Correlation of self-reported sleep duration with working memory of adolescents

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ABSTRACT

Context: With the increasing use of electronic devices and social media, the duration of sleep has consistently reduced in adolescents. Sleep restriction eventually leads to cognitive performance declines. Poor sleep and working memory difficulties are both associated with learning difficulties leading to poor academic performance. Aims: We postulated that decreased sleep duration decreases the working memory of adolescents and eventually their academic performance. Settings and Design: Cross-sectional Study. Methods and Material: The study was conducted on 114 school students; 62 boys and 52 girls (age 13.8 ± 0.91 and 13.65 ± 0.88 years, respectively). Sleep was monitored by self-reported diary. Working memory was tested by the n-back task. The students were given 1-back and 2-back visual tasks in two blocks and accuracy of each of the tests was calculated. Statistical Analysis Used: Prism software was used and Mann-Whitney-U test and Spearman Correlation tests were employed. Results: Sleep duration range was 4.15-12 hours with a mean of 7.63 ± 1.35 hours. The sleep duration in males and females, respectively was 6.94 ± 0.94 hrs. and 8.5 ± 1.31 hrs.; significant (p = 0.0001). The total n-back score accuracy (1-back and 2-back) was 52.11 ± 17.32% in males and 52.24 ± 17.40% in females (p = 0.976). Spearman Correlation between sleep-duration and total n-back score was not found to be statistically significant (p = 0.611). However, the correlation of total n-back score with academic performance was statistically significant. Conclusions: The working memory was not statistically different in males and females, and was not significantly correlated with sleep duration, though it was significantly associated with the academic performance.

Keywords: Academic performance, n-back test, sleep duration, working memory

Introduction

Sleep is important for optimal cognitive functioning. Self-reported short and long sleep durations have been repeatedly, though inconsistently, reported to increase the risk for poor cognitive function in older adults.¹² With increasing use of social media and mobile gaming, the duration of sleep is consistently decreasing in adolescents.¹³ It is documented that even an acute sleep loss results in compromised cognitive performance such as working memory deficits, depressive mood and involuntary sleep episodes during the day.¹⁵ Working memory is one’s ability to remember and manipulate new information which is interspersed with periods of distraction. It serves as the key for several higher-order cognitive functions, such as reasoning, intelligence, problem solving, and language comprehension.¹⁶ Thus, children with deficits in working memory may have learning difficulties and eventually poor academic performance. We hypothesized that a lower sleep duration would result in poorer working memory and academic performance in school.

Subjects and Methods

After taking approval from Institution Ethics Committee (IEC Letter No. AIIMS/IEC/2016/582) (dated 09/05/2016), permission of the school authorities and written consent from their parents were obtained. The study was conducted on 114 school students; 62 boys and 52 girls (age 13.8 ± 0.91 and 13.65 ± 0.88 years, respectively). Sleep was monitored by self-reported diary. Working memory was tested by the n-back task. The students were given 1-back and 2-back visual tasks in two blocks and accuracy of each of the tests was calculated. Statistical Analysis Used: Prism software was used and Mann-Whitney-U test and Spearman Correlation tests were employed. Results: Sleep duration range was 4.15-12 hours with a mean of 7.63 ± 1.35 hours. The sleep duration in males and females, respectively was 6.94 ± 0.94 hrs. and 8.5 ± 1.31 hrs.; significant (p = 0.0001). The total n-back score accuracy (1-back and 2-back) was 52.11 ± 17.32% in males and 52.24 ± 17.40% in females (p = 0.976). Spearman Correlation between sleep-duration and total n-back score was not found to be statistically significant (p = 0.611). However, the correlation of total n-back score with academic performance was statistically significant. Conclusions: The working memory was not statistically different in males and females, and was not significantly correlated with sleep duration, though it was significantly associated with the academic performance.

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the parents/guardians of all children was obtained after clearly explaining them the purpose of the study. A school was randomly selected and all its grade IX students (two sections) who gave assent for the study were enlisted. Since all the students were from the same grade, they had a similar syllabus, school hours, teachers and same examinations, assessments, and assessors.

The study was then performed on 114 school students; 62 boys and 52 girls (age 13.8 ± 0.91 years for boys and 13.65 ± 0.88 years for girls).

The exclusion criteria were any psychological illness, sleep deprivation on the previous night or prolonged fasting. Fasting was enquired by taking history and sleep was monitored by self-reported diary.

Each participant was required to complete a sleep diary for a week, that included schedules of bedtime and rise time and daytime napping behavior. The sleep duration was averaged out from all 7 nights duration.[8]

The students were enquired about their total mobile usage per day that included calls, social media, watching videos, and mobile gaming. They were also asked the time they specifically spent for mobile gaming. The time was rounded off to nearest 15 minutes.

Working memory was tested by the n-back task, a type of serial working memory task wherein a person must hold a series of information in working memory. A freely downloadable software, ‘Brain Workshop’ was used for the purpose. This software has been used in earlier studies and hence has been validated.[7] N-back test was administered individually to each student between 11 am to 12 noon. They were given a demo as to how the test was performed. 1-back and 2-back visual tasks were employed in two blocks. Each block consisted of 20 trials of geometric images presented to them in a random order. The image appeared for 0.5 sec and next image appeared after 2.5 sec. In 1-back, the student was supposed to respond if the image appeared was same as the previous trial and in 2-back test the correct response was the image that appeared two trials earlier [Figure 1]. The total correct and incorrect responses were recorded and the accuracy of each of the test was calculated. Accuracy = correct responses/correct + incorrect responses* 100

The academic performance of the students was obtained from the school authorities and the average score in all the subjects and all the assessments was calculated in percentage.

The sleep duration and n-back scores were looked for gender differences and correlations.

Demographic details of the study sample are presented in Table 1.

The data was tested for normality and was found to be non-parametric by Shapiro-Wilk test. So, Mann-Whitney U test was applied to study the gender differences in all the parameters.

Sleep duration range was 4.15–12 hours with a mean of 7.63 ± 1.35 hours. The sleep duration in males and females, respectively was 6.94 ± 0.94 hrs. and 8.5 ± 1.31 hrs.; significant (p = 0.0001).

Also, the difference in their total mobile use time and mobile gaming was significantly higher in males with P values 0.0001 and 0.004, respectively.

The total n-back score accuracy (1-back and 2-back) was 52.11 ± 17.32% in males and 52.24 ± 17.40% in females, which was statistically not significant (p = 0.976). Detailed scores are presented in Table 2.

Spearman Correlation between sleep-duration and total n-back score was not found to be statistically significant (p = 0.611). The other correlations are shown in Table 3.

The academic performance score for males and females was respectively 63.99 ± 19.28% and 69.35 ± 19.99%; not significant (p = 0.106). However, its correlation with total n-back score was statistically significant [Table 3].

Results

Prism software was used for statistical analysis.

Table 1: Demographic details of the population cohort

| Variable     | Males (n=62) | Females (n=52) |
|--------------|-------------|---------------|
| Age (years)  | 13.8±0.91   | 13.65±0.88    |
| Height (meters) | 1.62±0.08 | 1.54±0.06     |
| Weight (kg)  | 47.7±10     | 44.95±11      |
| BMI (kg/m²)  | 17.9±3.29   | 18.6±4.2      |

Table 2: Gender differences in various parameters

| Variable     | Males (n=62) | Females (n=52) | P     |
|--------------|-------------|---------------|------|
| Sleep duration (hrs) | 6.94±0.94 | 8.50±1.31     | 0.0001|
| Mobile use per day (min) | 89.7±58.03 | 30.12±25.20   | 0.0001|
| Gaming per day (min) | 29.08±31.94 | 11.15±16.55   | 0.004 |
| 1 back score | 70.14±25.73 | 71.48±26.1    | 0.776 |
| 2 back score | 37.97±27.70 | 32.10±20.23   | 0.446 |
| Total n back score | 52.11±17.32 | 52.24±17.40   | 0.976 |
| Academic Score (%) | 63.99±19.28 | 69.35±19.99   | 0.106 |

Table 3: Correlation results between Working memory with Sleep duration and academic performance

| Variable     | Sleep Duration (p) | Academic Score (p) |
|--------------|--------------------|--------------------|
| 1-Back Score | 0.443              | 0.004              |
| 2- Back Score | 0.407             | 0.328              |
| Total n-back score | 0.611         | 0.010              |
We studied correlation of total mobile usage per day and mobile gaming with academic performance and the result was statistically not significant ($p = 0.089$ and 0.48).

**Discussion**

The results of this study do not show a significant correlation between sleep-duration and working memory. Our results are in congruence with the study done by Del Angel et al. 2015, who observed no decrement in correct responses to the visual n-Back section or a general decrease in reaction time because of sleep reduction.\(^9\) Also Gerhardsson A et al. found that general working memory abilities in older adults are intact after one night of sleep deprivation.\(^9\)

In contrast, Santisteban et al. concluded that cumulative partial sleep deprivation negatively affects performance on a test of working memory capacity but does not affect performance on tests of sustained attention, response inhibition, or decision making.\(^10\) In our cohort, only visuospatial component of working memory was tested and only the recall response was tested. We did not calculate the latency responses and reaction-time for n-back test; which might have given us a relationship with sleep-duration.

The differences in total sleep duration, total mobile use time, and mobile gaming were significantly higher in males. Nevertheless, there was no significant difference in the academic performance of males and females. To study this in detail, we studied correlation of these parameters with academic performance and the result was statistically not significant ($p = 0.566$, 0.089, and 0.48).

However, the working memory was significantly associated with the academic performance. Literature reveals robust relationships between working memory, short-term memory, language skills, and fluid intelligence which are the basis for academic performance.\(^11\) It is also seen that the relationship between cardiorespiratory fitness and academic achievement is mediated by executive functions such as working memory in school children.\(^12\)

The results of this study would represent a foundation for understanding the role of working memory in academic achievements. This can enable us to identify slow learners, who can be given career counselling or increased attention while teaching. Further, some forms of working memory trainings may be beneficial for slow learners to enhance their learning and improve their academic performance. While evaluating children with learning disabilities, the primary care physicians may get the cognitive work-up of children done to understand working memory defects.

We propose that future studies should be prospectively designed, with objective sleep assessment by polysomnography or actigraphy as opposed to self-reported ones and the n-back test with its phonological component, latencies and reaction time, to get a better understanding of memory changes in sleep restrictions.

The working memory was not statistically different in males and females, and was not significantly correlated with sleep duration; though it was significantly associated with the academic performance. Exercises to boost working memory can be encouraged in school children.

**Acknowledgement**

The authors are thankful to the students who participated and their parents who gave their consent for the study.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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