



Executive Functioning in the Presence of Sleep-Disordered Breathing

Amy M. Sutton, M.A, William G. Hamilton, Ph.D., Thomas G. Burns, Ph.D., Lindsay M. Luton, & Pei-Ling Roerig
Children's Healthcare of Atlanta-Scottish Rite Campus, Atlanta, Georgia

INTRODUCTION

Sleep-disordered breathing (SDB) represents a spectrum of upper airway conditions that can be mild, such as snoring, or severe, such as obstructive sleep apnea (OSA). Research has focused on the consequences of SDB and reversibility of symptoms. Children with these problems may present with excessive sleepiness, failure to thrive, and a variety of cognitive and behavioral dysfunctions including impaired executive functioning. Beebe and Gozal (2002) developed a theoretical model to explain the impact of sleepiness and hypoxia on executive functioning. This model provides a framework for researchers to examine links between the medical disorder and the neuropsychological consequences. This study and its variables are driven by Beebe and Gozal's theory and use the constructs in the research design. The purpose of the study was to investigate whether SDB impairs executive functioning in children compared to controls. Additionally, the study sought to identify the executive functions at risk, the degree of SDB required for dysfunction, and the contribution of sleepiness versus hypoxic injury.

METHODS

Participants

48 participants

27 children referred for SDB (10 female, 17 male)

21 matched controls (11 female, 10 male) with no significant differences in IQ or SES

Clinical participant demographics

- Ethnicity: 6 African American, 18 Caucasian, 2 Asian American, 1 Hispanic
- Age range: 8-18
- Degree of SDB: 18 mild, 2 moderate, 7 none (based on polysomnography)

Procedure

Twenty-seven children with suspected SDB were tested with a sleep study called a polysomnography (PSG), and a neuropsychological battery. The children were referred to a large Southeastern children's hospital, ranging in age from 8 to 18, with no congenital or acquired brain damage. They were matched for age, gender, and socioeconomic status with 21 healthy controls. The Wechsler Abbreviated Scale of Intelligence (WASI) and subtests of Woodcock-Johnson Academic Achievement Battery were administered to determine intellectual ability and academic skills. The executive function protocol included subtests from the Delis-Kaplan Executive Function System (D-KEFS), the digit span subtest from the Wechsler Intelligence Scale for Children (WISC-IV), the Tower of London-Drexel University, the Behavioral Rating Inventory of Executive Functioning (BRIEF), and the Conners' Continuous Performance Test-II (CPT-II).

Statistical Analysis

Using the SPSS version 14.0 statistics package, Wilcoxon Rank-Sum non-parametric tests were used to compare the executive function performance of children referred for SDB with healthy controls. This test is used in place of a two-sample t-test when the populations being compared are not normal. Due to the large number of variables generated by the neuropsychological battery and the relative small sample size, only variables thought to be sensitive to differences, based on theory, were included in the statistical analyses.

RESULTS

Results of the Wilcoxon Rank-Sum tests demonstrate comparable intelligence scores between the SDB group and the control group. However, poorer performance in academic skills was found in the SDB group despite similar IQ scores. Several of the executive function measures appeared sensitive to group differences, including the D-KEFS subtests and the parent report measure, the BRIEF (see table).

Table 1. Sample Neurocognitive Findings

Test Administered	SDB Group		Control Group		Wilcoxon
	Mean	SD	Mean	SD	
WASI IQ	108.54	15.45	108.73	13.75	0.0139
Woodcock-Johnson Academic	98.96	12.61	108.64	9.27	0.0083
WISC IV- Digit Span	9.21	2.5	10.36	2.46	0.1113
DKEFS- Color-Word Switching	8.18	3.65	11.64	1.64	0.0007
DKEFS-Verbal Fluency Switching	10.00	2.76	12.59	2.52	0.0033
DKEFS- Trail-making Switching	8.14	4.62	10.55	3.12	0.1269
BRIEF-Planning/Organization	57.96	12.42	49.23	8.86	0.0047
BRIEF-Behavioral Regulation	56.43	14.21	48.14	10.18	0.0287
BRIEF-Inhibition	54.25	10.78	50.14	8.58	0.2180
BRIEF-Global Composite	58.43	13.18	49.23	8.86	0.0055

DISCUSSION

The results of the study suggest that children suspected of having SDB performed poorer than control participants on some tests of executive function and academic skills despite comparable IQ scores. Moreover, on parent report measures, parents of children with SDB endorsed overall problems with executive functioning skills in the home compared to the normal sample. The findings support previous research which has suggested that SDB impairs cognitive and academic functioning. The results of this study implicate executive function as an area of cognitive function which is especially susceptible to sleep disturbances. Interestingly, not all aspects of executive function have significant differences between SDB and control groups. The Drexel Tower, for example, measures various aspects of planning, initiation, and inhibition, but no between-group differences emerged. Although the findings show significant group differences, often these differences remained within the acceptable range of normal. Future studies should focus on the post-treatment cognitive function in those children who demonstrate cognitive deficits prior to an SDB treatment. It seems a likely conclusion that SDB has a negative impact on the higher-level cognitive function in children, which is a critical component in academics and life success.

REFERENCES

- Beebe, D.W., & Gozal, D. (2002). Obstructive sleep apnea and the prefrontal cortex: Towards a comprehensive model linking nocturnal upper airway obstruction to daytime cognitive and behavioral deficits. *Journal of Sleep Research*, 11, 1-16.