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An exploration of sleep and family factors in young children at familial risk for ADHD

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Running Head: Sleep and family in children at-risk of ADHD

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Abstract

Objective: The aim of the current study was to examine relations between sleep problems and family factors and early markers of ADHD in young children with and without a familial risk for ADHD.

Methods: Differences in sleep behavior and family functioning in children under six years with (n=72) and without (n=139) a familial risk for ADHD were investigated. The influence of family and sleep factors on the development of early temperament markers of ADHD (effortful control and negative affect) was explored. Parents/caregivers completed questionnaires on family functioning, child sleep behavior and general regulatory behaviors.

Results: A significant difference was observed between high-risk and low-risk groups for family functioning in the infant/toddler (<3 years) and preschool (>3 years) cohorts. Parents of infants/toddlers in the high-risk group reported poorer infant sleep. However, there were no sleep differences reported for the preschool cohort. Family functioning was found to predict effortful control, while sleep quality predicted negative affect.

Conclusion: The results of this study highlight potential family and sleep issues for young children with a familial history of ADHD and the potential influence of these factors on early temperament markers of ADHD. Future research should explore these relations further in order to better establish whether early sleep and family interventions could mitigate later ADHD symptomatology.

Keywords: ADHD risk, sleep, family functioning, attention

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Introduction

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder that is characterized by persistent symptoms of impulsivity, hyperactivity, and inattention (American Psychiatric Association, 2013). The average at diagnosis ranges from 6.2 to 7 years (Visser et al., 2014; Miller et al., 2020). Nevertheless, recent research suggests that temperamental differences may already be emerging in infancy (Nigg 2006; Sullivan et al., 2015; Wichstrom et al., 2018; Miller et al., 2020). ADHD affects approximately 5% of children worldwide (Polanczyk, et al., 2007). ADHD and its symptomatology are reported to be highly heritable (Thapar et al., 2000) with one study reporting a rate of 57% in children of parents with childhood onset ADHD (Biederman et al., 1995). Siblings of children with ADHD were found to have a three to five-fold increased risk of developing the disorder (Biederman et al., 1992; Faraone et al., 1993). ADHD is associated with poorer attention and executive control and poor adaptation to everyday life for children and adults (Salomone et al., 2016; Barkley, 2013). Studies have shown evidence for an influence of factors such as sleep problems and family functioning on attention control in both school-age children with ADHD (Moreau et al., 2013; Huang et al., 2018) and typically developing school-age children (Fallone et al., 2001; Sarsour et al., 2011). These factors may be particularly relevant to young children of parents with ADHD who are already at a higher risk of an ADHD diagnosis due to high heritability rates.

ADHD and sleep

The importance of assessing behavioral outcomes, such as ADHD symptomatology, of infants with regulatory problems such as sleep has been previously emphasised (Hemmi et al., 2011). Approximately one in four children with sleep problems in infancy later meet the diagnostic criteria for ADHD (Thunström, 2002). Sleep problems in school-age children with ADHD and other patient populations with known attention and executive deficits are common and are associated with poorer child and family outcomes, including attention problems (Downes et al.,

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2017; Hansen et al., 2014; Silvestri et al., 2009; Sung et al., 2008). Shorter sleep duration has been found to increase the risk of ADHD symptomatology in school-age children (Paavonen et al., 2009; Touchette et al., 2007). Children with ADHD report more night wakings than typically developing controls from as young as 5 years of age (O'Callaghan et al., 2010; Scott et al., 2013). Adolescents with ADHD have greater variability in bedtime, waketime, sleep duration, sleep onset latency, sleep quality, and night wakings in comparison to typical adolescents through sleep diaries (Langberg et al., 2019). The use of stimulant medication in the treatment of ADHD has been suggested to cause sleep problems such as sleep-onset delay, night awakenings, shorter sleep duration, and difficulty with morning awakening (Konofal et al., 2010; Mulraney et al., 2018). However, non-medicated children with ADHD still present with greater sleep disturbances than typically developing children (Konofal et al., 2010; Mulraney et al., 2018).

ADHD and family functioning

Families of school age children with ADHD report higher levels of family conflict, lower levels of cohesion, less organization and more conflict at home than controls (Pressman et al., 2006; Cussen et al., 2012; Schroeder & Kelley, 2010). These families also report lower marital satisfaction and higher rates of parental separation or divorce (Cussen et al., 2012). Parents of children with a diagnosis of ADHD score lower on family quality of life measures, particularly the domains of emotional impact and impact on family activities, after controlling for socio-demographic variables (Cussen et al., 2012). Studies also show higher rates of anxiety, stress, and depression in parents of children with ADHD (DuPaul et al., 2001; Cunningham & Boyle, 2002). Parental ADHD problems have been linked to higher levels of family conflict and fewer family routines (Agha et al., 2013; Murrar & Johnstone, 2006). As children with ADHD often have parents with subclinical traits of the disorder, it is necessary to examine family functioning as a whole unit (Thissen et al., 2014). The impact of family functioning on executive and

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behavioral development in both typically developing children and patient populations has been previously highlighted (Lucia & Breslau, 2006; Nadebaum et al., 2007; Schroeder & Kelley, 2010).

Effortful control, negative affect, and ADHD

Effortful control involves the ability to delay or inhibit a response, and is comprised of inhibitory control, attention focusing, low intensity pleasure, and perceptual sensitivity (Rothbart & Bates, 2006). Negative affect is described as high levels of negative emotions such as anger, sadness, and fear (Putnam et al., 2006). Children with ADHD have been found to have temperamental profiles with low levels of effortful control and high levels of negative affect (DePauw & Mervielde, 2011). It has been theorised that effortful control and negative affect may be early markers for developing ADHD as infants who later develop ADHD symptoms are shown to have higher levels of negative affect and low effortful control early in development (Auerbach et al., 2008; Einziger et al., 2017; Sullivan et al., 2015; Wichstrom et al., 2018). Recent research shows that high-quality caregiving can act as a buffer to reduce the influence of anger reactivity on inhibitory control in children with ADHD (Miller et al., 2019).

The current study

Early pathways to later ADHD diagnosis may be observable as early as infancy (Auerbach et al., 2004; Auerbach et al., 2008), particularly via temperament domains of effortful control and negative affect (Auerbach et al., 2008; Sullivan et al., 2015). This emphasizes the importance of investigating potential relations between early markers of ADHD and modifiable factors such as sleep and family functioning at a developmental stage where intervention will have its greatest impact.

The aim of the study was to investigate differences in sleep behavior and family functioning in young children under 6 years with (n=72) and a without a family history of ADHD (n=139) and to look at developmental trends from infancy to preschool. To capture age-related differences,

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sleep and family functioning was examined for infants/toddlers (under 3 years) and preschool children (3 years and over) separately. Given that temperament has been reported as a marker of later ADHD symptomatology (Einziger et al., 2017; Wichstrom et al., 2018), the influence of family and sleep quality and quantity on the development of early temperament ratings of effort control and negative affect was explored.

Although recent research has demonstrated temperamental differences related to a family history of ADHD in infants (Sullivan et al., 2015; Willoughby et al., 2017; Miller et al., 2018; Miller et al., 2020), there have been no previous attempts to explore the influence of modifiable factors, such as sleep and family functioning on the development of these differences. Previously, studies have explored sleep and ADHD symptomatology from school age onwards (Waldon et al., 2018) and family functioning differences for older children (Schroeder & Kelley, 2010). To the authors' knowledge, no previous study has explored sleep and family factors at this early stage of development or the combined influence of these factors for any stage in children with ADHD. Based on previous research, it is expected that young children in the high-risk group (with a family history of ADHD) will show lower levels of effortful control, higher levels of negative affect, poorer family functioning, and poorer sleep quality and quantity in comparison to typically developing controls (low-risk group) (DePauw & Mervielde, 2011; Yurumez & Kilic, 2016; Breaux & Harvey, 2019). Previous research has also suggested that higher levels of negative affect are associated with poorer family functioning (Crawford et al., 2011) and poorer sleep (Dahl, 1996) in typically developing children. Negative correlations have been observed between sleep and effortful control (Moore, et al., 2011; Crawford et al., 2011). Therefore, it is hypothesised that children with a higher burden of sleep and family problems in the high-risk group will demonstrate lower levels of effortful control and higher levels of negative affect.

Method

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Participants

Parents/caregivers with a child 6 years and under were invited to complete a series of online questionnaires. The online questionnaire was advertised through social media channels, parenting groups, and ADHD events. Parents self-selected to the study by following a link to the questionnaire on Qualtrics software. The study took approximately 35 minutes to complete. Children were included if they were born full-term, and had no history of brain injury or epilepsy due to the potential influence of these brain-related disorders and complications linked to preterm delivery on brain development, sleep, and family functioning. Twenty-one participants were removed in total due to not meeting the inclusion criteria: 14 born preterm (n=4 high-risk group, n=10 from low risk group); 2 epilepsy diagnosis (n=1 high-risk group, n=1 low risk group), 1 brain injury (n=1 low risk group), 7 outside age range (n=5 high-risk group, n=2 low risk group). The remaining participants were divided into high-risk or low-risk groups based on family history of ADHD. Parents were asked whether there was diagnosis of ADHD confirmed by a clinician in the immediate family and to indicate which family member received this diagnosis. Those in the high-risk group (n=65) had a history of ADHD in the immediate family (i.e. a parent (n=22, 33.8%); sibling (n=43, 66.2%)). Children's ages ranged from 6 months to 6 years 0 months (M= 2.96, SD=1.72). Most responders lived with a partner or spouse (n=164, 87.7%) and the majority were mothers (n=178, 95.2%). Maternal education was the sole marker for socioeconomic status due to its links to parenting behaviours and child development. As a standalone variable for socioeconomic status it is more informative in terms of identifying groups (Zadeh et al., 2010; Mendive et al., 2017). In the high-risk group, 23 families reported co-occurring ADHD and autism spectrum disorder (ASD). Two low-risk families reported a diagnosis of ASD. Those with ASD in their immediate family were not excluded from analyses due to the high co-occurring rate between the two disorders (Jang et al., 2013). See Table S1 for a demographic breakdown. Some members in the low risk group reported ADHD in their

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extended family (n=21). For analysis of developmental differences, groups were broken into >3 years (n= 103; n=24 high-risk, n=79 low risk) and <3 years (n= 84; n=41 high-risk, n=43 low risk).

Measures

Early Temperamental Markers of ADHD

The Infant Behavior Questionnaire (Very Short Form) (IBQ-VSF), Early Childhood Behavior Questionnaire (Very Short Form) (ECBQ-VSF) and Childhood Behavior Questionnaire (Very Short Form) (CBQ-VSF) were used to measure temperament. The IBQ-VSF is a caregiver report measure recommended for use with children up to 18 months of age, the ECBQ-VSF is designed for use up to 36 months of age and the CBQ-VSF is designed for 3 to 8-year-old children (Puntnam & Rothbart, 2006). Parents completed the age-appropriate temperament questionnaire. There is no temperament measure suitable for children across this age range. However, research has shown that the factors of surgency, negative affect, and effortful control from the IBQ, ECBQ, and CBQ are stable across measures (Putnam et al., 2006). Reliability analysis of the subscales report a Cronbach's alpha range of .7 to .78 for negative affect and .72 to .78 for effortful control (Putnam et al., 2010; Allan et al., 2013; Putnam et al., 2008). Based on factor affiliation described in Putnam et al., (2008) scores for each measure were converted to z-scores. Four outliers from the low risk group were removed from the analysis for having extreme scores on temperament domains (n= 2 from preschool group, n= 2 from infant/toddler group).

Family Functioning

Parents completed the Systemic Clinical Outcome and Routine Evaluation (SCORE-28) questionnaire of family functioning (Cahill et al., 2010). The SCORE-28 is a 28-item adapted version of the SCORE-40 (Stratton et al., 2006). The measure concerns aspects of healthy relationships within the home context. Family functioning is defined as the degree to which a family can adapt, overcome difficulties, and communicate effectively. It contains three subscales

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of family strengths, family difficulties, and family communication, whereby greater scores are indicative of increased issues with family functioning (Cahill et al., 2010). The SCORE-28 has excellent internal reliability, with a Cronbach's alpha of .93 (Cahill et al., 2010).

Sleep

Brief Infant Sleep Questionnaire (BISQ). Parents of children aged 6 months to 2 years and 11 months (n=23 high risk group, n=69 low risk group) filled out the BISQ, a questionnaire measuring infant sleep that has been validated against actigraphy and sleep diaries and has good test-retest reliability (Sadeh, 2004). Variables of interest include 1) nocturnal sleep duration; 2) daytime sleep duration; 3) number of night wakings; 4) duration of wakefulness at night; 5) sleep on-set at night; 6) time taken to fall asleep at night; 7) method of falling asleep; 8) location of sleep; 9) preferred body position; 10) whether the parent considers their child's sleep a problem. Three additional questions to explore the impact of infant sleep on parents were included, asking the parent whether they enjoyed bringing their child to bed, whether a lack of sleep impacts their daily abilities, if the child has an evening ritual, and whether they experienced a lack of sleep before their child was born. Parents are instructed to refer to their child's sleep during the two weeks prior to completing the questionnaire.

Child Sleep Habits Questionnaire (CSHQ). Parents of children aged 3-6 years (n=23 high risk group, n=29 low risk group) filled out the 45 item Children Sleep Habits Questionnaire (Owens et al., 2000). Statements are rated "usually" if the behavior occurs five to seven times/week; "sometimes" for two to four times a week; and "rarely" for zero/once a week. The CSHQ contains eight subscales: bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, night wakings, parasomnias, sleep disordered breathing, and daytime sleepiness, as well as a composite score (Owens et al., 2000). A high composite score reflects more disturbed sleep. The

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CSHQ is reliable, with a Cronbach's alpha of .68 for a community sample and .78 for a clinical sample (Owens et al., 2000).

Combined sleep variables

The BISQ and the CSHQ have a number of overlapping questions. The answers for these questions were combined to create three overlapping variables to capture typical sleep behaviours for the whole group: 1) Usual amount of sleep each night; 2) Usual amount of sleep each day; 3) Number of minutes night waking usually lasts. For the purpose of the current study, 'sleep quality' refers to the number of minutes spent awake at night, and 'sleep quantity' refers to the total time spent in sleep at night.

Procedure

Ethical approval was obtained from BLINDED FOR REVIEW. All parents provided informed consent before beginning the experiment. Questionnaires were completed using Qualtrics software.

Data Analysis

Reliability analysis was carried out on all scales, with Cronbach's alpha ranging from .591 to .929. Statistical analyses were conducted using SPSS version 24.0. All statistical tests were used with a significance level of $p < .05$. Mann Whitney-U test and chi squares were used to compare groups on individual items for the sleep questionnaires. Two separate regression analyses were run, one with effortful control as the outcome variable and a second with negative affect as the outcome variable. For both regression models, there was independence of residuals, as measured by a Durbin-Watson statistic of 1.839 (regression predicting effortful control) and 1.776 (regression predicting negative affect). Homoscedasticity was present, as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, with all tolerance values greater than 0.1, and no correlations higher than 0.8 (Berry et al., 1985; Neter et al., 2004). There were no studentized deleted

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residuals greater than ± 3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was met, as assessed by a Q-Q Plot.

Variables were added in four stages. Age as a continuous variable was added first to control for age-related differences. The second variable added to the model was group membership, as we expect that children with a diagnosis of ADHD in their family will show lower levels of effortful control and higher levels of negative affect in each respective model. The composite score from the SCORE28 was then added to the regression as poorer family functioning has been associated with ADHD diagnosis (Cussen et al., 2012). As reported above, night wakings are common in children with ADHD (Yurumez & Kilic, 2016; Scott et al., 2013). Finally, sleep quality was added as reports of frequent night wakings are more common in children with ADHD relative to typically developing controls (Lucas et al., 2017).

Results

The preschool cohort (>3years) was matched on all factors (high-risk $n = 41$, low risk $n = 43$) (see Table S1). In the infant/toddler cohort (< 3 years), the high-risk ($n = 24$) and low risk ($n = 79$) groups were matched for age, gender, ethnicity, and number of siblings but not marital status ($p = .043$), maternal education ($p = .003$), and birth order ($p = .008$) due to the self-selecting nature of study recruitment. The parents in the low-risk group were more likely to live with a partner or spouse, be educated to college level, and high-risk children were more likely to be the youngest child.

Family functioning

Family functioning in infants/toddlers

More family difficulties and poorer communication were reported for the high-risk group, ($p = .001$, $d = .93$; $p = .035$, $d = .48$ respectively). There was no significant difference between the groups in terms of family strengths ($p = .279$, $d = .25$). Overall, the high-risk group obtained significantly higher scores on the composite score of family functioning (i.e. total score for all

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scale items) ($p = .015, d = .70$). Given the known link between SES and family functioning, an ANCOVA was carried out to examine group differences in family functioning when controlling for maternal education. Significant differences between the groups remained ($p = .017$) for the family functioning composite score, after controlling for level of maternal education. According to Fay et al. (2013), a score of over 2.9 on average for the composite score is indicative of difficulty functioning within the family context. 16.8% of participants from the high-risk group and 6.5% of participants from the low-risk group fell into this category. When adjusting for the high-level of co-occurring ASD diagnosis in the high-risk group, significant group differences remained for the family difficulties subscale.

Family functioning in preschool children

The high-risk group reported higher scores, reflecting poorer family functioning for all subscales of the SCORE28 and the composite score ($p = .003, d = .70$) with 36.2% of the high-risk group and 16.1% of the low risk group scored above 2.9 for the SCORE28 composite score, suggesting difficulty functioning within the family context (Fay et al., 2013). When considering the co-occurrence of ASD diagnoses, significant differences between the groups remained for the family communications subscale and the composite score.

Sleep

Sleep in infants/toddlers

Parents of children under 3 years completed the BISQ. The infant/toddler groups differed in terms of both sleep quality and sleep quantity. The high-risk group spent more time awake at night ($p = .047, d = .41$) and reported poorer sleep quality ($p = .046, d = .60$). When adjusting for ASD diagnosis in the immediate family, high-risk children still reported significantly poorer sleep quality, but not quantity. Non-parametric tests observed that groups differed significantly on a number of variables with the high-risk group reporting, more time

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spent putting their baby to bed in the evening ($p = .0164, d = .71$), and more time for the baby to fall asleep in the evening ($p < .003, d = .92$). Infants/toddlers in the high-risk group were more likely to wake during the night, with a mean number of awakenings of 2.48 in comparison to 1.38 wakings on average in the low risk group ($p = .004, d = .72$). Babies in the low risk group were more likely to sleep on their own in a separate room ($p = .004, \text{Cramer's } V = .30$). Further, parents from the high-risk group were more likely to consider their child's sleep a problem ($p = .007, \text{Cramer's } V = .33$). In the additional questions added to the BISQ, parents from the high-risk group also report less enjoyment in putting their child to bed ($p = .024, \text{Cramer's } V = .24$) and being more likely to bring their baby into their own bed if he/she wakes during the night ($p = .008, \text{Cramer's } V = .28$).

On average, parents of the high-risk infant/toddler group report waking up 2.48 times each night, compared to 1.38 times for the low-risk group. In a large US-Canadian study which used the BISQ to examine sleep, the mean number of night wakings was 1.16 for 9-11 months, .93 for 12-17 months, and .82 for 18 to 36 months (Sadeh et al., 2009), similar to the mean wake time reported for the low risk group. The current study observed that infants/toddlers from the high-risk group were spending .56 hours awake on average, compared to .24 in the low risk group whose nighttime wakefulness was in line with previous findings (mean of 0.25 hours from 6-36 months) for typically developing infants (Sadeh et al., 2009).

Sleep in preschool children

Parents of children between 3 and 6 years of age recorded their child's sleep on the CSHQ and there were no significant differences for the total score. No significant differences emerged between the two groups in the preschool cohort in terms of sleep quality or sleep quantity. Only the subscale of parasomnias was significantly different between the groups ($p = .05$) with the high-risk group reporting lower scores (i.e. less experiences of parasomnias). Only one participant from the high-risk group scored one standard deviation above the mean of the

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community sample from Owens et al. (2000). No low risk participants fell outside the range of 1 standard deviation above the mean. Overall, both groups had lower mean scores than the community sample for the CSHQ composite score. The two groups were only found to significantly differ on needing a parent in the room to fall asleep, with the high-risk group more likely to need a parent present ($p = .028$, $Cramer's V = .41$).

Table S2 outlines how the whole group compare across the variables measured.

Effortful control and negative affect

Exploratory bivariate correlations for variables of interest are presented in Table S3 separately for the infant/toddlers, the preschool children, and combined age groups.

Predictors of effortful control

Hierarchical regression was conducted to determine whether group membership, family functioning, and sleep could predict effortful control, when controlling for age (Table 1). The model was not significant at stage 1 and introducing group membership did not show a significant R^2 change. The addition of family functioning composite score did explain an additional 9.8% of variance in effortful control. This change in R^2 was significant, $R^2 = .098$, $F(3,111) = 4.036$, $p = .009$, adjusted $R^2 = .074$. The addition of the sleep quality variable did not lead to a significant difference in R^2 , but the model remained significant, $R^2 = .129$, $F(4,110) = 4.055$, $p = .004$, adjusted $R^2 = .097$. Of all the variables, better family functioning was the strongest predictor of higher effortful control, ($\beta = -.290$, $p = .002$). All of the variables combined accounted for 12.9% of the variance in effortful control.

Predictors of negative affect

A hierarchical regression was carried out to determine whether group membership, family functioning, and sleep could predict negative affect, when controlling for age (Table 1). Age, group membership and family functioning variables did not contribute significantly to the model. The addition of the sleep quality variable contributed to a significant change in R^2 , $R^2 =$

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.152, $F(4,116) = 5.182$, $p = .001$, adjusted $R^2 = .122$. When all variables were included, it was found that more time spent in wakefulness at night, (.376, $p < .001$) and older age, (.202, $p = .040$) were significant predictors of higher levels of negative affect. Taken together, all of the variables accounted for 15.2% of variance of negative affect.

TABLE 1 HERE

Discussion

The aim of this study was to examine family and sleep factors and their influence on early temperament markers of ADHD in children with and without a familial risk for ADHD. Results showed that children at familial risk for ADHD had poorer total family functioning scores as well as poorer scores across all subdomains (Strengths, Difficulties, Communication) relative to children with no family history of ADHD, even when controlling for socioeconomic status. Differences in sleep patterns and habits emerged between the high-risk and low-risk groups for the infant/toddler cohort, but not for the preschool children. Positive family functioning predicted higher levels of effortful control, whilst higher age and poorer sleep quality were the best predictors of high negative affect levels, regardless of risk group membership.

The findings for poorer family functioning in families of children at-risk of ADHD are consistent with the literature on older children with a diagnosis (Deault, 2010). Living in a family with a diagnosis of ADHD influences the whole family (Moen et al., 2016). The findings of the current study are in line with existing literature in that families with ADHD are more likely to experience higher levels of difficulty and conflict (Agha et al., 2013). This is the first study to utilise the SCORE28 measure in this population, allowing us to examine family strengths and family communication in addition to family difficulties. Other family functioning studies in ADHD have rarely focused on family strengths (Eakin et al., 2004; Cussen et al., 2012). It has been previously observed that families with ADHD show poorer, less effective communication than control families (Tripp et al., 2007), which was also found in the current study.

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The findings of the present study suggest that sleep problems may be subtle yet present from an early developmental stage as infants/toddlers at-risk of ADHD had significantly longer sleep onset times and increased amounts of time spent in wakefulness at night. When family history of ASD was considered, the link between poor sleep and ADHD history held for sleep quality but not sleep duration. Notably, however, there were no sleep differences for preschool-aged children in the current study on the CSHQ. The preschool groups only differed on needing a parent in the room at bedtime. The finding that children in the high-risk group were more likely to need a parent to be present is similar to that observed in our younger participants - the infant/toddlers - as the high-risk group were more likely to sleep in their parents' bed. This may indicate a pattern of anxiety around bedtime and requires further research (Owens, 2009). Parents of preschool children at-risk of ADHD did not report that their child's sleep was an issue, which deviates from previous studies of children with an ADHD diagnosis (Sung et al., 2008). Given our mixed findings for the infant/toddler and preschool groups, it may be that sleep is an early development marker of ADHD liability that becomes less prevalent as children develop. However, this idea is not supported by the high prevalence of sleep problems reported in school-age children and adolescents with ADHD on subjective and objective measures (Becker et al., 2019; Stein et al., 2012). Another explanation for the lack of group sleep differences in the preschool-age group is the issue of validity of the CSHQ, the sleep measure used. Research has demonstrated that only one subscale of the CSHQ (night wakings) correlated with actigraphy data (Markovich et al., 2015). In contrast, the infant sleep measure, the BISQ, has been well validated against actigraphy and daily logs, which suggests that it may be a more robust measure of sleep (Sadeh et al., 2009).

Family functioning was the only significant predictor of effortful control, a potential liability marker for ADHD (Auerbach et al., 2008; Einziger et al., 2018; Wichstrom et al., 2018). This

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finding is similar to previous research that found that low effortful control in early childhood is associated with negative parenting (Eisenberg et al., 2015), which may further exacerbate ADHD symptoms (Wichstrom et al., 2018). There was a trend for an influence of sleep quality on effortful control, however this did not reach statistical significance. This observed trend is in line with previous research that suggests links between effortful control and sleep (Moore et al., 2011). Children with familial risk of ADHD show higher levels of negative affect (Auerbach et al., 2004). In the current study, sleep quality was the most significant predictor of negative affect. Previous research observed a similar association between sleep problems and negative affect in typically developing children (Kelmanson, 2013), and in children with a family history of ASD (Schwichtenberg et al., 2013). Thus, future research should further explore whether targeting early sleep problems and family functioning difficulties may alleviate higher levels of negative affect and poorer effortful control in children at-risk for later ADHD diagnosis (Sullivan et al., 2015).

Limitations

A limitation of the current study is that the whole group was skewed towards a more educated population, and so caution is advised in generalizing the results. As there is no existing parent-report sleep measure that spans this whole age range, two questionnaires were required to assess sleep habits and difficulties across the infant/toddler and preschool cohorts. This made it difficult to capture a complete picture of sleep problems across development, as the questionnaires had few overlapping variables. It should be noted that some participants in the low risk group reported ADHD in their extended family, which may contribute to an explanation for why group differences did not emerge on some measures. It could be that people who experience attention difficulties, or those with a history of ADHD in their extended family were more likely to engage with the study. Ireland has no dedicated adult ADHD service and so it is also possible that some adults in the low-risk group had undiagnosed ADHD. Furthermore, we did not consider whether

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those with a diagnosis were receiving treatment for ADHD or what kind of treatment this might be. As ADHD treatment may improve family functioning (Lo et al., 2020), not controlling for treatment or medication may have influenced the results.

An additional limitation to consider is that the measures in the current study rely on proxy-report (Gorber et al., 2007). Future research should combine proxy report with objective laboratory assessments, such as actigraphy and behavioural observations, to create a more robust picture of how sleep and family functioning could act as risk factors for ADHD in children who are already at risk of the disorder due to familial diagnosis.

Arnett and colleagues (2013) report that current screening tools for ADHD risk are not sensitive to early developmental differences and that appropriate screeners for ADHD should measure sleep problems and attention regulation. To our knowledge, this is the first study to examine both sleep problems and family functioning in this population, and the effect of these variables on early temperament markers of ADHD.

Conclusion

The current study informs researchers and clinicians of potential links between sleep and family functioning and early markers of ADHD development. Results suggest a link between family functioning and effortful control, with poorer family functioning predictive of lower effortful control. Poorer sleep quality was linked to higher levels of negative affect. By exploring links with modifiable factors in early development, we can better inform future interventions for children at risk of later ADHD diagnosis. Interventions targeting temperament domains of negative affect and effortful control in early development may be successful in reducing symptoms of ADHD later in life (Wichstrom et al., 2018). In addition, future research needs to determine whether interventions targeted at sleep problems and family functioning may reduce adverse outcomes in children at high-risk for ADHD (Willcutt et al., 2005).

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Table 1**Hierarchical regressions of age, group membership, family functioning, and sleep quality to predict effortful control and negative affect**

Effortful Control				
	Step 1	Step 2	Step 3	Step 4
R^2	.000	.019	.098	.129
F	.014	1.084	4.036**	4.055**
Age	.011	.051	.084	.022
Group	---	-.143	-.074	-.035
Family composite	---	---	-.294**	-.290**
Sleep quality	---	---	---	-.185
Negative Affect				
	Step 1	Step 2	Step 3	Step 4
R^2	.012	.027	.027	.152
F	1.462	1.653	1.092	5.182**
Age	.110	.068	.068	.202*
Group	---	.130	.130	.052
Family composite	---	---	.000	-.014
Sleep quality	---	---	---	.376**

Note: coefficients shown are standardized coefficients. * $p < .05$, ** $p < .01$