# Normative Data on the Sleep Habits of Australian Children and Adolescents

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**Study Objective:** To provide normative sleep data on 9-18 year old Australians.
**Design:** Cohort study.
**Setting:** Participants' homes.
**Participants:** 4032 Australians aged 9-18 years.
**Interventions:** N/A.
**Measurements and Results:** Participants completed a 48h use of time recall, comprising sleep data for one complete night. Sleep duration, bedtime and wake time were compared across age groups, between genders, and between school and non-school days using ANOVA. Sleep duration declined with age ($P < 0.0001$) at the rate of 12 min/ night per year of age on school days, and 4 min on non-school days. Girls slept slightly longer than boys (5 min/ night; $P = 0.03$). Non-school day sleep was 16 min longer than school day sleep ($P < 0.0001$), with the difference increasing with age. Bedtimes got later with age ($P < 0.0001$), however there were no differences in bedtimes between boys and girls. Bedtimes occurred 34 min later on non-school days ($P < 0.0001$). Wake times were very similar across age groups on school days, but increased at the rate of 10 min/ year of age on non-school days. Wake times were similar for boys and girls, and occurred on average 82 min later on non-school days ($P < 0.0001$). Overall, 17% of school days and 20% of non-school days failed to meet the American Centers for Disease Control and Prevention sleep duration guidelines.
**Conclusions:** Normative sleep data will provide a valuable yardstick for health and education professionals when dealing with sleep-related issues.
**Keywords:** Use of time, bedtime, wake time, sleep duration, children, adolescents
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RECENTLY, THERE HAS BEEN INCREASING INTEREST IN SLEEP IN BOTH ADULTS AND CHILDREN, ARISING FROM RESEARCH ASSOCIATING INSUFFICIENT sleep with a number of physical and psychosocial disturbances, including attention deficits, memory impairment, decrements in creativity, learning and school performance[1,2]; motor skill problems[3]; mood disorders and hyperactivity[4]; anti-social behavior[5]; poorer overall health and compromised immune function[6]; and greater risk of overweight in young people.[7-9]

There is some evidence that the sleep duration of children has been declining in recent decades. Iglowstein et al.[10] found declines of 20-40 min in nighttime sleep in Swiss children aged between 6 months and 14 years between 1974-8 and 1986-93. Dollman and colleagues[11] reported declines of about 30 min in the time in bed on school days of 10-15 year-old Australians between 1985 and 2004. In addition to secular declines, it appears that some children and adolescents suffer cyclical sleep deprivation on school days, mitigated by "catch-up" sleeping on weekends and holidays.[12]

Furthermore, sleep problems appear to be underreported by children,[13] and therefore under-diagnosed by primary health professionals and caregivers.[14,15] Similarly, many students and their families do not understand the impact of poor sleep on health and weight status and what constitutes poor or good sleep habits.[16] Part of this misunderstanding appears to arise from an ignorance of what is "normal" sleep duration for children and adolescents.

Despite the negative social and health outcomes associated with poor sleep, there are few population-level data available on how long young Australians sleep, nor on their usual bedtimes or wake-up times. Sleep data were collected as part of the 1985 Australian School Health and Fitness Survey,[17] however normative data have never been published. Australian Bureau of Statistics time-use surveys have provided data on sleep times in 15-19 year olds in 1992 and 1997[18]; however, since sleep was not the primary focus of that publication, the only sleep variables presented were mean sleep duration according to gender on school and non-school days. It is unclear whether sleep duration varied by age within this sample, and other parameters of sleep, such as bedtimes and wake times were not presented. Soupourmas[18] also acknowledged that the activity "lying awake in bed" was included in sleep duration calculations, and as such, sleep duration was likely to have been overestimated.

The aim of this study was therefore to provide normative data on the current sleep durations, bedtimes and wake up times of 9- to 18-year-old Australians. A secondary aim of the paper was to compare this data with international data regarding children and adolescents' sleep. Such data will be invaluable to medical, allied health, and education professionals in assessing sleep related deficits in individual children. Compilation of normative Australian sleep duration data would also form the

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essential first step towards the long-term goal of developing national sleep guidelines for Australian children.

## METHODS

### Participants

The participants for this study were 4,032 Australians aged between 9 and 18 years, who were interviewed as part of a series of surveys conducted between 2001 and 2007: (1) the 2007 Australian National Children's Nutrition and Physical Activity Survey ($n$ = 2,367), a random national survey of 9-16 year olds conducted between March and August 2007.[19] The response rate was 41%. (2) The 2005 Health of Young Victorians Survey (HOYVS; $n$ = 896), the third wave of a cohort study involving young people aged 13 to 18 years. Details of this survey have been published elsewhere.[20] (3) A series of South Australian studies of children and adolescents aged 10 to 15 years ($n$ = 769) conducted between 2001 and 2004. Schools were randomly selected from a list of all schools in the state and all children from a particular age group were invited to participate. In these surveys, the average response rate was 69% for schools, and 92% for children within the chosen age group within each school.

This age group was chosen because younger children are very poor at recalling recent activities.[21]

### Data Collection

Use of time data were collected in all 3 datasets using this same instrument, the Multimedia Activity Recall for Children and Adults (MARCA).[22] Participants completed at least two 24-h use-of-time recalls for 2 sequential days. The MARCA is a computerized 24-h time use recall which may be self- or interviewer-administered. It uses a segmented day format with self-determined anchor points, including wake up time and bedtime. Participants were asked to specify the time they turned out the light and went to sleep on the Day 1 recall (defined as "bedtime"). They were also asked to specify the time they woke up (not necessarily the time they got out of bed) on the Day 2 recall (defined as "wake time"). Sleep duration was calculated as the difference between reported bedtime on Day 1 and reported wake-up time on Day 2, plus intra-day naps on Day 1. "Lying awake in bed" was an activity option and was not included in sleep duration. Young people could report activities in time-slices as fine as 5 min. The MARCA has a same-day test-retest reliability (ICC) of 0.87 for sleep duration.[22] Where multiple nights' sleep data were recalled by individual participants, one was randomly selected for analysis, to avoid the effect of data clustering. Height and body mass were measured by trained interviewers according to the protocols of the International Society for the Advancement of Kinanthropometry.[23] Socioeconomic status was calculated at the postcode level using the Australian Bureau of Statistics' Socio-Economic Indicators For Areas (SEIFA) Index of Relative Disadvantage.[24]

### Data Treatment

Children were classified as either meeting or not meeting the sleep duration guidelines of the United States Centers for Disease Control and Prevention,[25] viz. ≥ 9 h/ night for 5-12 year olds, and ≥ 8.5 h/ night for > 12 year olds. Days were categorized as being "school days" (when the participants spent the bulk of the day at school) or "non-school days" (weekend days, holidays or days off school). Participants were classified into one-year age slices according to their age at last birthday. Because of relatively low numbers, adolescents aged 17 and 18 were put in the 17+ category.

Body mass index (BMI) scores were categorized into 5 classes according to the guidelines of Cole et al. 2000,[26] and Cole et al. 2007[27]: (1) obese (equivalent to an adult BMI ≥ 30), (2) overweight (equivalent to an adult BMI of 25.0-30.0), (3) normal weight (equivalent to an adult BMI of 18.5-25.0), (4) Grade 3 thinness (equivalent to an adult BMI of 17.0-18.5), and (5) Grade 2 thinness (equivalent to an adult BMI of 16.0-17.0). No participants fell into the Grade 1 thinness category (adult BMI < 16.0).

### Statistical Analysis

Means and standard deviations for sleep durations, bedtimes, and wake-up times were calculated within each age group for boys and girls separately, on school and non-school days separately. The percentage of children meeting the Centers for Disease Control and Prevention sleep duration guidelines was calculated within sex, age, and day type categories. Three-factor factorial ANOVAs, with sex, day type, and age group as the independent variables, and sleep duration, bedtime and wake up time as the dependent variables, were used in multivariate analysis. Sleep duration, bedtime and wake time were regressed against age separately for school and non-school days to calculate age-related rates of change. Chi-square tests were used to compare the proportion of participants meeting guidelines between boys and girls, and across age categories. Alpha was set at 0.05 for all analyses.

## RESULTS

### Participant Demographics

Participant and sample characteristics across all the surveys are shown in Table 1. Because of constraints on data collection during the school holidays, spring and summer were under-represented. Regionally, South Australia and Victoria are over-represented, and New South Wales under-represented.

### Sleep Duration

Table 2 and Figure 1 show sleep durations on school and non-school days. Age ($P < 0.0001$), day type ($P = 0.0002$), and sex ($P = 0.036$) were significantly associated with sleep duration. There was also a significant day type × age interaction ($P < 0.0001$). Sleep duration declined with age at the rate of 12 (95% confidence interval 10-13) min/ night per year of age on school days, but at only 4 (2-6) min/ year of age on non-school days. At ages 9-10, boys and girls slept about 10.5 h/ night on both school and non-school days. By ages 16-17, this had fallen to about 9 h per night on school days, and 9.5-10 h/ night on non-school nights. Non-school day sleep was on average 16 (8-23) min longer than school day sleep, with the difference increasing with age from close to zero at ages 9-11 to over 30 min/ night at age 17. Girls slept a little longer than boys [5 (1-9) min per night], mainly due to slightly longer sleeps on non-school days.

Table 3 shows sleep duration by day of the week, season, geographical location, and socioeconomic status. Analyses showed that sleep duration on all days of the week were different to one another ($P < 0.0001$), with the exception of Monday vs Tuesday, Wednesday or Thursday; Tuesday vs Wednesday; Wednesday vs Thursday; and Friday vs Saturday. There were only modest differences when data were analyzed by season, with mean sleep durations in autumn 8 min less than in winter ($P = 0.03$), but no other significant differences. Analyses according to geographic location also showed few differences, with sleep durations in Victoria slightly greater than those in New South Wales, Western Australia and South Australia, and sleep durations in Queensland slightly greater than those in South Australia ($P = 0.002$). There were no differences in sleep duration by socioeconomic status, when the sample was dichotomized into "high" vs "low" socioeconomic status on the basis of SEIFA values ($P = 0.20$).

### Bedtimes

Table 4 shows bedtimes for boys and girls on school and non-school days. Age ($P < 0.0001$) and day type ($P < 0.0001$) were significantly associated with bedtime. There was a weak day type × age interaction effect ($P = 0.03$). Bedtimes got later with age ($P < 0.0001$), at the rate of 17 (16-18) min per year of age on school days, and 16 (14-18) min on non-school days. At the ages of 9-10, children went to bed at about 20:45 on school days and 21:00 on non-school days. By the ages of 16-17, this had risen to about 22:30 on school days and 23:00 on

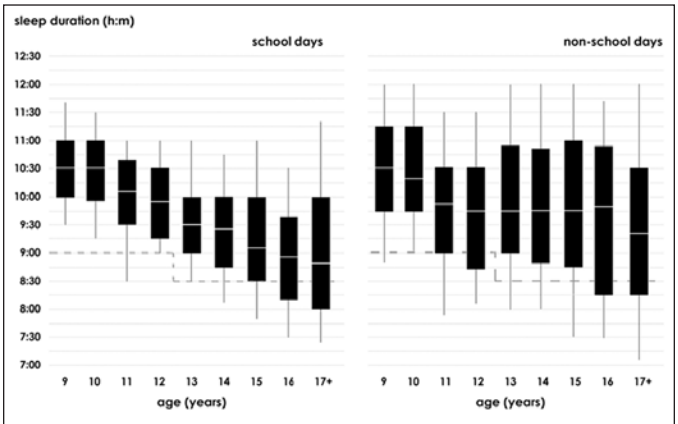


**Figure 1**—Box plots of sleep time for children and adolescents on school days (left panel) and non-school days (right panel). The white line at the center of the black box represents the median, and the upper and lower edges of the box the 75th and 25th percentiles. The ends of the whiskers represent the 90th and 10th percentiles. The dotted grey line represents the recommended sleep requirements according to the Centers for Disease Control and Prevention.

**Table 1**—Participant and sample characteristics

| | Boys | Girls | All |
|---|---|---|---|
| ***n*** | 1973 | 2059 | 4032 |
| **Mean years of age (SD)** | 14.1 (2.2) | 14.0 (2.2) | 14.0 (2.2) |
| **Weight status (%)** | | | |
| Obese | 5.1 | 6.5 | 5.8 |
| Overweight | 15.1 | 19.9 | 17.6 |
| Normal weight | 72.2 | 67.4 | 67.4 |
| Thinness grades 2, 3 | 7.6 | 6.1 | 6.8 |
| **Mean SEIFA (SD)** | | | 1016 (62) |
| **Season (% of datapoints)** | | | |
| Summer | | | 6 |
| Autumn | | | 36 |
| Winter | | | 48 |
| Spring | | | 10 |
| **Day type (% of datapoints)** | | | |
| School days | | | 56 |
| Non-school days | | | 44 |
| **State (% of datapoints)** | | | |
| Victoria | | | 33 |
| South Australia | | | 31 |
| New South Wales | | | 13 |
| Queensland | | | 10 |
| Western Australia | | | 6 |
| Rest of Australia | | | 6 |

SEIFA refers to Socioeconomic Indicators for Areas Index of Relative Disadvantage, a method used by the Australian Bureau of Statistics to characterize socioeconomic status at the postcode level. The national mean is 1000, with a standard deviation of 100.

**Table 2**—Sample size (*n*) and mean (SD) values for sleep duration (hours: minutes per night) for boys and girls on school days and non-school days

| | Boys | | | | Girls | | | |
|---|---|---|---|---|---|---|---|---|
| **Age** | ***n*** | **School days** | ***n*** | **Non-school days** | ***n*** | **School days** | ***n*** | **Non-school days** |
| 9 | 64 | 10:24 (1:02) | 39 | 10:13 (1:36) | 61 | 10:36 (0:50) | 55 | 10:23 (1:21) |
| 10 | 76 | 10:28 (0:42) | 46 | 10:11 (1:17) | 79 | 10:20 (1:02) | 40 | 10:39 (1:17) |
| 11 | 80 | 10:00 (0:54) | 76 | 9:41 (1:15) | 103 | 9:55 (1:15) | 98 | 9:44 (1:22) |
| 12 | 72 | 9:47 (0:47) | 84 | 9:30 (1:16) | 85 | 9:55 (0:55) | 100 | 9:50 (1:19) |
| 13 | 117 | 9:42 (0:55) | 95 | 9:45 (1:14) | 122 | 9:32 (0:58) | 98 | 9:59 (2:04) |
| 14 | 311 | 9:24 (1:13) | 206 | 9:54 (1:32) | 305 | 9:27 (1:08) | 215 | 9:51 (1:34) |
| 15 | 195 | 9:22 (1:24) | 121 | 9:45 (1:55) | 183 | 9:15 (1:18) | 152 | 9:52 (1:45) |
| 16 | 140 | 8:56 (1:20) | 118 | 9:30 (1:48) | 117 | 9:02 (1:29) | 124 | 9:42 (1:45) |
| 17+ | 61 | 8:54 (1:32) | 68 | 9:26 (1:48) | 69 | 9:12 (1:32) | 57 | 9:33 (1:35) |
| **all** | **1116** | **9:32 (1:16)** | **853** | **9:45 (1:34)** | **1124** | **9:34 (1:15)** | **939** | **9:53 (1:38)** |

non-school days. Bedtimes occurred on average 34 (31-37) min later on non-school days ($P < 0.0001$). There were no differences in bedtimes between boys and girls.

**Table 3**—Sleep duration (hours: minutes per night) according to day of week, season, geographical location and socioeconomic status

| Variable | Sleep duration (SD) | P |
|---|---|---|
| **Day of week** | | |
| Monday | 9:32 (1:18) | |
| Tuesday | 9:39 (1:19) | |
| Wednesday | 9:32 (1:13) | |
| Thursday | 9:29 (1:19) | |
| Friday | 10:11 (1:36) | |
| Saturday | 10:07 (1:42) | |
| Sunday | 9:15 (1:18) | < 0.0001 |
| **Season** | | |
| Summer | 9:40 (1:27) | |
| Autumn | 9:35 (1:22) | |
| Winter | 9:43 (1:25) | |
| Spring | 9:42 (1:22) | 0.03 |
| **State** | | |
| Victoria | 9:47 (1:31) | |
| South Australia | 9:30 (1:12) | |
| New South Wales | 9:37 (1:19) | |
| Queensland | 9:41 (1:22) | |
| Western Australia | 9:39 (1:15) | |
| Tasmania | 9:39 (1:34) | |
| Northern Territory | 9:41 (1:13) | |
| Australian Capital Territory | 9:41 (1:19) | 0.002 |
| **Socioeconomic status** | | |
| Low (SEIFA < 1000) | 9:38 (1:24) | |
| High (SEIFA > = 1000) | 9:42 (1:26) | 0.20 |

SEIFA refers to Socioeconomic Indicators for Areas Index of Relative Disadvantage, a method used by the Australian Bureau of Statistics to characterize socioeconomic status at the postcode level. The national mean is 1000, with a standard deviation of 100.

### Wake Times

Table 5 shows wake up times for boys and girls on school and non-school days. Age ($P < 0.0001$) and day type ($P < 0.0001$) were significant predictors of wake up time. There were also significant day type × age ($P < 0.0001$) and day type × sex interactions ($P = 0.004$). While wake up times were strikingly similar across sex and age groups on school days, with almost all participants rising close to 07:00, on non-school days wake times increased at the rate of 10 (8-12) min/ year of age on non-school days. Wake times occurred on average 82 (76-88) min later on non-school days. At ages 9-10, children woke at about 07:30 on non-school days. By ages 16-17 they were on average waking close to 09:00, while 10% were waking later than 11:00. Girls woke on average 15 min later than boys on non-school days, but at similar times on school days.

### Sleep Guidelines

Overall, 17% of school days and 20% of non-school days failed to meet the American Centers for Disease Control and Prevention sleep duration guidelines. There were no differences between boys and girls; however, the proportion failing to meet the guidelines increased rapidly with age, from 3% at age 9 to 36% at age 17 on school days, and from 8% at age 9 to 28% at age 17 on non-school days (both $P < 0.0001$). From Monday to Saturday, 15% to 19% of sleeps failed to meet the minimum recommendation. On Sundays, however, a significantly ($P = 0.006$) larger percentage (27%) had inadequate sleep.

### International Comparisons

We recently collated international data for a meta-analysis of adolescent sleep duration data, published elsewhere.[28] Figure 2 compares the data from the study to data on children and adolescents from other developed countries, including Australian data, from 1992-1997. Data from other countries show similar patterns of age-related decline. School day sleep in Australia is similar to that in Canada, France, and Switzerland, but a little higher than most other European countries, and markedly higher than sleep durations reported by American subjects.

Figure 3 shows international comparisons for sleep duration on non-school days. The non-school day sleep durations of Australians are similar to those of children and adolescents around the world. Young Australians appear to sleep a little less

**Table 4**—Sample size (*n*) and mean (SD) values for bedtime (hours: minutes) for boys and girls on school days and non-school days

| | Boys | | | | Girls | | | |
|---|---|---|---|---|---|---|---|---|
| **Age** | ***n*** | **School days** | ***n*** | **Non-school days** | ***n*** | **School days** | ***n*** | **Non-school days** |
| 9 | 64 | 20:34 (0:44) | 39 | 20:54 (1:35) | 61 | 20:30 (0:47) | 55 | 21:19 (1:19) |
| 10 | 76 | 20:46 (0:43) | 46 | 21:02 (1:10) | 79 | 20:53 (0:55) | 40 | 21:11 (1:04) |
| 11 | 80 | 21:00 (0:45) | 76 | 21:41 (1:07) | 103 | 21:11 (1:04) | 98 | 21:44 (1:13) |
| 12 | 72 | 21:17 (0:44) | 84 | 22:02 (1:06) | 85 | 21:10 (0:47) | 100 | 21:52 (1:10) |
| 13 | 117 | 21:27 (0:49) | 95 | 22:13 (1:15) | 122 | 21:32 (0:47) | 98 | 22:07 (1:33) |
| 14 | 311 | 21:51 (0:55) | 206 | 22:23 (1:10) | 305 | 21:52 (1:00) | 215 | 22:24 (1:10) |
| 15 | 195 | 22:08 (0:59) | 121 | 23:01 (1:28) | 183 | 22:14 (1:07) | 152 | 22:42 (1:19) |
| 16 | 140 | 22:35 (0:54) | 118 | 23:00 (1:29) | 117 | 22:34 (1:02) | 124 | 22:56 (1:08) |
| 17+ | 61 | 22:43 (0:55) | 68 | 23:03 (1:04) | 69 | 22:35 (0:50) | 57 | 22:46 (0:52) |
| **all** | **1116** | **21:45 (1:04)** | **853** | **22:21 (1:25)** | **1124** | **21:45 (1:08)** | **939** | **10:16 (1:20)** |

than Canadians and more than Americans. Collectively, the data show a much more gradual pattern of age-related sleep decline, and longer sleep times on non-school days than on school days.

## DISCUSSION

The main aim of this study was, using a large, recent, and relatively representative sample of young Australians, to provide normative data on the sleep habits of Australian children and adolescents for the use of researchers, health professionals, and caregivers. Sleep time decreased with age, but much more markedly on school days than on non-school days, leading to a widening gap between school day and non-school day sleep. Bedtimes got later with age, as did wake up times on non-school days. From age 13 onwards, for example, more than 10% of adolescents went to bed after midnight. However, due to the demands of school, wake up times did not change with age on school days.

### Strengths and Limitations

This study represents the largest collection of sleep data to date on Australian children. It relies, like all large-scale sleep surveys, on self-report. There is evidence that older children and adolescents are able to accurately and reliably report bedtimes and wake-up times from which sleep duration can be derived.[29,30] This study also involves just one day's report for each participant, and there is substantial day-to-day variability in sleep durations. Ridley et al.[31] report an intra-subject coefficient of variation in the sleep durations of Australian adolescents of

**Table 5**—Sample size (*n*) and mean (SD) values for wake up time (hours: minutes) for boys and girls on school days and non-school days

| | Boys | | | | Girls | | | |
|---|---|---|---|---|---|---|---|---|
| **Age** | ***n*** | **School days** | ***n*** | **Non-school days** | ***n*** | **School days** | ***n*** | **Non-school days** |
| 9 | 64 | 6:57 (0:40) | 39 | 7:24 (1:04) | 61 | 7:01 (0:30) | 55 | 7:50 (1:11) |
| 10 | 76 | 7:04 (0:37) | 46 | 7:27 (1:13) | 79 | 7:02 (0:35) | 40 | 7:44 (1:09) |
| 11 | 80 | 7:01 (0:37) | 76 | 7:43 (1:18) | 103 | 6:59 (0:31) | 98 | 8:01 (1:02) |
| 12 | 72 | 7:04 (0:25) | 84 | 7:57 (1:31) | 85 | 6:57 (0:33) | 100 | 8:34 (1:24) |
| 13 | 117 | 7:03 (0:32) | 95 | 8:14 (1:32) | 122 | 6:51 (0:39) | 98 | 8:06 (1:35) |
| 14 | 311 | 6:59 (0:34) | 206 | 8:19 (1:38) | 305 | 6:57 (0:38) | 215 | 8:21 (1:40) |
| 15 | 195 | 7:02 (0:39) | 121 | 8:47 (1:38) | 183 | 7:03 (0:35) | 152 | 8:41 (1:42) |
| 16 | 140 | 7:02 (0:39) | 118 | 8:58 (2:00) | 117 | 6:57 (0:42) | 124 | 8:42 (1:44) |
| 17+ | 61 | 7:16 (0:43) | 68 | 8:53 (1:58) | 69 | 7:12 (0:35) | 57 | 9:05 (2:10) |
| **all** | **1116** | **7:02 (0:36)** | **853** | **8:20 (1:52)** | **1124** | **6:59 (0:36)** | **939** | **8:35 (1:37)** |

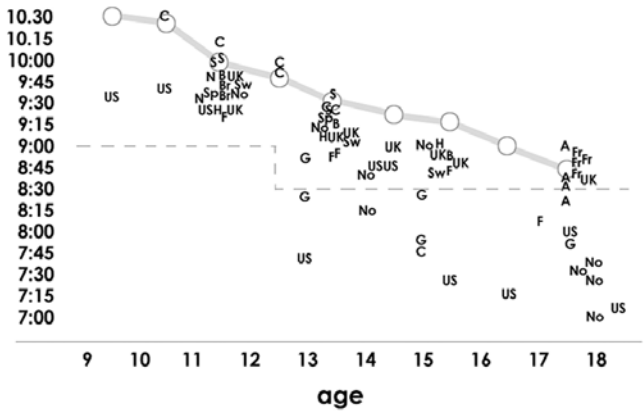


**Figure 2**—Comparison of school day sleeping times of young Australians from the current study (large dots, grey line) with recent data from other studies in developed countries. Note that in some cases, the number of data points for a country exceeds the number of studies conducted in that country because sleep duration data were presented separately for gender and/or region subsets. The dotted grey line represents the recommended sleep requirements according to the Centers for Disease Control and Prevention.
A, Australia[18]; B, Belgium[39]; Br, Brazil[42]; C, Canada[43,44]; F, Finland[39,45]; Fr, France[46]; G, Germany[47]; H, Hungary[39]; N, Netherlands[48]; No, Norway[39,49]; S, Switzerland[39,50]; Sp, Spain[39]; Sw, Sweden[39]; UK, United Kingdom[39,51,52]; US, United States.[12,53-56]

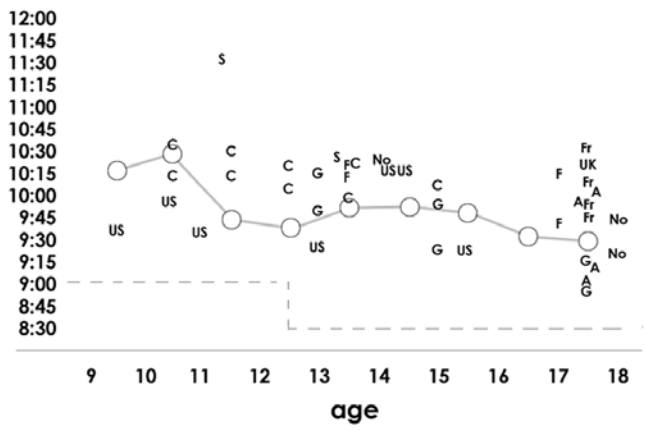


**Figure 3**—Comparison of non-school day sleeping times of young Australians from the current study (large dots, grey line) with recent data from other studies in developed countries. Note that in some cases, the number of data points for a country exceeds the number of studies conducted in that country because sleep duration data were presented separately for gender and/or region subsets. The dotted grey line represents the recommended sleep requirements according to the Centers for Disease Control and Prevention.
A, Australia[18]; C, Canada[43,44]; F, Finland[45]; Fr, France[46]; G, Germany[47]; No, Norway[49]; S, Switzerland[50]; UK, United Kingdom[52]; US, United States.[12,53-56]

12.2%, based on a 7-day sample. This will not bias estimates of population means, and because of the large sample size, sufficient precision (± 1.5% to 3%) can be achieved for each age × sex × day type slice.

The data do not represent a random national sample. Geographically, South Australia and Victoria are over-represented, and New South Wales under-represented. However, when adjusted for age, sex and day type, there were few differences in sleep time among the different Australian states and territories. Data were also not randomly sampled across seasons, with summer and spring being under-represented.

Although in this study we have made the traditional classification of school days and non-school days to facilitate comparison with other studies, sleep habits on days within each day type category can be quite different. Without the need to rise early for school on Saturday, young people can, and do, retire to bed later. By contrast, the spectre of school on Monday morning means that they retire earlier on Sunday than on Saturday night. Adjusted for age and sex, the children and adolescents slept most on Saturdays. Adjusted for age and sex, they slept 9:26 h on Mondays to Thursdays, 9:41 h on Sundays, 10:08 h on Fridays, and 10:09 h on Saturdays. It may therefore be more appropriate to group together Mondays to Thursdays and Sundays in one category (days when young people wake up on school days), and Friday and Saturday in another (when they wake up on non-school days).

Previous research has shown a negative association between sleep duration and pubertal development.[32] We did not collect data regarding pubertal stage, thus this relationship could not be explored in our analyses. Presumably, the inverse relationship between sleep duration and age detected in our analyses may in part reflect an underlying relationship between sleep duration and pubertal development.

### Do Young Australians Get Enough Sleep?

This study provides data on the actual sleeping patterns of older children and adolescents, but does not offer information about the how much sleep they actually need. However, given that reduced alertness and daytime sleepiness are commonly and increasingly reported in young people and that surveys regularly report that 60% to 70% of adolescents want more sleep[33] it may be that sleep needs in this age are not being met. Comparing our data to American guidelines, 17% to 20% of sleeps are below recommendations, notably those on Sunday evenings, and among older adolescents. About the same proportion of young people fail to meet guidelines on school days as on non-school days, even though sleep durations are longer on non-school days. This is because the standard deviations of sleep durations are much larger on non-school days, leading to more young people falling below the recommended cut-offs. Previous studies have suggested that among those at most risk may be high screen (television, videogame, computer) users,[34] overweight and obese children,[35] and those in low SES households.[36]

It was interesting to observe some seasonal variation in young people's sleep duration, with participants sleeping on average eight minutes longer in winter than in autumn ($P = 0.03$). The result concurs to an extent with the findings of Manz and colleagues,[37] who found 6-year-old French children slept longer in winter than in summer, presumably due to the effect of shorter hours of daylight. However, in our study shortest sleep durations were observed in autumn and not summer, and Epstein and colleagues[38] reported that sleep duration was shortest in spring. This indicates that there may be factors other than daylight hours contributing to seasonal variation in young peoples' sleep duration.

### "Yo-yo Sleeping"

Australian children and adolescents show large and increasing gaps between school day and non-school day sleep. This pattern of "yo-yo sleeping"—relative under-sleeping from Sunday to Thursday, and then catching up on Friday and Saturday nights—increases with age. At age 17, for example, adolescents slept 84 minutes more on Saturdays (10:10 h) than on Mondays (8:46 h). A large discrepancy between sleep rhythms on school and non-school days has been shown to have negative effects on school attendance and performance.[39] The overall effect of school may be to distort sleep rhythms, obliging older adolescents to rise earlier than they otherwise would, and constraining adolescents with differential sleep patterns (e.g., evening types[40]) to a standardized rhythm. This pattern suggests that sleep habits may be improved by later, or more flexible, school start times.

### Distributions of Sleep Durations

The standard deviations of sleep durations tended to increase with age (Figure 1; Table 2), probably reflecting the greater diversity of academic and recreational commitments of older adolescents, and less parental control on bed times. Standard deviations were also much greater on non-school days than on school days (Figure 1; Table 2), reflecting freedom from the time-constraints of the school regimen. Overall, boys tended to sleep slightly less than girls, due mainly to slightly shorter sleeps on non-school days. There were no differences in bedtimes between boys and girls; however, boys tended to wake 15 minutes earlier than girls on non-school days. It is possible that this is due to boys' higher engagement in organized morning weekend sport.[41]

### International Comparisons

For both school days and non-school days, sleep duration data from the current study was consistent with the sleep durations reported for 15-19 year old Australians by Soupourmas.[18] School day sleep in Australia was similar to that in Canada, France, and Switzerland, but higher than most other European countries, and American subjects. It is possible that this was because other surveys frequently asked participants about "typical" school day sleep, and respondents may have excluded Friday nights as being atypical. If Friday might were excluded in the present analysis, school day sleep times would be on average 13 minutes less.

## CONCLUSION

National Australian guidelines exist for physical activity, screen time and a wide variety of dietary practices. However, there are no national sleep guidelines, in spite of growing evidence of powerful associations between inadequate sleep and a spectrum of social functioning and physical and mental health

deficits. The American Centers for Disease Control and Prevention sleep guidelines do not have a strong empirical basis, and are based on the normal sleeping times of US children, which appear to be much lower than those of Australians and Europeans (Figure 2). There is a need for a large national survey measuring both sleep durations and daytime sleepiness, so as to establish evidence-based sleep recommendations for young people. In addition, results from this study demonstrated that key sleep characteristics (e.g., bedtime) may differ on days within school or non-school day categories, suggesting that the convention of categorizing children's sleep on this basis may need reconsideration.


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