Original Article

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

Bharati Mehta[1], Prathamesh H. Kamble[2], Mahesh Gadhvi[1], Ayush Kaushal[3]

[1]Department of Physiology, AIIMS, Jodhpur, Rajasthan, [2]Department of Physiology, AIIMS, Nagpur, Maharashtra, India, [3]Trainee, Emirates Speciality Hospital, Dubai Health Care City, Dubai, United Arab Emirates

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.[1,2] With increasing use of social media and mobile gaming, the duration of sleep is consistently decreasing in adolescents.[3] 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.[4] 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.[5] 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

Address for correspondence: Dr. Bharati Mehta, H-53, Shastri Nagar, Jodhpur, Rajasthan - 342 003, India.
E-mail: drbharati2005@yahoo.com

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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.[6]

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.

Results

Prism software was used for statistical analysis.

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].

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 ±.08	1.54 ±.06
Weight (kg)	47.7±10	44.95±11
BMI (kg/m^2)	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

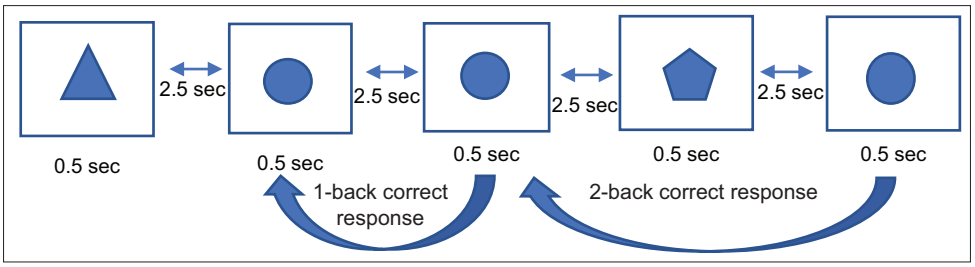

Figure 1: Representative image of n-back task for working memory

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.[8] 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.

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Conflicts of interest

There are no conflicts of interest.

References

1. Lo JC, Groeger JA, Cheng GH, Dijk DJ, Chee MW. Self-reported sleep duration and cognitive performance in older adults: A systematic review and meta-analysis. Sleep Med 2016;17:87-98.
2. Kronholm E, Sallinen M, Suutama T, Sulkava R, Era P, Partonen T. Self-reported sleep duration and cognitive functioning in the general population. J Sleep Res 2009;18:436-46.
3. Foerster M, Henneke A, Chetty-Mhlanga S, Röösli M. Impact of adolescents' screen time and nocturnal mobile phone-related awakenings on sleep and general health symptoms: A prospective cohort study. Int J Environ Res Public Health 2019;16:518.

4. Porkka-Heiskanen T, Zitting K-M, Wigren H-K. Sleep, its regulation and possible mechanisms of sleep disturbances. Acta Physiol 2013;208:311-28.
5. Cowan N. Working memory underpins cognitive development, learning, and education. Educ Psychol Rev 2014;26:197-223.
6. Lawrence G, Muza R. Assessing the sleeping habits of patients in a sleep disorder centre: A review of sleep diary accuracy. J Thorac Dis 2018;10(Suppl 1):S177-83.
7. Jaeggi SM, Buschkuehl M, Jonides J, Perrig WJ. Improving fluid intelligence with training on working memory. Proc Natl Acad Sci U S A 2008;105:6829-33.
8. Del Angel J, Cortez J, Juárez D, Guerrero M, García A, Ramírez C, *et al.* Effects of sleep reduction on the phonological and visuospatial components of working memory. Sleep Sci 2015;8:68-74.
9. Gerhardsson A, Fischer H, Lekander M, Kecklund G, Axelsson J, Åkerstedt T, *et al.* Positivity effect and working memory performance remains intact in older adults after sleep deprivation. Front Psychol 2019;10:605.
10. Santisteban JA, Brown TG, Ouimet MC, Gruber R. Cumulative mild partial sleep deprivation negatively impacts working memory capacity but not sustained attention, response inhibition, or decision making: A randomized controlled trial. Sleep Health 2019;5:101-8.
11. Rosenberg MD, Martinez SA, Rapuano KM, Conley MI, Cohen AO, Cornejo MD, *et al.* Behavioral and neural signatures of working memory in childhood [published online ahead of print, 2020 May 25]. J Neurosci 2020;JN-RM-2841-19. doi: 10.1523/JNEUROSCI.2841-19.2020.
12. Visier-Alfonso ME, Sánchez-López M, Martínez-Vizcaíno V, Jiménez-López E, Redondo-Tébar A, Nieto-López M. Executive functions mediate the relationship between cardiorespiratory fitness and academic achievement in Spanish school children aged 8 to 11 years. PLoS One 2020;15:e0231246.