Sleep and Student Performance at School

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ABSTRACT: *To review the state of research on the association between sleep among school-aged children and academic outcomes, the authors reviewed published studies investigating sleep, school performance, and cognitive and achievement tests. Tables with brief descriptions of each study's research methods and outcomes are included. Research reveals a high prevalence among school-aged children of suboptimal amounts of sleep and poor sleep quality. Research demonstrates that suboptimal sleep affects how well students are able to learn and how it may adversely affect school performance. Recommendations for further research are discussed.* (J Sch Health. 2005;75(7):248-254)

Health professionals frequently remind educators of the correlation between healthy behaviors and educational outcomes. However, evidence for this connection is not always apparent or readily available. The increasing emphasis on accountability for schools has amplified the importance of demonstrating connections between students' health and their academic performance. An understanding of the impact of student health on educational outcomes has major implications. Among them are ramifications for how schools address health concerns, such as the focus of their school health programs.

The National Coordinating Committee on School Health and Safety (NCCSHS), comprising representatives of several federal departments and national nongovernmental organizations, encourages school districts to respond to evolving challenges by developing coordinated school health programs. To enhance awareness of existing evidence linking health and school performance and to identify gaps in knowledge, the NCCSHS is reviewing the state of research in related areas. The project involves a literature search of peer-reviewed, published research reporting on the relationship between students' health and their performance in school. Compilations of research articles that explore the association between academic performance and health include various chronic conditions (eg, asthma, diabetes), nutrition, and physical activity. This article summarizes what is known on the association of sleep with academic outcomes among school-aged children.

BACKGROUND ON SLEEP

Most children need at least 9 hours of restful sleep each night.[1] However, for many reasons, school-aged children may receive less than the recommended number of hours of sleep. These reasons include the working, eating, and bedtime patterns of students and their families, early school start times, and childhood sleep disorders such as disrupted sleep from snoring or breathing pauses. A number of research articles have reported on the prevalence of suboptimal sleep in school-aged children and the association of quality and quantity of sleep with school performance and measures of cognitive ability.

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SELECTION OF SLEEP ARTICLES

Only articles meeting the following criteria were selected for review: (1) study subjects were school-aged children (5-18 years); (2) the article was published in the past 10 years (1994-2004) in a peer-reviewed journal; and (3) the research included at least 1 of the following outcomes—school attendance, academic achievement, a measure of cognitive ability (such as general intelligence, memory), and attention. The outcome of students' level of attention was acceptable only if measured objectively. Studies were identified using MedLine and similar Internet-based searches. If a full article could not be retrieved, studies with detailed abstracts were included. Many studies cited in this review had major outcome measures other than those pertinent to the objectives of this project. These alternative outcomes may not be described at all or are briefly mentioned.

LITERATURE REVIEW

Investigators are attempting to answer several questions: How much sleep are students getting? Do inadequate amounts or quality of sleep affect educational outcomes or cognitive performance? What is the effect of sleep-disordered breathing on students? Is daytime sleepiness associated with school performance?

Tables 1-3 contain lists of articles on sleep that met the inclusion criteria. A brief description of the experimental design and the outcome also is included for each. Table 1 lists general articles on sleep in school-aged children.

The largest number of articles studied sleep disorders and sleep habits and patterns, particularly among adolescents. Many studies on sleep disorders are on sleep-disordered breathing. Most are relatively recent and include control groups. Research findings appear to be relatively consistent, although outcome measures differ. An excellent review by Blunden et al[2] in 2001 of 13 articles demonstrated that reduced attention, memory, intelligence, and increased problematic behavior resulted from sleep-related obstructive breathing. With the exception of 1 study in this review, children in all studies improved in neurocognitive, behavioral, and/or school performance after an adenoidtonsillectomy. Articles listed in Table 2 are those not reviewed by Blunden et al that investigate the same issues. Like the conclusions of Blunden et al, the findings of these studies raise concern because of the high prevalence of

sleep-disordered breathing among elementary school student populations. Most articles demonstrate an effect on neurocognitive ability. Fewer demonstrate effects on academic performance. It is encouraging that academic achievement among children with disordered breathing improves after corrective measures are taken, such as surgery or tonsillectomy/adenoidectomy. If minor sleep disorders, such as snoring, can be identified and managed prior to or during the school-age years, significant improvement in educational outcomes may ensue.

Table 3 lists published research that investigates sleep patterns among children and adolescents. The research findings raise several important issues for educators. The onset of adolescence appears to be accompanied by a decrease in sleep in a 24-hour period among many youth at this stage of life. The academic consequences of these changes in sleep habits are inconclusive. Data collection in studies performed to date is based more on surveillance of parents, teachers, or students—a methods that requires some level of validation.

Some school districts have pushed back school start times for adolescents, and the issue of school starting times is widely debated among parents of adolescents and school administrators. Unfortunately, published peer-reviewed studies that investigate the benefits of such modifications are virtually absent in the literature. Experimental conditions of sleep restriction and deprivation appear to impair neuropsychological performance related to higher-level cognitive functions and attention. But reversal of this through changed school start times has yet to be proven.

An excellent article by Fallone et al[3] reviewed many of the studies included in this collection and concluded that varying definitions of "good" versus "poor" sleep limit the ability to compare studies. A review of the literature was performed by Wolfson and Carskadon[4] in 2003. These reviewers noted that a majority of studies in this field rely

Table 1
General Articles on Sleep in School-Aged Children

Reference (Origin)	Experimental Design	Outcome
Eliasson A, Eliasson A, King J, Gould B, Eliasson A. Association of sleep and academic performance. *Sleep Breath*. 2002;6(1):45-48. (United States)	Teachers administered a 1-page questionnaire to 1000 students in 9th through 12th grades in a number of schools in 1 community as well as to 200 7th graders. Self-reported Grade Point Average (GPA) included in questionnaire.	90% of students feel groggy at school from sleepiness, 40% very groggy. Average sleep time 6.7 hours/night on weekdays (7.7 on weekends). No correlation between sleep time and academic performance in any grade.
Kahn A, Van de Merckt C, Rebuffat E, et al. Sleep problems in healthy preadolescents. *Pediatrics*. 1989;84(3):542-546. (Belgium)	Parents of 972 3rd- to 5th-grade children completed questionnaires about their own and their children's sleeping habits and schooling.	Sleep difficulties lasting more than 6 months were present in 43% of children. Among the 132 poor sleepers, 21% failed 1 or more years of school—a significantly higher percentage than found among those without sleep problems. 28% expressed a desire for counseling.
Link SC, Ancoli-Israel S. Sleep and the teenager. *Sleep Res.* 1995;24A:184. (United States)	150 high school students (mean age 16 years) were given a questionnaire that included sleep questions and GPA.	High GPA correlated significantly with waking up later on school days, early rising on weekends, less time taken to fall asleep, fewer night awakenings, and fewer daytime naps on school days.
Meijer AM, Habekothe HT, Van Den Wittenboer GL. Time in bed, quality of sleep and school functioning of children. *J Sleep Res.* 2000;9(2):145-153. (Netherlands)	449 students (9-14 years) responded to classroom questionnaires, including Bourdon-Vos pencil/paper test measured attention, School Perception Questionnaire of school functioning, and a sleep questionnaire. Study also controlled for psychosomatic and neurotic complaints that could influence the association between sleep and school functioning (using a standardized questionnaire measuring these characteristics).	15% report sleep problems, 43% have difficulty getting up in the morning, and 25% do not feel rested at school. Regression analyses demonstrated that although sleep characteristics do not have an impact on concentration, they do have a significant impact on some aspects of school functioning, in particular, children's motivation to achieve in school.

Table 2
Articles on Disordered Sleep *(Continued on next page)*

Reference (Origin)	Experimental Design	Outcome
Ali NJ, Pitson D, Stradling JR. Sleep disordered breathing: effects of adeno-tonsillectomy on behavior and psychological functioning. *Eur J Pediatr*. 1996;155:56-62. (United Kingdom)	33 children (6-12 years) who snored and were on a waiting list for having their adenoids and tonsils removed were visited at home and monitored during sleep with a video and oximetry (measure of air exchange and oxygenation). Of these, 12 had evidence of sleep disturbance secondary to airway obstruction and 11 of those remaining on the waiting list were matched by age and sex with the 12. Another 10 control children were studied as well. All children were studied for intelligence (WISC-R), attention (continuous performance test), and tests of impulsivity and behavior were performed before surgery and 3-6 months after surgery.	Children with sleep-disordered breathing improved in aggression, inattention, hyperactivity, and vigilance after surgery, but not on intelligence. The other 2 groups did not change on pre- and posttests, or changed for only hyperactive behavior and vigilance.
Andreou G, Karapetsas A, Agapitou P, Gourgoulianis K. Verbal intelligence and sleep disorders in children with ADHD. *Percept Mot Skills.* 2003;96(3 Pt 2):1283-1288. (Greece)	18 children (8-13 years) with ADHD were matched with 18 age- and sex-matched control children. Measures were ADHD assessments, five verbal scales of the WISC-III (intelligence scale), and polysomnographic studies of sleep.	Poor quality of sleep was found on children with ADHD (apnea, desaturated hemoglobin, and awakenings associated with limb activity and snoring). These children had low performance (of up to 20 points) on the WISC-III verbal scores.
Blunden S, Lushington K, Kennedy D, Martin J, Dawson D. Behavior and neurocognitive performance in children aged 5-10 years who snore compared to controls. *J Clin Exp Neuropsych*. 2000;22(5):554-568. (Australia)	16 children referred to ENT/pulmonary clinic for snoring evaluation (mean age 7.2). Matched with 16 controls for age and sex. WISC (and WPPSI-R for preschoolers), WRAML, Auditory Continuous Performance Test and Child Behavior Checklist measured intelligence, memory and learning, attention and behavior. Sleep measured using parents' 7-day sleep log, polysomnography, and a sleep disturbance scale.	Compared to controls, children who snored (but who did not necessarily have obstructive sleep apnea) showed significantly impaired attention, lower memory and intelligence scores (although memory and intelligence were within normal range). Mild sleep-disordered breathing affected daytime functioning.
Chervin RD, Clarke DF, Hoffman JL. School performance, race, and other correlates of sleep-disordered breathing in children. *Sleep Med.* 2003;4:21-27. (United States)	Students in 2nd and 5th grades in 1 school district recruited by sending letters home. Sleep-disordered breathing was measured using a validated parent questionnaire. School performance was measured using teachers' ratings (5-point scale) and year-end Reading and Math assessments.	146 parents completed the questionnaires on their children. Sleep-disordered breathing was associated with poor teacher rating. Sleep-disordered breathing was not significantly associated with Reading or Math assessment scores.

Table 2
Articles on Disordered Sleep *(Continued from previous page)*

Reference (Origin)	Experimental Design	Outcome
Gozal D. Sleep-disordered breathing and school performance in children. *Pediatrics*. 1998:102(3);616-620. (United States)	1st-grade children ranked in the lowest 10th percentile of class were identified (297). Parents completed a questionnaire on obstructive sleep apnea; children received overnight recordings of sleep and respiratory function/gas exchange at night. Parents of children with abnormal results were encouraged to seek surgical correction. Schools provided academic grades for 2 successive years.	Gas exchange difficulty, indicative of obstructive sleep apnea, occurred frequently among 1st graders with academic difficulty (18%). Those with gas exchange problems who received a tonsillectomy/adenoidectomy significantly improved their grades (2.4-2.9) the following year, whereas those electing not to get recommended surgery had no significant increase. No academic improvements occurred in those without evidence of obstructive sleep apnea.
Owens J, Spirito A, Marcotte A, McGuinn M, Berkelhammer L. Neuropsychological and behavioral correlates of obstructive sleep apnea syndrome in children: a preliminary study. *Sleep Breath*. 2000;4(2):67-77. (United States)	18 children (age 7.3 years) with obstructive sleep apnea were tested for a number of neuropsychologic functions: general cognitive functioning (McCarthy Scales); language (Peabody Picture Vocabulary); executive functioning, such as planning and organization; and attention, memory (Memory Scale of McCarthy Scale), and visual perception and visual motor integration. Motor and behavioral measures (parent ratings) were also conducted. Eight children who received an adenoid-tonsillectomy were reevaluated.	Modest impairments in executive functioning, attention, and motor skills were found. There was little correlation between the severity of the obstructive sleep apnea (as measured by Apnea Hypopnea Index) and the level of functioning. Tests did not significantly improve after surgery, although some approached statistical significance for improvement.
Roberts RE, Roberts CR, Chen LG. Functioning of adolescents with symptoms of disturbed sleep. *J Youth Adolesc.* 2001;30:1-18. (United States)	Data from a large school-based survey of 5423 students (grades 6-8) were used to examine the association between levels of functioning and symptoms of insomnia (a period of at least 2 weeks of having trouble falling asleep, staying asleep, or awakening too early) and "hypersomnia" (at least 2 weeks of sleeping too much).	Approximately 6%, 12%, and 3% of student population reported hypersomnia only, insomnia only, and both (respectively). Using those without sleep problems as a reference group and logistic regression analysis, the authors found that reported absence due to illness was significantly increased among students who had insomnia and those with both hypersomnia and insomnia.

ADHD, Attention Deficit/Hyperactivity Disorder; WISC-III, Wechsler Intelligence Scale for Children—Third Edition; WISC-R, Wechsler Intelligence Scale for Children—Revised; WPPSI-R, Wechsler Preschool and Primary Scale—Revised; WRAML, Wide Range Assessment of Memory and Learning—Second Edition.

Table 3
Articles on Sleep Habits and Sleep Deprivation *(Continued on next page)*

Reference (Origin)	Experimental Design	Outcome
Allen RP. Social factors associated with the amount of school week sleep lag for seniors in an early starting suburban high school. *Sleep Res*. 1992;21:114. (United States)	All students attending 12th grade in a human behavior class in 1 "early starting" school (7:40 AM) were surveyed anonymously for sleep patterns, partying habits, grades, alcohol consumption, and other habits.	Those students who went to bed later on weekends (ie, they did not "catch up" on sleep lost during the week as a result of an early start) had poorer grades. A usual weekend bedtime after 2:30 AM was reported by 15% of students with A and B+ grades, and 35% of those reporting average grades.
Drake C, Nickel C, Burduvali E, Roth T, Jefferson C, Pietro B. The pediatric daytime sleepiness scale (PDSS): sleep habits and school outcomes. *Sleep.* 2003;26(4):455-458. (United States)	450 students (age 11-15) responded to a written survey of sleep and school achievement and sleepiness.	Significant linear relationships found between sleep time and daytime sleepiness. Significant linear relationships found between daytime sleepiness and school achievement. Sleepiness across grade levels indicated that sleepiness increased significantly with grade level.
Epstein R, Chillag N, Lavie P. Starting times of school: effects on daytime functioning of fifth-grade children in Israel. *Sleep*. 1998;21(3):250-256. (Israel)	5th-grade pupils (10-12 years old) from 28 classes in 18 schools throughout Israel were divided into "early risers" (N = 232), who started school at 7:10 AM (42%) at least 2 times a week, and "regular risers" (N = 340), who always started school at 8:00 AM (58%). Children completed self-administered questionnaires concerning sleep habits during school days, weekends, and holidays, daytime fatigue, sleepiness, and difficulties concentrating and paying attention in school.	Mean sleep time of the "early risers" was significantly shorter than that of the "regular risers." Early risers complained significantly more about daytime fatigue and sleepiness, and about attention and concentration difficulties in school. Their complaints were independent of the reported hours of sleep.
Fallone G, Acebo C, Arnedt JT, Seifer R, Carskadon MA. Effects of acute sleep restriction on behavior, sustained attention, and response inhibition in children. *Percept Mot Skills.* 2001;93:213-229. (United States)	82 children (age 8-15) completed 5 nights of baseline sleep and then randomly assigned to optimized (10 hours) or restricted (4 hours) sleep in an overnight lab. Behavior, performance, and sleepiness were assessed the following day. Students reported sleepiness and were given several observation measures of attentiveness.	Although sleep restriction was associated with increased child reports of sleepiness and inattentive behaviors, there was no significant impaired performance on tests of response inhibition and of sustained attention.
Fredriksen K, Rhodes J, Reddy R, Way N. Sleepless in Chicago: tracking the effects of adolescent sleep loss during the middle school years. *Child Dev*. 2004;75(1):84-95. (United States)	2259 students (age 10 through 14 over the course of the study) were given a survey annually for 3 consecutive years by their middle school teacher. Sleep, depressive symptoms, self-esteem, and academic outcomes were self-reported by the students. A statistical model was used to determine whether fewer hours of sleep caused poor grades, lower self-esteem, and depressive affect or whether these caused poor sleep.	Girls initially reported more sleep than boys, yet reported a sharper decline over the course of 3 years than boys. Girls reported higher grades than boys initially and over the 3 years. Students who initially reported higher levels of sleep also tended to report higher grades. The rate of change in hours of sleep over the 3 years was not significantly associated with their grades. Grades (and esteem and affect) were influenced by sleep, not vice versa.

Table 3
Articles on Sleep Habits and Sleep Deprivation *(Continued from previous page)*

Reference (Origin)	Experimental Design	Outcome
Giannotti F, Cortesi F, Sebastiani T, Ottaviano S. Circadian preference, sleep and daytime behaviour in adolescence. *J Sleep Res*. 2002;11(3):191-199. (Italy)	Over 6600 adolescents (age 14-18) completed a comprehensive questionnaire. The questionnaire helped to categorize adolescents into morning types and evening types.	Study confirmed an increasing tendency with age to be less sleepy during evenings and more sleepy during mornings (evening type). Evening types demonstrated more sleepiness during day, reported poorer school achievement, less attentiveness, and higher consumption of caffeine beverages.
Randazzo AC, Muehlbach MJ, Schweitzer PK, Walsh JK. Cognitive function following acute sleep restriction in children ages 10-14. *Sleep*. 1998;21:861-868. (United States)	16 children (10-14 years) were randomly assigned to a control group (11 hours in bed) or an experimental group (sleep deprived with maximum 5 hours in bed) on a single night in a sleep laboratory. Sleep was monitored using a polysomnograph test, sleep latency was measured (time to fall asleep), and testing was done the next day. Tests included the Digit Symbol Substitution Test, Steer Clear test for visual vigilance, WRAML (assessment of learning and memory), Torrance Test of Creative Thinking, Children's Category Test (learning and problem solving), Wisconsin Card Sorting Test, and California Verbal Learning Test.	Cognitive tests with significant differences between the control and sleep-deprived groups were always worse for the sleep deprived, but limited to the following cognitive functions: verbal creativity and the Wisconsin Card Sorting Test. All other tested areas were similar between control and sleep-restricted groups.
Sadeh A, Gruber R, Raviv A. The effects of sleep restriction and extension on school-age children. *Child Dev.* 2003;74:444-455. (Israel)	The sleep of 77 children in 4th through 6th grades (9-12 years) was monitored nightly. Neurobehavioral function tests were measured on the 2nd day of their normal sleep schedule. On the 3rd through 5th nights, 40 children were asked to extend their sleep by 1 hour and 37 children were asked to restrict their sleep by 1 hour. Tests were repeated on the 6th day. Tests included finger tapping (motor speed), reaction time, continuous performance test (visual attention and motor speed), symbol-digit substitution (visual memory, scanning, and speed), visual digit span test (working memory, attention), serial digit learning (working memory, learning strategies).	Children who extended their sleep significantly improved their performance on the digit forward memory test and reaction time with the continuous performance test. Those children who decreased or maintained the same number of sleep hours as they had at baseline showed no change in neurobehavioral functioning. The authors conclude that even modest extensions in sleep per night could have benefits in neurobehavioral functioning.
Shin C, Kim J, Lee S, Ahn Y, Joo S. Sleep habits, excessive daytime sleepiness and school performance in high school students. *Psychiatry Clin Neurosci.* 2003;57(4):451-453. (South Korea)	Survey of 4781 11th-grade students from 10 randomly selected schools. Excessive daily sleepiness based on "Epworth Sleepiness Scale." Achievement was based on the quartile students' ranked in their final exams of their first semester. There was an 80% response rate.	Mean total sleep time was 6.4 hours/day. Total sleep time did not significantly correlate with excessive daily sleepiness. Prevalence of excessive daily sleepiness increased significantly with a decline in school performance.

Table 3
Articles on Sleep Habits and Sleep Deprivation *(Continued from previous page)*

Reference (Origin)	Experimental Design	Outcome
Wolfson AR, Carskadon MA. Sleep schedules and daytime functioning in adolescents. *Child Dev.* 1998;69(4):875-887. (United States)	Sleep habits survey given to 3120 students (age 13-19 years) at 4 high schools. Cross-sectional study. Sleep time and school performance were self-reported. A depressive mood scale was also given.	Students of older ages report decreasing hours of sleep (a decrease of 45 minutes/night from age 13 to 19) due to later bedtimes. Students with grades averaging C, D, and F obtained 25 minutes less sleep and went to bed 40 minutes later than students with A's and B's. Weekend delays in bedtime were also associated with poorer grades.

WRAML, Wide Range Assessment of Memory and Learning.

on self-report. Self-reported shortened sleep time, erratic sleep/wake schedules, late bed and rise times, and poor sleep quality are negatively associated with academic performance for adolescents from middle school through college years. Future research designs must go beyond subjective feelings of sleepiness to measure academic performance. We need methodologies that include control groups and randomization.

Despite the drawbacks in the literature on sleep deprivation among teenage populations, the preponderance of literature that recognizes the detrimental effects of sleep disorders is astounding and perhaps not fully appreciated among many primary care providers, school health professionals, and educators. Professionals faced with school-aged children with learning or attention disorders have enough scientific justification to suspect that poor sleep may be a contributing factor. These children and their families should be asked about regularity and duration of sleep, bedtime resistance, sleep onset delay, night-wakings, sleep-disordered breathing, and increased daytime sleepiness. ■

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