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RESEARCH ARTICLE

Nocturnal sleep duration trajectories in early childhood and school performance at age 10 years

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Summary

Sleep plays a fundamental role in brain development and resultant functions. The aim was to verify whether nocturnal sleep duration during early childhood has long-term associations with academic achievement at age 10 years. The present study is part of the Quebec Longitudinal Study of Child Development, a representative cohort of infants born in 1997–1998 in the province of Quebec, Canada. Children with known neurological conditions were excluded from this cohort. Four trajectories of parent-reported nocturnal sleep duration at ages 2.5, 3, 4, 5 and 6 years were determined using a SAS procedure named PROC TRAJ. Sleep duration at age 10 years was also reported. Teachers provided data on academic performance when the children were age 10 years. These data were available for 910 children (430 boys, 480 girls; 96.6% Caucasians). Univariate and multivariable logistic regressions were performed using SPSS. Children who slept less than 8 hr per night at 2.5 years but normalized later on (Traj1) had three–five times the odds of having grades below the class average in reading, writing, mathematics and science compared with children who slept sufficiently (Traj3–4: 10–11 hr per night). Children who slept about 9 hr per night throughout childhood (Traj2) had two–three times the odds of being below the class average in mathematics and science. Sleep duration at age 10 years was not correlated with the academic performance. These results point to the presence of a very important early period during which sufficient sleep is needed to fine-tune the functions necessary for academic achievement later on.

KEYWORDS
cognition, public health

1 | INTRODUCTION

Sleep is an essential pillar of neurodevelopment. During the first years of life, sleep occupies more than half of each day and is the primary source of brain activity. Sleep thus plays a crucial role in brain development and maturation (Kurth et al., 2013) that lies beneath the astonishingly rapid development observable in early childhood. Sleep is an important player in emotional regulation, memory and several other cognitive domains in children. Cognitive functioning has been consistently related to academic achievement in preschoolers and school-age children (Best et al., 2011; Espy et al., 2004; Willoughby et al., 2012). When investigated directly, the relation between sleep and school functioning was often studied concurrently. This makes it hard to disentangle two possible underlying mechanisms: sleepiness due to current/recent sleep loss versus impairment in neuronal development caused by persistent insufficient sleep in early childhood. For example, a meta-analysis (Astill et al., 2012) of 52 studies investigated the relation between sleep duration and cognition or school performance and found an association. However, few studies focused on preschoolers and even fewer were longitudinal in nature. Among these, our study (Touchette et al., 2007) had shown that trajectories of short nocturnal sleep durations in early childhood were associated with poorer performance on cognitive tasks at ages 5 and 6 years when compared with trajectories of sufficient sleep. We had also shown later that the trajectory of short sleepers had higher odds of presenting poor receptive vocabulary at age 10 years (Seegers et al., 2016). An actigraphy study demonstrated that children with later sleep timing at 30 months had poorer academic performance at 54 months (Hoyniak et al., 2020). Another group has rather demonstrated that the decrease of total sleep duration between ages 2 and 4 years was related to academic achievement when the children were age 7 years (Bernier et al., 2021), likely due to the decrease of daytime sleep duration. Finally, one longitudinal study found that sleep problems trajectories in early childhood were associated with poorer cognitive functioning and poorer school achievement later (Williamson et al., 2020). That latter study did not look at sleep duration per se, and this is of major importance considering that duration was identified as the important sleep parameter for different outcomes in children (Astill et al., 2012; Chaput et al., 2017). Moreover, populational studies reported a growing percentage of children with insufficient sleep duration (Iglowstein et al., 2003; Matricciani et al., 2012).

The objective of the present study was to determine whether the trajectories of sleep duration in early childhood have a longer-term association with academic achievement at age 10 years, as assessed by the teacher, or whether current sleep duration is really the important factor in school success.

Based on previous findings, it is hypothesized that a short sleep duration during early childhood will be associated with poorer academic performance at age 10 years, irrespective of sleep duration at that age.

2 | METHODS

2.1 | Participants

This study was part of the Quebec Longitudinal Study of Child Development (QLSCD). All children were recruited from the Quebec Master Birth Registry. A randomized stratified survey design was used to study a representative sample of infants born in 1997–1998 in the province of Quebec, Canada. At the QLSCD inception (March 1998), 2223 children aged 5 months were included. Throughout the years, attrition occurred ($n = 1402$ at age 10 years). For the present study, we had to exclude the children for whom the teacher's assessments were unavailable ($n = 411$) and children with known major neurological conditions (autism, epilepsy, mental incapacity; $n = 6$). Finally, of the remaining sample, we excluded children for whom the sleep duration trajectory could not be drawn ($n = 75$). Therefore, 910 children, aged 10 years were included. All families signed a consent form before each assessment. The protocol was approved by the "Institut de la Statistique du Québec" ethics committee.

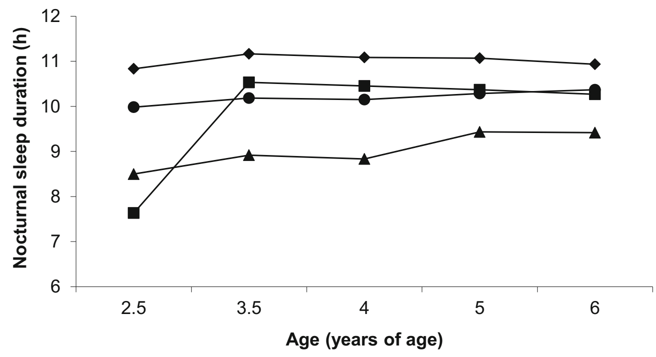

FIGURE 1 Four nocturnal sleep duration patterns from 2.5 to 6 years old ($n = 1829$): Traj1 = ■ short increasing sleep duration ($n = 88$, 4.8%); Traj2 = ▲ short chronic sleep duration ($n = 109$, 6.0%); Traj 3 = ● 10-hr persistent sleep duration ($n = 920$, 50.3%); and Traj4 = ◆ 11-hr persistent sleep duration ($n = 712$, 38.9%). Data courtesy of the Quebec Institute of Statistics

2.2 | Data collection

2.2.1 | Nocturnal sleep duration trajectories

Nocturnal sleep duration was measured at 2.5, 3.5, 4, 5, 6 and 10 years old by an open question to the mother: "Indicate how long in total your child sleeps during the night (on average). Do not count the hours that your child is awake". Using all available data points of the QLSCD cohort when children were age 6 years, a trajectory methodology (described in more details elsewhere; Touchette et al., 2007; Touchette et al., 2008) assigned children to different sleep duration trajectories based on a posterior probability rule. A SAS procedure (SAS Institute, Cary, NC, USA) called PROC TRAJ (Jones et al., 2001) yielded a model with four sleep duration trajectories (Figure 1). The very short but increasing sleep duration trajectory (Traj1) was composed of children who slept very little (8 hr or less per night) in early childhood, but whose sleep duration increased to about 10 hr around age 3.5 years; the persistently short sleep trajectory (Traj2) was composed of children sleeping about 9 hr per night until age 6 years; the 10-hr persistent sleep trajectory (Traj3) was composed of children who slept persistently approximately 10 hr per night; and the 11-hr persistent sleep trajectory (Traj 4) composed of children who slept persistently about 11 hr per night. Mean probability estimates of being classified into the correct trajectory were 0.79 for Traj1, 0.85 for Traj2, and 0.85 for both Traj3 and Traj4, indicating a good fit of the model.

2.2.2 | Academic achievement

Academic achievement at age 10 years was assessed by the teacher with the following five questions: How would you rate this child's current academic achievement in reading? … in written work (spelling, grammar)? … in mathematics? … in science? … across all areas of instruction? For each question, the choice of answers was: (a) *I do not teach [the subject] to this child*; (*b*) *Near the top of the class*; (*c*) *Above the middle of the class, but not at the top*; (*d*) *In the middle of the class*; (*e*) *Below the middle of the class, but above the bottom*; or (*f*) *Near the bottom of the class*. Each of the five variables was then dichotomized in the following manner: $b + c + d$ versus $e + f$ (a was considered as missing).

2.2.3 | Potential confounders

Because of their associations with academic outcomes reported in the literature, the following 13 potential confounders were taken into account: sex of the child (Anastas & Reinherz, 1984); prematurity (Patil & Metgud, 2014); low birth weight (Chatterji et al., 2014); ethnic origin (Nitardy et al., 2015); immigrant status of the mother (Sullivan et al., 2016); language spoken at home (Bermejo et al., 2021); insufficient family income (Hair et al., 2015); maternal education level (Tamayo Martinez et al., 2022); coercive parental practices (Alyahri & Goodman, 2008); smoking (Kristjansson et al., 2018); or use of drugs or alcohol during pregnancy (Richardson et al., 2002); and maternal depression (Murray et al., 2010). These confounders were assessed through a computerized questionnaire completed by an interviewer at the home of the families when the child was 5 months old, except for parental practices, which was part of an auto-administered questionnaire completed by the mother. The insufficient family income is defined as a household income below the pre-tax low-income cut-off established by Statistics Canada for that year.

2.3 | Statistical analyses

Descriptive statistics compared demographic data of the study sample with those of children lost to follow-up or with missing data. The distribution of the children of the present sample within the four sleep duration trajectories was also compared with that of children lost to follow-up or with missing data, and with that of the original sample from which these trajectories were established. To examine whether sleep duration trajectories in early childhood predict later academic performance, univariate and multivariable logistic regressions were performed.

As aforementioned, the adjusted model took into account the following 13 potential confounders. Odds ratios (ORs) are reported with their 95% confidence intervals (CIs). Considering the well-known association between concurrent sleep duration and academic functioning, we first tested whether current sleep duration (age 10 years) was correlated with the five academic outcomes variables. Alpha levels were set at 0.05, and SPSS version 26 (IBM) was used for all statistical analyses.

3 | RESULTS

Table 1 presents sociodemographic data of children who were included in the present study, of children lost to follow-up or with missing data, and of those of the initial representative sample. Compared with both children lost to follow-up or excluded and with the initial sample, the studied sample had fewer boys ($p = 0.003$), fewer children of immigrant mothers ($p < 0.001$), fewer allophones ($p < 0.001$), and fewer cases of insufficient family income ($p < 0.001$).

In addition, the present sample has a smaller proportion of children in Traj2 and a greater proportion of children in Traj1 compared with the sample from which these trajectories were first established (Table 2).

We pooled together Traj3 and Traj4 for the present analyses as they both respect the sleep duration recommendations for preschool children (Chaput et al., 2018; Hirshkowitz et al., 2015; Paruthi et al., 2016). Moreover, there were no significant differences between Traj3 and Traj 4 on the outcome variables studied. Table 3 presents the sociodemographic data for the present sample as a function of the three nocturnal sleep duration trajectories.

As for *daytime* sleep duration at age 2.5 years, there were no between-trajectory differences: Traj1 = 109 ± 38 min, Traj2 = 108 ± 25 min and Traj 3–4 = 115 ± 33 min ($F_{2,787} = 1.46$, $p = 0.23$). We had already reported, in the same cohort, that short nocturnal sleep duration in poor sleepers at age 2.5 years was not compensated by more daytime sleep (Touchette et al., 2005).

The main results are presented in Figure 2 and Table 4. Compared with children in Traj3–4 (sleeping 10–11 hr per night), a greater percentage of children in Traj1 (very short sleep duration but increasing later on) were rated by their teacher as performing below the class average in reading, writing, mathematics, science and overall (Figure 2; all $p < 0.001$).

In fact, children in Traj1 had 3.2–5.5 times the odds of performing below the class average in these subjects compared with children who had sufficient sleep during early childhood (Table 4, unadjusted model). Children in Traj2 (9 hr per night) had 2.3–3.2 times the odds of being below the class average in mathematics and science compared with children in Traj3–4. Results remained the same, with slightly lower OR for Traj1 than in unadjusted analyses, even after controlling for the following potential confounders: sex of the child, prematurity, low birth weight, ethnic origin, insufficient family income, maternal immigrant status, language spoken at home, maternal education level, coercive parental practices, smoking or use of drugs or alcohol during pregnancy, and maternal depression (Table 4 adjusted model).

Importantly, sleep duration at age 10 years was not correlated with the academic performance. The correlation coefficients were −0.015 for reading; 0.001 for writing; 0.034 for mathematics; −0.054 for science; and −0.003 for overall (all p = ns). Mean sleep durations

TABLE 1 Demographic data of the study sample and comparison with the sample of children lost to follow-up or with missing data

Variables	This sample ($n = 910$)	Lost to follow-up or with missing data ($n = 1232$)	Total initial sample ($n = 2223$)	p
Sex of the child (boy)	47.3	53.6	51.0	0.003
Prematurity (< 37 weeks)	4.9	4.9	4.9	0.93
Low birth weight (< 2.5 kg)	3.2	4.3	3.8	0.20
Ethnic origin (non-Caucasian)	3.4	12.3	8.6	< 0.001
Immigrant mothers	5.6	15.8	11.6	< 0.001
Allophones[a]	2.4	8.1	5.8	< 0.001
Insufficient family income	18.4	27.9	24.0	< 0.001
Maternal education level (no high school diploma)	12.2	18.6	16.0	< 0.001

Note: Data courtesy of the Quebec Institute of Statistics. Data are expressed as percentages.
[a]Speaking a language other than English or French.

TABLE 2 Number (and %) of children in the three nocturnal sleep duration trajectories of early childhood; comparisons with sample of children lost to follow-up or with missing data

Sleep trajectories	*N* (%) study sample ($n = 910$)	*N* (%) lost to follow-up or with missing data ($n = 919$)	Sample at 6 years ($n = 1{,}829$)	p
Traj1 = short increasing sleepers	48 (5.3%)	40(4.4%)	88 (4.8%)	0.05
Traj2 = short persistent sleepers	39 (4.3%)	70 (7.6%)	109 (6.0%)	
Traj3-4 = 10-hr and 11-hr persistent sleepers	823 (90.4%)	809 (88.0%)	1632 (89.2%)	

Note: Data courtesy of the Quebec Institute of Statistics.

TABLE 3 Proportions of children in sociodemographic variables as a function of the three nocturnal sleep trajectories

	Nocturnal sleep trajectories			
Sociodemographic variables	Traj1 (*N* and %) Short increasing sleepers ($n = 48$)	Traj2 (*N* and %) Short persistent sleepers ($n = 39$)	Traj3-4 (*N* and %) 10–11 hr sleepers ($n = 823$)	p
Sex of the child (boy)	22 (45.8%)	20 (51.3%)	388 (47.1%)	0.86
Prematurity (< 37 weeks)[a]	3 (6.3%)	5 (12.8%)	37 (4.5%)	0.06
Low birth weight (< 2.5 kg)[a]	2 (4.3%)	4 (10.3%)	23 (2.8%)	0.03
Ethnic origin (non-Caucasian)[a]	4 (8.3%)	4 (10.3%)	23 (2.8%)	0.007
Immigrant parents	6 (12.5%)	5 (12.8%)	40 (4.9%)	0.01
Allophones (versus FR or EN)[a]	1 (2.1%)	4 (10.3%)	17 (2.1%)	0.005
Insufficient family income	20 (42.6%)	7 (17.9%)	139 (17.0%)	< 0.001
Maternal education level (no high school diploma)	12 (25.0%)	8 (20.5%)	91 (11.1%)	0.004

Note: Data courtesy of the Quebec Institute of Statistics.
[a]These analyses should be interpreted with caution (cells comprised of fewer than five children).

at age 10 years were 9 hr 33 min (± 57 min) for Traj1, 9 hr 28 min (± 48 min) for Traj2, and 9 hr 56 min (± 37 min) for Traj3–4.

4 | DISCUSSION

The present study aimed to determine whether the trajectories of nocturnal sleep duration in early childhood have long-term associations with academic success at age 10 years or whether current sleep duration is the important factor for such success.

Our study showed that short sleep duration, especially if occurring very early in life, is strongly associated with increased risk of having grades below the class average near the end of elementary school. Moreover, sleep duration at age 10 years showed no correlation with the academic performance. In addition, despite similar mean sleep durations at age 10 years for Traj1 and Traj2, children in Traj1 who

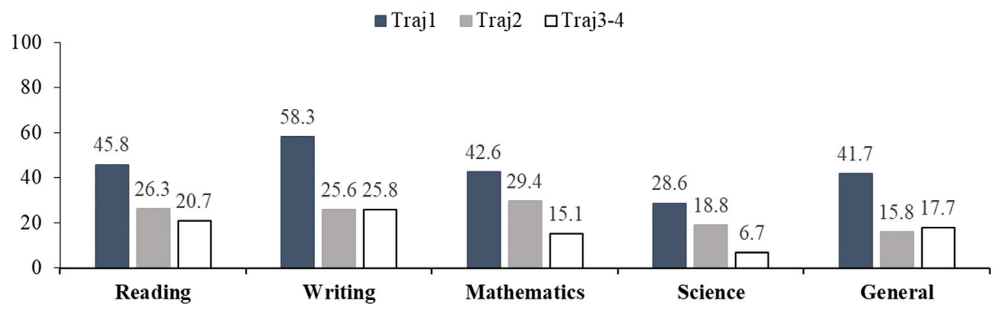

FIGURE 2 Percentage of children with grades below the class average in different subjects as a function of sleep duration trajectories. Chi-squared tests were significant ($p < 0.001$). Data courtesy of the Quebec Institute of Statistics

suffered greater sleep loss before age 3 years showed worse academic outcomes than did children in Traj2. The associations between short sleep duration in early childhood and academic outcomes are also independent of sex of the child, prematurity, low birth weight, ethnic origin, language spoken at home, maternal immigrant status, maternal education level, insufficient family income, coercive parental practices, smoking or use of drugs or alcohol during pregnancy, and maternal depression.

Our findings corroborate and expand the existing literature on the subject. A systematic review (Chaput et al., 2016) of sleep duration and school performance in children aged 5–17 years reported that 11 of the 17 cross-sectional and three of the four of the longitudinal studies found longer sleep durations were associated with better school performance. Similarly, a meta-analysis (Astill et al., 2012) reported a significant association of sleep duration (20 studies), but not of sleep efficiency (10 studies), with school performance. Interestingly, this meta-analysis showed a sleep duration contribution to executive and multiple-domain cognitive functioning, but not to sustained attention or memory, two domains sensitive to sleep deprivation (Born et al., 2006; Lim & Dinges, 2010). This highlights the differential effects of acute sleep deprivation before a task and insufficient sleep during early development. Our results show that early sleep duration trajectories are associated with later school performance whereas current sleep duration is not correlated with it. This challenges the notion that sleepiness/current sleep loss is *the* mediator of impaired cognition. Although sleep has undeniable short-term benefits, our findings support an active role of sleep in functional brain development. The meta-analysis reported that only nine studies were longitudinal in nature and these studies did not necessarily investigate sleep duration in early childhood (Astill et al., 2012). Two longitudinal studies did focus on early childhood sleep problem trajectories and later school functioning. The first found associations between early childhood sleep profiles and teacher-reported poor social–emotional school adjustment but did not report on academic performance (Williams et al., 2016). The other epidemiological study looked at how sleep trajectories in early childhood affect later cognitive functioning and academic achievement (Williamson et al., 2020). It reported that children in the persistent sleep problems trajectory had more teacher-rated language/literacy and mathematical thinking impairments than did children in the other trajectories. However, in these two studies the trajectories were based on the perception of a sleep problem rather than on sleep duration.

One longitudinal study (Bernier et al., 2021) did investigate early childhood sleep duration trajectories in relation to performance and mathematics in grade 1 (age 6 years). They found that children whose sleep duration decreased more rapidly between ages 2 and 4 years performed better in school. The key difference between their study and ours is that they measured total sleep duration, which includes daytime naps. It is well known that daytime sleep duration normally and progressively decreases from age 2 years to age 4 or 5 years (Weissbluth, 1995). Also, there is high variability in the age and speed at which daytime sleep subsides and this, as Bernier and colleagues pointed out, seems to reflect brain maturation. In contrast, trajectories of nocturnal sleep duration are more stable over time, and our aim was to look at correlates of short or insufficient sleep duration over childhood.

Finally, we did not find any correlations between sleep duration at age 10 years and school performance at the same age. This is a bit surprising in light of the previously mentioned reviews (Astill et al., 2012; Chaput et al., 2016), showing that even cross-sectional studies showed a relationship in most cases (but not all). However, it must be mentioned that when this relationship is demonstrated, the correlation coefficients can be quite small. In addition, many studies that did not find a notable association between sleep duration and either current or even later school performance included older children (Li et al., 2013; Mayes et al., 2008) or adolescents (Dewald et al., 2010; Eliasson et al., 2002; Loessl et al., 2008). In fact, a meta-analysis of 17 studies (Dewald et al., 2010) reported that effect sizes were larger for studies that included younger participants. Perhaps other measures of sleep such as daytime somnolence or the difference between weekend and school nights sleep duration would have been more telling in older children.

4.1 | Sensitive period for the role of sleep in development

Our findings point to a very important period for the effect of sleep on development. Using the same trajectories, we have shown previously that the children who slept insufficiently during early childhood, but whose sleep duration later normalized to about 10 hr of sleep per night (Traj1), were nonetheless more at risk for poor performance on cognitive tasks (Touchette et al., 2007). They were also more at risk of being overweight or obese at age 6 years, even after adjusting for

TABLE 4 ORs and 95% CIs for academic performance below the class average based on sleep duration trajectories (unadjusted model[c]) and after controlling for potentially confounding variables (adjusted model[d]) in the final logistic regression model[a]

	Reading			Writing			Mathematics			Science			Overall		
	Below average ($n = 200$[c]/ $n = 195$[d])			Below average ($n = 245$[c]/ $n = 233$[d])			Below average ($n = 149$[c]/ $n = 143$[d])			Below average ($n = 65$[c]/$n = 60$[d])			Below average ($n = 169$[c]/ $n = 161$[d])		
Risk factors	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***
Unadjusted model[c]															
Sleep trajectories[b]															
Traj1	3.2	(1.8–5.8)	< 0.001	4.0	(2.2–7.3)	< 0.001	4.2	(2.3–7.7)	< 0.001	5.5	(2.7–11.5)	< 0.001	3.3	(1.8–6.0)	< 0.001
Traj2	1.4	(0.7–2.9)	0.41	1.0	(0.5–2.1)	0.99	2.3	(1.1–5.0)	0.03	3.2	(1.3–8.2)	0.02	0.9	(0.4–2.1)	0.76
		$n = 896$			$n = 889$			$n = 869$			$n = 773$			$n = 892$	
Adjusted model[d]															
Sleep trajectories[b]															
Traj1	2.4	(1.3–4.6)	0.007	3.2	(1.6–6.1)	< 0.001	2.9	(1.5–5.8)	< 0.001	4.5	(2.0–10.4)	< 0.001	2.3	(1.2–4.4)	0.001
Traj2	1.4	(0.6–2.9)	0.44	1.0	(0.5–2.2)	0.83	2.4	(1.1–5.5)	0.05	3.0	(1.1–8.2)	0.03	0.9	(0.3–2.2)	0.64
		$n = 866$			$n = 859$			$n = 840$			$n = 744$			$n = 862$	

Note: Data courtesy of the Quebec Institute of Statistics.
[a]Data are given as OR (95% CI).
[b]The reference for sleep duration trajectories in the logistic regressions was Traj3-4.
[c]Unadjusted OR (95% CI) without controlling for potentially confounding factors.
[d]Adjusted OR (95% CI) while controlling for sex of the child, prematurity, low birth weight, ethnic origin, language spoken at home, maternal immigrant status, insufficient family income, maternal education level, coercive parental practices, smoking or use of drugs or alcohol during pregnancy, and maternal depression.
CI, confidence interval; OR, odds ratio.

many potentially confounders (Touchette et al., 2008). Likewise, a longitudinal twin study showed that poor sleep consolidation during the two years of life, which often results in sleep curtailment, was a risk factor for language skills at age 5 years (Dionne et al., 2011).

Compared with many species, humans are very immature at birth. Brain development must then continue after birth, structurally and functionally, and sleep contributes greatly to this development. A relation was shown between the immaturity of a newborn mammal and the amount/percentage of rapid eye movement (REM) sleep it has at birth (Zepelin, 2005). Human infants sleep 14–18 hr a day, and REM sleep occupies half of that time. This percentage slowly decreases to reach adult levels around age 5 years, but stays relatively high during the first 3 years. Similarly, non-REM sleep activity and connectivity patterns undergo huge transformations during the first years of life, and these changes reflect brain maturation (Kurth et al., 2013). Consequently, if sustained sleep loss occurs during that sensitive period, some functions will likely suffer. The prefrontal cortex, the seat of higher executive functions and emotional regulation, has been shown to be particularly sensitive to sleep deprivation (Horne, 1993). Moreover, it is the region that matures the latest (Teffer & Semendeferi, 2012); which makes it more vulnerable to disruptions occurring in the first years of life. Indeed, it was shown that higher volume in orbitofrontal and prefrontal cortex (as well as temporal cortex, precuneus and supramarginal gyrus) was correlated with longer sleep duration in children (Cheng et al., 2021). Moreover, higher volume in these regions was associated with higher cognitive scores (Cheng et al., 2021).

The differential academic outcomes obtained between children in Traj1 and Traj2 might be explained by the presence of genetically determined true short sleepers mixed in the group of children of Traj2. True short sleepers are individuals who really *need* less sleep to function normally. Indeed, a longitudinal twin study observed a strong heritability (71% of the variance) for the short persistent trajectory (Traj2; Touchette et al., 2013). These individuals will be sleeping less throughout their life without significant consequences on their daily functioning. By opposition, only common and unique environment accounted for the variance in the short increasing sleep trajectory (Traj1), which showed more negative outcomes (Touchette et al., 2013).

4.2 | Preventive and corrective actions

Contrary to popular belief, early childhood sleep problems do not always spontaneously disappear, especially night wakings, which are responsible for the reduction in sleep duration (Touchette et al., 2005). In some cases they do but in many others they tend to persist over several years if left untreated (Byars et al., 2012; Kataria et al., 1987). What then is there to do to insure sufficient sleep for a specific child in that very important period? First, as already mentioned, there are true short sleepers, even at this young age, who will not suffer any functional daytime deficits. It is an uncommon and heritable trait. Another cause of short sleep duration in young children might be neurodevelopmental or medical disorders. These will require medical attention. However, in healthy children with neurotypical development, the strongest determinants of sleep loss during the first three years are inadequate parental behaviours around their child's bedtime and in response to night wakings (Touchette et al., 2005; Yu et al., 2017). A review by the American Academy of Sleep Medicine (Mindell et al., 2006) on the management of bedtime problems and night wakings in young children focuses indeed on helping parents adopt appropriate bedtime behaviours (Mindell & Williamson, 2018) with their child. In fact, strong empirical support has been reported for the following paediatric sleep recommendations to parents (Allen et al., 2016): ensuring age-appropriate sleep duration, establishing bedtime routines, and teaching children to develop their sleep autonomy. However, more research is needed to quantify the long-term impacts of those recommendations on child development, including cognition.

4.3 | Limitations of the study

The first limitation is that sleep duration trajectories were not based on objective measures but rather on parental reports, which usually overestimate sleep duration (Dayyat et al., 2011). However, if true in general, this overestimation does not disallow the association between insufficient sleep and the outcomes measured. In addition, the fact that the parent estimated sleep durations and the teacher evaluated outcome variables limits the convergence bias that might be present in other studies. Second, it is important to mention that there was only one time point (age 10 years) for the assessment of academic performance. Third, the outcome variables were not grades per se but an evaluation of how well the students were performing with respect to the class. This has both positive and negative aspects. On one side, it allows a standardized comparison to be made across classrooms and schools about a problematic outcome. On the other side, it results in categorical instead of continuous variables, which is less powerful for making correlations with the trajectories. Moreover, because a greater proportion of children in Traj1 and Traj2 are non-Caucasian, born of immigrant mothers, speak other languages at home and have insufficient family income, implicit sociodemographic biases may affect the teachers in their evaluation. Fourth, although we have controlled for the main possible confounders, logistic regressions assess risk but cannot be used to infer causality. A confounder not measured, attention disorder with or without hyperactivity for example, could possibly mediate the relationship. Finally, there were few children in the two trajectories of short sleep duration. Although this is understandable because insufficient sleep during early childhood should not be a common occurrence, these results should be interpreted with caution and should be replicated in larger samples.

5 | CONCLUSIONS

These findings emphasize the importance of promoting sufficient sleep throughout childhood in order to give children an optimal chance at academic achievement—a good start in life. Sufficient sleep duration is especially important during early childhood, a period where the brain undergoes major development and connectivity restructuring. The various paediatric guidelines and recommendations, which can really help in preventing insufficient sleep in early childhood, should be made more accessible to new parents.

AUTHOR CONTRIBUTIONS

Dominique Petit conceptualized and designed the study, interpreted the data, drafted the initial manuscript, reviewed and approved the final manuscript as submitted.

Jean Paquet conceptualized and designed the study, carried out the statistical analyses, interpreted the data, and critically reviewed the manuscript for important intellectual content.

Marie-Hélène Pennestri, Evelyne Touchette and Jacques Y. Montplaisir conceptualized and designed the study, interpreted the data, and critically reviewed the manuscript for important intellectual content.

Sylvana Côté, Richard E. Tremblay, Michel Boivin and Jacques Y. Montplaisir participated in the entire QLSCD conceptualization and design, designed the data collection instruments, coordinated and supervised the data collection, and critically reviewed the manuscript for important intellectual content.

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CONFLICT OF INTEREST STATEMENT

Dominique Petit, Evelyne Touchette, Jean Paquet, Sylvana Côté, Richard E. Tremblay and Michel Boivin have no conflict of interest to disclose. Jacques Y. Montplaisir received consultant honorarium during the study period from Takeda Pharmaceuticals, Novartis Pharmaceuticals, Merck Pharmaceuticals, Jazz Pharmaceuticals, UCB Canada, and Valeant Canada during the study period. None of the financial disclosures is relevant to the submitted work.

DATA AVAILABILITY STATEMENT

Data has been obtained from a third party: The data analyzed in this study was obtained from the Institut de la statistique du Québec and, as stipulated in the clauses 10 and 11 of the Institut de la statistique's Québec Act (Canada), the access to the data is restricted to the parties identified in the partnership agreement signed to ensure the conduct of the study and which describes the author's right. In the QLSCD cohort, the participants only consented to share their data to the study's financial partners and affiliated researchers and their collaborators. Those partners and researchers have only access after signing a data sharing agreement. Requests to access these data can be directed to the Institut de la statistique du Québec's Research Data Access Services - Home (www.quebec.ca). For more information, contact Marc-Antoine Côté-Marcil (SAD@stat.gouv.qc.ca).

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REFERENCES

Allen, S. L., Howlett, M. D., Coulombe, J. A., & Corkum, P. V. (2016). ABCs of SLEEPING: A review of the evidence behind pediatric sleep practice recommendations. *Sleep Medicine Reviews*, *29*, 1–14. https://doi.org/10.1016/j.smrv.2015.08.006

Alyahri, A., & Goodman, R. (2008). Harsh corporal punishment of Yemeni children: Occurrence, type and associations. *Child Abuse & Neglect*, *32*(8), 766–773. https://doi.org/10.1016/j.chiabu.2008.01.001

Anastas, J. W., & Reinherz, H. (1984). Gender differences in learning and adjustment problems in school: Results of a longitudinal study. *The American Journal of Orthopsychiatry*, *54*(1), 110–122. https://doi.org/10.1111/j.1939-0025.1984.tb01479.x

Astill, R. G., Van der Heijden, K. B., Van Ijzendoorn, M. H., & Van Someren, E. J. (2012). Sleep, cognition, and behavioral problems in school-age children: A century of research meta-analyzed. *Psychological Bulletin*, *138*(6), 1109–1138. https://doi.org/10.1037/a0028204

Bermejo, V., Ester, P., & Morales, I. (2021). How the language of instruction influences mathematical thinking development in the first years of bilingual schoolers. *Frontiers in Psychology*, *12*, 533141. https://doi.org/10.3389/fpsyg.2021.533141

Bernier, A., Cimon-Paquet, C., Tetreault, E., Carrier, J., & Matte-Gagne, C. (2021). Prospective relations between sleep in preschool years and academic achievement at school entry. *Journal of Sleep Research*, *30*(3), e13183. https://doi.org/10.1111/jsr.13183

Best, J. R., Miller, P. H., & Naglieri, J. A. (2011). Relations between executive function and academic achievement from ages 5 to 17 in a large, representative national sample. *Learning and Individual Differences*, *21*(4), 327–336. https://doi.org/10.1016/j.lindif.2011.01.007

Born, J., Rasch, B., & Gais, S. (2006). Sleep to remember. *The Neuroscientist*, *12*(5), 410–424. https://doi.org/10.1177/1073858406292647

Byars, K. C., Yolton, K., Rausch, J., Lanphear, B., & Beebe, D. W. (2012). Prevalence, patterns, and persistence of sleep problems in the first 3 years of life. *Pediatrics*, *129*(2), e276–e284. https://doi.org/10.1542/peds.2011-0372

Chaput, J. P., Dutil, C., & Sampasa-Kanyinga, H. (2018). Sleeping hours: What is the ideal number and how does age impact this? *Nature and Science of Sleep*, *10*, 421–430. https://doi.org/10.2147/NSS.S163071

Chaput, J. P., Gray, C. E., Poitras, V. J., Carson, V., Gruber, R., Birken, C. S., MacLean, J. E., Aubert, S., Sampson, M., & Tremblay, M. S. (2017). Systematic review of the relationships between sleep duration and health indicators in the early years (0-4 years). *BMC Public Health*, *17*(Suppl 5), 855. https://doi.org/10.1186/s12889-017-4850-2

Chaput, J. P., Gray, C. E., Poitras, V. J., Carson, V., Gruber, R., Olds, T., Weiss, S. K., Gorber, S. C., Kho, M. E., Sampson, M., Belanger, K., Eryuzlu, S., Callender, L., & Tremblay, M. S. (2016). Systematic review of the relationships between sleep duration and health indicators in school-aged children and youth. *Applied Physiology, Nutrition, and Metabolism*, *41*(6 Suppl 3), S266–S282. https://doi.org/10.1139/apnm-2015-0627

Chatterji, P., Kim, D., & Lahiri, K. (2014). Birth weight and academic achievement in childhood. *Health Economics*, *23*(9), 1013–1035. https://doi.org/10.1002/hec.3074

Cheng, W., Rolls, E., Gong, W., Du, J., Zhang, J., Zhang, X. Y., Li, F., & Feng, J. (2021). Sleep duration, brain structure, and psychiatric and cognitive problems in children. *Molecular Psychiatry*, *26*(8), 3992–4003. https://doi.org/10.1038/s41380-020-0663-2

Dayyat, E. A., Spruyt, K., Molfese, D. L., & Gozal, D. (2011). Sleep estimates in children: Parental versus actigraphic assessments. *Nature and Science of Sleep*, *3*, 115–123. https://doi.org/10.2147/NSS.S25676

Dewald, J. F., Meijer, A. M., Oort, F. J., Kerkhof, G. A., & Bogels, S. M. (2010). The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review. *Sleep Medicine Reviews*, *14*(3), 179–189. https://doi.org/10.1016/j.smrv.2009.10.004

Dionne, G., Touchette, E., Forget-Dubois, N., Petit, D., Tremblay, R. E., Montplaisir, J. Y., & Boivin, M. (2011). Associations between sleep-wake consolidation and language development in early childhood: A longitudinal twin study. *Sleep*, *34*(8), 987–995. https://doi.org/10.5665/SLEEP.1148

Eliasson, A., Eliasson, A., King, J., Gould, B., & Eliasson, A. (2002). Association of sleep and academic performance. *Sleep & Breathing*, *6*(1), 45–48. https://doi.org/10.1007/s11325-002-0045-9

Espy, K. A., McDiarmid, M. M., Cwik, M. F., Stalets, M. M., Hamby, A., & Senn, T. E. (2004). The contribution of executive functions to emergent mathematic skills in preschool children. *Developmental Neuropsychology*, *26*(1), 465–486. https://doi.org/10.1207/s15326942dn2601_6

Hair, N. L., Hanson, J. L., Wolfe, B. L., & Pollak, S. D. (2015). Association of child poverty, brain development, and academic achievement. *JAMA Pediatrics*, *169*(9), 822–829. https://doi.org/10.1001/jamapediatrics.2015.1475

Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., Hazen, N., Herman, J., Katz, E. S., Kheirandish-Gozal, L., Neubauer, D. N., O'Donnell, A. E., Ohayon, M., Peever, J., Rawding, R., Sachdeva, R. C., Setters, B., Vitiello, M. V., Ware, J. C., … Adams Hillard, P. J. (2015). National Sleep Foundation's sleep time duration recommendations: Methodology and results summary. *Sleep Health*, *1*(1), 40–43. https://doi.org/10.1016/j.sleh.2014.12.010

Horne, J. A. (1993). Human sleep, sleep loss and behaviour. Implications for the prefrontal cortex and psychiatric disorder. *The British Journal of Psychiatry*, *162*, 413–419. https://doi.org/10.1192/bjp.162.3.413

Hoyniak, C. P., Bates, J. E., McQuillan, M. E., Staples, A. D., Petersen, I. T., Rudasill, K. M., & Molfese, V. J. (2020). Sleep across early childhood: Implications for internalizing and externalizing problems, socioemotional skills, and cognitive and academic abilities in preschool. *Journal of Child Psychology and Psychiatry*, *61*(10), 1080–1091. https://doi.org/10.1111/jcpp.13225

Iglowstein, I., Jenni, O. G., Molinari, L., & Largo, R. H. (2003). Sleep duration from infancy to adolescence: Reference values and generational trends. *Pediatrics*, *111*(2), 302–307. https://doi.org/10.1542/peds.111.2.302

Jones, B. L., Nagin, D. S., & Roeder, K. (2001). A SAS procedure based on mixture models for estimating developmental trajectories. *Sociological Methods & Research*, *29*, 374–393.

Kataria, S., Swanson, M. S., & Trevathan, G. E. (1987). Persistence of sleep disturbances in preschool children. *The Journal of Pediatrics*, *110*(4), 642–646. https://doi.org/10.1016/s0022-3476(87)80571-1

Kristjansson, A. L., Thomas, S., Lilly, C. L., Thorisdottir, I. E., Allegrante, J. P., & Sigfusdottir, I. D. (2018). Maternal smoking during pregnancy and academic achievement of offspring over time: A registry data-based cohort study. *Preventive Medicine*, *113*, 74–79. https://doi.org/10.1016/j.ypmed.2018.05.017

Kurth, S., Achermann, P., Rusterholz, T., & Lebourgeois, M. K. (2013). Development of brain EEG connectivity across early childhood: Does sleep play a role? *Brain Sciences*, *3*(4), 1445–1460. https://doi.org/10.3390/brainsci3041445

Li, S., Arguelles, L., Jiang, F., Chen, W., Jin, X., Yan, C., Tian, Y., Hong, X., Qian, C., Zhang, J., Wang, X., & Shen, X. (2013). Sleep, school performance, and a school-based intervention among school-aged children: A sleep series study in China. *PLoS One*, *8*(7), e67928. https://doi.org/10.1371/journal.pone.0067928

Lim, J., & Dinges, D. F. (2010). A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. *Psychological Bulletin*, *136*(3), 375–389. https://doi.org/10.1037/a0018883

Loessl, B., Valerius, G., Kopasz, M., Hornyak, M., Riemann, D., & Voderholzer, U. (2008). Are adolescents chronically sleep-deprived? An investigation of sleep habits of adolescents in the Southwest of Germany. *Child: Care, Health and Development*, *34*(5), 549–556. https://doi.org/10.1111/j.1365-2214.2008.00845.x

Matricciani, L., Olds, T., & Petkov, J. (2012). In search of lost sleep: Secular trends in the sleep time of school-aged children and adolescents. *Sleep Medicine Reviews*, *16*(3), 203–211. https://doi.org/10.1016/j.smrv.2011.03.005

Mayes, S. D., Calhoun, S. L., Bixler, E. O., & Vgontzas, A. N. (2008). Nonsignificance of sleep relative to IQ and neuropsychological scores in predicting academic achievement. *Journal of Developmental and Behavioral Pediatrics*, *29*(3), 206–212. https://doi.org/10.1097/DBP.0b013e31816d924f

Mindell, J. A., Kuhn, B., Lewin, D. S., Meltzer, L. J., Sadeh, A., & American Academy of Sleep Medicine. (2006). Behavioral treatment of bedtime problems and night wakings in infants and young children. *Sleep*, *29*(10), 1263–1276.

Mindell, J. A., & Williamson, A. A. (2018). Benefits of a bedtime routine in young children: Sleep, development, and beyond. *Sleep Medicine Reviews*, *40*, 93–108. https://doi.org/10.1016/j.smrv.2017.10.007

Murray, L., Arteche, A., Fearon, P., Halligan, S., Croudace, T., & Cooper, P. (2010). The effects of maternal postnatal depression and child sex on academic performance at age 16 years: A developmental approach. *Journal of Child Psychology and Psychiatry*, *51*(10), 1150–1159. https://doi.org/10.1111/j.1469-7610.2010.02259.x

Nitardy, C. M., Duke, N. N., Pettingell, S. L., & Borowsky, I. W. (2015). Racial and ethnic disparities in educational achievement and aspirations: Findings from a statewide survey from 1998 to 2010. *Maternal and Child Health Journal*, *19*(1), 58–66. https://doi.org/10.1007/s10995-014-1495-y

Paruthi, S., Brooks, L. J., D'Ambrosio, C., Hall, W. A., Kotagal, S., Lloyd, R. M., Malow, B. A., Maski, K., Nichols, C., Quan, S. F., Rosen, C. L., Troester, M. M., & Wise, M. S. (2016). Recommended amount of sleep for pediatric populations: A consensus statement of the American Academy of sleep medicine. *Journal of Clinical Sleep Medicine*, *12*(6), 785–786. https://doi.org/10.5664/jcsm.5866

Patil, Y. J., & Metgud, D. (2014). Comparison of non verbal learning difficulties in preschoolers born preterm with the term born peers. *Indian Journal of Pediatrics*, *81*(4), 346–349. https://doi.org/10.1007/s12098-013-1254-x

Richardson, G. A., Ryan, C., Willford, J., Day, N. L., & Goldschmidt, L. (2002). Prenatal alcohol and marijuana exposure: Effects on neuropsychological outcomes at 10 years. *Neurotoxicology and Teratology*, *24*(3), 309–320. https://doi.org/10.1016/s0892-0362(02)00193-9

Seegers, V., Touchette, E., Dionne, G., Petit, D., Seguin, J. R., Montplaisir, J., Vitaro, F., Falissard, B., Boivin, M., Tremblay, R. E., & Tremblay, R. E. (2016). Short persistent sleep duration is associated with poor receptive vocabulary performance in middle childhood. *Journal of Sleep Research*, *25*(3), 325–332. https://doi.org/10.1111/jsr.12375

Sullivan, A. L., Houri, A., & Sadeh, S. (2016). Demography and early academic skills of students from immigrant families: The kindergarten class of 2011. *School Psychology Quarterly*, *31*(2), 149–162. https://doi.org/10.1037/spq0000137

Tamayo Martinez, N., Xerxa, Y., Law, J., Serdarevic, F., Jansen, P. W., & Tiemeier, H. (2022). Double advantage of parental education for child educational achievement: The role of parenting and child intelligence. *European Journal of Public Health*, *32*(5), 690–695. https://doi.org/10.1093/eurpub/ckac044

Teffer, K., & Semendeferi, K. (2012). Human prefrontal cortex: Evolution, development, and pathology. *Progress in Brain Research*, *195*, 191–218. https://doi.org/10.1016/B978-0-444-53860-4.00009-X

Touchette, E., Dionne, G., Forget-Dubois, N., Petit, D., Perusse, D., Falissard, B., Tremblay, R. E., Boivin, M., & Montplaisir, J. Y. (2013). Genetic and environmental influences on daytime and nighttime sleep duration in early childhood. *Pediatrics*, *131*(6), e1874–e1880. https://doi.org/10.1542/peds.2012-2284

Touchette, E., Petit, D., Paquet, J., Boivin, M., Japel, C., Tremblay, R. E., & Montplaisir, J. Y. (2005). Factors associated with fragmented sleep at night across early childhood. *Archives of Pediatrics & Adolescent Medicine*, *159*(3), 242–249. https://doi.org/10.1001/archpedi.159.3.242

Touchette, E., Petit, D., Seguin, J. R., Boivin, M., Tremblay, R. E., & Montplaisir, J. Y. (2007). Associations between sleep duration patterns and behavioral/cognitive functioning at school entry. *Sleep*, *30*(9), 1213–1219. https://doi.org/10.1093/sleep/30.9.1213

Touchette, E., Petit, D., Tremblay, R. E., Boivin, M., Falissard, B., Genolini, C., & Montplaisir, J. Y. (2008). Associations between sleep duration patterns and overweight/obesity at age 6. *Sleep*, *31*(11), 1507–1514. https://doi.org/10.1093/sleep/31.11.1507

Weissbluth, M. (1995). Naps in children: 6 months-7 years. *Sleep*, *18*(2), 82–87. https://doi.org/10.1093/sleep/18.2.82

Williams, K. E., Nicholson, J. M., Walker, S., & Berthelsen, D. (2016). Early childhood profiles of sleep problems and self-regulation predict later school adjustment. *The British Journal of Educational Psychology*, *86*(2), 331–350. https://doi.org/10.1111/bjep.12109

Williamson, A. A., Mindell, J. A., Hiscock, H., & Quach, J. (2020). Longitudinal sleep problem trajectories are associated with multiple impairments in child well-being. *Journal of Child Psychology and Psychiatry*, *61*(10), 1092–1103. https://doi.org/10.1111/jcpp.13303

Willoughby, M. T., Blair, C. B., Wirth, R. J., & Greenberg, M. (2012). The measurement of executive function at age 5: Psychometric properties and relationship to academic achievement. *Psychological Assessment*, *24*(1), 226–239. https://doi.org/10.1037/a0025361

Yu, X. T., Sadeh, A., Lam, H. S., Mindell, J. A., & Li, A. M. (2017). Parental behaviors and sleep/wake patterns of infants and toddlers in Hong Kong, China. *World Journal of Pediatrics*, *13*(5), 496–502. https://doi.org/10.1007/s12519-017-0025-6

Zepelin, H. (2005). Mammalian sleep. In M. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and practice of sleep medicine* (pp. 91–100). W. B. Saunders.

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