Poor Sleep and Lower Working Memory in Grade 1 Children: Cross-Sectional, Population-Based Study

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Abstract

Objective: Poor sleep and working memory difficulties are both associated with learning difficulties, but it is not known whether they are linked with each other in childhood. We aimed to determine, in a population-based sample of grade 1 children, whether poor sleep is associated with reduced working memory capacity.

Methods: Cross-sectional population-based study. All grade 1 children in 44 elementary schools in metropolitan Melbourne, Australia; 1749 children were included (participation rate 65%, mean age 6.9 years). Parents completed a written questionnaire at home, after which researchers administered one-on-one child computerized assessments at school. Predictor measures were parent-reported 1) perceptions of poor sleep, 2) regularity of bedtime, 3) sleep duration, and 4) sleep onset latency. Outcome measures were backward digit recall (verbal working memory) and Mister X (visuospatial working memory) subtests of the Automated Working Memory Assessment (AWMA). Associations were examined using linear regression, adjusted for duration of schooling, gender, age, and social status.

Results: Increasing poor sleep ($P = .03$), less regularity of bedtime ($P < .001$), and shorter sleep duration ($P = .03$) were all associated with poorer verbal working memory, with effect sizes ranging from 0.3 to 1.2. Poor sleep was not associated with visuospatial working memory.

Conclusions: At a population level, poor sleep in early school-age children is associated with poorer verbal working memory, an important predictor of academic difficulties.

Keywords: child; cross-sectional studies; epidemiology; learning difficulties; memory; short-term; sleep

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What's New

Although sleep problems are consistently associated with poorer working memory in adults, findings in school-age children remain limited. We demonstrate, at a population level, that sleep problems and irregular bedtimes are associated with poorer verbal, but not visuospatial, working memory performance.

Building solid academic foundations during the early years of school is strongly associated with long-term academic outcomes[1] as well as social and employment outcomes in later life.[2] Working memory—a child's ability to remember and manipulate new information—is crucial in enabling a child to learn.[3,4] A good night's sleep is also considered an essential prerequisite for successful learning. Children who experience poor sleep, typically defined as disrupted or inadequate sleep, are at greater risk of poor academic attainment and grade repetition.[5,6] Although studies have reported that poor sleep is related to poorer working memory[7] and other executive functions,[8,9] there are no population-level data about what specific aspects of sleep are associated with poorer working memory during the early years of school. In particular, if aspects of poor sleep were causally related to low working memory, affected children's ability to learn in the early years of school may be improved via sleep interventions, already known from translational trials to be practicable and effective in population settings.[10,11]

Working memory can be differentiated into verbal and visuospatial components. Verbal working memory involves storing and manipulating auditory/verbal stimuli such as sounds, phonemes, and words for a short period. This is considered important for language and literacy development and is involved in remembering, comprehending, and following instructions.[12] Visual-spatial working memory, which involves storing and manipulating visually presented information, is needed for numeracy development and to remember sequences of patterns, events, or images.[12] Children with weak working memory

may become overloaded in the classroom and forget crucial task information. This is because working memory is used to construct mental models for problems (eg, word and sentence construction) and to coordinate multiple tasks,[13] including monitoring and manipulation of mental calculations and task sequences.[14,15]

In this study, we focused on the possible role of poor sleep in influencing a child's working memory. Poor sleep is common, affecting about 40% of children during the preschool and early years of school.[16,17] It is associated with increased behavior problems, poorer concentration, and poor academic attainment in school.[7,18] A review by Kopasz et al[8] reported that inadequate or disrupted sleep is associated with poorer prefrontal cortex function, which encompasses working memory. More recently, it has been reported that preschool children who slept longer at night performed better on higher-order cognition.[9] Research also suggests differences in child learning are related to sleep duration on both school and non–school nights,[19] bedtime regularity,[20] and sleep latency (the time it takes a child to fall asleep while in bed).[21]

Poor sleep is consistently associated with poorer working memory performance in adolescent and adult populations,[22] but the relationship between multiple aspects of sleep and working memory have not been examined at a population level in early childhood. This is an important research gap, as the characteristics of poor sleep, the development of working memory, and the consequences of poor working memory are different in young children compared with adults. Adult sleep problems typically have a medical etiology, such as obstructive sleep apnea, whereas sleep problems in children are predominantly behavioral in nature, such as bedtime resistance and sleep phase disorders.[23] Whereas working memory is thought to be stable in adults, it is still developing in children.[24] A study of 60 children aged 6 to 13 years by Steenari et al[7] reported that actigraphy measurements of reduced sleep quality was associated with poorer working memory scores on the n-back test. It is important to understand whether this relationship persists at the population level in order to inform future working memory intervention trials using evidence-based population-level sleep interventions.[10,11] Sleep interventions may offer a quicker, more developmentally appropriate, and less disruptive mechanism for maximizing working memory performance compared with intensive and expensive working memory training programs.

We aimed to determine the association between a range of parent-reported child sleep parameters and working memory in a population-level cohort of early elementary school children. We hypothesized that parent-reported sleep problems, irregular sleep times, shorter sleep duration, and increased sleep latency would all be associated with lower verbal and visual working memory.

METHOD

This cross-sectional study used baseline population-level screening data from the large Memory Maestros randomized control trial, described in detail in its published protocol.[25] Memory Maestros was approved by the human research ethics committee at the Royal Childrens Hospital in Melbourne, Australia (HREC 30104), the Victorian Department of Education and Early Childhood Development, and the Victorian Catholic Education Office, and parents provided written informed consent for each child to participate.

DESIGN AND SAMPLE

Elementary schools were randomly selected from each of Melbourne's 4 metropolitan school regions (northern, southern, western, and eastern) and were proportionately drawn from all 3 school sectors (government, independent, and Catholic). The regions and sectors represent a broad range of socioeconomic and cultural backgrounds.[26] Recruitment of grade 1 children in the 44 schools occurred in 2012 over the 4 terms of the school year. Grade 1 refers to the second formal school year in Victoria, Australia, when almost all children are aged between 6 and 7 years.

PROCEDURES

Recruitment packs were sent to families of all grade 1 students via the classroom teacher in all participating schools. The recruitment pack included the parent information statement, consent form, and parent baseline questionnaire. Because the questionnaires were completed before the working memory assessments, parents were unaware of the child's working memory abilities. Children were excluded if they had conditions that prevented them participating in the computerized working memory screening tasks (eg, blind, deaf, selective mutism) or if their parents had insufficient English-language skills to complete the screening survey.

Once all informed consent forms had been received for a given school, trained research assistants administered the working memory assessments to each child individually. Assessments were conducted within 1 week of informed consent and the baseline questionnaire being received, and all assessments occurred during school hours.

MEASURES

Parents reported on several child sleep variables.[4] Child sleep problems were assessed by parent response to the question, "Is your child's sleep or sleep habits a problem for you?" The 4 possible responses were trichotomized into no, small, and moderate/large sleep problem, in line with previous research examining the relationship between sleep problems and objectively measured child learning.[4] Child sleep patterns were assessed by parent response to the question, "Does your child go to bed at regular times?" The 5 possible responses were trichotomized into always/usually, sometimes, and never/rarely categories of sleep pattern regularity, in line with previous research.[4] Child sleep time, duration, and latency were derived from parent answers regarding the time the child usually 1) went to bed, 2) fell asleep and 3) woke up, with separate responses elicited for school days and non–school days. Specifically,