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Patrick Cooper

Mark Kohler

Sarah Blunden

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ORIGINAL ARTICLE

Sleep and academic performance in Indigenous Australian children from a remote community: An exploratory study

Patrick Cooper,¹ Mark Kohler^{2,3} and Sarah Blunden^{3,4}

¹Northern Territory Department of Education and Training, Katherine, Northwest Territories, ²Children's Research Centre, University of Adelaide, ³School of Psychology, Social Work and Social Policy and ⁴Centre for Sleep Research, University of South Australia, Adelaide, South Australia, Australia

Aim: Disruptions to sleep in childhood are associated with poor behaviour and deficits in academic performance and executive function. Although academic performance of indigenous children from remote communities in Australia is documented as well below that of non-indigenous children, the extent of sleep disruption and its contribution to academic performance among this population has not been assessed. This pilot study aimed to objectively assess the sleep of remote indigenous children and the association between sleep disruption and both academic performance and executive function.

Method: Twenty-one children from a remote Australian indigenous community aged 6–13 years wore actigraphy for two consecutive nights, reported subjective sleepiness, and were objectively assessed for academic performance (Wechsler Individual Achievement Test, 2nd Edition) and executive function (NEuroloPSYcological Assessment-II).

Results: Results show marked reduction in sleep time, sleep fragmentation, academic performance and auditory attention compared with non-indigenous norms. Sleep duration was not associated with performance, possibly because of reduced sleep and performance observed across the entire group. Sleep fragmentation was associated with reduced reading and numerical skills ($P < 0.05$).

Conclusions: The sleep of indigenous children in remote communities is an important area of future inquiry, and our initial findings of poor sleep and an association between sleep disruption and academic performance may have important implications for intervention strategies aimed at 'closing the gap'. Further studies should assess a broader range of demographic, social and economic factors to better understand the associations reported here and guide future intervention.

Key words: academic performance; child; indigenous Australian; neurocognition; sleep.

What is already known on this topic

- 1 Inadequate sleep can impair childhood behaviour, cognition and school performance.
- 2 Indigenous children living in remote communities have the lowest rates of academic success in schools across Australia.
- 3 Subjectively assessed sleep in urban indigenous children is associated with increased problematic behaviour.

What this paper adds

- 1 Indigenous children living in remote communities have worse sleep than published norms in non-indigenous children.
- 2 Sleep disruption was significantly associated with poor academic performance.
- 3 This knowledge can help address the gap in educational equality of remote indigenous children.

Introduction

Inadequate sleep can impair childhood behaviour, cognition and school performance (for review see¹). Sleep has been long recognised as an important factor in school performance² and a number of studies in children have concluded that shortened sleep times, delayed bed time and rise time, and poor sleep quality are negatively associated with academic performance and attention.³ There may be several pathways through which

poor sleep impacts on school performance. It has been argued that the association between poor sleep and poor school performance can be in part explained by the role of sleep in memory encoding and consolidation,⁴ brain plasticity,⁵ and motivation to perform in school.⁶ Moreover, lower socio-economic status is related to poorer sleep health and reduced academic performance.⁷ While much of the current focus is aimed towards developing a model to explain the mechanisms through which these relationships exist, the existence of any relationship has not been investigated in a cohort of significant educational underachievement in Australia, namely indigenous children living in remote communities.

Indigenous children living in remote communities have the lowest rates of academic success in schools across Australia. A

Correspondence: Mr Patrick Cooper, 25 Gap Road, PO Box 1604, Alice Springs NT 0871, Australia. Fax: (08) 8951 4435; email: patrick.cooper@caac.org.au

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national assessment in 2008 indicated that 92.1% of all third-year students in Australia achieved the reading benchmark compared with only 68.3% of indigenous third-year students.⁸ Moreover, the benchmark for reading was obtained by only 25.4% of students classified as living in 'very remote' Northern Territory, which most accurately describes the sample in this study.

A recent survey of Aboriginal and Torres Strait Islander Children⁹ suggested that indigenous children are experiencing sleep difficulty, with parental interviews identifying close to one in four children having had problems sleeping in the 4 weeks prior.

Improving sleep has led to improved educational outcomes in studies of American children;¹⁰ however, only one published study has investigated the relationship between sleep and daytime performance in indigenous Australian children.¹¹ In that study, both sleep and academic performance were measured by parental report only and despite no observed significant relationships between sleep and academic performance, poor sleep was associated with increased problematic behaviour. Previous government reports have speculated that sleep may play a factor in educational underachievement,¹² and if there are significant sleep problems among indigenous children these may be key to understanding and improving problems of academic outcomes and other important health variables.¹³

This pilot study sought to further explore these relationships by objectively measuring sleep quantity and quality in indigenous Australian children in a remote community with specific examination of its effects on academic performance and attention, and executive function. Given the disproportionate disadvantage reported in indigenous Australian children¹⁴ we anticipate that sleep will be disrupted in this population and that the severity of this sleep disruption will be associated with reduced academic performance, attention and executive function.

Materials and Methods

Measures

Assessment of sleep and sleepiness

Objective measurements of sleep were obtained using actigraphy (Actiware-Sleep, Mini Mitter Co. Inc., Bend, OR, USA). This is a watch-like monitoring device worn on the non-dominant wrist of the participant, which measures acceleration and movement greater than 0.1 g. Using the recording of movement, researchers infer timing and length of sleep periods (i.e. periods of minimal movement) via computer analyses. Actigraphy is widely acknowledged as a reliable and valid measure for the study of sleep in children and adults^{15,16} and has been used in previous studies investigating wake patterns in relation to school performance.^{17,18} Agreement rates for sleep parameters between actigraphy and full overnight sleep monitoring (polysomnography) have been reported between 85% and 95%.^{12,19} Given the reported inaccuracy of sleep diaries in children,²⁰ and the majority of families in this sample not living to a Western construct of 'time', we decided not to ask children or parents to complete a sleep diary. Children were instructed to press an 'event marker' on the actigraph to indicate time going to bed

Table 1 Definitions of sleep variables recorded using actigraphy

Sleep parameters	Definition
Bedtime	Time children physically went to bed
Sleep start time (h)	Time that children commenced sleep.
Sleep latency (min)	Time between bedtime and sleep start time.
Sleep end time (h)	Time that students woke up
Get up time	Time children physically got out of bed
Time in bed (min)	Total time spent in bed, as calculated by time elapsed between bed time and get up time.
Total sleep time (min)	Total amount of time spent asleep between sleep start and sleep end time
Sleep efficiency (%)	The percentage of total sleep time out of total time in bed
Minutes moving	Total time of recorded minutes moving
Movement fragmentation index	A measure of restlessness as calculated using ratios of mobile and immobile bouts of time.

in the evening and time getting up from bed the following morning. The actigraph measured sleep/wake information continually over two weekdays in 1-minute epochs. The sleep variables reported are summarised in Table 1.

Assessment of executive and academic performance

Our measures of executive and academic performance were selected in accordance with recommendations of Werner and Campbell²¹ for adapting administration of testing for a cross cultural context. Specifically, subtests used consisted of simple sentences and avoided the use of pronouns, metaphors, and colloquialisms. Items chosen also avoided use of the passive voice, hypothetical phrasing and reference to subjective mood. Testing items were also selected to be appropriate based on the age and expected ability levels of the child and were compared with the standardised sample of the same age.

Academic performance was assessed using the Wechsler Individual Achievement Test (2nd Edition) – Australian Abbreviated (WIAT-II) (2007). The WIAT-II is a short test assessing areas of Word Reading, Numerical Operations, and Spelling. Word Reading assesses letter identification skills along with phonological awareness. Numerical Operations involves items that assess early maths skills (e.g. number recognition) and higher calculation skills (e.g. solving equations). Spelling assesses the individuals' ability to spell dictated letters, words and letter blends.

Executive performance was assessed using three subtests from the NEuroloPSYcological Assessment (NEPSY) and NEPSY-II, both batteries of neuropsychological assessment in children.²² Subtests included were the Auditory Attention, Auditory Response (Inhibition) and the Visual Attention tasks. The Auditory Attention and Auditory Response subtests were taken from the more recent NEPSY-II. The Visual Attention subtest from

the earlier version of the NEPSY provided a more appropriate measure of visual attention for the target population. The NEPSY has been used in previous studies to examine the effects of sleep on aspects of executive functioning in children.^{23–25} The Auditory Attention subtest assesses selective sustained auditory attention. The Auditory Response subtest assesses the individual's ability to shift executive set to a new and more complex task and inhibit impulse. The Visual Attention task assesses selective sustained visual attention and requires children to search and locate target pictures on a page.

All data was collected over a 5-day period in June 2008. Ethical approval was obtained from the University of South Australia research and ethics committee. All children were administered the assessment battery in English in a quiet distraction-free environment at their school, with the total assessment battery taking between 25 and 35 min to complete. Data analysis was performed using Statistical Package for the Social Sciences (SPSS) Version 17.0 (SPSS Inc., Chicago, IL, USA). Associations were assessed using Pearson correlations and chi-squared tests. All *P*-values are two-tailed, with statistical significance determined at $\alpha = 0.05$. Data are presented as mean and standard deviation (SD) unless otherwise stated.

Results

Participants

All participants were from a small remote Indigenous community within a day's drive from Katherine, Northern Territory, Australia ($n = 21$ aged 6–13 years). The community is serviced with a clinic and school, with the majority of students speaking English as a second or third language. The school has regular attendance and an enrolment of less than 50 students, all of whom were invited to participate in the study. Parental consent was obtained for 21 students, and a full data set was obtained for all of these students which consisted of 15 males and 6 females, with a mean age of 9.3 years (SD = 1.95, range 6.4–13.5 years).

Sleep

Actigraphy data was obtained for two consecutive weeknights in 16 students and for a single weeknight in five students. Comparisons between students for whom data was available for two nights with students for whom data was available for one night only showed no significant differences in sleep parameters. Where data was available for two consecutive nights there was no significant difference in sleep variable between nights and data for the two nights was therefore combined. On average, children went to bed at 22:11 (SD = 1 h, 5 min) and got out of bed at 7:51 (SD = 23 min) with an average time in bed of 9.60 h (SD = 59.2 min) and total sleep time of 8.78 h (SD = 49.6 min) on weeknights. There were no significant differences between male and female, or younger (6–9 years) and older (7–13 years) students in relation to sleep parameters reported. A summary of the sleep recordings are presented in Table 2.

Table 2 Sleep actigraphy results for 21 indigenous children in a remote community

	Mean (SD)	Range
Bed time (time)	22:11 (65.5 min)	20:24–00:21
Wake time (time)	7:44 (30.5 min)	7:00–9:02
Time in bed; TIB (min)	578.5 (59.2)	437.0–670.0
Total sleep time; TST (min)	527.9 (49.6)	422.0–616.0
Sleep efficiency (%)	79.0 (6.8)	64.8–96.9
Sleep latency (min)	38.5 (35.9)	6.0–126.0
Movement (min)	69.5 (27.0)	7.0–103.0
Fragmentation index	27.8 (10.9)	1.3–44.3

SD, standard deviation; TIB, time in bed; TST, total sleep time.

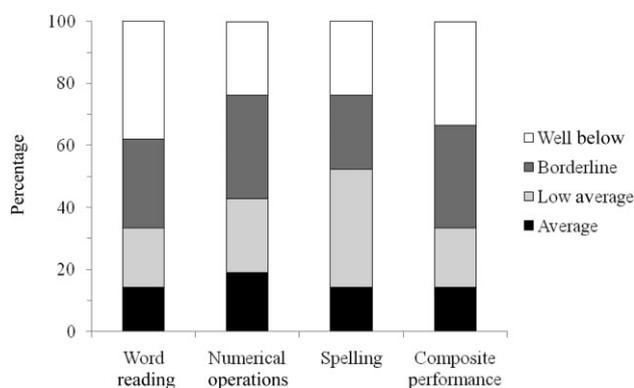


Fig. 1 Distribution of academic performance rankings according to test norms. NB. Well below = less than second percentile rank; Borderline = second to ninth percentile rank; Low average = 9–25th percentile rank; Average = 25–75th percentile rank.

Academic performance and executive function

For the WIAT-II, scores were below average across all measures including Word Reading, Numerical Operations and Spelling. The distribution of performance for each WIAT-II domain is presented in Figure 1.

Overall, students performed in the lower end of the test average range on measures of inhibition, and visual attention. Auditory attention scores were below the test average range. Of particular note is the wide distribution of scores for all measures of academic performance and executive function.

The association of sleep and performance

While measures of academic performance and executive functioning are reported as below test norms, these instruments have not been normed in the target population. Our interest in these scores was primarily for answering questions about the relationship between sleep variables and executive functioning within this sample. It is important to note we did not correct for multiple comparisons as this was an exploratory study. A summary of the correlations between variables is provided in Table 3.

Table 3 Correlation coefficients (*r*) for associations between school/executive performance and sleep measures

	Age	Reading	Numerical	Spelling	Composite	Auditory attention	Visual attention	Inhibition
Age	1	-0.22	-0.30	0.16	-0.10	-0.28	-0.17	-0.02
Bed time	-0.22	0.22	0.12	-0.06	0.16	0.26	-0.21	0.28
Wake time	-0.06	0.31	0.27	0.19	0.30	0.04	-0.30	0.09
TIB	0.27	-0.10	-0.05	<0.01	-0.04	-0.25	0.13	-0.27
TST	-0.13	0.08	0.21	-0.06	0.06	-0.18	0.21	-0.10
Sleep efficiency	-0.58**	0.50*	0.39	0.01	0.03	0.25	0.01	0.16
Sleep latency	0.59**	-0.19	-0.31	0.09	-0.10	-0.18	-0.16	-0.25
Movement	0.18	-0.52*	-0.28	-0.25	-0.41	-0.27	0.15	-0.05
FI	0.21	-0.62***	-0.47*	-0.04	-0.55**	-0.37	0.02	-0.22

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.005$. FI, fragmentation index; TIB, time in bed; TST, total sleep time. NB: significant results are presented in bold.

Greater sleep efficiency was significantly and moderately associated with increased word-reading ability, greater movement time during sleep was significantly and moderately associated with reduced word-reading ability, and greater fragmentation of sleep was significantly and moderately associated with reduced word-reading ability, numerical operations and overall composite WIAT-II performance. Increased age was also significantly associated with reduced sleep efficiency and greater sleep latency. No significant associations were found between sleep measures and measures of spelling ability on the WIAT-II or with measures of attention or inhibition from the NEPSY.

Discussion

These results suggest an association between sleep and school performance; however, the pilot nature of this study requires that several limitations be highlighted before the findings can be considered. Firstly, data reported has been gathered from a small, targeted sample using assessment tools that were not developed, nor have been normed for this population. Secondly, only a limited range of factors that could potentially impact on both sleep and academic performance were measured, leaving possible confounding variables unaccounted. For instance, participants performed particularly poorly on a task of auditory attention, which may potentially be due to hearing problems. Factors such as parent level of education, socio-economic status, school attendance, crowding and other demographic variables have not been included and may play an important role in the association between sleep and school achievement.

Withstanding these limitations, in this first study to objectively assess sleep and both academic performance and executive function in indigenous Australian children, we found that such children have relatively less sleep at night and go to bed at a later time on school nights compared with predominantly non-indigenous urban Australian children.²⁶ In addition, children in this sample showed relatively poor sleep efficiency and fragmentation. Consistent with this finding, around one-quarter of children reported frequent daytime tiredness and reduced academic performance. Of particular note was that despite there

being no significant association between sleep time and academic and executive performance measures, reduced sleep efficiency, increased movement time and increased sleep fragmentation were associated with poorer reading ability. Increased fragmentation was also associated with poorer numerical ability and overall academic performance.

A strong relationship exists between poor sleep, executive deficits and decreased school performance in both clinical^{24,27-30} and non-clinical studies.^{18,31-33} However, despite the significant impact of sleep problems on children's daytime performance the investigation of the frequency of reported sleep problems in Australian indigenous children, a population with documented poor academic performance, is reported in only three previous studies. Two of these were descriptive studies of sleep disturbance related to asthma^{34,35} and did not measure daytime performance. The third was the only known study to have compared sleep and daytime performance in indigenous and non-indigenous children.¹³ In that pilot study, associations between total behaviour problems and sleep disturbance were stronger for indigenous children than for non-indigenous children; however, the sample was small, from an urban population and all data were subjectively reported. The current study, expanding on these latter data and using objective measurements, supports previous findings that sleep is a significant contributor to the daytime performance deficits in indigenous children.

It is also of note that children in this study had an average of only 8.8 h of sleep during weeknights which was largely because of a late sleep onset time. Of greater concern was that even younger children aged between 6 and 9 years had a mean bed time of 22:47 with a total sleep time of just under 9 h. In non-indigenous Australian populations, recent data suggests that 9-14-year old children have a considerably earlier average sleep onset of 20:25-21:37 on school days as compared with children in this study.²⁶

Despite the observed associations between sleep *quality* and academic performance, we did not observe a significant association between sleep *quantity* (i.e. total sleep time) and school or executive performance. Associations between sleep time and school performance may be observed in a larger sample with

greater variance in sleep times. Our results are also consistent with the 'sleep continuity hypothesis' which suggests sleep quantity is not as crucial as sleep quality, and that uninterrupted continuous sleep of even a shorter duration may be more restorative than sleep that is longer but interrupted.³⁶

Being the first study to objectively describe the sleep of indigenous Australian children, further studies using a larger randomised sample from several communities and including a broader range of socio-economic, demographic and health-related variables is necessary to (i) determine key contributors to this sleep disruption, and (ii) investigate the interplay of factors in contributing to academic performance. As highlighted in this pilot study, a lack of appropriately developed and validated assessment tools pose a threat to ongoing research in this area and will continue to restrict until such tools are developed. The wide variation among measures of executive functioning, for instance, suggests that while some students performed well, others may have not fully comprehended the task. There is a need for tools suitable for use in indigenous populations to be developed and validated to enable research in this area to continue.

The associations observed in this study are perhaps not surprising to sleep researchers as reduced sleep quality in association with reduced academic and executive performance is well documented in children. Encouragingly, sleep is a modifiable factor, and establishing the key influences of poor sleep in this population may lead to novel and effective strategies to improve not only academic outcomes but also a range of health factors known to be associated with sleep.³⁷

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