their child's sleep as a small or serious problem than parents of TD children. There were no significant differences in the frequency of parental involvement when falling asleep or in sleep positions (see Table 3).

2. *ISVIS* Mothers of children with WS had significantly lower scores than mothers of TD children (maternal scores matched by chronological age of the children) on expectations of distress in relation to child sleep ($t(12) = 2.51$, $p = .027$, $d = 0.86$) and significantly higher scores on limit-setting beliefs ($t(12) = 3.80$, $p = .003$, $d = 1.23$) (see Table 2). Relationships between the ISVIS scores and night sleep duration, number of night wakings, and duration of night wakefulness from the BISQ were

Table 2
BISQ, ISVIS, PSQIP, and MDI Scores.

	WS group			TD group		
	n	*M*	SD	*n*	*M*	SD
BISQ						
Duration sleep night (7pm–7am)	18	9:20	2:23	18	11:06	0:50
Duration sleep day (7am–7pm)	15	1:06	0:52	18	0:45	0:42
Number night wakings	18	1.92	1.88	18	0.72	0.83
Duration night wakefulness	18	0:49	0:59	18	0:06	0:07
Settling duration	17	0:41	0:47	18	0:11	0:06
Time fall asleep	17	20:13	1:08	18	19:41	0:30
ISVIS						
Infant distressed	13	2.97	0.73	14	3.71	0.97
Need to limit interference	13	4.28	0.53	14	3.36	0.92
Infant temperament as cause	13	3.07	0.80	14	3.01	1.01
PSQIP component scores						
1 Subjective sleep quality	14	1.07	0.83	14	1.00	0.39
2 Sleep latency	14	0.57	0.51	14	0.93	0.73
3 Sleep duration	14	0.79	0.80	14	0.43	0.51
4 Habitual sleep efficiency	14	0.36	0.74	14	0.21	0.43
5 Sleep disturbances	14	1.00	0.39	14	1.07	0.47
6 Sleep medication	14	0.00	0.00	14	0.14	0.53
7 Daytime dysfunction	14	0.93	0.92	14	0.50	0.65
PSQIP global score	14	4.71	3.07	14	4.29	2.33
MDI	11	7.55	5.81	11	7.36	7.61

Table 3
BISQ Frequences and Odds Ratios and CBCL Frequencies.

BISQ	WS *n*	TD *n*	*B*	SE	Odds Ratio (WS only vs. TD)	LCL	UCL
How fall asleep							
Alone	8	12					
Parent involved	10	6	−0.92	0.69	0.40	0.10	1.54
Constant			1.32	1.05			
Sleep arrangement							
Alone/share room with sibling	12	17					
With parent	6	1	2.14	1.14	8.5	0.90	80.03
Constant			−1.79	1.08			
Sleep problem							
No	8	17					
Small/serious	10	1	3.06	1.13	21.25	2.31	195.80
Sleep position							
On belly	7	7					
On side	8	4	−0.85	0.87	0.43	0.77	2.37
On back	3	7	−1.54	0.92	0.21	0.04	1.31
Constant			0.85	0.69	2.33		
CBCL sub-scales							
Emotionally reactive							
Normal	8	14					
Borderline/clinical	6	0					
Anxious/depressed							
Normal	12	14					
Borderline/clinical	2	0					
Somatic complaints							
Normal	11	14					
Borderline/clinical	3	0					
Withdrawn							
Normal	12	14					
Borderline/clinical	2	0					
Sleep problems							
Normal	10	14					
Borderline/clinical	4	4					
Attention problems							
Normal	7	14					
Borderline/clinical	7	0					
Aggressive problems							
Normal	11	14					
Borderline/clinical	3	0					

assessed separately for the WS and TD groups.[1] In the TD group, there was a significant positive relationship between the mean number of child night wakings and perceptions of distress ($\tau(12) = .55$, $p = .015$), and a significant negative relationship between the number of night wakings and attitudes towards limit setting ($\tau(12) = -.56$, $p = .013$). Therefore, the attitudes of the mothers of TD children that reflect greater interpretations of distress in their children and less limit-setting may be linked to more night wakings in the TD children. In contrast, there were no significant relationships seen in the WS group. Thus, the attitudes towards sleep in the mothers of the children with WS may be unrelated to the reported sleep disturbances.

3. *PSQIP* Paired samples *t*-tests showed no significant differences between the mothers of TD and WS children on all 7 components of this scale, nor the global scale suggesting that the sleep quality of the mothers in both groups were similar (see Table 2). PSQIP Global scores above 5 are indicative of the existence of sleep difficulties. Half of the mothers of WS children ($n = 7$) and 36% of the mothers of TD children ($n = 5$) had scores above 5, a non-significant difference in frequency. Kendall's τ correlations[1] were performed separately for each group between the global PSQIP score and BISQ variables: night sleep duration, mean number of night wakings, and duration of night wakefulness. For the WS group, there were significant positive correlations between the PSQIP global score and the mean number of night wakings ($\tau(12) = .58$, $p = .01$) and night wakefulness in the children ($\tau(12) = .53$, $p = .016$). This suggests that as the mean night wakings and wakefulness in the WS children increased, the poorer the sleep quality of the mothers.

[1] With Bonferroni adjustments.

Table 4
Multiple regression analyses with MCDI Understands and Says raw score, age, and night time sleep.

	B	*SE B*	*β*
Step 1			
Constant	−270.81	69.97	
Age	12.36	2.12	.86**
Step 2			
Constant	−2687.70	900.95	
Age	10.91	1.80	.76**
Log night sleep	541.21	201.35	.34*

$R^2 = .74$ for Step 1, $\Delta R^2 = .1$ for Step 2 ($p = .021$).
* $p < .05$.
** $p < .001$.

Table 5
Multiple regression analyses with maternal MDI and WS children's BISQ night sleep and number of wakings.

	B	*SE B*	*β*
Constant	−42.73	77.53	
Log sleep night	9.96	16.83	.15
Log night wakings	16.76	5.29	.80*

$R^2 = .53$.
* $p < .05$.

4. *CBCL* 1.5–5. Scores above the 93rd and 97th percentiles for each sub-scale are classified as borderline or clinical. Compared to controls, significantly higher frequencies of children with WS were classified as borderline/clinical on the Emotionally Reactive ($\chi^2(1) = 7.63$, $p = .006$), Sleep Problems ($\chi^2(1) = 4.67$, $p = .031$) and Attention Problems sub-scales ($\chi^2(1) = 9.33$, $p = .002$) (see Table 3). Point-biserial correlations[1] were performed between these sub-scales and the mean night sleep duration and mean number of night wakings with the WS group. Only the Sleep Problems sub-scale was significantly negatively related to the log transformed night sleep duration ($r_{pb}(12) = -.77$, $p = .001$). Thus higher scores on this scale (indicating greater severity) were associated with less sleep as recorded in the BISQ.

5. *MCDI* As most of the TD children were at ceiling for this measure only the data for the WS group was analysed. Hierarchical multiple regression analysis was performed assessing the variance in the raw score for the number of words produced and understood ($M = 120.71$, SD = 137.76, range: 7–345) in relation to the age of the participants and night sleep duration (log transformed). Chronological age was a significant predictor, but sleep duration also explained a significant portion of the variance in the MCDI score (see Table 4).

6. *MDI* One mother from the TD group met the criteria for depression with a score that fell within the range for mild depression. There were no significant differences found between the WS and TD groups on the MDI Total score. However, significant positive relationships were found in both groups of mothers between the MDI and PSQIP (WS: $r(11) = .74$, $p = .004$, TD: $r(11) = .56$, $p = .045$). Multiple regression analyses were performed separately for the WS and TD groups assessing the relationship between the MDI and the log transformed BISQ night sleep duration and number of night wakings variables. The number of night wakings was a significant predictor of mothers' MDI scores for the WS group (see Table 5).

4. Discussion

This is the first study to explore sleep in toddlers with WS, a rare developmental disorder. We sampled over 50% of the toddlers up to 48 months of age registered on the WS Foundation UK database. The findings here provide evidence that sleep problems are prevalent early in life in children with WS. According to parental report, the WS children here had shorter night sleep duration, more night wakings, more night wakefulness, took longer to settle, and had later bed times than age-matched TD children. This is consistent with previous studies with older children with WS (e.g., Annaz et al., 2011; Arens et al., 1998; Bódizs et al., 2012; Mason et al., 2011). Additionally, a high proportion of mothers of children with WS considered their child's sleep to be problematic.

More of the children with WS shared a bed with a parent but there were similar rates of parental involvement in bedtime routines across both groups. However, the parents of children with WS had possibly adapted to child's sleep difficulties as their scores on interpretations of distress in child sleep difficulties were lower than parents of TD children, and their scores on beliefs about limit setting around child sleep were higher. Similar to Tikotzky and Sadeh (2009), relationships between child night wakings and higher perceptions of distress and lower scores on attitudes towards limit setting amongst the parents of TD children were found. Interestingly, this was not the case amongst the parents of WS children, suggesting that parental attitudes are unlikely to explain the frequency of night wakings in the WS children.

The present findings revealed an interesting association between night sleep duration and language development in the children with WS. Nighttime sleep duration accounted for 10% of the variance in a measure of language development, beyond that accounted for by age. Relationships between sleep and language development have been found with TD toddlers (e.g., Dearing et al., 2001; Touchette et al., 2007), but this is the first finding that we are aware of with toddlers with WS. Language development in children with WS is relatively good yet atypical (Laing et al., 2002). Further investigations preferably in the form of a longitudinal study and alternative language measures would be of interest.

Consistent with Mason and colleagues (2011), we did not find any relationship between sleep and daytime behaviour (CBCL). This is perhaps surprising as children with WS typically have problems with sustained attention, and up to 65% are diagnosed with behavioural problems and attention-deficit hyperactivity disorder (ADHD) (Dykens, 2003; Einfeld, Tonge, & Florio, 1997; Leyfer, Woodruff-Borden, Klein-Tasman, Fricke, & Mervis, 2006; Pober & Morris, 2007). Sleep problems have also been found to be strongly related to behavioural problems such as ADHD in children (Cohen-Zion & Ancoli-Israel, 2004). However, Mason et al. did not find differences in sleep variables between WS participants with ADHD features and those without. It is possible that larger sample sizes with narrower age ranges are required to detect the effects of sleep on behaviour. Perceptions of problematic behaviour are likely to vary across different age ranges thus rendering the data highly variable. Even in the current study, the age range was relatively narrow compared to previous studies but behaviour varies dramatically in the early years. More sensitive measures of behaviour, cognition, and language are also required. In older TD children, experimental sleep restrictions have been reported to negatively affect classroom behaviour and attention (Fallone, Acebo, Seifer, & Carskadon, 2005) as well as decreased verbal creativity and abstract thinking (Randazzo et al., 1998). Associations have also been found between poorer sleep efficiency and visuospatial working memory in TD children (Steenari et al., 2003). In contrast, sleep-dependent memory, an effect where procedural and declarative performance on recently learned tasks is enhanced following a period of sleep as compared to an equal number of waking hours, is frequently found in adults (Walker & Stickgold, 2006), and in some studies with children (e.g., Ashworth, Hill, Karmiloff-Smith, & Dimitriou, 2013b; Wilhelm, Prehn-Kristensen, & Born, 2012). However, this effect was recently not observed in children with WS (Dimitriou, Karmiloff-Smith, Ashworth, & Hill, 2013). Therefore, more experimental measures with young children with WS are necessary to characterise the specific effects of sleep difficulties on cognition, language, and behaviour.

There were no significant differences seen in the measures of maternal sleep quality and mood (as measured by the MDI) between the mothers of TD and WS children. However, up to 50% of the mothers in both groups had scores indicative of poor sleep quality. Furthermore, the sleep quality scores of the mothers of children with WS were significantly related to their child's night wakings and night wakefulness. Gress et al. (2010) also found that infant night wakings was a predictor of maternal subjective ratings of their own sleep quality. A more objective measure of maternal sleep quality would be useful to determine if maternal sleep is in fact disturbed or whether they perceive their sleep to be poor because of the sleep difficulties of their children. Equally, it is possible that mothers with poor sleep quality are more vigilant at night and therefore more likely to be aware of their child's night wakings. Interestingly, the number of night wakings in the children with WS accounted for a significant proportion of variance in the maternal mood scores (MDI). We hypothesise that night wakings in children with WS may disrupt maternal sleep and in turn impact on maternal mood. Sleep loss in adults is detrimental to their moods, which may affect their own daytime functioning and ability to cope with parenting (Banks & Dinges, 2007; Moore, David, Murray, Child, & Arkwright, 2005). In turn, this may affect parental sleep and future studies with objective measures could be used to quantify this association.

Apart from Dimitriou and colleagues' (2013) study, the relationships between sleep in children with WS and cognitive domains, and behaviour have been implicated but not supported. A possible relationship between night sleep duration and language development was found here, but not between sleep and behaviour. Given the numerous studies linking sleep and behaviour (e.g., Jansen et al., 2011; Touchette et al., 2007), and the attenuation of behavioural problems following sleep interventions (Chervin et al., 2006), this is somewhat surprising. Further, both ADHD and PLMS are reported to be prevalent in the WS participants in sleep studies but clear relationships with sleep have not been found (e.g., Arens et al., 1998; Mason et al., 2011). Adding to the complexity of this issue, some of the parents of the children with WS in this study reported that their child slept well, yet had observed high levels of movement during nighttime sleep. Night wakings could be a reflection of increased sleep spindle activity associated with increased thalamocortical oscillatory dynamics in WS as suggested by Bódizs et al. (2012). Equally, behavioural insomnia (ICSD) such as limit setting disorder or sleep onset association disorder may be involved (Hill, 2011).

4.1. Limitations of the current study

Relying on parental reports is of course not ideal. The BISQ has been found to correlate well with actigraphy (Sadeh, 2004), however, compared to sleep diaries recorded by parents, more night awakenings and shorter sleep have been found amongst infants with actigraphy (Acebo et al., 2005; Sadeh, 1994, 1996; Sadeh, Acebo, Seifer, Aytur, & Carskadon, 1995; So, Adamson, & Horne, 2007; So, Buckley, Adamson, & Horne, 2005). Therefore, the reports here may underestimate the sleep difficulties experienced by the children with WS and possibly the TD children. Parents are reported to be often unaware of their child's sleep problems (Owens & Witmans, 2004 but see Gringras et al., 2012 for discussion on good sleep estimates using sleep diaries). Mason et al. (2011) found that some WS children with low sleep efficiency, according to polysomnography, were described as sleeping sufficiently by their parents. Future studies would benefit from the use of objective measures but one needs to bear in mind the difficulties of testing children with developmental disorders. This study is the first to provide

evidence of sleep problems early in development for WS with a narrow age range using subjective measures. The next step to extend our knowledge would be to use objective measures such as actigraphy and examine sleep in toddlers with different syndromes.

4.2. Clinical and educational implications

Significant changes occur during early central nervous system development, and as sleep makes up a major part of life in the early years it is thus hugely important for brain development (Kohyama, 1998; Owens & Witmans, 2004). Interventions and education for parents on the importance of sleep hygiene in early childhood has been shown to be beneficial (Kerr, Jowett, & Smith, 1996; Tikotzky & Sadeh, 2009; Wolfson, Lacks, & Futterman, 1992). Despite the prevalence of sleep difficulties, paediatricians and GPs report lacking confidence in diagnosing and treating sleep problems in the early years (Chervin, Archbold, Panahi, & Pituch, 2001; Owens, 2001; Owens & Witmans, 2004). Ideally, greater awareness, interventions and recommendations should be provided for parents of children with WS in the early months. This may contribute significantly to long-term outcomes and may also help to prevent other issues such as sleep resistance behaviours later in life (Annaz et al., 2011).

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