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The association between insomnia, chronotype, and positive airway pressure adherence in children and adolescents

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ABSTRACT

Study objectives: Positive airway pressure (PAP) therapy is highly efficacious for the treatment of sleep-disordered breathing in children but is limited by poor adherence. We sought to evaluate the relationship between insomnia and chronotype on PAP adherence in children.

Methods: This is a cross-sectional study conducted at the Hospital for Sick Children (Toronto, Canada) of children aged 4–18 years old prescribed PAP for a minimum of six months. Self-reported and/or caregiver-reported questionnaires including the Pediatric Insomnia Severity Index and Children's Chronotype Questionnaire were completed. PAP therapy usage was measured using objective download data.

Results: There were 159 participants included (median age = 14.2 years, females = 38%). Median PAP usage was 436.0 min/night (IQR 147.0, 516.0) for the morning group, 417.0 min/night (IQR 189.2, 538.8) for the intermediate group, and 161.5 min/night (IQR 6.0, 405.2) for the evening group. Children with an evening chronotype used PAP therapy for a median of 264.4 min less per night than children with an intermediate chronotype (95% CI 65.8, 397.1; $p = 0.0018$). Children used PAP therapy for 37.0 min less per night for each 1-point increase in the sleep maintenance problems score (95% CI 10.0, 47.7; $p < 0.001$) and 33.7 min less per night for each 1-point increase in the sleep onset problems score (95% CI 20.0, 39.5; $p < 0.001$). Sleep onset and sleep maintenance problems significantly influenced the relationship between chronotype and PAP usage.

Conclusion: We found that insomnia and evening chronotype were associated with reduced PAP adherence in children. These may be modifiable factors to promote PAP adherence.

1. Introduction

Sleep-disordered breathing (SDB) is common in children and adolescents, and is associated with reduced health-related quality of life [1,2], mood disorders, [1,2], and cardiovascular consequences [3–6]. SDB is often treated with positive airway pressure (PAP) therapy, which is highly efficacious but limited by poor adherence rates of less than 50% [7]. The identification of modifiable factors associated with PAP therapy usage is required to address suboptimal adherence [8].

Emerging literature in adult populations suggests that sleep-wake characteristics and behaviors may be associated with PAP usage [9,10]. Insomnia, characterized by difficulties initiating and maintaining sleep, has been demonstrated to affect PAP therapy tolerance amongst adult populations [10]. Chronotype refers to the endogenous preference for sleep-wake timing and may also be associated with PAP adherence. Individuals with morning chronotype tend to have advanced bedtimes and rise times as compared to individuals with an evening chronotype who tend to have delayed bedtimes and rise times. Intermediate chronotype has no preference for morning or evening. Evening chronotype is a potential risk factor for the development of insomnia symptoms due to the misalignment between the social and biological clock [11]. Further, chronotype may influence sleep-related behaviors that in turn impact

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PAP usage [9].

The prevalence of evening chronotype as well as insomnia symptoms are increased during adolescence and early adulthood. Chronotype changes significantly during the lifespan with eveningness peaking at the age of 20 years [12]. Similarly, insomnia symptoms progressively increase in prevalence with pubertal maturation [13]. Therefore, the evaluation of these factors with PAP adherence is of importance for this population. To date, the relationship between chronotype, insomnia, and PAP adherence has not been established in children and adolescents.

This study addresses a critical knowledge gap regarding the association between insomnia, chronotype, and PAP therapy adherence amongst children and adolescents with SDB. We hypothesized that PAP therapy adherence would be decreased amongst children and adolescents with evening chronotypes as well as those with insomnia symptoms. Understanding the impact of chronotype and insomnia on PAP adherence in children and adolescents may inform future targeted treatment strategies to improve PAP therapy adherence.

2. Study design and methods

2.1. Study design

This was a single-center cross-sectional study. Following enrollment, caregivers completed electronic questionnaires regarding their child's sleep-wake timing, daytime behaviors, psychosocial functioning, and demographics. A subgroup of children and adolescents also completed self-report questionnaires. The electronic medical record was reviewed. Ethics approval was obtained from the Hospital for Sick Children (REB#1000080572) and the study was registered (Clinicaltrials.gov: NCT05949164). Patients and/or caregivers provided verbal informed consent in accordance with the Declaration of Helsinki. Study method and results are reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement for cross-sectional studies [14].

2.2. Patient population

From May 2022 to May 2024, we enrolled the caregivers of adolescents aged 4–18 years old who were prescribed PAP therapy, including continuous and bilevel PAP, for at least six months from the Hospital for Sick Children (Toronto, Canada). A time period of six months was chosen to capture a period of stable adherence because we expected PAP usage to vary over the first three months of PAP being prescribed [7,15]. We also enrolled a subgroup of children and adolescents aged 8–18 years old who were deemed to be capable of completing questionnaires independently by a member of their care team. Caregivers and children and adolescents with limited knowledge and proficiency in English were excluded because the study questionnaires were only validated in English.

2.3. Study measures

2.3.1. Exposures

2.3.1.1. Insomnia. Insomnia symptoms were evaluated with the caregiver-reported Pediatric Insomnia Severity Index [16]. The Pediatric Insomnia Severity Index assesses the domains of sleep maintenance problems and sleep onset problems with a maximum score of 15 points per domain [16]. There is currently no validated cutoff for diagnosing insomnia using the Pediatric Insomnia Severity Index.

In the subgroup analysis of children and adolescents with self-reported questionnaire data, the diagnosis of insomnia was based on the self-reported Insomnia Severity Index questionnaire [17,18]. Children and adolescents were classified as having insomnia on the self-reported Insomnia Severity Index questionnaire using a cut-off of $\geq$9 points, which has a sensitivity of 0.87 and specificity of 0.75 based on the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition [17].

2.3.1.2. Chronotype. Chronotype was defined by the caregiver-reported Children's Chronotype Questionnaire, which was developed for children aged 4–11 years old [19] and extended by another study group to adolescents aged up to 18 years old [20]. Chronotype was defined by scores of 0–22, 23–32, and $\geq$33 representing morning, intermediate, and evening chronotypes, respectively [20].

In the subgroup analysis of children and adolescents with self-reported questionnaire data, chronotype was also defined by the self-reported reduced Morningness-Eveningness Questionnaire with categories of 0–11, 12–17, and $\geq$18 representing morning, intermediate, and evening chronotypes, respectively [21–24].

2.3.2. Outcome

The primary outcome was PAP therapy usage measured as the mean minutes of nightly PAP usage over six months as this timeframe was expected to be a more stable representation of PAP adherence and sleep patterns. Adherence is a clinically important outcome because a dose-response relationship exists between the duration of PAP usage and clinical outcomes [25]. PAP therapy usage was objectively assessed using device downloads captured remotely and manually.

2.3.3. Other measures

The covariates age and gender were determined *a priori*. Age was collected from the medical record at the time of consent and gender was caregiver-reported from the demographic form. Annual household income, highest household education, race and ethnicity, height, weight, and gender were collected through caregiver-reported questionnaires. Complex chronic conditions were defined according to Feudtner et al. as "any medical condition that can be reasonably expected to last at least 12 months (unless death intervenes) and to involve either several different organ systems or 1 organ system severely enough to require specialty pediatric care and probably some period of hospitalization in a tertiary care center." [26] A history of adenoidectomy or tonsillectomy was caregiver-reported.

We hypothesized that chronotype may be associated with PAP adherence through direct or indirect relationships. We studied variables that may influence the relationship between PAP adherence and chronotype including insomnia, anxiety, depression, daytime sleepiness, and neurobehavioral functioning [25,27]. Insomnia was measured with the Pediatric Insomnia Severity Index [16], described earlier. Anxiety and Depression were measured with the electronic versions of the caregiver-reported PROMIS Pediatric Item Bank v2.0 for anxiety and depressive symptoms, respectively [28]. A score of 50 is the average for the United States general population with a standard deviation of 10. T-scores greater than 50 indicate more symptoms than average whereas T-scores lower than 50 indicate less symptoms than average. Daytime sleepiness was evaluated with the caregiver-reported Epworth Sleepiness Scale, which yields a total score out of 24 with higher scores indicating greater sleepiness [29,30]. Neurobehavioral functioning was evaluated with the caregiver-reported Strengths and Difficulties Questionnaire, which assess psychological attributes to identify problems in the domains of conduct, hyperactivity, emotion, issues with peers, and prosocial behaviors [31,32]. The total difficulties score ranges from 0 to 40, with higher scores indicating greater dysfunction. The Adolescent Sleep Hygiene Scale is a self-report questionnaire to assess sleep hygiene and was completed by children and adolescents in the subgroup of study participants capable of completing questionnaires independently [33].

2.4. Statistical analysis

Individuals with complete data for PAP usage, insomnia measures,

and chronotype were included in the analysis. Descriptive statistics were used to summarize the baseline demographic variables. Continuous data were described with medians and interquartile ranges (IQR) and categorical variables were presented as frequency (percentage). Kruskal-Wallis tests and Chi-squared tests were utilized to compare characteristics amongst groups. The Bonferroni correction was used to adjust for multiple comparisons.

Multivariable quantile regression models were constructed to assess the association between chronotype and insomnia with PAP therapy usage, with adjustment for covariates determined *a priori* including age and caregiver-reported gender. The analyses for the median are presented. We analyzed the indirect associations between chronotype and PAP adherence to better understand how additional variables may influence this relationship using the R package mediation [34]. This analysis provides information regarding the extent to which PAP usage changes when the chronotype is held constant and a third variable changes.

Subgroup analyses were completed for children and adolescents with and without self-reported questionnaire data. Sensitivity analyses were completed for PAP usage data averaged over the preceding 3 months and 2 weeks. Additional sensitivity analyses were completed for the primary outcome including 1) a multivariable logistic regression using a binary adherence outcome defined as PAP usage for at least 4 h/night for 70% of nights based on the Centers for Medicare and Medicaid Services definition [35]; and 2) a multivariable quantile regression defining PAP usage as a percentage of caregiver-reported total sleep time on the Children's Chronotype Questionnaire.

All analyses were performed using R [36]. Statistical significance was defined as $p < 0.05$, and two-sided tests were performed throughout. The associated 95% confidence intervals (CI) were estimated using bootstrapping with 1000 replicates [37].

3. Results

We approached the caregivers of 291 children and adolescents who were confirmed to be eligible for the study and 216 (74%) consented to participate. Complete study data was collected for 159 participants.

3.1. Baseline demographics

The median (IQR) age was 14.2 (10.7, 16.7) years and there were 60/159 females (38%). The median (IQR) body mass index z-score was 2.0 (0.3, 3.1) and 129/159 participants (81%) had one or more complex chronic conditions (Table 1). There were 95/159 participants (60%) who used continuous PAP. Children and adolescents were prescribed PAP therapy for a median (IQR) duration of 44.1 (21.0, 66.9) months. Those using continuous PAP had been prescribed PAP therapy for a median (IQR) duration of 31.6 (17.0, 51.5) months and those using bilevel PAP had been prescribed PAP therapy for a median of 57.6 (IQR 38.3, 80.7) months.

3.2. Insomnia

The median (IQR) score for sleep maintenance problems was 4.0 (3.0, 6.0) and the score for sleep onset problems was 4.0 (2.0, 8.0) (Table 1). When adjusted for age and gender, children and adolescents used PAP therapy for 37.0 min less per night for each increase in the sleep maintenance problems score by 1 point (95% CI 10.0, 47.0; $p < 0.001$). Similarly, PAP therapy usage decreased by 33.7 min per night for each increase in the sleep onset problems score by 1 point (95% CI 20.0, 39.5; $p < 0.001$) (Table 2 and Fig. 2).

3.3. Chronotype

There were 29/159 participants (18%) with a morning chronotype, 64/159 (40%) with an intermediate chronotype, and 66/159 (42%)

Table 1
Demographics by Chronotype

Characteristic, median (IQR)	Total Sample (N = 159)	Morning (n = 29)	Intermediate (n = 64)	Evening (n = 66)
Age (years)[k]	14.2 (10.7, 16.7)	12.2 (7.3, 15.7)	13.6 (10.6, 16.5)	15.2 (12.0, 17.4)
Male gender, n (%)	99.0 (62.3)	19.0 (65.5)	38.0 (59.4)	42.0 (63.6)
Body mass index z-score	2.0 (0.3, 3.1)	1.9 (0.5, 3.0)	1.9 (0.0, 3.2)	2.3 (0.3, 3.3)
One or more complex chronic conditions, n (%)	129 (81.1)	25 (86.2)	56 (87.5)	48 (72.7)
History of adenoidectomy or tonsillectomy, n (%)	73 (45.9)	14 (48.3)	26 (40.6)	33 (50.0)
Annual household income, n (%)				
<$20,000	7 (4.4)	0 (0.0)	2 (3.1)	5 (7.5)
$20,000-49,999	10 (6.3)	2 (6.9)	2 (3.1)	6 (9.1)
$50,000-79,999	23 (14.5)	4 (13.8)	11 (17.2)	8 (12.1)
>$80,000	22 (13.8)	2 (6.9)	9 (14.1)	11 (16.7)
Prefer not to answer	97 (61.0)	21 (7.2)	40 (62.5)	36 (54.5)
Highest caregiver education level, n (%)				
Completed elementary	22 (13.8)	2 (6.9)	8 (12.5)	12 (18.2)
Completed post-secondary	82 (51.6)	17 (58.6)	31 (48.4)	34 (51.5)
Completed secondary	51 (32.1)	9 (31.0)	25 (39.1)	17 (25.8)
Prefer not to answer	4 (2.5)	1 (3.4)	0 (0.0)	3 (4.5)
Race and ethnicity, n (%)				
Hispanic or Latino	3 (1.9)	0 (0.0)	1 (1.6)	2 (3.0)
Black or African Canadian	19 (11.9)	3 (10.3)	6 (9.4)	10 (15.2)
Asian or Pacific Islander	31 (19.5)	3 (10.3)	12 (18.8)	16 (24.2)
White	73 (45.9)	17 (58.6)	33 (51.6)	23 (34.8)
Indigenous	3 (1.9)	1 (3.4)	1 (1.6)	1 (1.5)
Other or not sure	23 (14.4)	4 (13.8)	7 (10.9)	12 (18.2)
Prefer not to answer	7 (4.4)	1 (3.4)	4 (6.2)	2 (3.0)
Prescribed PAP duration (months)[l]	44.1 (21.0, 66.9)	50.9 (34.2, 66.2)	48.9 (27.6, 77.1)	30.8 (15.0, 53.1)
PAP type, n (%)				
Continuous PAP	95 (59.7)	17 (58.6)	36 (56.2)	42 (63.6)
Bilevel PAP	64 (40.3)	12 (41.4)	28 (43.8)	24 (36.4)
Epworth Sleepiness Scale	6.0 (2.0, 11.0)[a]	4.0 (1.8, 11.2)[b]	4.0 (1.3, 9.5)[c]	6.0 (2.0, 11.0)[b]
Anxiety T-score	51.7 (44.9, 58.3)[d]	53.0 (46.0, 61.6)[a]	50.9 (44.5, 56.6)[a]	51.7 (46.2, 58.3)[e]
Depression T-score[l]	51.0 (44.7, 57.7)[d]	51.6 (44.7, 58.4)[a]	47.8 (41.0, 53.2)[a]	53.7 (47.7, 61.6)[e]
Strengths and Difficulties Total Difficulties Score[l]	19.0 (16.0, 24.0)[f]	21.0 (17.0, 25.0)	18.0 (14.0, 23.0)[a]	21.0 (17.0, 26.0)[c]
Mean daily caffeine consumption (mg)[k]	109.5 (20.8, 561.9)[c]	54.0 (0.0, 183.7)	83.9 (22.4, 300.5)[b]	275.3 (66.5, 746.0)[b]
Average sleep time (min)[k]	533.6 (492.1, 592.9)	574.3 (535.0, 608.6)	531.4 (496.8, 602.0)	526.4 (477.3, 563.8)
Sleep onset problems[k,l]	4.0 (2.0, 8.0)	2.0 (1.0, 3.0)	3.0 (2.0, 5.0)	7.0 (4.0, 10.0)
Sleep maintenance problems[k, l]	4.0 (3.0, 6.0)	4.0 (1.0, 6.0)	3.0 (2.0, 5.2)	5.0 (4.0, 8.8)

Abbreviations: IQR = interquartile range; PAP = positive airway pressure.
[a] 4 missing values; [b] 1 missing value; [c] 2 missing values; [d] 13 missing values; [e] 5 missing values; [f] 6 missing values; [g] 21 missing values; [h] 3 missing values; [i] 8 missing values; [j] 10 missing values; [k] statistically significant difference between evening and intermediate groups (adjusted $p<0.05$); [l] statistically significant difference between evening and morning groups (adjusted $p<0.05$)

Table 2
Relationship between caregiver-reported insomnia symptoms, chronotype, and positive airway pressure usage.

Characteristic (N = 159)	PAP usage (min/night)	95% CI	p-value
Sleep Maintenance Problems	−37.0	−47.7, −10.0	<0.001
Sleep Onset Problems	−33.7	−39.5, −20.0	<0.001
Chronotype			
Morning	19.9	−225.7, 142.6	0.83
Intermediate	Ref		
Evening	−264.4	−397.1, −65.8	0.0018

Abbreviations: CI = confidence interval; PAP = positive airway pressure. All analyses adjusted for age and gender.

with an evening chronotype. As compared to participants with morning chronotypes, children and adolescents with an evening chronotype were older and reported higher daily caffeine consumption. Amongst the subgroup that completed self-reported questionnaires, 43/86 participants (50%) reported never consuming caffeine in the evening on the Adolescent Sleep Hygiene Scale, with no significant differences observed across chronotypes. As compared to participants with intermediate chronotypes, children and adolescents with an evening chronotype were prescribed PAP therapy for a shorter duration (Table 1).

Children and adolescents with a morning chronotype used PAP therapy for a median of 436.0 min per night (IQR 147.0, 516.0), those with an intermediate chronotype used PAP therapy for 417.0 min per night (IQR 189.2, 538.8), and those with an evening chronotype used PAP therapy for 161.5 min per night (IQR 6.0, 405.2). Children and adolescents with an evening chronotype used PAP therapy for a median of 264.4 min less per night than participants with an intermediate chronotype (95% CI 65.8, 397.1; p = 0.0018) when adjusted for age and gender. There was no difference in PAP usage between participants with morning and intermediate chronotypes (Table 2 and Fig. 1).

Depression T-scores were the lowest amongst children and adolescents with an intermediate chronotype. Compared to participants with evening and morning chronotypes, children and adolescents with an intermediate chronotype also had improved neurobehavioral functioning based on the Strengths and Difficulties total difficulties score (Table 1).

3.4. The influence of insomnia on the association between chronotype and positive airway pressure adherence

We hypothesized that the association between chronotype and positive airway pressure adherence may be influenced by insomnia symptoms. Because we did not find a meaningful difference in PAP adherence between children and adolescents with morning and intermediate chronotypes, we assessed the influence of insomnia in participants with an evening chronotype referenced to the morning and intermediate chronotypes combined. These analyses found evidence that sleep onset problems and sleep maintenance problems significantly influenced the relationship between chronotype and PAP usage. Specifically, sleep onset problems influenced 60% (95% CI 10%, 160%) of the total association between chronotype and PAP usage whereas sleep maintenance problems influenced 22% (95% CI 1%, 126%) of this association (Table S1).

We did not demonstrate an influence of depression symptoms, anxiety symptoms, daytime sleepiness, or neurobehavioral functioning on the association between chronotype and PAP usage.

3.5. Subgroup analysis in children and adolescents with self-reported data

There were 86 children and adolescents with self-reported questionnaire data. Amongst this subgroup, self-reported chronotype was not associated with PAP usage. However, the self-reported presence of insomnia was associated with reduced PAP usage by 348.6 min/night (95% CI 192.0, 437.0 min/night; p < 0.001) (Table 3).

3.6. Sensitivity analyses

The use of different adherence outcomes, including PAP usage as a percentage of total sleep time and a binary definition of adherence, supported our primary findings (Table S2). Children and adolescents with an evening chronotype according to caregiver-report used PAP therapy for an average of 43.3% less total sleep time compared to those with an intermediate chronotype (95% CI 10.6%, 68.9%; p = 0.0054).

We found similar relationships with the average PAP download data over three months and two weeks (Table S3).

4. Discussion

In this study, we assessed the relationship between insomnia,

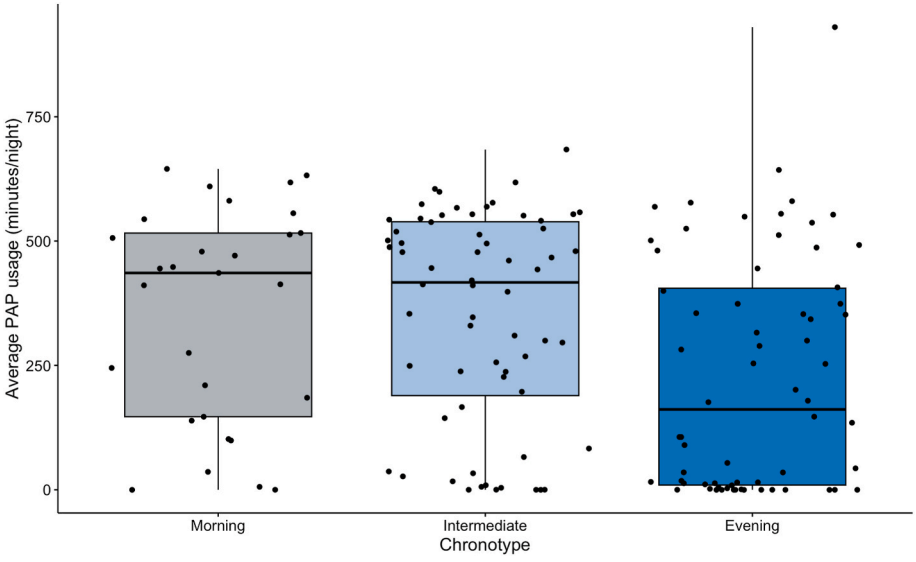

Fig. 1. Positive Airway Pressure Adherence by Chronotype
Boxplots indicate the median and interquartile ranges of positive airway pressure usage by chronotype. Abbreviations: PAP = positive airway pressure.

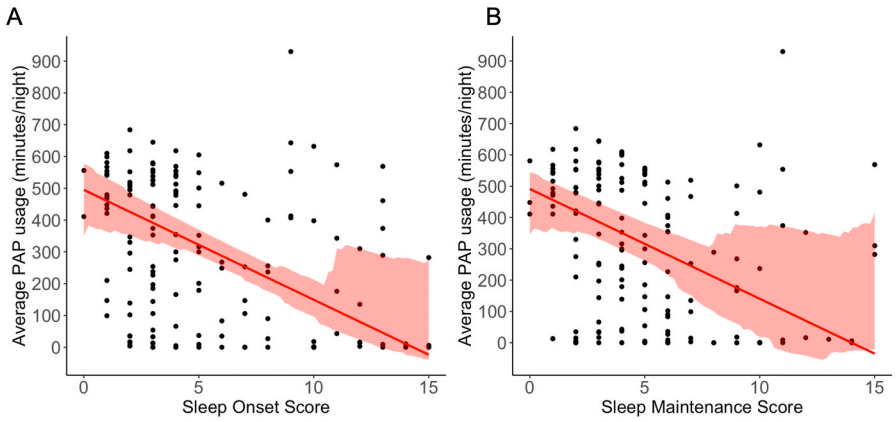

Fig. 2. Association Between Positive Airway Pressure Adherence and Insomnia
(A) Scatterplot depicts the relationship between average nightly positive airway pressure usage over 180 days and sleep onset problems from the Pediatric Insomnia Severity Index. The red line and shading represent the median and standard error, respectively. (B) Scatterplot depicts the relationship between average nightly positive airway pressure usage over 180 days and sleep maintenance problems from the Pediatric Insomnia Severity Index. The red line and shading represent the median and standard error, respectively. Abbreviations: PAP = positive airway pressure. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 3
Subgroup analysis of relationship between insomnia symptoms, chronotype, and positive airway pressure usage in children and adolescents with self-reported data.

Characteristic (n = 86)	PAP usage (min/night)	95% CI	p-value
Insomnia	−348.6	−437.0, −192.0	<0.001
Chronotype			
Morning	16.5	−114.0, 300.3	0.87
Intermediate	Ref		
Evening	−166.7	−306.2, 185.8	0.20

Abbreviations: CI = confidence interval; PAP = positive airway pressure. All analyses adjusted for age and gender.

chronotype, and PAP adherence amongst children and adolescents and found that eveningness and insomnia were both associated with reduced PAP usage. Specifically, sleep onset insomnia exerted a greater influence on the association between evening chronotype and reduced PAP usage compared to sleep maintenance problems.

The biological clock and social clock are often misaligned in children and adolescents who have evening chronotypes. This mismatch may lead to poor sleep quality as well as increased sleep variability with shorter weekday sleep duration and longer free day catch-up sleep [38]. In the evening, a late circadian sleep window may prevent children and adolescents from falling asleep at their desired weekday bedtime despite attempts to fall asleep, predisposing to sleep onset issues [39]. Aligned with this, our study found that children and adolescents with an evening chronotype were more likely to experience sleep onset problems as compared to other chronotypes. Subsequently, sleep onset insomnia may contribute to the early discontinuation of PAP therapy due to the perceived discomfort of PAP therapy, which may be especially disruptive and poorly tolerated while attempting to fall asleep. Eveningness also predisposes to modified sleep architecture and sleep fragmentation. Not only does poor sleep quality have a stronger association with reduced health-related quality of life compared to obstructive sleep apnea [40], individuals who experience difficulty maintaining sleep may also be more likely to awaken and discontinue PAP therapy due to discomfort and frustration [41].

Our study found that the relationship between chronotype and PAP therapy adherence is largely influenced by sleep onset problems. Sleep onset problems have a greater influence on the association between chronotype and PAP therapy adherence compared to sleep maintenance problems. Similarly, within a general population of young adults, insomnia has also been identified as an important mediator between eveningness and other negative health outcomes including mood disorders and suicidality [42]. Taken together, these findings emphasize the need to address the misalignment of the social and biological clocks for individuals with an evening chronotype in addition to insomnia symptoms in children and adolescents using PAP therapy for SDB [43,44].

Previous trial data in an adult population with comorbid insomnia and sleep apnea showed that cognitive behavioral therapy for insomnia improves PAP usage [45]. However, as adolescents have a higher predilection for an evening chronotype, additional treatments beyond cognitive behavioral therapy for insomnia alone must be considered. Addressing the misalignment of social and biological clocks in children and adolescents may include modifications on an individual or systemic level. On an individual level, there may be consideration for circadian entrainment therapies such as morning bright light treatment and evening melatonin to advance the sleep phase for individuals with an evening chronotype. On a systemic level, delaying school start times to better align with the evening chronotype commonly found in adolescents may increase sleep duration and improve satisfaction with sleep [46,47]. Future interventions addressing both insomnia and the misalignment of social and biological clocks that occurs with an evening chronotype must be evaluated.

A strength of the current study is the diverse study sample including children and adolescents of varying socioeconomic status and medical complexity. The diverse sample is supported by the provincial healthcare system that heavily subsidized or fully covered the cost of PAP devices for children and adolescents depending on their underlying diagnosis, mitigating the impact of financial constraints on equipment acquisition and PAP usage. Additionally, the robustness of our results was demonstrated through numerous sensitivity analyses assessing PAP adherence with different measures.

However, there are limitations that must be considered. Firstly, this cross-sectional study cannot be used to establish causality. Future longitudinal studies are required to further elucidate the relationship between chronotype, insomnia, and PAP adherence. As the Pediatric Insomnia Severity Index does not have a validated cutoff for diagnosing insomnia, future studies could also be strengthened by collecting sleep diaries or objective data on sleep-wake timing such as actigraphy. The use of self-reported and caregiver-reported questionnaires may be impacted by recall bias and objective measures may help to minimize this. Our study was also limited by the modest pediatric sample size

which may have led to imprecision in estimates and large confidence intervals. It is also important to note that our study reflects contemporary patient populations cared for in academic tertiary hospitals as 81% of our study participants had at least one complex chronic condition. Therefore, the results may not be generalizable to children and adolescents without complex chronic conditions. Additionally, the underlying indication for PAP therapy also varied amongst the study group and 40% of participants used bilevel PAP therapy.

This study highlights the importance of sleep-wake timing and behaviors on PAP therapy usage in children and adolescents. In the context of emerging therapies for the treatment of SDB beyond PAP therapy, future studies should evaluate chronotype and insomnia as modifiable risk factors impacting adherence to PAP therapy as well as alternative therapies for SDB.

CRediT authorship contribution statement

Lena Xiao: Writing – original draft, Visualization, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Rianna Sarbajna:** Writing – review & editing, Investigation. **Sarah Kuyntjes:** Writing – review & editing, Investigation. **Nisha Cithiravel:** Writing – review & editing, Investigation. **Reshma Amin:** Writing – review & editing. **Jackie Chiang:** Writing – review & editing. **Adele Baker:** Writing – review & editing, Investigation. **Indra Narang:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization.

Ethics approval

Ethics approval was obtained from the Hospital for Sick Children (REB#1000080572) and the study was registered (Clinicaltrials.gov: NCT05949164).

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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Non-Financial Disclosures

Dr. Xiao is a committee member of the American College of Chest Physicians and Program Committee for the Pediatric Assembly in the American Thoracic Society. Dr. Amin is a committee member of the American College of Chest Physicians.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: **Financial Disclosures:** Dr. Narang holds research grants from Canadian Institutes of Health Research (CIHR) and Physicians' Services Incorporated. Dr. Xiao holds research funding from the International Pediatric Sleep Association, Sleep Research Society Foundation, United States, Cure SMA Canada, Canada, Muscular Dystrophy Canada, Canada, American Academy of Sleep Medicine, United States, British Columbia Children's Hospital Research Institute, University of British Columbia, Columbia, CIHR, Canada, IMPaCT Training Award, and Accelerating Clinical Trials. Dr. Amin holds research grants from CIHR, Cure SMA Canada, Canada, Muscular Dystrophy Canada, Canada Defeat Duchenne Canada, Canada and Accelerating Clinical Trials.

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Glossary

CI	confidence interval
IQR	interquartile range
PAP	positive airway pressure
SDB	sleep-disordered breathing
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2025.106745.

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