

Adherence to Guidelines for Screening Polysomnography in Children with Down Syndrome

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Abstract

Objectives. To compare the percentage and mean age of children with Down syndrome (DS) who underwent polysomnography (PSG) to evaluate for obstructive sleep apnea (OSA) before and after the introduction of the American Academy of Pediatrics guidelines recommending universal screening by age 4 years.

Study Design. Retrospective cohort study.

Setting. Single tertiary pediatric hospital.

Methods. This study is a review of patients with DS seen in a subspecialty clinic. Children born preguidelines (2000-2006) were compared with children born postguidelines (2007-2012) regarding percentage receiving PSG, age at first PSG, and rate of OSA.

Results. We included 766 children with DS; 306 (40%) were born preguidelines. Overall, 61% (n = 467) underwent PSG, with a mean \pm SD age of 4.2 ± 2.9 years at first PSG; 341 (44.5%) underwent first PSG by age 4 years. The rate of OSA (obstructive index ≥ 1 event/hour) among children undergoing first PSG was 78.2%. No difference was seen in the percentage receiving PSG preguidelines (63.4%) versus postguidelines (59.4%, $P = .26$). The mean age at the time of first PSG was 5.3 ± 3.5 years preguidelines versus 3.4 ± 2.0 years postguidelines ($P < .0001$). Children in the postguidelines cohort were more likely to undergo first PSG during the ages of 1 through 4 years (67.4% vs 52.1%, $P < .0001$). There was no difference in rates of OSA between the pre- and postguidelines cohorts (79.8% vs 75.9%, $P = .32$).

Conclusions. Nearly two-thirds of children with DS (61%) underwent PSG overall, with a significant shift toward completion of PSG at an earlier age after the introduction of the American Academy of Pediatrics guidelines for universal screening for OSA.

Keywords

Down syndrome, polysomnography, sleep study, obstructive sleep apnea, birth cohort

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Obstructive sleep apnea (OSA) is a common condition among children, with a prevalence of 1% to 3% in the general pediatric population. OSA is more common among children with Down syndrome (DS), with an estimated prevalence of 30% to 60%.¹⁻⁴ Multiple anatomic and physiologic factors have been attributed to this predisposition for OSA among children with DS, including adenotonsillar hypertrophy, midface and mandibular hypoplasia, relative macroglossia, glossoptosis, generalized muscular hypotonia, and obesity.²⁻⁵ Long-term adverse effects of OSA among children range from impairments in growth, neurocognitive development, and quality of life to the development of pulmonary hypertension and cor pulmonale.²⁻⁵

Given the high risk of OSA among individuals with DS and the significant clinical sequelae of untreated OSA, the American Academy of Pediatrics (AAP) provided

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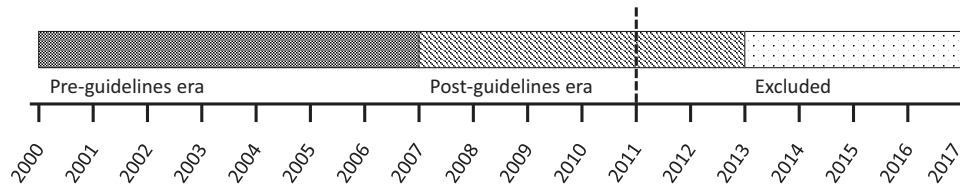


Figure 1. Pre- and postguidelines era cohorts, defined by year of birth relative to the 2011 publication of the American Academy of Pediatrics' guidelines for polysomnography for children with Down syndrome.

recommendations regarding screening for OSA in the 2011 guidelines for health supervision for children with DS.^{6,7} Providers are recommended to discuss symptoms of OSA with parents of infants with DS during their first year of life and to refer patients to a physician with expertise in pediatric sleep disorders if any associated symptoms are present. Through early childhood, providers are recommended to (1) discuss symptoms of OSA at each well-child visit, (2) refer all children with DS to a pediatric sleep laboratory for polysomnography (PSG) by 4 years of age, (3) refer any child with signs or symptoms of OSA or abnormal PSG results to a physician with expertise in pediatric sleep, and (4) discuss obesity as a risk factor for OSA.⁷

The objective of the current study was to investigate adherence to guidelines for the evaluation of OSA among children with DS. To do so, we aimed to determine the rate of completion of PSG among children with DS before and after the publication of AAP guidelines in 2011, to compare the proportion of children with DS obtaining PSG by 4 years of age before and after the publication of AAP guidelines, and to compare the rate and severity of OSA among children with DS before and after the publication of AAP guidelines.

Methods

A retrospective cohort study was performed that included all pediatric patients with DS born between January 1, 2000, and January 31, 2018, who were identified by query of the electronic medical record by relevant *International Classification of Diseases, Ninth Revision* codes and cross-referenced to clinical encounters within the Division of Developmental and Behavioral Pediatrics at Cincinnati Children's Hospital Medical Center (CCHMC). The division encompasses the Thomas Center for Down Syndrome—a multidisciplinary clinic that includes developmental pediatricians, psychologists, nutrition services, and therapy services (speech-language pathology, occupational therapy, and physical therapy). Demographic and clinical data, including date of birth, sex, and race, were obtained from a review of the electronic medical record. Polysomnographic data, including age at time of first PSG, sleep stage, and respiratory scoring, were obtained for each patient with DS from a comprehensive password-protected sleep study database, which is maintained by the Division of Pulmonary Medicine–Sleep Medicine at CCHMC and includes all patients who have received PSG within the institution. For children with DS receiving PSG, the first documented PSG was included for analysis. All data

extracted and analyzed were maintained on a password-protected server. This study was approved by the CCHMC Institutional Review Board.

The cohort of children with DS were classified into 2 epochs: the pre- and postguidelines eras. The epochs were defined by the date of birth relative to the year of the publication of the current AAP guidelines in 2011. Children born between 2000 and 2006 were included in the “preguidelines era,” as these children turned 4 years old before 2011 and would not have been exposed to these guidelines. Children born between 2007 and 2012 were included in the “postguidelines era,” as they turned 4 years old during or after 2011, at which time the guidelines were introduced. Children with DS born after 2013 were excluded from this study, as these children had not yet turned 4 years old at the time of analysis, and we were unable to evaluate the impact of these guidelines on these patients (**Figure 1**).

Overnight PSG

All children underwent overnight PSG in our pediatric sleep laboratory. Children went to bed at the time of their preference, and studies were terminated when they awoke spontaneously, typically between 5 AM and 6 AM. The following parameters were recorded simultaneously: body position, bilateral electrooculogram, >3-channel electroencephalogram, chin electromyogram, anterior tibialis electromyogram, tracheal microphone, electrocardiogram, pulse oximetry, thoracic and abdominal inductance plethysmography, and nasal pressure transduction. Scoring of the PSG was performed with standard criteria as defined by the American Academy of Sleep Medicine.⁸ Sleep stage and respiratory scoring were performed by a certified sleep technician and a board-certified sleep specialist. An obstructive apnea was defined as a cessation or decrease in airflow or a decrease in the sum channel from inductive plethysmography by >90% of the preceding breath. An obstructive hypopnea was defined as a decrease in airflow or a decrease in the sum channel from inductive plethysmography by >30% when compared with the preceding breath, which was associated with an oxygen desaturation of $\geq 3\%$, an arousal, or awakening. All obstructive events were ≥ 2 breaths' duration. The number of apneas (including central apneas) and hypopneas per hour was calculated and reported as the apnea-hypopnea index (AHI). The obstructive apnea-hypopnea index (oAHI) was defined as the number of obstructive apneas and hypopneas per hour. In studies where oAHI was missing, the AHI was used.

Table 1. Baseline Patient Characteristics of Children with Down Syndrome in the Pre- and Postguidelines Era Cohorts.

Characteristic	Era (Birth Year), n (%)		P Value ^a
	Preguidelines (2000-2006)	Postguidelines (2007-2012)	
Patients	306	460	—
Female	116 (37.9)	218 (47.4)	.01
Race ^b			.23
White	247 (80.7)	362 (78.7)	
Black/African American	33 (10.8)	39 (8.5)	
Asian	5 (1.6)	11 (2.4)	
Multirace	3 (1)	13 (2.8)	
Other	11 (3.6)	15 (3.3)	
Unknown	7 (2.3)	20 (4.4)	

^aWilcoxon rank sum test.^bParent reported.

Clinical Definitions

Subjects were considered to have OSA if their PSG showed an oAHI ≥ 1 event/hour, with an oAHI ≥ 1 and < 5 classified as mild OSA; ≥ 5 and < 10 , moderate; and ≥ 10 , severe.⁸

Statistical Analysis

Descriptive statistics, including frequencies with percentages and medians with ranges, were generated for the entire study population as well as the pre- and postguidelines era cohorts. The primary outcome was rate of completion of first PSG. The secondary outcome was rate of OSA diagnosed on first PSG. The percentage of patients undergoing PSG, the median age at first PSG, the percentage of patients undergoing PSG from 1 through 4 years of age, the percentage of patients with OSA diagnosed on PSG, and the severity of diagnosed OSA were compared between the pre- and postguidelines era cohorts with the chi-square test (for categorical variables) and Wilcoxon rank sum test (for continuous variables). A *P* value $< .05$ indicated a statistically significant difference between groups. All data analysis was performed with SAS 9.4 (SAS Institute, Cary, North Carolina).

Results

Patient Characteristics

A total of 984 children with DS born after January 1, 2000, were seen for evaluation or therapy within the Division of Developmental and Behavioral Pediatrics; 218 children were excluded because they were born during or after 2013. Of 766 remaining children, 306 were born between 2000 and 2006 and were considered the preguidelines era cohort; 460 were born between 2007 and 2012 and were considered the postguidelines era cohort (**Table 1**).

Completion of First Polysomnogram

Among the 766 children included in this analysis, 467 (61%) received at least 1 polysomnogram and had a median

age of 4.1 years (range, 0.1-16.2) at the time of the first documented PSG. Of these, 285 (61%) received PSG during the ages of 1 through 4 years. **Table 2** compares the pre- and postguidelines cohorts. There was no statistically significant difference in the percentage of children with DS who received PSG at any age between the pre- and postguidelines eras (63.4% vs 59.4%, respectively; *P* = .26). Among children who received PSG, the median age at the time of first PSG was 4.5 years (range, 0.1-16.2) in the preguidelines era and 3.6 years (0.1-8.9) in the postguidelines era (*P* $< .0001$). Children in the postguidelines era were more likely than those in the preguidelines era to receive their first PSG during the ages of 1 through 4 years (67.4% vs 52.1%, respectively; *P* $< .0001$) (**Figure 2**).

Results of First Polysomnogram

Overall, 366 children with DS had a diagnosis of OSA on the first PSG, representing 78.4% of patients who received PSG and 47.8% of all patients. The median oAHI was 2.6 events/hour (interquartile range [IQR], 1.2-6.9) for all children undergoing PSG and 3.8 events/hour (IQR 2.1-8.5) for children with OSA, and the median oxygen saturation nadir was 88% (IQR, 85%-91%) for all children undergoing PSG and 88% (IQR, 83%-91%) for children with OSA. Rates of OSA were not significantly different between patients in the pre- and postguidelines era cohorts (76.3% vs 79.9%, respectively; *P* = .36). Likewise, OSA severity was not significantly different between the cohorts (*P* = .50; **Table 2**). In the preguidelines era cohort, 48% of children with OSA were diagnosed during the ages of 1 through 4 years; by comparison, 66.5% of children with OSA in the postguidelines era cohort were diagnosed during the ages of 1 through 4 years (*P* $< .0001$).

Discussion

In this study, we evaluated a large cohort of children with DS who presented to a single tertiary care pediatric hospital through a developmental-behavioral pediatrics specialty practice. Although the current AAP guidelines recommend

Table 2. Rates of PSG Completion, Diagnosis of OSA, and Severity of OSA among Children with Down Syndrome in the Pre- and Postguidelines Era Cohorts.

Characteristic	Era (Birth Year), n (%) or Median (Range)		P Value
	Preguidelines (2000-2006)	Postguidelines (2007-2012)	
Documented PSG	194 (63.4)	273 (59.4)	.26
Age at first PSG, y ^a	4.5 y (<1 mo–16.2 y)	3.6 y (<1 mo–8.9 y)	<.0001
First PSG by age, y ^a			<.0001
<1	12 (6.2)	44 (16.1)	
1-4	101 (52.1)	184 (67.4)	
>4	81 (41.8)	45 (16.5)	
OSA	148 (76.3)	218 (79.9)	.36
OSA severity (oAHI) ^b			.50
Mild (≥ 1 and < 5)	87 (60)	126 (58.1)	
Moderate (≥ 5 and < 10)	31 (21.4)	40 (18.4)	
Severe (≥ 10)	27 (18.6)	51 (23.5)	

Abbreviations: oAHI, obstructive apnea-hypopnea index; OSA, obstructive sleep apnea; PSG, polysomnogram.

^aAmong those who received a PSG.

^bAmong those with OSA.

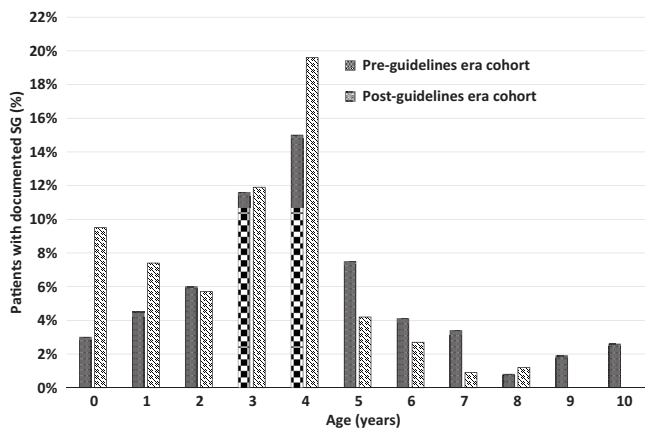


Figure 2. Rates of completion of first polysomnogram among children with Down syndrome in the pre- and postguidelines era cohorts by age in years.

universal screening for OSA among children with DS at or before the age of 4 years, only about 60% of children in our study cohort received at least 1 polysomnogram.⁷ Furthermore, the overall rate of PSG completion among children who were exposed to the guidelines (postguidelines era cohort) was not significantly better than that among children who had already turned 4 years of age at the time when the recommendations came into effect (preguidelines era cohort; 59.4% vs 63.4%, respectively; $P = .26$).

However, children with DS in the postguidelines era cohort were far more likely to receive their first PSG by 4 years of age (67.4%) than were those in the preguidelines era cohort (52.1%). Additionally, their first PSG was obtained at a significantly younger mean age: 3.4 years for the postguidelines era cohort versus 5.3 years for the preguidelines era cohort. This shift suggests successful implementation of the guidelines for PSG among children with DS as

they approach age 4 years. In the entire cohort, 78% of children with DS undergoing PSG were diagnosed with OSA, and 40% had moderate to severe disease (oAHI ≥ 5). The majority of children in the postguidelines era cohort with OSA were diagnosed by the age of 4 years. These results reinforce the importance of the current guidelines, as earlier diagnosis of OSA has the potential to facilitate treatment and improve the sequelae of untreated OSA.

Prior to the publication of the guidelines in 2011, the AAP recommended that primary care practitioners discuss clinical signs and symptoms associated with OSA with the caregivers of children with DS aged ≥ 5 years, but no recommendation for specific testing was made.^{6,7} A prospective cohort study of 56 children with DS undergoing PSG between the ages of 3.5 and 4 years was performed by Shott et al,³ which showed evidence of abnormal PSG results for 32 patients (57%), including an elevated oAHI for 21 (37.5%). Further evidence showed that these numbers increase as children with DS grow older.^{1,9,10} Unfortunately, the ability of parents to predict the sleep abnormalities of their children with DS is poor.^{1,3,11} Shott et al demonstrated a low rate of reported parental concern for sleep problems (31%) and a low predictive value of parental reporting of signs and symptoms of sleep problems for abnormal PSG results. Given a high estimated prevalence of OSA among children with DS—particularly children who are asymptomatic or for whom sleep concerns are not consistently reported by caregivers—the AAP supplemented its recommendations for discussion of symptoms from infancy through childhood with a recommendation for referral for PSG for all children with DS by 4 years of age regardless of symptoms.^{1-5,7,11-13}

Since the publication of the current AAP guidelines, multiple studies have demonstrated the utility of screening PSG for the diagnosis of OSA among children with DS.^{4,14-16}

Lin et al performed a cohort study of 49 children with DS who were referred to a sleep center at a single institution for PSG between 2008 and 2012.¹⁴ When compared with a cohort of typically developing peers for whom PSG was performed for suspected OSA, there was a significantly higher rate of severe OSA among children with DS versus the peer group (39% vs 13%, $P < .001$). Furthermore, fewer normal PSG results or those in which primary snoring was diagnosed were seen among children with DS (29%) versus the typical peer group (40%).

Similarly, Maris et al performed a cohort study of 147 children with DS for whom PSG was recommended between the years 2008 and 2015.⁴ Children were referred for PSG if parents reported persistent snoring or witnessed apneas, independent of age, or if they were >4 years old and had not had PSG, regardless of their symptoms. Asymptomatic children <4 years of age were not referred for PSG. Overall, OSA was diagnosed for two-thirds of children, with a median α AHI of 8.2 per hour. Seventy percent of children diagnosed with OSA had moderate-severe disease. Although the rate of OSA among symptomatic children with DS was significantly higher (75.7%), over half of asymptomatic children aged >4 years who were referred for PSG were diagnosed with OSA (53.8%, $P = .019$). These studies emphasized the need to perform PSG for all children with DS, regardless of clinical history.

Despite the intention of guidelines to enact changes in clinical care pathways for individuals with DS, consistent implementation of recommendations has remained a challenge. Recent studies showed that adherence to screening and preventive health care recommendations for children and adults with DS is often low.¹⁷⁻²¹ Specifically, the reported rates of adherence to recommendations to obtain PSG ranged from 12% to 66%.¹⁷⁻¹⁹ In 2017, Santoro et al performed a retrospective review of the well-child visits of 264 children with DS across multiple hospital-affiliated pediatric care sites across 3 states, in an attempt to determine adherence to AAP guideline screening recommendations for celiac disease, cervical spine instability, swallowing dysfunction, and OSA.¹⁷ In this study, adherence to screening at all care sites ranged widely, from 0% to 79%. In regard to screening for OSA, about 50% of patients and caregivers were asked about symptoms associated with OSA, and $<30\%$ of children underwent PSG. There was no correlation between the presence of symptoms and the completion of PSG.

Santoro et al performed a longitudinal cohort study with a review of 235 children and adults with DS undergoing clinical visits across multiple care sites at a single institution to obtain baseline rates of adherence to AAP guidelines, including those pertaining to PSG for OSA, and to determine the impact of an electronic medical record–based intervention on adherence rates.¹⁹ Over the course of the first year of study, between 2015 and 2016, the baseline adherence rate to the recommendation for PSG for children >4 years of age was 51%. After integration of best-practice advisory prompts and health maintenance record tracking into the electronic health

record in 2016, adherence rates across all studied guidelines increased significantly, including guidelines for PSG (postintervention adherence, 66%; $P = .05$).

In regard to our results, the baseline adherence rate to the AAP guidelines for obtaining PSG for children with DS was comparable to, if not slightly higher than (67.4% in the postguidelines era cohort), that of previously published studies. These data further support an overall low rate of adherence to the guidelines. Although we did not specifically look at the factors associated with a low adherence rate, we postulate that there are several issues that contribute. First, there is a known lag time from guideline publication to physician awareness and acceptance, and it is unclear when physicians implement published guidelines.^{13,14,17} Second, the extent of physician expertise in the diagnosis and treatment of OSA among children with DS, as well as caregiver knowledge of OSA and interest in screening, is not known.^{13,14,17} Additionally, there are resource limitations for PSG and potential patient disparities, such as barriers to referrals or resources for testing.^{22,23} Many types of interventions were shown to improve adherence, including physician education, integration of recommendations into the electronic medical record, and incorporation of care in multidisciplinary specialty clinics.^{18,19,24} As a result, these additional factors need to be more clearly defined and addressed in future studies to increase adherence rates to the current AAP guidelines.

Our study has several limitations. First, the study cohort represents a nonselected population of all children with DS presenting to a single tertiary care institution through various clinical encounters within a multidisciplinary specialty clinic setting. This was thought to be the least biased population, as opposed to children who present to an otolaryngology clinic or sleep medicine clinic with concern for OSA. Although our patients were treated at a tertiary care center, which may limit generalization to other practice locations, we treat $>75\%$ of the children in our region and thus believe that we are able to accurately reflect the local population. Second, the first PSG obtained for any individual patient was included in the analysis, without distinction of screening or diagnostic PSG—where a screening PSG was defined as one performed on an otherwise asymptomatic individual and a diagnostic PSG was defined as one performed on a patient presenting with symptoms of OSA, such as snoring, apneic pauses, restless sleep, uncommon sleep positions, frequent arousals, daytime sleepiness, and/or behavior problems that could be associated with poor sleep. Data pertaining to categorization of PSG as screening or diagnostic were not obtained, so conclusions about the relationship to the diagnosis of OSA and associated symptoms cannot be made. Third, there is the potential that sleep studies obtained at outside institutions were not accounted for this in the analysis. Similarly, surgical or medical therapies preceding first PSG were not studied.

While the objective of the current study was to determine whether the publication of guidelines improves the rate at which we test children with DS for OSA, we did not directly evaluate the clinical course and outcomes for

patients receiving PSG within our study cohort, nor did we look at barriers to guideline adherence, although our data support their presence. Future studies will be directed at understanding disparities in obtaining recommended testing, with a particular interest in the potential effects of socioeconomic status, medical coverage, and payer distribution. An understanding of such barriers should allow for subsequent initiatives aimed at improving adherence rates and ultimately illustrating the clinical impact of these guidelines.

Conclusion

The AAP currently recommends universal screening of all children with DS for OSA with PSG obtained by 4 years of age. This study is a retrospective cohort study comparing rates of PSG completion among children with DS before and after the publication of the AAP guidelines. Nearly two-thirds of children with DS (61%) underwent PSG overall. OSA was diagnosed among 78.4% of patients who received PSG and 47.8% of all patients. After the introduction of the AAP guidelines for universal screening, there was a significant shift toward completion of PSG at an earlier age, and the majority of children with DS with OSA were diagnosed by 4 years of age. Our results illustrate the importance of the current guidelines while emphasizing the need to evaluate barriers and improve adherence to completion of screening PSG.

Author Contributions

Philip D. Knollman, conception and design, drafting of manuscript, final approval for submission, agreement to be accountable for all aspects of the work; **Christine H. Heubi**, conception and design, drafting of manuscript, final approval for submission, agreement to be accountable for all aspects of the work; **Jareen Meinen-Derr**, conception and design, acquisition and analysis of data, drafting of manuscript, final approval for submission, agreement to be accountable for all aspects of the work; **David F. Smith**, contributions to interpretation of data, critical revision for intellectual content, final approval for submission, agreement to be accountable for all aspects of the work; **Sally R. Shott**, contributions to conception and interpretation of data, critical revision for intellectual content, final approval for submission, agreement to be accountable for all aspects of the work; **Susan Wiley**, contributions to conception and interpretation of data, critical revision for intellectual content, final approval for submission, agreement to be accountable for all aspects of the work; **Stacey L. Ishman**, contributions to conception and interpretation of data, critical revision for intellectual content, final approval for submission, agreement to be accountable for all aspects of the work.

Disclosures

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