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Examining sleep hygiene factors and sleep in young children with and without autism spectrum disorder

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ABSTRACT

Objective/background: Sleep problems are common in young children, especially young children with autism spectrum disorder (ASD). Sleep hygiene is a set of practices, which promote good sleep. However, other than bedtime routines and schedules, sleep hygiene is not often examined in this age group, or in ASD. The aim of this study was to examine sleep problems in young children with and without ASD and their relationship to sleep hygiene practices.
Participants: Parents (N = 101) of young children aged 2–5 years (M = 47.5 mths, SD = 1.3) were surveyed. Children included 28 with ASD, 2 with global developmental delay, and 71 who were typically developing.
Methods: A survey of sleep and sleep hygiene practices and the Children's Sleep Habits Questionnaire (CSHQ) examined via parent-report sleep problems and their relationship with thermal comfort, screen time, and diet.
Results: More than half of all children (55.4%; 78.6% of children with ASD) had a sleep problem. Children with ASD and a sleep problem slept fewer hours than other children, but they did not differ on their CSHQ score. Areas of sleep hygiene associated with poorer sleep for children with and without ASD included thermal comfort factors and screen usage.
Conclusions: These results suggest that too much screen time may be related to sleep problems for young children with and without ASD. Parents also may need advice about maintaining appropriate thermal comfort for their sleeping child. Although these findings provide preliminary relationships and require replication and specific intervention recommendations, these results are particularly important for children with ASD who are at high risk for poor sleep.

1. Introduction

Problematic sleep in children presents a common problem for parents and their child. Parents of over 3000 children aged up to 3-years reported 29% of children had a sleep problem (Armstrong, Quinn, & Dadds, 1994) and moderate to severe sleep problems were reported in 13.5% of over 4000 pre-school aged children (Hiscock, Canterford, Ukoumunne, & Wake, 2007). For children diagnosed with autism spectrum disorder (ASD), up to 80% have a parent-reported sleep problem (Herrmann, 2016; Richdale & Schreck, 2009), with their sleep differing from that of other children from around 30 months (Humphreys et al., 2014). Thus, parents require information about practices that can promote the development and maintenance of good sleep in their child.

One recommended practice for improving sleep involves modifying children's sleep hygiene, a set of behaviours and activities that

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help to promote good sleep habits and improve sleep quality (Owens, Spirito, & McGuinn, 2000). Sleep hygiene is particularly important consideration when addressing sleep in children with a developmental disability (Jan et al., 2008) and incorporates both child and parent sleep-related behaviours centring on the child's sleep environment, daily activities, and bedtime practices (Mindell, Meltzer, Carskadon, & Chervin, 2009). In addition to schedules and bedtime routines, sleep hygiene factors include food intake, caffeine, environmental noise, light exposure, exercise, television and electronic media use, and temperature (thermal comfort). Nevertheless, little research evidence exists to support many recommended sleep hygiene practices (Jan et al., 2008; Stepanski & Wyatt, 2003). Mindell et al. (2009) noted that while evidence existed for bedtime routines, more evidence was required for the influence of food intake (e.g., caffeine), screen time (e.g., television), and other sleep hygiene factors (e.g., bedroom environment) on children's sleep.

The examination of the role of diet on children's sleep has primarily involved obesity risk (Hart, Hawley, Kuhl, & Jelalian, 2013), but meal timing, regularity, composition (protein, carbohydrates, fats), and macronutrients and vitamins can impact children's sleep (Jan et al., 2008; Peuhkuri, Sihvola, & Korpela, 2008; Stepanski & Wyatt, 2003). Hunger at bedtime may be detrimental to sleep and a light carbohydrate snack or drink may alleviate this (Jan et al., 2008; Stepanski & Wyatt, 2003), but large meals within 2-hours of bedtime are not recommended (Gruber, Constantin, Cassoff, & Michaelsen, 2013; Jan et al., 2008). High-energy intake at the evening meal, particularly high GI carbohydrates, has been associated with longer sleep in toddlers (Diethelm, Remer, Jilani, Kunz, & Buyken, 2011), while both decreased energy intake during late afternoon to early evening, and increased night energy intake (7 pm −6 am), particularly from milk, were associated with reduced total sleep (McDonald et al., 2015). Children also should not consume caffeine (Gruber et al., 2013; Jan et al., 2008) as late day consumption can increase bedtime alertness and may cause insomnia, reduced sleep quality, and increased daytime sleep (Bootzen, Cousins, Kelly, & Stevens, 2013; Pollak & Bright, 2003). Even one caffeinated drink per day may reduce night sleep in typically developing children aged 3- to 10-years (Mindell et al., 2009). Despite these recommendations, little research has investigated influences of food and beverage consumption or meal timing on children's sleep, and it appears to be absent for children with autism who may have unusual food fads or feeding difficulties (American Psychiatric Association, 2013).

A variety of stimuli may promote wakefulness in children, including environmental noise, exercise, screen time, and thermal discomfort. Noise in the bedroom (e.g., traffic noise, sudden/loud noises) has been suggested to disrupt children's sleep (Stores, 2001) and consequently should be reduced (Gruber et al., 2013). Additionally, activity around bedtime may provide too much stimulation and disrupt sleep. Sleep hygiene recommendations routinely include reducing physical activity directly before bedtime (Gruber et al., 2013; Jan et al., 2008), but increasing physical activity during the day (Stepanski & Wyatt, 2003). A recent study suggested that daytime exercise and motor skills training improved sleep for 10 young boys with ASD (Brand, Jossen, Holsboer-Trachsler, Pühse, & Gerber, 2015)

Although some may view screen use (e.g., television, computers, etc.) as an appropriate method for reducing physical activity at bedtime, it can contribute to poor sleep quality and shortened sleep in children (Gradisar & Short, 2013). For typically developing children and adolescents, longer television viewing, and bedroom television, computer, and electronic devices create reduced sleep time, disrupted sleep quality, and increased sleep anxiety (Brockman et al., 2016; Garrison, Liekweg, & Christakis, 2011; Li et al., 2007; McDonald, Wardle, Llewellyn, van Jaarsveld, & Fisher, 2014; Mindell et al., 2009; Olds, Ridley, & Dollman, 2006; Taveras, Rifas-Shiman, Oken, Gunderson, & Gillman, 2008). For children with ASD, screen time also results in poor sleep patterns. From middle childhood to adolescence, children with ASD experience longer sleep onset latency (SoL), shortened sleep times, and general sleep disruptions when exposed to bedroom screen time, playing video games, and violent media material (Englehardt, Mazurek, & Sohl, 2013; Mazurek, EngelHardt, Hilgard, & Sohl, 2016). Both the content of screen time and the light exposure to viewing screens at night may contribute to the reported disruptions in sleep and increased alertness (Akacem, Wright, & LeBourgeois, 2016; Chang, Aeschbach, Duffy, & Czeisler, 2015; LeGates, Fernandez, & Hattar, 2014). While, evidence indicates that screens should be avoided in the evening and in the bedroom, less is known about younger children, particularly younger children with ASD.

In addition to food intake and screen time, thermal comfort may impact sleep due to its ability to affect core body temperature (Liu, Song, Wang, Wang, & Liu, 2014). Sleep propensity is highest near the core body temperature minimum and an increase in core body temperature may inhibit sleep, while a decrease promotes sleep (Lushington, Pamula, Martin, & Kennedy, 2013). Core body temperature reduction occurs via heat loss through the skin, thus skin temperature (Tsk) increases at sleep onset (Okamoto-Mizuno & Mizuno, 2012). In particular, warm feet (distal Tsk) promote sleep onset (Kräuchi, Cajochen, Werth, & Wirz-Justice, 1999), and proximal (trunk) Tsk promotes deeper sleep during the night in adults (Raymann, Swaab, & Van Someren, 2008). Distal heat loss is associated with SoL in adults (Kräuchi et al., 1999) and in infants (Abe & Kodama, 2014). In preschool children proximal Tsk was shown as important for heat dissipation and sleep maintenance (Okamoto-Mizuno, Mizuno, & Shirakawa, 2018). Room temperature, bedcovers, and sleepwear contribute to heat maintenance and loss and thus optimal thermal comfort for promoting sleep. Fibre type, fibre blends, and fabric construction of bedcovers and sleepwear can provide differing thermal resistance (insulation). Therefore, bedcovers and sleepwear may differentially affect sleep quality due to their effects on the bed microclimate and thermal regulation (Li & Lian, 2016). While bedrooms are recommended to be cool (Gruber et al., 2013), the relationship between thermal comfort and children's sleep appears virtually unexplored; thermal comfort may be particularly relevant to children with ASD who may have reduced sensitivity to heat or cold (American Psychiatric Association, 2013; Duerden et al., 2015).

Thus, while sleep hygiene recommendations that may promote or inhibit children's sleep exist, other than bedtime routines and schedules, most remain under-studied or unexplored in early childhood, particularly in children with ASD who have a high incidence of sleep problems. The aim of this study was to conduct a preliminary survey of a range of typical, but largely under-researched sleep-hygiene factors and their relationships with child sleep quality in children aged 2–5 years, with and without ASD. We expected that sleep problems would be more frequent in the children with ASD and that they would sleep less (Richdale & Schreck, 2009), but that

their sleep problem severity as measured by the Children's Sleep Habits Questionnaire (CSHQ) would be similar to the non-ASD children (Goodlin-Jones, Sitnick, Tang, Liu, & Anders, 2008, b). Based on anecdotally reported effects or recommendations for sleep hygiene practices, we hypothesised that this preliminary research would support poor thermal comfort, diet (composition, timing) and increased screen time, would be associated with poorer sleep (parent reported sleep problem, sleep problem severity, total night sleep) in both groups of children.

2. Method

2.1. Participants

Participants were caregivers of children aged 2- to 5-years; 204 caregivers of children attending a university community children's centre catering to children from infancy to pre-school age and 68 caregivers of similar age children, registered with a research centre participant registry were invited to participate. In total, 100 families (36.8%) returned 105 surveys, with 101 usable surveys (63 boys, 34 girls, 4 unknown), including five sibling pairs.

Most children had no parent-reported developmental delay (NDD: 70.3%), 2% ($n = 2$) had global developmental delay (GDD) and 27.7% had ASD. ASD diagnosis was confirmed via the ADOS for children at the community centre ($n = 22$) and by parent-report for those from the participant registry ($n = 6$). Overall, the children's mean age was 47.5 months ($SD = 1.3$ mths). The ASD group ($M_{age} = 52.22$ months, $SD = 13.29$) was older than the NDD group ($M_{age} = 45.58$ months, $SD = 12.47$), $t\ (92) = 2.29$, $p = .02$, $\eta^2 = .06$, and one child with ASD was 77 months. No differences in the expected ratios of boys to girls were found for either group (NDD group expected 1:1 ratio, $\chi^2\ (1) = 2.88$, $p = .09$; ASD group expected 4:1 ratio, $\chi^2\ (1) = .08$, $p = .77$).

A variety of medical conditions were reported. These were asthma ($n = 5$), visual impairment ($n = 4$), poor muscle tone ($n = 3$), allergies ($n = 2$), eczema ($n = 2$), hearing impairment ($n = 1$), aching legs at night ($n = 1$), anaphylaxis ($n = 1$), pigeon chest ($n = 1$), Turner's syndrome ($n = 1$), physical disability with hands and arms ($n = 1$) and Short Stature syndrome ($n = 1$). While a higher proportion of children with ASD (34.1%) had a medical condition than children without ASD (10.1%), Fishers exact, $p = .011$, $V = .29$, having a medical condition was not associated with reporting a sleep problem or CSHQ total score. Additionally, in the ASD group, one child had a comorbid developmental delay, one had comorbid GDD, one had comorbid language disorder and developmental delay, and one had comorbid GDD and attention difficulties. Six children, three in each group, took regular medication including two children with ASD taking melatonin for sleep.

2.1.1. Family demographics

Primary caregivers were mostly mothers (91%). Similar to 2011 Australian Census data, most primary caregivers were born in Australia (72%) and three caregivers were Aboriginal/Torres Straight Islanders (3.1%). Most caregivers had a university education (27.7% undergraduate; 55.8% post-graduate) and were professionals (48.3%) working part-time (35.5% part-time; 20.4% full-time). Approximately 1/3 were not employed (35.5%). Most children (90.9%) lived with both parents who were married or in a de facto relationship (91.3%). Household incomes mostly exceeded $100,000 per year for 53.7% of families with 20.4% of families earning > $150,000 per year.

2.2. Materials & design

This was a survey study which included questions about demographics, sleep hygiene practices, and children's sleep quality. Demographics included the child's date of birth, sex, medical conditions, medications, number of siblings, and information about developmental disability. The primary caregiver's relationship to the child, education, employment, country of birth and ethnic background, main language spoken at home, caregivers' relationship status, child's living arrangements, and total yearly family income were requested.

We were aware of only one published scale examining sleep hygiene (Malow et al., 2009), which gave only a total sleep hygiene score, and did not cover the full range of practices, sleeping and daytime habits and behaviours to be examined here. Thus a survey was developed for children from a related, unpublished, adult survey (University of Sydney), which was developed based on National Sleep Foundation Sleep in America polls. The questionnaire had four sections: (1) Thermal Sleep Environment description, (2) Diet habits, (3) Sleep problems, and (4) Other sleep hygiene factors. Thermal sleep environment items (n = 16) included the child's typical bedding (i.e., sheets, fibre type of covers usually used), sleep wear (i.e., fibre type usually worn) and sleep environment (i.e., room heating and cooling; warmth while sleeping). Parents responded to questions about their typical use of these options (e.g., open/close windows, bedding and sleepwear fibre composition) as Yes, No, or Unsure. Parents also responded to (a) the number of times (i.e., seldom, 1–2 / week, $\geq$ 3 / week) in the winter months children used extra stimuli to keep warm (e.g., hot water bottle, hat, socks, etc.) and (b) if the child was too cold or hot at night (n = 5 items). Questions were asked for warm-hot/cool-cold weather or summer/winter.

Diet items included parental report of typical meal patterns and foods eaten, such as (a) type of food consumed at meals (e.g., meat, fish, vegetable, other); (b) meal timing (i.e., immediately before bedtime, < 1 h, < 2 h, < 3 h before bed); (c) drink types (i.e., water, milk, juice, carbonated drink, cordial, chocolate); and (d) drink timing and amounts (i.e., after 6 pm, bedtime, number of days per week).

"Other" sleep hygiene factors included questions about medications, vitamin supplements, special diets, playtime, and screen time (television / electronic devices). Parents responded yes / no to their child using sleep medications and for eating special diets, and if

'yes' specified what was used. Use of supplements included calcium, iron, multivitamins, omega-3, probiotics, vitamin, and 'other'. Parents reported the number of minutes per day the child engaged in outside playing, watching television, and other electronic media use (computer/tablet, mobile device) and 'other' activities as determined by the parent.

Parents also were asked if their child had a sleep problem (yes / no) in the past month. Those answering "yes" completed eight further items. They responded "yes" or "no" and/or the number of times per week their child experienced trouble falling asleep, waking up at night, regular sleeping hours, daytime naps (including time of day and length of time) and early morning waking. Parents reported time taken to fall asleep at night (0–10 min, 11–20 min, 21–30 min, 31–60 min, > 60 min), how many hours their child slept per night, and if their child had regular sleeping hours. Factors that could disrupt their child's sleep (i.e., toilet use, bedwetting, noise, light/sunlight, growing pains, snoring, heat, cold, funny feelings in legs, leg movements, restless/fidgety, bad dreams/nightmares, difficulty getting back to sleep, woken by pets) were evaluated on a 4-point scale (not past month, not past week, 1–2 / week, $\geq$ 3 /week).

Children's sleep problems were examined using the Children's Sleep Habits Questionnaire (CSHQ: Owens et al., 2000). This parent-report questionnaire evaluated the frequency of child sleep behaviours on a 3-point scale (1–3), with 33 questions contributing to a total score (score > 41 indicative of problematic sleep); and total daily hours slept. The CSHQ total score has adequate internal consistency in a clinical sample (α = .78) and test-retest reliability in a community sample of 4–10 year old children (Owens et al., 2000), and is reported as clinically valid with 2–5 year old children, typically developing children, and children with developmental delay and ASD (Goodlin-Jones, Sitnick et al., 2008, b). Chronbach's α = .84 for the CSHQ total score for the current sample.

2.3. Procedure

Following university ethics approval, the childcare Director distributed surveys and participant information statements (PIS) to families of children aged 2 to 5 years attending the children's centre. The child's primary caregiver completed and returned the anonymous survey (demographics, sleep hygiene and CSHQ) via the centre in a sealed envelope. Families from the participant registry were emailed and those expressing interest were posted the survey and PIS, including a pre-addressed, return postage-paid envelope. Surveys were distributed and returned between mid-October and the first 2-weeks of December (mid- to late-Spring), and weather conditions may fluctuate considerably. Consent was implied by survey return. Those returning the survey could nominate for a prize draw (1x$250 gift voucher or 10x$50 gift vouchers); entries were returned in separate, sealed envelopes in the same way as surveys.

A reminder poster for caregivers was placed at the children's centre entrance and the Director sent out a reminder email to all families. A research assistant sent a reminder email to families on the participant registry. Two weeks later a second email reminder with a short extension for return for the prize draw entry also was sent to families; 95.8% of families entered the prize draw.

2.4. Analysis

For data analysis, questions answered 'unsure' on the Sleeping and Daytime Habits and Behaviours Questionnaire were removed from analyses. To indicate where these data were omitted or items were not answered sample size is reported for questionnaire item responses. Analyses examining relationships between sleep variables and sleep hygiene survey questions (e.g., thermal comfort, diet, screen time) were conducted first for all children. Sleep variables were parent report of a sleep problem (1 = Yes, 2 = No; sleep hygiene survey), sleep problem severity (CSHQ total score) and total hours slept (CSHQ). Comparisons were then made between the ASD children and the children with no developmental delay (NDD); as poor sleep is common in children with GDD (Goodlin-Jones, Sitnick et al., 2008,b), the two children with GDD in the non-ASD group were omitted from these group comparisons. Analyses included *t*-tests, Mann-Whitney U test, ANOVA, ANCOVA, Chi-square and Pearson correlations as appropriate. Effect sizes are reported and alpha was set at .05.

3. Results

Only results for significant differences between the NDD and ASD groups were reported, otherwise the results reported refer to all children.

3.1. Sleep problems

The majority of children (55.4%) had a parent-reported sleep problem over the past month, nevertheless 88.2% of these children reportedly had regular sleeping hours. CSHQ total score (M = 46.74; SD = 8.22; N = 101) was strongly associated with a parent-reported sleep problem, r (101) = -0.53, p < .001. Comparisons of children with and without a sleep problem indicated that those with a sleep problem had a higher CSHQ score than children without a sleep problem (Table 1), t (97.87) = 6.37, p < .001, η^2 = .30. Parents of children with a sleep problem reported sleep-related factors, which disturbed their child's sleep; the most common were nightmares, trouble getting back to sleep, and restlessness (Fig. 1). Children in the ASD group (47.6%) had more difficulty getting back to sleep more frequently than the NDD group (17.1%), χ^2 (1, N = 53) = 4.57, p = .03, φ = .33.

Children with and without a sleep problem did not differ on age or sex. When CHSQ scores were examined by group, age was not significantly associated with CSHQ scores for children with ASD but it was for the NDD group, r (67) = −.25, p = .04; younger children in the NDD group tended to have higher CHSQ scores. Age also was associated with hours slept, r (96) = −.43, p < .001;

Table 1
Mean (SD) total score and hours slept reported for the CSHQ.

CSHQ Variable	Sleep Problem					
	All Children (n = 101)		NDD (n = 71)		ASD (n = 28)	
	Yes	No	Yes	No	Yes	No
Total score	50.60 (7.93)	41.94 (5.70)	49.81 (7.94)	42.15 (5.92)	50.98 (7.30)	40.11 (4.52)
Usual daily sleep (hrs)	10.48 (1.49)	10.94 (1.29)	11.14 (1.09)	10.93 (1.29)	9.51 (1.53)	10.92 (1.50)

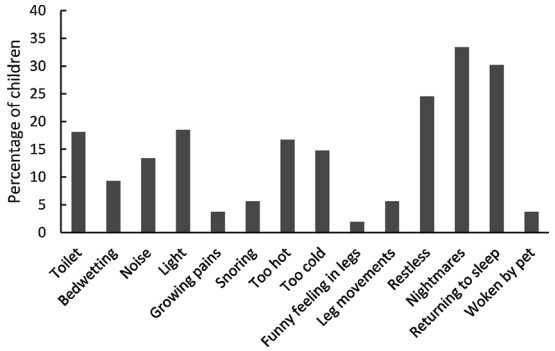

Fig. 1. Factors associated with disturbed sleep (1or more times per week) in children with a sleep problem.
Note: Due to missing data sample size varies from 52 (Noise) to 55 (Toilet).

younger children tended to have more sleep. Independent of age, boys (M = 47.15, SD = 9.10) and girls (M = 45.85, SD = 6.53) had similar CHSQ scores and similar hours slept (boys M = 10.54, SD = 1.52; girls M = 10.16, SD = 1.20).

Examining the NDD and ASD groups, more children with ASD (78.6%) had a parent-reported sleep problem than did NDD children (46.5%), χ^2 (1, N = 99) = 7.13, p = .008, φ = −.29. Comparing NDD and ASD group CSHQ scores, there was no significant CSHQ by group interaction but there was a main effect for sleep problem, F (1, 95) = 26.80, p < .001, partial η^2 = .22; children with a sleep problem had higher CSHQ scores (Table 1).

When comparing hours slept for the NDD and ASD groups, with age as a covariate, there was a significant covariate effect, F (1, 89) = 14.93, p < .001, partial η^2 = .14, and a significant group by sleep problem interaction, F (1, 89) = 4.16, p = .04, partial η^2 = .05 (Table 1). There was also a significant main effect for group, F (1, 89) = 4.14, p = .045, partial η^2 = .04, and for sleep problem, F (1, 89) = 4.93, p = .03, partial η^2 = .05. Overall, children with ASD with a sleep problem slept less than all other children.

3.2. Sleep hygiene

Parents' report of typical bedroom cooling or heating methods (e.g., open windows, air conditioners, duct heating) was not significantly associated with sleep problems (Fig. 2). However, use of electric or gas heaters was related to higher CSHQ scores (M_{heater} = 49.84, SD = 9.78; $M_{no\ heater}$ = 45.17, SD = 6.98), t (48.5) = 2.45, p = .018, η^2 = .06), suggesting warmer rooms may disturb sleep. Children were twice as likely to be reported as too hot (66%) than too cold (33%) during sleep; for about half of these

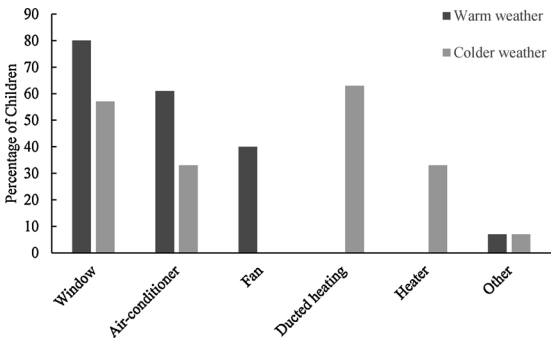

Fig. 2. Methods used by parents for room cooling and heating (N = 100).

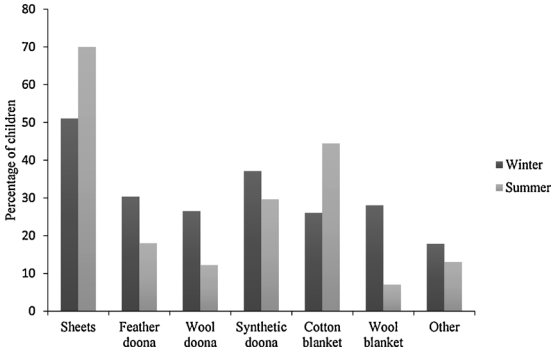

Fig. 3. Percentage of children using different bedcovers in winter and summer.
Note: Due to 1–4 parents answering "unsure" in each category, sample size varies from 97 to 100 across categories.

children this was seasonal and for most children this was not frequent or intense. Children who felt too hot had a higher score on the CSHQ than those who did not, t (98) = 2.04, p = .044, η^2 = .04). However, of the 33 children reported as feeling too cold during sleep, 75.8% had a parent-reported sleep problem, compared with 44.8% of those children not feeling too cold, χ^2 (1, N = 100) = 7.34, p = .007, φ = .29. This was supported by CHSQ scores as children who reportedly felt too cold had a higher CSHQ score than those who did not, t (98) = 2.59, p = .011, η^2 = .06. In cold weather parents also used a variety of supplemental methods to attempt to warm their children (e.g.,bedsocks = 48%; bedsocks ≥3 per week = 56.3%; warm bath before bed = 83.8%; warm bath ≥3 per week = 71.1%) but these were not related to sleep.

Sleepwear remained relatively consistent across seasons and was predominantly cotton. No significant relationship existed between types of sleepwear fibres and sleep problems when adjusted for age. However, the use of specific bedcovers related to sleep problems, except for the use of sheets. Since sheets were uniformly used across all seasons (winter = 51%; summer 71%), this variable was not examined further. Additional bedcovers used in winter included wool or cotton blanket, or feather, synthetic or wool doona, whereas in summer, cotton blankets tended to be preferred (Fig. 3). The types of bedcovers were related to reported sleep. Children who slept under a woollen blanket in winter (78.6%) had more parent-reported sleep problems compared with those sleeping under other bed covers (48%), χ^2 (1, N = 100) = 7.45, p = .006, φ = .30. However, comparison of CSHQ scores and types of bedcovers indicated that woollen doonas (i.e., duvets) in winter [t (96) = −1.75, p = .08, η^2 = .03] or summer [t (96) = −1.82, p = .07, η^2 = .03] tended to be associated with lower CSHQ scores. The seven children (all NDD group) using woollen blankets in summer had lower CSHQ total scores, t (98) = −2.68, p = .009, η^2 = .07. Children using a synthetic doona in winter slept approximately 35 min less than those who did not, t (95) = −2.06, p = .042, η^2 = .04. This difference in hours slept remained significant after adjusting for age, F (1, 90) = 7.34, p = .008, partial η^2 = .08. These children also had significantly higher sleep problems scores on the CSHQ [t (53.24) = 2.62, p = .01, η^2 = .07]. Sleeping with synthetic doonas in summer [t (96) = 1.86, p = .07, η^2 = .03] also tended to be associated with higher CSHQ scores. There were no other significant associations between parent-reported sleep problem, CSHQ scores, or hours slept and bedcovers or sleepwear.

Meal timing, meal type, drinks and supplements were not significantly related to parent-reported sleep problem, CSHQ score, or hours slept. Only 10.9% of children ate a special diet (NDD = 8.5%; ASD = 17.9%). The evening meal was usually meat-based (70.3%) and eaten within two hours before bed (one hour = 25.7%; two hours = 58.4%). The most common beverages drunk after 6 pm and at bedtime were milk (after 6 pm = 44.5%; bedtime = 31.8%) and water (after 6 pm = 39.6%; bedtime = 16.8%). The remainder of the children did not drink during these times. Drinking carbonated (3%) or chocolate beverages (4%) was unusual after 6 pm. Dietary supplements and multivitamins were not commonly used; most children (59.4%) took no dietary supplements or multivitamins. Compared with NDD children, children with ASD more frequently took iron (NDD = 1.4%; ASD = 18.5%), p = .006; Omega-3 (NDD = 8.6%; ASD = 25.3%), p = .04; Probiotic (NDD = 2.9%; ASD = 37%), p < .001; or another supplement (NDD = 2.9%; ASD = 23.1%), p = .005.

Children's playtime was not related directly to sleep problems, but screen time was. Across all children, outside play averaged 148.12 min per day (SD = 76.66), was similar for the NDD and ASD groups, and was not significantly related to sleep. Television and electronic screen time were both related to sleep problems. Television was watched by 95% of children, averaging 68.52 min per day (SD = 56.05) and was similar for both NDD and ASD groups. One NDD child spent 450 min per day watching television and was excluded from these analyses. Across all groups, television screen time was associated with higher CSHQ sleep problem scores (r (99) = .38, p < .001) and lower daily hours slept (r (99) = -.31, p = .002). These relationships remained significant across all children controlling for age, (CSHQ and watching television r (91) = .34, p = .001; hours slept and watching television, r (91) = −.27, p = .01). Examining the NDD and ASD groups, watching television was associated with increased CSHQ scores (r (69) = .38, p = .001) and fewer hours slept (r (69) = -.33, p = .005) for the NDD children, but after controlling for age only CSHQ total score remained significant, r (62) = .34, p = .007.

Electronic devices were used by 65% of all children for an average of 19.35 min per day (SD = 20.98). Time spent on electronic devices was related to higher CSHQ scores (r (100) = .24, p = .02) and fewer hours slept (r (100) = -0.43, p < .001). These relationships remained significant controlling for age (CSHQ and electronic devices, r (92) = .28, p = .007; hours slept and electronic devices, r (92) = −-.29, p = .004). Children in the ASD group spent longer per day on electronic devices (M = 30.89 min,

SD = 20.69) than NDD children (*M* = 14.64 min, *SD* = 19.64), t (96) = −3.65 $p < .001$, $\eta^2 = .12$. Comparing the NDD and ASD group showed that fewer hours slept was associated with increased time on electronic devices for both the NDD group (r (70) = −.29, p = .02) and ASD group (r (28) = −.43, p = .02), but after controlling for age there were no significant correlations remained in either group.

4. Discussion

The purpose of this paper was to survey novel areas of sleep hygiene behaviours (e.g., thermal environment, diet/meals, and screen time) and examine their relationships with sleep problems for young children aged 2- to 5-years old with and without ASD. Our results supported previous research regarding rates of sleep problems for children with and without ASD. While the majority of these 2- to 5-year-olds had a parent-reported sleep problem, the majority had regular sleeping hours. Consistent with previous research, sleep problems rose to nearly 80% for the ASD group (Herrmann, 2016; Richdale & Schreck, 2009). As also reported by Goodlin-Jones, Sitnick et al. (2008, b), children with a sleep problem had higher CSHQ scores than those without a sleep problem, but no significant difference existed between the NDD and ASD groups for sleep problems. The most common parent-reported sleep problems included nightmares, trouble getting back to sleep, and restlessness. Younger children had longer total sleep and in the NDD group sleep problems tended to be more severe in younger children. Children with ASD and a parent-reported sleep problem slept less than all other children, which is consistent with reports that children with ASD sleep less than TD children from 30 months of age (Humphreys' et al., 2014).

As hypothesised, reported thermal comfort variables related to sleep problems. Using a room heater and reported feeling of being too hot or too cold were associated with poorer sleep quality. This relationship may be due to inappropriate use of the supplemental heater, either setting heat too high based on pre-sleep comfort as opposed to overnight comfort (Li & Lian, 2016), or parents turning the heater off when they go to bed resulting in room cooling (or noise changes that could disturb the child). The type of bed coverings used by the child (e.g., wool or synthetic) also related to sleep quality with wool tending to be associated with better sleep and synthetic with poorer sleep. These relationships require further research to determine causality. However, several possible mechanisms may explain these relationships. The differences between bedcover fibres may provide differing bed microclimates, insulation, and thermal regulation (e.g., skin heat loss) during sleep (Li & Lian, 2016). If bedding or sleepwear is too insulating, the child may overheat; conversely if too much heat escapes the child may become too cold with consequent adverse sleep effects. Additionally, retailers often do not provide information concerning the insulation properties of bedcovers or sleepwear, or if they do, parents may not know how to interpret this information.

Recent research also suggests that heat loss and maintenance in children may be different from adults, and both bed climate and skin Tsk during sleep are reported as lower (Okamoto-Mizuno et al., 2018). Thus, thermal comfort recommendations for sleeping may be different for children and adults. For young children with ASD, hypo- and hyper-responsivity to sensory stimuli in the touch domain, particularly the latter, have been reported as related to poor sleep (Tzischinsky et al., 2018), and this domain includes temperature sensitivity. Additionally, adolescents with ASD are reported to have "reduced thermal sensitivity" (Duerden et al., 2015) which may impact perceptions of thermal comfort during sleep and optimal Tsk maintenance for good sleep. Overall, recommendations for appropriately warm or cool sleeping environments rarely provide specific advice for obtaining optimal thermal comfort when sleeping (Gruber et al., 2013; Jan et al., 2008; Li & Lian, 2016), no guidelines exist for comfortable bedroom temperatures during sleep (Li & Lian, 2016), and there is a lack of guidance for thermal comfort recommendations in children. Further research is clearly required to determine causal relationships among thermal comfort and sleep problems and to determine optimal thermal sleeping environments in the home for children with and without ASD.

Most children routinely ate their evening meal 2-hours before bedtime, ingested very little to no caffeine, and primarily drank milk and water. However, children also ate evening meals high in protein (meat), rather than lighter or more carbohydrate-based meals (Diethelm et al., 2011) and about a quarter ate within one hour of bedtime, which is not recommended if the meal is heavy (Gruber et al., 2013; Jan et al., 2008; Stepanski & Wyatt, 2003). Nevertheless, contrary to our expectations, no sleep associations were found with meals, drinks, or dietary supplements. This may be due to parental responses being requested for routine meal practices instead of a direct comparison of nightly meals and sleep. As evening and night-time energy consumption patterns have been reported as associated with reduced sleep in toddlers (McDonald et al., 2015), an examination of the influence of diet in young children, using a diet diary correlating with nightly sleep is indicated, especially as children with ASD often have eating difficulties or particular dietary preferences and habits (American Psychiatric Association, 2013).

Our young children, both with and without ASD, played more outside during the day, but play was not related to sleep. Almost all the children watched some television, while electronic devices were used by about 2/3 of children with the ASD group, which averaged about twice as long on electronic devices as the NDD group. As expected, increased television screen time directly related to sleep problems, which is similar to other recent reports (Brockman et al., 2016; McDonald et al., 2014). However, television viewing primarily related to the sleep of children without ASD. Overall sleep quality tended to decrease with increased use of electronic devices across all children, even after controlling for age. Evening computer and video gaming have been associated with reduced night sleep and increased SoL in older children, including those with ASD (Englehardt et al., 2013; Li et al., 2007; Mazurek et al., 2016), but as far as we are aware, children in the age range reported here have not been examined.

One explanation for the relationship between screen use and sleep problems may be the content of the television shows and electronic games. Electronic games and television shows may be arousing and may induce anxiety if they contain unsuitable themes for the child's age (Garrison & Christakis, 2012; Gradisar & Short, 2013) – a situation contraindicated for good sleep hygiene. Since this study did not examine screen time content (e.g., fearful, stimulating, etc.), it cannot be determined if the amount of screen time

versus content type interacted. An interaction could be expected as unstimulating/healthy media may improve sleep in 3- to 5-year-olds (Garrison & Christakis, 2012) and this should be considered in future research.

Although direct causation needs to be established between electronic devices and sleep problems, possible explanations for relationships between the two exist. Electronic devices (e.g., tablets, television) are often viewed close to the face, with the potential for exposure to high intensity light. This light may influence the sleep/wake rhythm by shifting the evening melatonin rise associated with sleep onset to later in the evening, increasing alertness and delaying sleep onset (LeGates et al., 2014). In pre-school children Akacem et al. (2016) reported that light exposure in the 2-hours before bed affected the timing of evening increase in melatonin (DLMO) in 4- to 5-year-old children. Melatonin is particularly sensitive to blue light (Chang et al., 2015), as are brain processes involved in attention and alertness (LeGates et al., 2014). In adults, regular reading prior to sleep using a light-emitting eReader decreased sleepiness, phase delayed sleep onset, and suppressed melatonin (Chang et al., 2015), resulting in increased SoL and decreased morning alertness; this did not occur when reading a regular book (Chang et al., 2015). The potential influence of high intensity light from electronic screens on sleep in young children requires further research, especially with the continuing rise in the use of tablet devices and televisions by children.

While the examination of the relationships of most of the sleep hygiene practices reported here was unique for young children with and without ASD, and measured sleep quality and total hours slept using a widely used and valid sleep questionnaire, the CSHQ, there are several limitations. This was a cross-sectional, parent-report survey of sleep and sleep hygiene, which although based upon the National Sleep Foundation Sleep in America polls, cannot substitute for more objective measures. Reporting will likely be influenced by seasonal temperatures, which fluctuate greatly in Melbourne. For example, the seasonal, daily minimum temperature ranged from 4.5 °C to 23 °C during data collection, and maximum daily temperature ranged from 15 °C to 36.5 °C (Australian Bureau of Meteorology). This may have influenced sleep hygiene practices and influenced parents' reports. However, the timing of the questionnaires during Melbourne's variable temperatures and spring weather also may also have allowed accurate comparisons between CSHQ and sleep hygiene questions. Nevertheless, some potential sleep-thermal environment relationships may have been missed, or over- or under-estimated. Future research should build upon the associations found in this study through replication and extension to contiguous observation of sleep behaviour and sleep hygiene variables.

As this study was a preliminary and novel examination of the existence, influence, or relationship of relatively unstudied sleep hygiene variables (i.e., thermal comfort, diet, and screen time), significant future research must be conducted. This research may include determining the relationships among these sleep hygiene variables and more commonly researched variables, such as bed time routines (Mindell et al., 2009). Additionally, by examining parenting behaviours (e.g., permissiveness for bedtime, diet, and amount of screen time) and their relationships to sleep problems and routines, sleep problem prevention and remediation may be improved. In some clinical practices, professionals report that parents may misconstrue the cause of sleep problems; thus, further research could investigate parental accuracy in attributing sleep hygiene causes of sleeping problems. The current sample also was relatively well off and largely from one children's centre, thus the results may not generalise to all children with or without ASD. Future research would require expansion of the numbers of participants in both the ASD and non-ASD groups.

5. Conclusion

This study surveyed a range of often over-looked sleep hygiene practices in young children, providing novel findings. The data showed that parents of children with and without ASD use similar sleep hygiene practices, and that these related to sleep similarly in both groups of children. Results indicated the potential importance of regulating screen time before sleep and of establishing thermal comfort during sleep. However, causal relationships remain to be established. Given the high rate of sleep problems in ASD (Herrmann, 2016), incorporating good sleep hygiene practices seem particularly important for these children; these findings have particular implications for the assessment of sleep problems and the sleep hygiene advice given to parents. Clinicians working with families require a better understanding of sleep hygiene practices, besides schedules and bedtime routines. This study provides possible sleep hygiene variables to be evaluated within clinical practice. In general, good sleep hygiene practices generally require little effort to implement and may provide a high impact intervention or adjunct to intervention for young children with sleep problems.

Statement

This work was conducted in accordance with the Declaration of Helsinki code of ethics.

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