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Parent Reports Versus Objective Behavioral Measures in Pediatric Sleep-Disordered Breathing

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ABSTRACT

Objective(s): To determine the association between parent-reported problem behaviors and objectively measured response inhibition in children with sleep-disordered breathing (SDB). Understanding this concordance could facilitate better clinical decision-making, as parent reports often guide treatment decisions despite unclear relationships with objective behavioral measures.

Methods: This prospective observational study was conducted at a tertiary care pediatric otolaryngology clinic from 1/1/24–12/1/2024. Children aged 5–11 years with SDB symptoms were included, while those with clinically significant psychiatric or neurologic disorders were excluded. Parent-reported problem behaviors were measured using the Behavior Rating Inventory of Executive Function (BRIEF), with the inhibit *T*-score as the primary predictor. The primary outcome was performance on the Flanker Test of Inhibitory Control and Attention, which measures response suppression to irrelevant stimuli while maintaining attention to target stimuli. Relationships between BRIEF scores and Flanker Test performance were assessed using Pearson correlation and linear regression, adjusting for sociodemographic factors.

Results: Among 84 participants (mean age: 93 months [95% CI, 89–98], 56% male), parent-reported inhibitory problems showed a small but statistically significant correlation with response inhibition performance ($r = -0.23$, $p = 0.04$) in unadjusted analyses. This relationship was attenuated after adjusting for demographic and socioeconomic factors. Other behavioral domains showed weaker associations. Adjusted R^2 values ranged 0.14–0.16, indicating parent reports explained minimal variance in objective scores.

Conclusion: Parent-reported behavioral problems showed limited concordance with objective measures of response inhibition in children with SDB. Treatment decisions for pediatric SDB should not rely solely on parent-reported behavioral symptoms, highlighting the need for integrating objective assessments when feasible.

Level of Evidence: 3.

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1 | Introduction

Sleep-disordered breathing (SDB) is characterized by increased respiratory effort during sleep and ranges in severity from primary snoring to obstructive sleep apnea (OSA) [1]. SDB affects 5%–10% of children [2] and is associated with lower cognition and behavioral problems, including inattention, hyperactivity, and executive dysfunction via its putative impacts on the prefrontal cortex (PFC) [3–7]. Cognitive-behavioral deficits observed in children with untreated SDB relate to memory [8], executive function [9], school performance [10], social competencies [4], aggression [11], and inattention [6].

As adenotonsillar hypertrophy is the principal risk factor for children with SDB, the first line of treatment in otherwise healthy children is adenotonsillectomy (AT) [3]. Over 500,000 ATs are performed in the United States annually, making it the most common surgery under general anesthesia in children under 15 years of age [1, 12]. Although SDB severity is stratified by polysomnography (PSG) [3], more than 90% of ATs are performed based on clinical symptoms and signs alone [13, 14]. Due to the associated resource requirements, the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS) Clinical Practice Guidelines recommend the selective use of PSG in children with risk factors such as obesity. Therefore, parent-reported symptoms of SDB are a key component of the management of a child with SDB [3]. Furthermore, parent observations of SDB symptoms are more strongly associated with children's behavioral outcomes than the apnea–hypopnea index or other PSG-derived measures [6, 15, 16].

The subjective nature of parent-reported symptoms may introduce measurement variability in the assessment of pediatric SDB [3, 6, 16, 17]. The statistical adjustment for socioeconomic and demographic covariates often mitigates the association between parent-reported children's SDB symptoms and their cognitive performance measures [17]. Parents aware of the potential link between SDB and cognitive-behavioral problems may provide biased recounts [6]. Concerns over social stigma or desirability may also modify their reports [16]. Cultural norms of co-sleeping with children impact parental observations of their child's snoring frequency [18]. Biologically, children with SDB may experience worse symptoms in the early morning, when parents are least likely to observe their sleep [3]. Even if caregivers observe all SDB events, the volume of snoring, which does not necessarily reflect the severity of obstruction, may influence parental reporting of their SDB symptoms [3].

Standardized behavioral questionnaires are commonly used to assess children's behavior in clinical and research environments and serve as key outcome measures in AT-related clinical trials [19, 20]. While validated in typically developing children, these instruments may introduce measurement variability when applied to SDB assessment due to symptom overlap between sleep disruption and problem behaviors. Specifically, parent reports of problem behaviors in children with SDB might be influenced by their observations of symptoms, making it challenging to isolate actual executive function deficits.

Despite the epidemiological importance of pediatric SDB and AT that affects 10% of children or more, only one study related to SDB has reported on the convergent validity of parent-reported children's behavior and executive function as part of the development of a psychometric task [21]. As a result, there is a persistent knowledge gap related to the discordance between parent reports and objectively measured facets of behavior when otolaryngologists evaluate children with SDB in a typical clinical setting. To address this knowledge gap, we examined the relationship between parent-reported executive function and performance-based assessment of attention in children with SDB. Inhibitory control is the cognitive ability to suppress inappropriate or irrelevant responses while selecting and executing appropriate behaviors. This fundamental executive function, thought to be impaired in untreated SDB, supports attention, self-regulation, and goal-directed behavior. We focused on inhibitory control, as both parent-reported behavioral ratings and objective cognitive assessments evaluate aspects of response inhibition mediated by PFC networks vulnerable to sleep disruption [22]. Given their shared neurobiological substrates, we hypothesized that parent reports of inhibitory behavior problems correlate with the objective assessment of response inhibition. This is particularly relevant for clinical decision-making in SDB, where behavioral assessments often influence treatment planning despite a limited understanding of their relationship to objective cognitive measures.

2 | Methods

2.1 | Study Design and Participants

We conducted a prospective observational study of children with SDB at the University of Maryland Pediatric Otolaryngology Clinic from January 1, 2024, to December 1, 2024. All analyses were performed from December 1, 2024, to December 31, 2024. The inclusion criteria were (1) age between 5 and 11 years (inclusive), (2) clinically significant symptoms of SDB (habitual snoring, sleep disruption, mouth breathing, etc.), (3) candidates for AT or watchful waiting as determined by the treating otolaryngologist, and (4) parents' ability and willingness to consent and the child's assent for the study (if older than 7 years). Exclusion criteria included: (1) uncorrected cardiac disease, (2) craniofacial disorders including cleft palate, (3) severe psychiatric or neurologic disorder, (4) autism spectrum disorder, (5) history of traumatic brain injury with loss of consciousness >30 min, (6) an inability to understand English (parent or child), (7) attention deficit hyperactivity disorder on pharmacotherapy or the use of sedative-hypnotics, psychotropic, or anti-seizure medications, (8) current continuous positive airway pressure therapy, and (9) severe chronic health conditions, such as severe cardiopulmonary disorders, sickle cell anemia, epilepsy requiring medication, diabetes requiring medication, and developmental delay. The age range of 5–11 was selected owing to the ability of children to participate in the psychometric tasks as well as due to past studies that focused on the age range owing to the greater prevalence of SDB [19]. The Institutional Review Board of the University of Maryland, Baltimore, approved this study.

Eligible children were identified through pre-screening and a clinical visit to the University of Maryland Pediatric Otolaryngology Clinic. After evaluation by the attending otolaryngologist, families of children who met the inclusion criteria

were approached by research staff and provided with detailed information about the study. Parents gave written informed consent, and children aged 7 years and older provided assent. All assessments were completed during a single visit lasting approximately 45–60 min.

2.2 | Assessment of Children's Behavior

We measured children's cognition using the National Institutes of Health Toolbox (NIH-TB) for Assessment of Neurological and Behavioral Function Cognitive Battery [23]. The NIH-TB is a validated, easily accessible, computer-based assessment administered via an iPad; all domains have established reliability and construct validity [23]. Specifically, we assessed children's attentional performance using the Flanker Inhibitory Control and Attention Test, which measures a child's ability to focus on relevant stimuli while suppressing responses to irrelevant stimuli [24, 25]. The task presents stimuli in the form of fish with arrows overlaid on them. Participants must indicate the direction (left or right) of the central fish/arrow. The task consists of two types of trials: congruent and incongruent. In congruent trials, all fish point in the same direction (e.g., all fish/arrows pointing left). In incongruent trials, the flanking fish point in the opposite direction of the central target (e.g., middle fish/arrow pointing left while flanking fish point right). Participants respond by touching an arrow on the left or right side of the iPad screen.

The test begins with a practice block to ensure task comprehension. Following practice, participants complete two blocks of trials. Both accuracy and reaction time are recorded for each trial. The final composite score combines the accuracy and reaction time scores, yielding a value between 0 and 10. Raw scores are then converted to age-corrected standard scores (mean = 100, standard deviation = 15) based on normative data from a nationally representative sample. Higher scores indicate better performance in both attention and inhibitory control.

Children's behavior as reported by the parent or caregiver was assessed using the Behavior Rating Inventory of Executive Function (BRIEF), Second Edition, a 63-item parent-report questionnaire [26, 27]. The BRIEF demonstrates strong psychometric properties, including high internal consistency, test–retest reliability, construct validity, and robust interrater reliability [28]. The measure yields multiple clinical subscales that assess distinct aspects of executive function, including inhibition, self-monitoring, shifting, emotional control, initiation, working memory, planning/organization, task monitoring, and organization of materials. These subscales are aggregated into broader indices: the Behavior Regulation Index, Emotion Regulation Index, and Cognitive Regulation Index, collectively forming the Global Executive Composite. The BRIEF has been extensively validated in children aged 5–18 years with strong psychometric properties in both typically developing children and those with various clinical conditions, including sleep disorders.

2.3 | Statistical Methods

Our primary outcome was the BRIEF Inhibit subscale, which assesses children's ability to control impulses and stop behavior at appropriate times. The inhibit subscale captures behavioral manifestations of inhibitory control that theoretically align with the cognitive control processes measured by the Flanker task [28].

To determine an appropriate sample size, we conducted a power analysis using G*Power 3.1 software [29]. Since both the BRIEF Inhibit subscale and NIH-TB Flanker task assess aspects of inhibitory control, we anticipated a medium effect size ($r = 0.3$). Using an exact test for bivariate normal correlation with $\alpha = 0.05$ (two-tailed) and a desired power of 0.80, we calculated that 84 participants would be needed. This sample size provides sufficient power to detect meaningful relationships between parent-reported behavioral ratings and psychometrically assessed inhibitory control performance measures while accounting for the historically modest correlations (typically $r = 0.2$–0.4) documented in the executive function literature between informant ratings and cognitive assessments [30].

For the primary analyses of the BRIEF Inhibit subscale, we first examined the bivariate relationship with Flanker performance using Pearson correlation, followed by exploratory linear regression models. The regression models assessed the relationship between NIH-TB Flanker Age-Corrected Standard Scores (dependent variable) and BRIEF Inhibit T-scores (independent variable), given the theoretical alignment between these measures of inhibitory control. We specified two regression models: (1) an unadjusted model examining the direct association, and (2) an adjusted model incorporating sociodemographic covariates (sex at birth, self-reported race, ethnicity, insurance type [public/private], parental education [high school completion], and household income [< \$30 K, \$30–50 K, > \$50 K]). As secondary analyses, we examined correlations and regression models between Flanker performance and other relevant BRIEF subscales (Self-monitor, Task-monitor, Working memory) and the Behavior Regulation Index (BRI). All analyses were conducted using R software version 4.4.1 (R Foundation for Statistical Computing, https://cran.r-project.org).

3 | Results

Table 1 presents the demographic characteristics of our study sample ($N = 84$). The mean age of participants was 93 months (95% CI, 89–98), representing children approximately 7–8 years old. The sample included 47 males (56%). The racial composition was predominantly Black (54%, 64%), followed by White (23%), and most participants identified as non-Hispanic (94%). Socioeconomic indicators revealed that most families were insured by a public provider (80%), and most primary caregivers (88%) had completed high school. Income distribution showed that 48% of families reported pretax annual earnings below \$30,000, with 20% earning \$30,000–\$50,000, and 29% earning more than \$50,000. The mean BMI Z-score was 1.26 (95% CI, 0.96–1.56), and 12% of participants reported smoke exposure. No serious comorbidities were reported.

In our primary analysis of the relationship between BRIEF Inhibit scores and Flanker performance (Figure 1a), we identified a small but statistically significant negative correlation ($r = -0.23$, $p = 0.04$) in unadjusted analyses, indicating

TABLE 1 | Demographic characteristics and problem behaviors reported among study participants.

Variable	Value
Age (months)	93 (89–98)
Sex	
Male	47 (55.9)
Female	37 (44)
Race	
Black	54 (64.3)
White	19 (22.6)
Other	11 (13.1)
Ethnicity	
Non-Hispanic	79 (94.1)
Hispanic	5 (5.9)
BMI *Z* score	1.26 (0.96–1.56)
Insurance	
Public	67 (79.8)
Private	17 (20.2)
Smoke exposure	10 (11.9)
Parent completed high school education	74 (88.1)
Total pretax family income	
<$30,000	40 (47.6)
$30,000–$50,000	17 (20.2)
>$50,000	24 (28.6)
Flanker	92.9 (89.8–96.0)
BRIEF	
Inhibit	54.3 (51.8–56.8)
Self-monitor	53.7 (51.4–56.1)
Behavior regulation index	54.6 (52.2–57.0)
Shift	58.0 (55.3–60.7)
Emotional control	56.8 (54.1–59.6)
Emotional regulation index	58.0 (55.3–60.7)
Initiate	53.3 (51.0–55.5)
Working memory	56.8 (54.3–59.2)
Plan/organize	52.5 (50.3–54.7)
Task-monitor	51.9 (49.6–54.1)
Organization of materials	54.6 (52.2–57.0)
Cognitive regulation index	54.4 (52.1–56.7)
General executive composite	57.0 (54.3–59.7)

Note: Data are presented as *n* (%) for categorical variables and mean (95% confidence interval) for continuous variables. The study sample included 84 participants. Behavior rating inventory of executive function (BRIEF) scores are age-normed *T*-scores (mean = 50, SD = 10) where higher scores indicate greater problem behaviors. Flanker scores are age-corrected standard scores (mean = 100, SD = 15), where higher scores indicate better performance. Sex is sex assigned at birth. Race and ethnicity are self-selected. Body mass index (BMI) *Z*-scores are age- and sex-adjusted using height and weight norms derived from Centers for Disease Control growth charts.

that higher parent-reported inhibitory problems were associated with lower Flanker task performance. The magnitude of this correlation represents a weak effect size. The secondary analyses of other BRIEF subscales revealed consistently negative but weaker associations with Flanker performance (Figure 1b–e), with none reaching statistical significance. The unadjusted correlations were small in magnitude for all secondary measures: Self-monitor ($r = -0.13$, $p = 0.25$), Task-monitor ($r = -0.14$, $p = 0.22$), Working memory ($r = -0.18$, $p = 0.11$), and the Behavior Regulation Index ($r = -0.20$, $p = 0.07$). These relationships did not meet the threshold for statistical significance in any of the adjusted models (Figure 1f–j): Inhibit ($\beta = -0.21$, 95% CI, −0.49 to 0.07, $p = 0.14$), Self-monitor ($\beta = -0.14$, 95% CI, −0.43 to 0.15, $p = 0.34$), Task-monitor ($\beta = -0.16$, 95% CI, −0.46 to 0.14, $p = 0.29$), Working memory ($\beta = -0.15$, 95% CI, −0.41 to 0.11, $p = 0.26$), and the Behavior Regulation Index ($\beta = -0.20$, 95% CI, −0.48 to 0.09, $p = 0.18$). The adjusted R^2 values were similar and small across all models (ranging 0.14–0.16), with the Inhibit model explaining the highest proportion of variance in Flanker scores after accounting for the number of predictors.

4 | Discussion

Our findings show weak agreement between parent-reported children's behavior and psychometrically assessed response inhibition in children with SDB. Although we noted a statistically significant correlation between BRIEF inhibit and Flanker scores, the effect size was small. This relationship was not statistically significant after adjusting for demographic and socioeconomic factors. This pattern suggests that while parent reports and objective measures capture related constructs, the associations are weak and partially confounded by demographic variables. The modest magnitude of even the unadjusted correlation, combined with the minimal variance explained in adjusted models ($R^2 = 0.14–0.16$), indicates limited convergent validity between these assessment approaches.

Our findings extend previous work examining measurement validity in pediatric SDB. While Clark et al. [21] reported similar modest correlations between behavioral ratings and cognitive task performance using baseline data from the Pediatric Adenotonsillectomy Trial [20], their study employed a combined Go/No-Go and Continuous Performance Task and focused on children screened to exclude children with moderate to severe OSA or significant oxygen desaturation. Our study examines a broader clinical population using a task that assesses explicit interference control, a distinct component of executive function mediated by PFC networks known to be vulnerable to SDB [31, 32]. Importantly, we examine convergent validity at the critical pre-surgical evaluation phase when parental expectations may influence symptom reporting. In contrast, previous work examined this question in the context of randomized trial enrollment. These differences in population, assessment tools, and clinical context provide complementary evidence that parent reports and objective measures show limited concordance across diverse SDB populations and assessment paradigms.

The disconnect between subjective and objective measures is particularly noteworthy given the shared neurobiological substrates these assessments target. The PFC, vulnerable to sleep

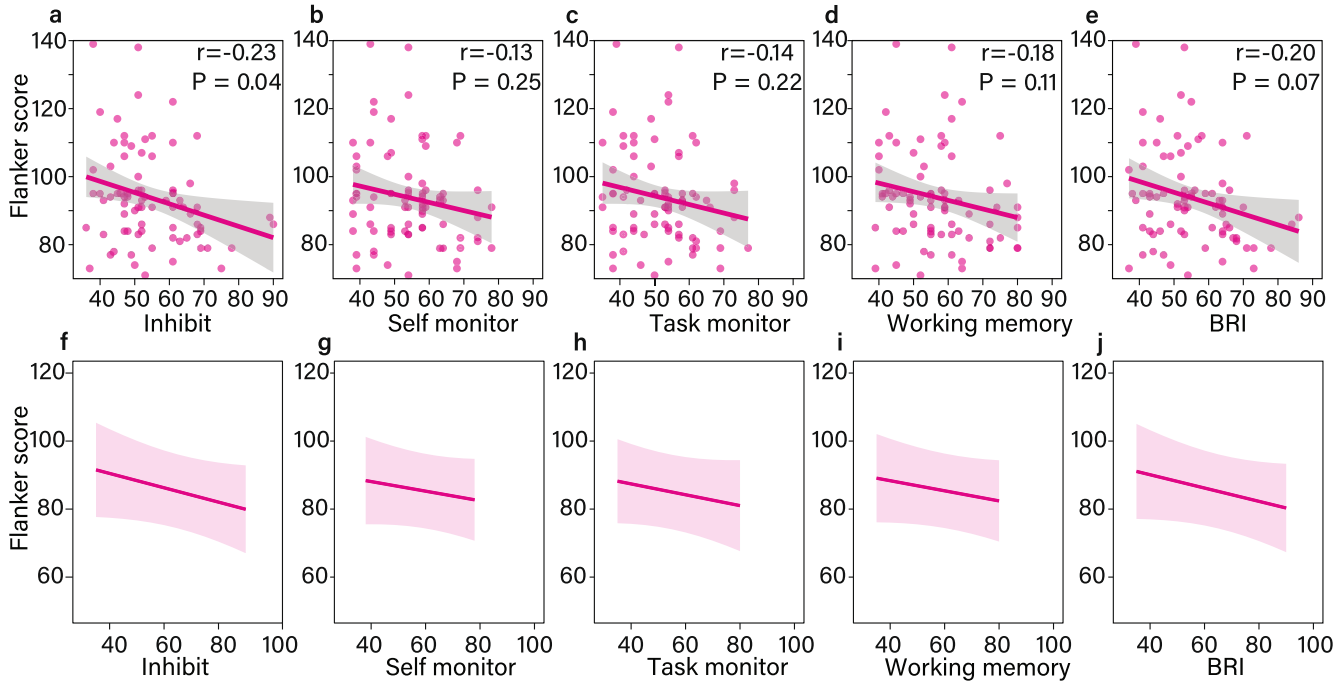


FIGURE 1 | Relationships between Behavior Rating Inventory of Executive Function (BRIEF) subscales and National Institutes of Health Toolbox (NIH-TB) Flanker scores. Scatter plots illustrate the relationships between Flanker inhibitory control scores and BRIEF subscales. Panels (a–e) display unadjusted correlations with individual data points, regression lines (pink), and 95% confidence intervals (gray). Panels (f–j) present marginal effects that control for demographic and socioeconomic factors (sex, race, ethnicity, insurance type, parental education, and household income), accompanied by 95% confidence bands (pink). The panels depict the relationships between (a,f) Inhibit, (b,g) Self-monitor, (c,h) Task-monitor, (d,i) Working memory, and (e,j) Behavior Regulation Index (BRI) subscales on the *x*-axis and Flanker scores on the y-axis. Higher BRIEF T-scores indicate a greater burden of problem behaviors. Only the Inhibit subscale displayed a significant unadjusted correlation ($r = -0.23$, $p = 0.04$).

disruption and intermittent hypoxemia in SDB [22, 33], is central to response inhibition and attentional control [34]. The Flanker task specifically engages these PFC networks by requiring participants to suppress responses to irrelevant stimuli while maintaining attention to target stimuli [25]. Similarly, the BRIEF Inhibit subscale and Behavior Regulation Index were designed to capture real-world manifestations of these PFC-mediated functions [32, 35, 36].

The weak correlation we observed for the Inhibit subscale aligns with the biological framework established by studies of the PFC within the context of untreated SDB [22, 33]. Neuroimaging research has demonstrated that SDB-related sleep fragmentation and intermittent hypoxemia are negatively associated with cortical thickness within the PFC [37–39]. These structural changes correlate with deficits in executive function, particularly in inhibitory control and attention domains. Large population-based cohorts ($n > 10{,}000$) have demonstrated that even mild sleep disruption can impact PFC-dependent cognitive processes [32]. In contrast, typical clinical studies in SDB often involve much smaller samples, which may limit detecting subtle cognitive effects. While our findings are statistically significant, the modest magnitude of the correlation suggests that individual parent reports should be interpreted cautiously when making clinical decisions.

The modest agreement between parent reports and objective cognitive measures in our study parallels findings from the broader literature on attention assessment methodology in typically developing children and those with attentional problems [40, 41]. Assessment of convergent validity using the baseline data from the Pediatric Adenotonsillectomy Trial [20] found similarly small correlations between behavioral ratings and task performance, albeit using a different cognitive paradigm [21]. While our study employed a Flanker task measuring interference control through responses to congruent and incongruent visual stimuli, Clark et al. used a combined Go/No-Go and Continuous Performance Task assessing sustained attention and response inhibition through target detection and response suppression. Additionally, the children in the clinical trial were specifically screened to exclude sleep apnea or significant oxygen desaturation. At the same time, our findings demonstrate similar patterns in a broader cohort of children referred for usual clinical care of SDB. In the specific context of SDB, these findings have important clinical implications. While objective cognitive measures may capture subtle attention and inhibitory control deficits, parent-reported symptoms may have crucial ecological insights that better predict daily functioning and SDB outcomes than traditional metrics alone.

Current clinical practice heavily relies on parent-reported symptoms for SDB diagnosis and evaluation of its cognitive-behavioral impacts, as PSG is recommended only for high-risk children [1]. Recent studies indicate that the outcomes following AT are not solely determined by PSG data, with parent-reported symptoms having an outsized role in SDB management [15, 42, 43]. While treatment-related expectations could bias these outcomes, subjective and objective measures could play a complementary role in clinical evaluations of SDB.

Our study has several strengths, including its prospective design, use of validated assessment tools, and control for sociodemographic factors. However, important limitations include the lack of PSG data to confirm SDB severity and objectively characterize disruption of sleep architecture. While this reflects typical clinical practice where most AT decisions are made without PSG [14, 44] and in accordance with the AAO-HNS guidelines [1], it limits our ability to relate cognitive measures to specific sleep parameters. Additionally, while recent studies indicate that parent-reported symptoms may better predict post-treatment improvements than PSG metrics [45], the weak correlations we observed between parent reports and objective cognitive measures suggest the need for integrated assessment approaches. Our inclusion and exclusion criteria, while necessary to ensure measurement validity, may limit generalizability. By excluding children with ADHD on medication, autism spectrum disorder, and severe psychiatric or neurologic conditions, we studied a relatively homogeneous group with SDB as the primary concern. This may underestimate the true variability in executive function that otolaryngologists encounter in clinical practice, where comorbidities are common. Our use of a single objective measure (Flanker task) rather than a comprehensive cognitive battery limits our ability to characterize the full spectrum of executive dysfunction. However, this focused approach provided strong theoretical alignment between the objective and subjective measures of inhibitory control and offers a clinically feasible assessment that could be implemented in practice. Nevertheless, future studies employing comprehensive batteries that assess multiple executive function domains could provide a more complete picture of convergent validity across different cognitive constructs. Lastly, the inclusion of children mostly from urban backgrounds may limit generalizability to other populations.

These findings have clinical implications for assessing and treating pediatric SDB. The modest correlation between parent reports and objective measures suggests that treatment decisions should incorporate multiple assessment modalities when feasible. This is particularly crucial given that most of the 500,000 ATs performed annually in the United States are primarily based on parent-reported symptoms [1, 14]. Recent longitudinal studies have shown that parent-reported behavioral symptoms, particularly those related to attention and hyperactivity, may be more sensitive indicators of post-AT improvement than traditional PSG metrics [15]. For instance, children with normal PSG parameters but significant behavioral symptoms often show meaningful improvements following intervention [20]. This suggests that while parent reports may not strongly correlate with concurrent objective measures, they may have unique value in capturing functionally significant aspects of SDB that predict treatment response.

Healthcare providers should remain cognizant of the socioeconomic factors influencing symptom reporting and healthcare access. The substantial variability in AT rates across racial and socioeconomic groups highlights the need for more standardized assessment approaches [46, 47]. Integrating objective cognitive measures with symptom reports could help reduce these disparities while ensuring appropriate treatment for those most likely to benefit. Furthermore, understanding the relative strengths and limitations of different assessment tools could improve shared decision-making with families and lead to more personalized treatment plans based on each child's specific pattern of cognitive and behavioral symptoms.

5 | Conclusion

Among children with SDB, we observed limited agreement between parent-reported behavioral problems and objective assessments of response inhibition. Although parent-reported inhibitory issues initially showed a weak, statistically significant correlation with performance-based attention measures in unadjusted analyses, this relationship was mitigated and was no longer significant after controlling for sociodemographic factors. These findings suggest that parent reports and objective measures evaluate related but separate aspects of executive function, with their weak association partly due to demographic confounders. Treatment decisions for pediatric SDB should not depend solely on parent-reported behavioral symptoms and should include objective behavioral assessments when available. Future research should investigate whether combining parent reports with objective measures can enhance the identification of children most likely to benefit from surgical intervention.

Conflicts of Interest

Amal Isaiah receives patent-related royalties from the University of Maryland, Baltimore, for inventions related to sleep apnea diagnosis.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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