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Incontinence and sleep disturbances in young children: A population-based study

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Abstract

Aims: Nocturnal enuresis (NE), daytime urinary incontinence (DUI), fecal incontinence (FI), as well as sleep and behavioral problems are common in young children. The aim of this study was to analyze the association of sleep and psychological parameters for all types of incontinence in a representative sample of young children.

Methods: Six hundred thirty eight (of 1161) children with a mean age of 5.9 years (50.9% boys) were assessed during their mandatory school entry examination. The participation rate was 55%. Instruments included the Strengths and Difficulties Questionnaire, the Children's Sleep Habits Questionnaire and other clinical questions. Incontinence was diagnosed according to ICCS standards. Constipation was assessed by two questions.

Results: 17.1% of children had at least one type of incontinence, 14.8% had NE, 5.0% DUI, 2.1% FI, and 4.8% were constipated. 6.7% of children had clinically relevant psychological problems. 22.7% of children had sleep problems regularly (5−7 times/week). A wide variety of sleep problems were reported. Children with incontinence were not affected by a higher rate of sleep problems. Children with NE had fewer night wakings and those with constipation fewer parasomnias. Sleep and psychological problems were significantly associated, especially in children with DUI and FI.

Conclusions: Sleep and behavioral problems are common in young children. Psychological problems have a clear impact on sleep. Young children with incontinence do not have more sleep problems than continent children. Therefore, both sleep and psychological problems should be addressed in young children with incontinence.

KEYWORDS

daytime urinary incontinence, fecal incontinence, nocturnal enuresis, preschool children, psychological problems, sleep disorders

1 | INTRODUCTION

Nocturnal enuresis (NE), daytime urinary incontinence (DUI), fecal incontinence (FI), as well as sleep problems are common disorders in school-aged children. At least 25% of all children are affected by sleep problems.[1] Many excellent studies on sleep and incontinence, both clinical and polysomnographic, have been published in the past decades. Most of these studies have focused on children with NE as outlined by Pedersen et al.[2] and Van Herzeele et al.[3] Most episodes of NE occur early during sleep, that is, in the first two- thirds of the night.[2] NE episodes can occur in all sleep stages, especially in Stage 2 of non-rapid eye movement (REM) sleep. Wetting during REM-stages is the exception. Preceding NE episodes, periods of arousal are typical in some children. Many children have repeated transient arousals leading to poor sleep quality and fragmentation. NE can be associated with circadian variations of blood pressure, heart-rate variability, vasopressin secretion and urine production.[2] NE in children is also associated with abnormalities in respiratory parameters and autonomic control.[4] Sleep-disordered breathing (SDB) and periodic limb movements (PLMS) have also been reported.[2] Also, children with NE are more difficult to arouse, a phenomenon many parents report.[5,6]

In contrast to this extensive database, no studies have analyzed associations between DUI and sleep. One large, prospective population-based study analyzed which psychosocial risks have an influence on later FI and/or constipation.[7] Behavioral sleep problems at the age of 2−3 years were among the most influential factors for FI and/or constipation at the ages of 4−10 years. Specifically, "no regular sleep routine" increased the risk for constipation, soiling and constipation with soiling two fold. Other factors such as "refusal to go to bed" and "difficulty to go to sleep" were also important risks.[7] Another study has shown that children with non-retentive FI were affected reduced by sleep duration and sleep efficiency, possibly modulated by Orexin-A plasma levels.[8]

Far fewer sleep studies have focused on the preschool age, even though the rate of sleep problems among children aged 3−5 years varies from 15% to 30%.[1] At this age, the average duration of sleep per day is 10−13 h.[9] Sleep duration is associated with cognitive and behavioral problems in preschool children, as well as with health and family interactions.[10]

The main aim of this study was to assess frequencies of sleep problems and their interrelation with incontinence and psychological problems in preschool-aged children, while most studies so far have analyzed school-aged children. As many studies have been performed on selected groups of patients, the aim was also to conduct a population-based study, which provides representative data. In addition, all types of incontinence were assessed, not just NE, but also DUI and FI, and constipation. Besides, we wanted to assess means and frequencies of specific sleeping habits (e.g., average sleeping time, average sleep duration, parental strain by children's sleeping behavior) that are frequently mentioned by parents.

We hypothesized that sleep habits and psychological problems would be more prevalent in children with incontinence than without. In addition, we aimed to explore the complex associations between incontinence, sleep behavior and psychological problems.

2 | MATERIALS AND METHODS

Following informed consent, we asked parents of all children at the mandatory pediatric school-entry examination to participate in the study from December 2016 to January 2017. These young children had not entered school yet, that is, they were pre-school children. They lived in a defined geographical area, the Saarpfalz Kreis in Saarland, Germany. The study was approved by the local ethics committee. Parents were asked to answer a questionnaire regarding sleep behavior, incontinence and psychological symptoms at preschool age, which included the widely used Children's Sleep Habits Questionnaire (CSHQ) and the Strengths and Difficulties Questionnaire (SDQ).

The CSHQ is a standardized and widely used questionnaire for 4- to 10-year-old children with good psychometric properties.[11] In its original form, parents answer 45 items capturing major clinical sleep complaints within a three-point rating scale. The items can be grouped into eight sleep domains: "bedtime resistance," "sleep onset delay," "sleep duration," "sleep anxiety," "night wakings," "parasomnias," "Sleep-disordered breathing," and "daytime sleepiness." A total CSQH sum score with a cut-off ≥ 41 is derived from 33 items and yields a sensitivity of 0.80 and specificity of 0.72 for clinically relevant sleep problems.[11] The CSHQ has been adapted for toddlers and preschool children.[12] Due to time restraints during the school-entry examination, the CSQH was shortened to 21 items in this study, encompassing the four most important subscales of "bedtime resistance," "sleep onset delay," "night wakings," and "parasomnias." A raw score for all questions was calculated. In addition, we added 11 additional clinically relevant items.

The SDQ is an internationally validated, standardized behavioral screening questionnaire for 3- to 17-year-old

children and adolescents consisting of 25 items, which were all included in this study.[13,14] Current versions are freely available online for noncommercial purposes. It is used worldwide, has been translated into 77 languages, and has satisfactory to good reliability (Cronbach's $\alpha = 0.73$; $r_{tt} = 0.62$).[15] The items are scored on a three-point scale: not, somewhat, and certainly true. The 25 items are divided into five scales: "emotional symptoms" (five items), "conduct problems" (five items), "hyperactivity" (five items), and "peer problems" (five items), which form the "total difficulties" score. Scores above the 90th percentile are associated with a substantial higher risk (odds ratio = 15.3 for parents' ratings) for being affected by a psychiatric disorder.[16] The fifth scale measures "prosocial behavior" (five items). The prosocial scale comprises the items: "considerate of other people's feelings," "shares readily with other children," "helpful if someone is hurt, upset or feeling ill," "kind to other children," and "often volunteers to help others."[13,14] In general, prosocial behaviors are defined as voluntary actions that are intended to help others.

The ICSS-criteria for incontinence were used to define NE and DUI, the *Diagnostic and statistical manual of mental disorder*-5 criteria for FI.[17,18] Incontinence was diagnosed in children aged 5 years for NE and DUI (4 years regarding FI, respectively) or older if it occurred at least once per month. Constipation was diagnosed when parents answered with "yes" or when the child had two or fewer bowel movements/week. Incontinence was assessed with four specific questions in total. Questionnaires were available in German, Arabic, and Turkish languages to increase reliability of parental answers.

For all statistical analyses, we used IBM SPSS Statistics 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0; IBM Corp.). The significance level for all analysis was set to $p < 0.05$. Due to the narrow age range of the sample (mean age 5.9 years, standard deviation 0.4), we did not control for age. To analyze differences in frequency distributions of sex and self-reported sleep disorders across children with incontinence problems and children without, we conducted χ^2 tests and Fisher's exact tests. We conducted one-sample t tests to compare means of CSHQ scales of our sample to normative data of a healthy and clinical sample provided by Owens et al.[11] Independent t tests and Mann−Whitney U tests, respectively, were used to further analyze differences in children with incontinence and variables for measuring sleep behavior and psychological problems as well as to check for significant sex differences regarding sample characteristics. Small subsample sizes for children affected by both incontinence and psychological problems did not allow further inferential analyses. To

consider the way of interaction we used a descriptive visual approach for significant unidimensional SDQ and CSHQ differences.

3 | RESULTS

A total number of 638 children (out of 1161 children) participated in this study. The participation rate was 55%. The mean age was 5.9 years (standard deviation: 0.4; range: 4.5−8.7 years) and 50.9% were boys.

Table 1 depicts descriptive data of incontinence, sleep, and psychological problems. In total, 17.1% of children had at least one type of incontinence, 14.8% NE, 5.0% DUI, 2.1% FI, and 4.8% were constipated. There were no significant differences between boys and girls regarding incontinence.

6.7% of children had clinically relevant total SDQ score (scores > 90th percentile). Conduct problems and clinically low prosocial behavior were most prevalent, affecting 15.2% and 16.4% of children, respectively. Boys had more conduct and hyperactivity problems than girls.

Regularly (5−7 times/week) occurring sleep problems (falling asleep or sleeping through the night) occurred in 22.7% of children (Table 1). The mean sleep duration per night was about 10.7 h (SD 1.0). There were no sex differences regarding the CSHQ-total and raw scores.

One sample t tests for CSHQ-subscale scores with reference data from Owens et al. revealed significant higher mean values for the current sample regarding "bedtime resistance" ($t(637) = 14.76$, $p < 0.001$), "sleep onset delay" ($t(623) = 10.63$, $p < 0.001$), "night wakings" ($t(617) = 13.05$, $p < 0.001$), and "parasomnias" ($t(623) = 3.90$, $p < 0.001$).[11] When comparing mean subscale scores with a reference clinical sample of children with behavioral sleep disorder, parasomnia or SDB according to Owens et al., scores regarding "bedtime resistance" did not differ ($t(637) = 0.10$, $p < 0.918$).[11] Scores for "sleep onset delay" ($t(623) = -7.08$, $p < 0.001$), "night wakings" ($t(617) = -11.80$, $p < 0.001$), and "parasomnias" ($t(623) = -14.68$, $p < 0.001$) were significantly lower.

Table 2 shows absolute and relative frequencies of sleep-related single items. On a regular basis (5−7×/per week), sleepwalking occurred in 124 cases (21.5%), night terrors in 125 (21.4%), nightmares in 195 (19.5%), bruxism in 116 (19.7%), and loud snoring in 108 children (18.2%). The rates of other sleep-related symptoms were also high.

The mean time children went to bed was 07:48 p.m. (SD 38 min) and the mean getting up time was 6:53 a.m. (SD 46 min). More than 95% of the parents stated that they were not at all stressed (78.6%) or mildly stressed (16.5%) by their children's sleeping behavior.

TABLE 1 Description of sample, incontinence, sleep, and behavioral problems

	Total		Boys		Girls			
	M	SD	*M*	SD	*M*	SD	*t*	*p*
Mean age (years)	5.9	0.42	5.9	0.4	5.9	0.4	−0.18	0.854
Incontinence	*n*	%	*n*	%	*n*	%	χ^2	*p*
NE	92	14.8	53	16.8	32	13.1	0.15	0.218
DUI	31	5.0	16	5.0	10	4.1	0.30	0.587
FI	13	2.1	4	1.3	6	2.4	1.13	0.289
Al least one type of incontinence	105	17.1	60	19.3	37	15.2	0.17	0.211
Constipation	30	4.8	14	4.4	14	5.7	0.47	0.492
Behavioral problems	*n*	%	*n*	%	*n*	%	χ^2	*p*
SDQ total score (clinical range: cut-off ≥ 90th percentile	43	6.7	24	7.4	16	6.4	0.22	0.640
Emotional problems ≥ 90th percentile	53	8.3	25	7.8	26	10.4	1.24	0.266
Conduct problems ≥ 90th percentile	96	15.0	59	18.3	29	11.6	4.80	0.028*
Hyperactivity ≥ 90th percentile	31	4.9	21	6.5	7	2.8	4.11	0.043*
Peer problems ≥ 90th percentile	46	7.2	24	7.4	18	7.2	0.01	0.927
Prosocial behavior ≤ 10th percentile	104	16.3	58	18.0	33	13.3	2.33	0.127
Difficulties in falling asleep and/or sleeping through the night								
Sometimes (2−4×/week)	78	12.7	45	14.4	28	11.6	1.01	0.603
Regularly (5−7×/week)	139	22.7	73	23.3	56	23.1	-	-
Mean sleep duration (h)	10.7	1.0	10.7	1.0	10.7	1.0	−0.41	0.681
CSHQ-scales	*M*	SD	*M*	SD	*M*	SD	*t*	*p*
Bedtime resistance	9.5	4.1	9.4	4.1	9.6	4.0	−0.56	0.547
Sleep onset delay	2.4	0.8	2.4	0.8	2.4	0.8	−0.54	0.591
Night wakings	4.7	2.2	4.7	2.2	4.7	2.2	0.036	0.720
Parasomnias	8.8	4.2	8.8	4.3	8.7	4.1	0.53	0.598
CSHQ-total raw score	26.7	11.8	26.9	12.0	26.8	11.5	0.16	0.876

Abbreviations: CSHQ, Children's Sleep Habits Questionnaire; DUI, Daytime urinary incontinence; FI, Fecal incontinence; NE, Nocturnal enuresis; SDQ, Strengths and Difficulties Questionnaire.

Note: We did not perform list-wise exclusion in case of any missing data. Therefore, subsamples of boys and girls do not sum up to total sample size. Missing sex information in 63 from a total of 638 included cases.

*Significant at $p \leq 0.05$.

Nonetheless, 3.7% consider the sleeping behavior as severely stressing and 1.1% as very severely stressing.

Table 3 provides comparisons for clinically significant psychological problems across children with different incontinence problems. Compared to children without incontinence, children with DUI showed clinically relevant SDQ-total and hyperactivity problems more frequently. Children with FI had clinically relevant SDQ-total, hyperactivity and peer problems more often and displayed prosocial behavior less often (Table 4).

Table 4 shows results of the nonparametric *U* tests. Children with NE showed significantly lower scores for

"night waking" and children with constipation lower scores for "parasomnias" when compared with continent children. All remaining comparisons regarding NE, DUI, FI, and constipation were not significant. The mean sleep duration did not differ across children with incontinence/constipation or without. When asking parents if their child has difficulties with falling asleep or sleeping through there were no significant frequency distributions across children with incontinence/constipation or without.

Table 5 depicts comparisons of CSHQ scores between children within the normal versus clinical range of

TABLE 2 Frequencies of sleep-related characteristics from the Children's Sleep Habits Questionnaire (CSHQ) and other items

	Rarely (≤ 1×/week)		Sometimes (2−4×/week)		Regularly (5−7×/week)	
	n	*%*	*n*	*%*	*n*	*%*
Child has difficulties with falling asleep/sleeping through	396	64.6	78	12.7	139	22.7
Child goes to bed at the same time at night[a]	135	21.3	58	9.2	440	69.5
Child falls asleep within 20 min after going to bed[a]	125	20.0	107	17.1	392	62.8
Child falls asleep alone in own bed[a]	184	29.3	68	10.8	376	59.9
Child falls asleep in parent's or sibling's bed[a]	362	60.4	86	14.4	151	25.2
Child falls asleep with rocking or rhythmic movements	435	75.9	12	2.1	126	22.0
Child needs special object to fall asleep (doll, special blanket, stuffed animal, etc.)	302	49.3	88	14.4	223	36.4
Child needs parent in the room to fall asleep[a]	351	58.7	74	12.4	173	28.9
Child resists going to bed at bedtime	347	58.0	139	23.2	112	18.7
Child is afraid of sleeping in the dark alone	325	54.5	110	18.5	160	26.8
Child sleeps about the same amount each day[a]	155	24.8	110	6.1	160	69.1
Child talks while sleeping[a]	358	59.0	148	24.4	101	16.6
Child is restless and moves a lot during sleep[a]	313	51.9	180	29.9	110	18.2
Child sleepwalks during the night[a]	437	75.7	16	2.8	124	21.5
Child moves to someone else's bed during the night (parent, sibling, etc.)[a]	320	54.3	127	21.6	142	24.1
Child awakens during the night and is sweating, screaming, and inconsolable[a]	444	76.0	15	2.6	125	21.4
Child awakens during the night by a scary dream[a]	417	70.2	61	10.3	116	19.5
Child grinds teeth during sleep[a]	363	61.6	110	18.7	116	19.7
Child snores loudly[a]	383	64.5	103	17.3	108	18.2
Child wakes up once during the night[a]	316	52.4	153	25.4	134	22.2
Child wakes up more than once during the night[a]	430	74.1	32	5.5	118	20.3
Child wakes up by him/herself[a]	128	20.5	239	38.2	258	41.3
Child wakes up very early in the morning	313	51.5	156	25.7	139	22.9
Child seems tired during the daytime[a]	397	66.9	91	15.3	105	17.7
Child naps during the day	423	72.6	39	6.7	121	20.8
Child falls asleep while involved in activities[a]	431	78.1	1	0.2	120	21.7

[a]Original questions from CSHQ.

psychological problems. Especially hyperactivity, emotional, and conduct had significant influence on bedtime resistance and total CSHQ score, hyperactivity and conduct problems impact on night waking and parasomnias. Sleep onset delay was not associated with any type of behavioral problems, while clinically low prosocial behavior was associated with total sleep problems.

When asking parents if their child has difficulties with falling asleep or sleeping through (sometimes/usually), 11.1% had clinically relevant total SDQ scores, 12.5% emotional problems, 22.2% conduct problems, 11.1% hyperactivity, 9.7% peer problems, and 20.8%

showed significantly low prosocial behavior (not shown in table). Simultaneously, 57.1% of children with clinically relevant total SDQ (χ^2 (1) = 9.26, p = 0.002), 50.9% with emotional problems (χ^2 (1) = 6.07, p = 0.014), 50.5% with conduct problems (χ^2 (1) = 11.06, p = 0.001), 77.4% with hyperactivity (χ^2 (1) = 25.12, p < 0.001), and 45.5% with low prosocial behavior (χ^2 (1) = 5.09, p = 0.024) had sleeping difficulties. Comparisons for peer problems remained insignificant (not shown in tables).

As shown in the previous sections, the comparatively small subsample sizes for children affected by both

TABLE 3 Clinically significant psychological problems across children with different incontinence problems in comparison to continent children

	No incontinence (n = 508)		Any incontinence (n = 105)			NE (n = 92)			DUI (n = 31)			FI (n = 13)			Constipation (n = 30)		
	n	**%**	**n**	**%**	**p**	**n**	**%**	**p**	**n**	**%**	**p**	**n**	**%**	**p**	**n**	**%**	**p**
SDQ total score	31	6.1	9	8.6	n.s.	6	6.5	n.s.	5	16.1	**0.045**	3	23.1	**0.048**	3	10.0	n.s.
Emotional problems	39	7.7	10	9.5	n.s.	8	8.7	n.s.	4	12.9	n.s.	2	15.4	n.s.	2	8.3	n.s.
Conduct problems	77	15.2	12	11.5	n.s.	10	11.0	n.s.	6	20.0	n.s.	1	8.3	n.s.	6	0.0	n.s.
Hyperactivity	21	4.1	9	8.6	n.s.	7	11.0	n.s.	6	19.4	**0.002**	3	23.1	**0.023**	3	10.0	n.s.
Peer problems	38	7.5	6	5.8	n.s.	5	5.5	n.s.	3	10.0	n.s.	3	25.0	**0.044**	1	3.3	n.s.
Prosocial behavior	82	16.1	19	18.3	n.s.	16	17.6	n.s.	7	23.3	n.s.	5	41.7	**0.034**	1	3.3	n.s.

Note: SDQ-values above the 90th percentile are considered as clinically significant. Significant results ($p < 0.05$) are printed in bold. Absolute and relative frequencies and *p*-values of each column reflect dichotomous group comparisons for a given incontinence condition.

Abbreviations: DUI, daytime urinary incontinence; FI, fecal incontinence; n.s., nonsignificant; NE, Nocturnal enuresis; SDQ, Strengths and Difficulties Questionnaire.

incontinence and clinically relevant psychological problems did not allow further inferential analyses. Nonetheless, the one-dimensional non-parametric analyses indicate that NE and constipation are associated with significantly fewer night-wakings and parasomnias, respectively (Table 4). Further, conduct problems and hyperactivity are associated with night wakings and parasomnias. Therefore, Figures 1–4 were chosen to depict the associations between NE, constipation, sleep, and behavior descriptively. The figures show that more children with NE and constipation with conduct problems (Figure 1) or hyperactivity (Figure 2) have night wakings. In analogy, more children with NE or constipation and conduct problems (Figure 3) or hyperactivity (Figure 4) have parasomnias.

4 | DISCUSSION

This is the first study to analyze the associations between incontinence, behavioral and sleep problems in pre-school children. These young children had high rates of incontinence, only slightly higher than other population-based studies of comparable design and age-group.[19] Possibly, parents were more open to respond to questions regarding incontinence when also asked about sleep problems, which are stressful for some parents.

The rate of total behavioral problems was lower than the norm values of 10%.[19] This low rate might be due to parental apprehension to address psychological problems during the school-entry examination, as they may fear that this could have an influence on recommendations on the type of schooling. Again, this trend has been apparent in other studies attached to the school-entry appraisal by community pediatricians.[19] However, parents did report both higher rates of conduct problems and of prosocial behavior than would be expected (again, 10% would reflect norm values at a cut-off at the 90th percentile). In addition, children with DUI and FI had more behavioral problems, which is in congruence with many other studies showing that children with NE are least affected by psychological symptoms compared to other types of incontinence.[20]

Sleep problems were also very common among young children, as reported in the review of Ophoff et al.[1] 22.7% of parents reported either sleep-onset and/or night-waking problems regularly, comparable to the 15% to 30% in other studies.[1] In addition, the duration of sleep of 10.7 h was comparable to the rates of 10−13 h in other studies.

The children of this study had higher rates of sleep-associated problems than reported by Owens et al.[11] However, the reference sample was older and had a mean age of 7.6 years. A wide range of different problems

TABLE 4 CSHQ scores of children with different incontinence problems compared to continent children

CSHQ-scores	Any incontinence (n = 105)		NE (n = 92)		DUI (n = 31)		FI (n = 13)		Constipation (n = 30)	
	Z	p	Z	p	Z	p	Z	p	Z	p
Bedtime resistance	−0.12	n.s.	−0.61	n.s.	−0.51	n.s.	−0.29	n.s.	−0.92	n.s.
Sleep onset delay	−0.69	n.s.	−0.15	n.s.	−1.64	n.s.	−0.10	n.s.	−1.38	n.s.
Night wakings	−1.58	n.s.	**−2.01**	**0.044**	−0.12	n.s.	−0.44	n.s.	−1.38	n.s.
Parasomnias	−1.30	n.s.	−1.51	n.s.	−1.37	n.s.	−1.02	n.s.	**−2.56**	**0.010**
Total raw score	−0.62	n.s.	−1.19	n.s.	−0.74	n.s.	−0.05	n.s.	−0.55	n.s.

Note: Due to large differences in subsample sizes, we conducted non-parametric U tests for dichotomous incontinence conditions. Significant results ($p < 0.05$) are printed in bold.

Abbreviations: CSHQ, Children's Sleep Habits Questionnaire; DUI, daytime urinary incontinence; FI, fecal incontinence; n.s., nonsignificant; NE, Nocturnal enuresis.

TABLE 5 CSHQ scores of children with psychological problems in the clinical range compared to children without clinically relevant pychological problems

CSHQ-scores	Total Problems		Emotional Problems		Conduct problems		Hyperactivity		Peer problems		Prosocial behavior	
	Z	p	Z	p	Z	p	Z	p	Z	p	Z	p
Bedtime resistance	**−2.51**	**0.012***	**−3.14**	**0.002****	**−2.66**	**0.008****	**−3.07**	**0.002****	−1.83	n.s.	−0.90	n.s.
Sleep onset delay	−0.06	n.s.	−0.11	n.s.	−1.20	n.s.	−1.59	n.s.	−0.66	n.s.	−1.93	n.s.
Night wakings	−0.50	n.s.	−0.57	n.s.	**−2.04**	**0.041***	**−2.83**	**0.005****	−1.61	n.s.	−0.87	n.s.
Parasomnias	−0.90	n.s.	−1.66	n.s.	**−2.20**	**0.028***	**−3.59**	**<0.001*****	−1.32	n.s.	−1.00	n.s.
Total raw score	**−2.47**	**0.014***	**−3.16**	**0.002****	**−3.20**	**0.001****	**−4.29**	**<0.001*****	**−2.60**	**0.009****	−0.88	n.s.

Note: Due to large differences in subsample sizes, we conducted non-parametric U tests for dichotomous SDQ range. SDQ-values above the 90th percentile are considered as clinically significant.
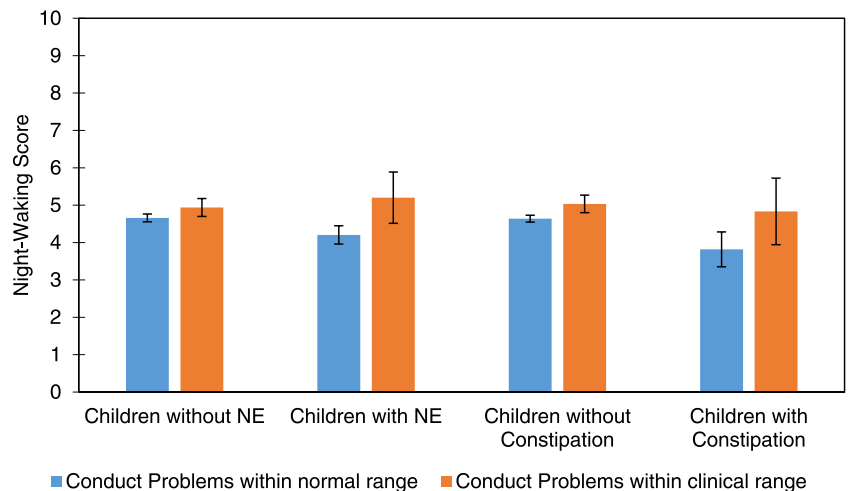
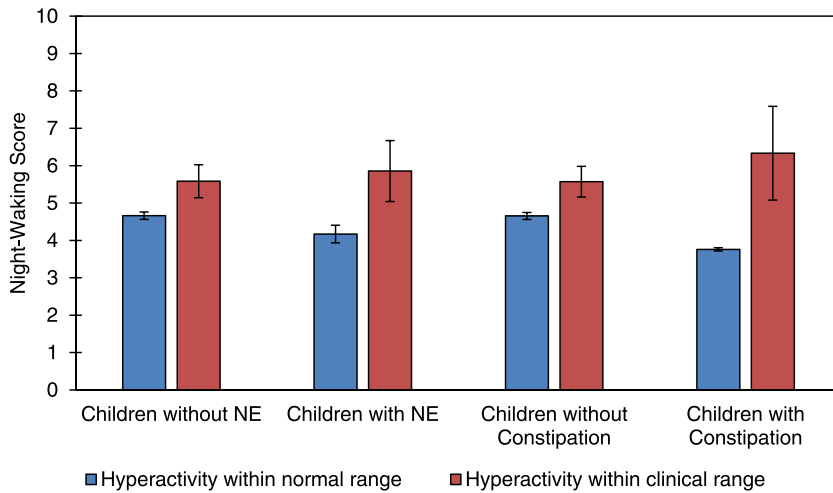Abbreviations: CSHQ, Children's Sleep Habits Questionnaire; n.s., nonsignificant.

*Significant at $p \leq 0.05$

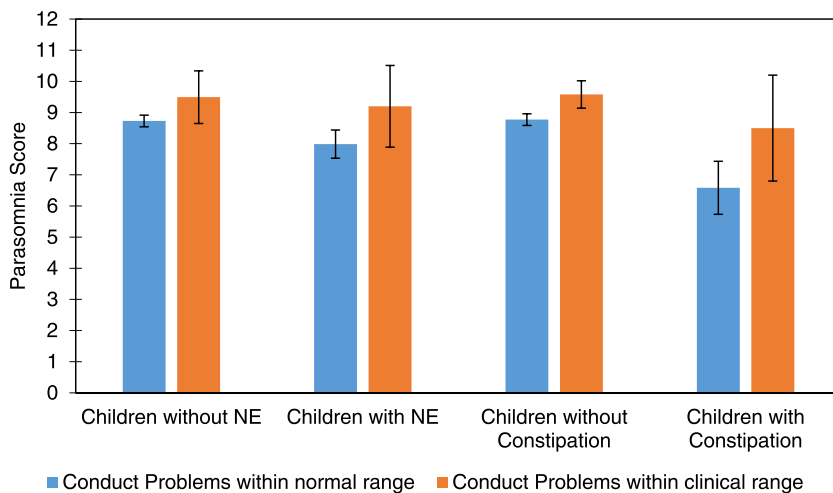**Significant at $p \leq 0.01$.

***Significant at $p < 0.001$; Significant results ($p < 0.05$) are printed in bold.

FIGURE 1 Impact of NE/constipation and conduct problems on night waking. Error bars are SEM. NE, nocturnal enuresis
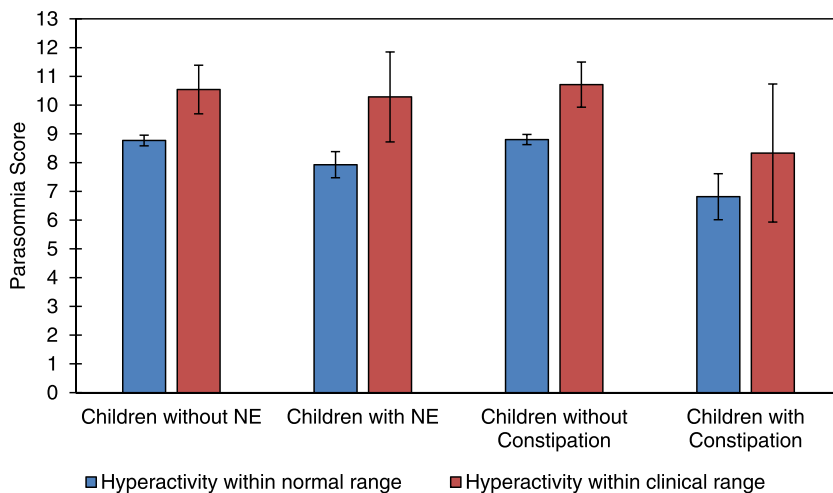
FIGURE 2 Impact of NE/constipation and hyperactivity on night-waking. Error bars are SEM. NE, nocturnal enuresis

FIGURE 3 Impact of NE/constipation and conduct problems on parasomnias. Error bars are SEM. NE, nocturnal enuresis

FIGURE 4 Impact of NE/constipation and hyperactivity on parasomnias. Error bars are SEM. NE, nocturnal enuresis

occurred, ranging from sleep resistance, co-sleeping, nightmares, snoring, and daytime sleepiness.[9] One has to take into account that these are parent-reported symptoms, not professionally and objectively diagnosed disorders.

Contrary to expectation, most children with incontinence were not affected more by sleep problems than their continent peers. Children with NE had fewer night wakings, that is, they seem have a higher arousal threshold in general. Even though parents view their

children as "deep sleepers," who are more difficult to arouse, newer studies have shown that sleep fragmentation and wakings are not uncommon.[2,3,5,6,21] These subtle aspects of sleep such as transient arousals and PLMS can only be measured by objective measures such as polysomnography and would be overlooked by some parents.[2,3]

In addition, children with constipation were less affected by parasomnias. On the one hand, this might be due to the fact that constipation was assessed by two items only due to the constraints of the school-entry examination. The reliable gold standard would have been the Rome-IV definitions, which would have required many additional items and would not have been feasible in a population-based study.[22] As the enteric nervous system and the central nervous system are closely associated in functional gastrointestinal disorders, one would have expected even more sleep problems in children with FI and constipation, as other studies have shown.[22] A lack of a regular sleeping routine at the age of 3 ½ years was associated with constipation and FI in later childhood in a large representative study.[7] Typical sleep problems in toddler age included no regular sleep routine, refusal to go to bed, difficulty going to sleep, nightmares, getting up after being put to bed and waking up in the night. In another study, reduced sleep of under 7 h was one of four factors significantly associated with childhood constipation in a study from Hong Kong.[23] In adults, sleep disorders may worsen the physical- and mental health of patients with chronic constipation.[24] Sleep disturbance can lower the quality of life in adults with constipation indirectly through the combined effects of anxiety, depression, and constipation.

Sleep and psychological problems were significantly associated. A systematic review showed that length of sleep is inversely associated with externalizing problems such as aggressiveness and conduct problems, attention and hyperactivity problems, but also anxious, depressed and other emotional problems with a great heterogeneity of results.[10] Our study demonstrated that psychological problems are associated with core sleep problems, not just the length of sleep. Taking the associations of sleep, incontinence and behavioral together, the study suggests that psychological problems have a greater impact compared to incontinence/constipation on sleep quality.

Unfortunately, questions of causality cannot be answered by the cross-sectional design of this study. What one can deduct from the study is that behavioral and sleep problems are more closely associated than incontinence and sleep problems. Both directions of causality are possible: some sleep problems have an effect on behavior while behavioral problems can certainly affect

sleep quality. For example, Joinson at al. show that sleep problems precede later constipation and FI.[7] On the other hand, the systematic review of Reynaud et al. shows that sleep problems seem to affect behavior in children.[10]

A major strength of this study is that it is representative due to the population-based design. The focus on preschool children before school entry is another asset, as this age group has been neglected in research. Also, standardized criteria were used both for the assessment of sleep and behavior problems, as well as incontinence. Finally, the study provides data on DUI and FI, not just on NE as in most previous studies.

One limitation is the participation rate of 55%, which is probably due to the voluntary participation of parents in this study. Another limitation is the cross-sectional design, which does not allow causal conclusions, only associations. Longitudinal studies would be needed to elucidate causal associations. Despite the large number of participants, subgroups of children (e.g., with incontinence, sleep and behavioral problems) were too small to allow inferential analyses. In addition, constipation was assessed by two questions only and not according to the Rome-IV criteria.[22] In addition, all items were assessed by parental questionnaires only and not by clinical examination of the child.

A major limitation is that that this study concentrated on a few types of sleep problems, which can be measured with the CSHQ questionnaire ("bedtime resistance," "sleep onset delay," "night wakings," and "parasomnias"). These sleep problems are distinct, but can coexist as comorbid problems. Due to the large number of variables analyzed in this study, we did not analyze comorbidity separately, that is, how many children were affected by more than one sleep problem. We also did not administer the full CSHQ due to time restraints. Future studies with large sample sizes and clinical assessments are needed to clarify the associations of sleep, comorbid sleep problems, behavioral problems and incontinence in more detail.

5 | CONCLUSIONS

The study showed high rates of incontinence, sleep, and behavioral disorders among preschool children. Young children did not per se have more sleep problems than continent children–those with NE and constipation had even fewer-associated abnormalities. As these factors interact in a complex way, it is recommended to assess all children with incontinence for concomitant psychological and sleep problems.

CONFLICT OF INTERESTS

Conflicts of interests forms have been submitted.

ETHICS STATEMENTS

The study was approved by the local ethics committee. Parents of children participated following informed consent.

AUTHOR CONTRIBUTIONS

Alexander von Gontard wrote the paper; Hannah Mattheus conducted the statistical analyses; the study was designed and supervised by Justine Hussong, Jana Friese-Jaworsky and Alexander von Gontard; data was collected by Jana Friese-Jaworsky, Anna-Michaela Moritz and Sigrid Thome-Granz; Sylvia Roozen and Leopold Curfs revised the paper, contributed towards the methodology and towards aspects of sleep research; Gommert van Koeveringe revised the paper and contributed towards urological research aspects

DATA AVAILABILITY STATEMENT

Data available on request from the authors.

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