



Original Article

Sleep efficiency (but not sleep duration) of healthy school-age children is associated with grades in math and languages



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ABSTRACT

Objective: The objective of this study was to examine the associations between objective measures of sleep duration and sleep efficiency with the grades obtained by healthy typically developing children in math, language, science, and art while controlling for the potential confounding effects of socioeconomic status (SES), age, and gender.

Study design: We studied healthy typically developing children between 7 and 11 years of age. Sleep was assessed for five week nights using actigraphy, and parents provided their child's most recent report card.

Results: Higher sleep efficiency (but not sleep duration) was associated with better grades in math, English language, and French as a second language, above and beyond the contributions of age, gender, and SES.

Conclusion: Sleep efficiency, but not sleep duration, is associated with academic performance as measured by report-card grades in typically developing school-aged children. The integration of strategies to improve sleep efficiency might represent a successful approach for improving children's readiness and/or performance in math and languages.

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1. Introduction

Low academic achievement in children is a common and serious problem that affects 10–20% of the population [1,2]. School outcomes largely determine long-term social and economic success, and a successful start to formal learning in school is formative to these outcomes [3]. Short or poor sleep is a significant risk factor for poor academic performance that is frequently ignored. Cognitive processes that underlie academic performance include executive functions [4–7], memory [8], and attention [9,10]. Sufficient and efficient sleep is essential for and intimately related to the optimal functioning of each of these processes [11,12]. On the other hand, poor or insufficient sleep can disrupt them and is associated with poor academic performance [13–15]. It is therefore critical that we investigate the association between sleep and the academic performance of children.

A considerable proportion of elementary school-aged children get less sleep than is recommended [16,17]. In a large survey, 34% of toddlers, 32% of preschoolers, and 27% of school-aged children were reported to sleep fewer hours than what their parents/caregivers thought they needed [18]. Objective evidence confirms these concerns, as a recent study using wrist actigraphy showed that children aged 4–10 years slept an average of 8 h per night, even though the recommended sleep duration for this age range is 10 h per night [19]. However, the amount of sleep needed remains an individual matter, and is difficult to determine precisely. In addition, studies using objective measures of sleep have revealed that even the normative population of typically developing children experiences a high prevalence of approximately two night wakings per night on average [20]. This is a major concern given that restricted and disrupted sleep can seriously impair the cognitive processes needed for academic success [21,22].

Previous studies have reported positive associations between sleep and academic performance, as well as memory. A review of studies that evaluated the association between sleep and memory in children and adolescents reported that sleep is associated with improved working memory and memory consolidation in children and adolescents [23]. Another study with three separate meta-analyses indicated associations between sleep quality, sleep duration, sleepiness, and school performance in children and adolescents, with younger participants demonstrating a larger effect size [24]. In these

Abbreviations: SES, Socioeconomic status; GS, Good sleep; PS, Poor sleep; SD, Standard deviation; M, Mean.

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meta-analyses, sleepiness showed the strongest association with school performance, followed by sleep quality and sleep duration.

However, previous studies examining the associations between academic performance and sleep in school-aged children have suffered from multiple limitations that bar us from clearly determining the nature and strength of associations between sleep duration/quality and the report-card grades of typically developing healthy elementary-school-aged children. The limitations are in the following domains.

Academic Outcome Measures. A large proportion of the studies [15,25–35] conducted to examine the association between sleep and academic performance did not use report-card grades but used indirect measures of academic performance such as performance on standardized tests that measure ability or neurocognitive batteries that measure cognitive skills associated with academic performance [26–28,33]. This does not indicate how this translates to grades – that is, to the measures by which academic performance is being measured.

Other studies [13,25,34,35] have used teachers' reports on scales associated with achievement but do not measure it directly and are not specific to academic subjects. This makes it impossible to assess accurately the association between the actual performance in school and sleep, and it does not allow for any conclusion regarding potential differential associations between sleep and specific subjects to be drawn.

Of the studies that included information related to report-card grades [15,30,31,36–40], all but two [36,38] used general proxies of performance rather than the actual grades; that is, they asked for general descriptions of overall performance. Such nonspecific information does not allow to precisely determine the nature of the associations between sleep and report-card grades. In addition, these studies lumped different subjects together, even though sleep might not affect all subjects similarly. It is important to determine which aspects of academic performance are specifically affected by short or poor sleep because sleep interventions may then be developed to improve these domains.

Sleep Measures Used. To date, only two studies [36,38] have examined the associations between sleep and actual report-card grades of typically developing elementary school students. However, these studies used subjective measures of sleep.

Using these kinds of measures is another problem that has limited the usefulness of the previous studies: with four exceptions [13,27,28,33], all of the studies that examined sleep and academic performance in typically developing school-aged children used subjective sleep measures, such as sleep logs [15,37], sleep questionnaires [15,25,26,29,31,32,34–38,40], interviews [39], or surveys [30]. These measures do not allow for the retrieval of objective documentation of either sleep duration or sleep quality – the two aspects of sleep that are believed to affect academic performance – although Mayes et al. [28] found no significant associations between sleep and academic performance.

The four studies that used objective sleep measures either did not use report-card grades to measure academic performance [13,28,33] or focused on students with sleep disruption rather than on typically developing children [27], so their findings do not apply to the larger cohort of typically developing students.

Population Studied. The only study that used objective sleep measures and actual report-card grades focused on students with sleep disturbances [41]. This is a general problem in the field: a large proportion of the studies examining sleep and academic performance have focused on children with reported sleep disturbances [42]. Unfortunately, clinical sleep disorders (e.g., sleep apnea) can be associated with cognitive deficits that may affect academic performance. Therefore, such studies do not allow to draw meaningful conclusions regarding the associations between sleep and

academic performance in the larger cohort of typically developing children who do not suffer from a sleep disorder [42].

With the exception of four studies [34,43–45], most of the existing studies failed to control for socioeconomic status (SES) [13,15,25,26,28–31,33,35–40]. Buckhalt et al. [44] found that SES and ethnicity moderated the relation between sleep and cognitive performance, where more optimal sleep protected against cognitive performance difficulties. The same moderation effect was found 2 years later in a follow-up study [45]. Bub et al. [43] also reported race/ethnicity to be a significant moderator of the link between sleep and cognitive performance, with Sleepiness serving as a vulnerability factor for poor cognitive outcomes, especially among African-American children. Similarly, Li et al. [34] reported that sleep behaviors were linked to SES differences (such as parental education). Consequently, failing to control for SES might bias the results, adding to the limitations of previous studies.

Finally, several of the previous studies analyzed data from school-aged children and adolescents together [15,26,29–33,35,36]. This is an issue because sleep needs, sleep patterns, and executive functions all show significant changes in adolescence. In addition, mixing the two age groups could have led to the loss of important information that is unique to younger children, whose developing cognitive systems may be more susceptible to the impacts of sleep.

The goal of the present study was to examine the associations between the objective measures of sleep duration and sleep efficiency with the actual report-card grades that healthy typically developing school-aged children obtained in math, languages, science, and art, while controlling for the potential confounding effects of SES, age, and gender. Our questions were as follows: 1) Of the academic subjects taught in elementary school (math, languages, science, and arts), is performance specifically associated with sleep and, if so, among which subject(s)? 2) What aspects of sleep are relevant to academic performance, as indicated by report-card grades? 3) To what extent is sleep associated with each subject, that is, how much of the variance in predicting the subjects' grades could be explained by sleep efficiency or sleep duration?

1.1. Hypotheses

1) Based on the important role sleep plays in learning and memory [23,46], we hypothesized that sleep will be significantly associated with academic performance in all of the subjects taught in elementary school. 2) Based on the previous findings reviewed by Dewald et al. [24], we hypothesized that sleep efficiency will contribute more than sleep duration to explain the variances in the prediction of report-card grades. 3) Given the role of executive functions in math and languages, and studies showing that sleep disruption and deprivation negatively impact executive functions [11,21], we hypothesized that the degrees of variance explained by sleep will be larger for the subjects of math and languages.

2. Method

2.1. Participants

The sample consisted of 75 participants: 41 boys and 34 girls aged 7–11 years (mean = 8.85, standard deviation (SD) = 1.6) who were enrolled in Cycle 1 (Grades 1 and 2, $N = 23$), Cycle 2 (Grades 3 and 4, $N = 26$), and Cycle 3 (Grades 5 and 6, $N = 26$). A participant was excluded from the study if he or she had: 1) a history of psychiatric illness, developmental disorder, learning disability, or psychosis that might affect academic performance; 2) any medical or psychiatric condition (e.g., depression or anxiety) that might interfere with sleep; and/or 3) was taking any medication that might interfere with sleep. Based on these criteria, seven children were excluded from participation (four with anxiety, one with

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