Effect of Partial Sleep Deprivation on Cognition in Young Adults

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Abstract

Background: Sleep deprivation (SD) is an emerging pandemic. Young adults voluntarily sleep deprive due to increased social demands and to achieve better in academics. The present study is therefore intended to observe if partial sleep deprivation improves performance of cognitive functions.

Objective: To compare cognitive performance in partially sleep deprived young adults and subjects with adequate sleep duration.

Materials and Method: A total of 56 young adults 18-25 years of age were recruited based on inclusion and exclusion criteria. By recall method they were allotted into partially sleep deprived group (n=30) (<6 hr/day for 5 consecutive days) and group with normal sleep duration (7-9 hours/day) (n=26). Epworthsleepscale (ESS) was used to measure day time sleepiness. Cognitive domain like sustained attention, executive function, learning and memory were tested for all subjects in both the groups by neuropsychological battery from "A compendium of neuropsychological test" by Strauss and Spreen. Descriptive statistics and Independent "t" test were used for statistical analysis.

Results: Daytime sleepiness was significantly higher in partially sleep deprived group (P=0.0235).Sustained attention score was significantly lower (p=0.026) in partially sleep deprivation group than the other group. There was no significant difference between the groups in parameters like executive functions, learning and memory.

Conclusion: Partially sleep deprived group showed impaired attention as attention being associated with frontal regions of the brain that are the first to be affected by sleep deprivation. Executive functions, learning and memory were not statistically different between the 2 groups as other regions of brain involved would remain active until the sleep deprivation becomes more severe.

Keywords: *Sleep deprivation, cognition, attention, executive function.*

Introduction

Sleep is a biologic process that is essential for life and optimal health. Sleep plays an important role in maintaining brain function and systemic physiology including metabolic functions, appetite regulation and the functioning of immune, hormonal and cardiovascular system[1].

National Sleep Foundation suggests that young adults between 18-25 years of agere quire sleep duration of 7-9 hours[1]. Average sleep duration in adults has declined from 8.5 hours per night to <7 hours per night over last 40 years[2]. Sleep-deprivation is prevalent across various age groups and is considered to be an

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emerging public health epidemic.[3] Sleep deprivation leads to various deleterious long term effects in healthy individuals including hypertension, dyslipidemia, cardiovascular disease, obesity, metabolic syndrome, type 2 diabetes mellitus and it has immediate outcomes adversely affecting brain functions and cognition[4]. Sleep duration in young adults is changed due to increased social, educational and professional demands[2].

Overzealous college and school students voluntarily sleep deprive to achieve better in academics and to meet professional targets[5]. The present study is therefore done to compare cognitive performance in partially sleep deprived young adults and young adults with adequate sleep duration.

Objective: To compare cognitive performance in partially sleep deprived young adults and subjects with adequate sleep duration.

Materials and Method

The study was done in 56 young healthy adults between age group of 18-25 years. The study and the control groups were age and gender matched. The study was done in department of physiology, Bangalore medical college and research institute in the period of March 2019 to June 2019. Written informed consent from subjects was taken after explaining the study protocol. Individuals with acute or chronic illnessor, those suffering from family bereavement while collecting data were excluded from the study. Subjects with sleep duration more than 9 hours/day and showing moderate or severe stress on the perceived stress scale questionnaire, subjects on sedatives, hypnotics or taking energy drink or nicotine to keep them awake were also excluded.

Based on duration of sleep in the last one week by recall method, they were classified into two groups, group 1 consisted of 30 subjects who were partially sleep deprived (with sleep duration less than 6 hours per day for 5 consecutive days) and group- 2 consisted of 26 subjects with normal sleep duration for the given age. Demographic details were taken. Daytime sleepiness was assessed by Epworth sleep scale. The ESS questionnaire consisted of 8 questions. Respondents were asked to rate on a 4-point scale (0-3), about the usual chances of dozing off or falling asleep while engaging in eight different activities. Higher the ESS score indicated higher daytime sleepiness.

Cognitive functions were assessed in a quiet room by neuropsychological battery from "Compendium of neuro psychological test" by Strauss and Spreen through series of test which measured domains such as attention, executive functions, learning and memory. Sustained attention was measured by digit vigilance test. The test sheet consisted of 30 rows and 50 columns with numbers 1 to 9 randomly placed. Subjects were asked to cancel 6 and 9 as fast as possible without missing the targets or canceling the wrong numbers in given duration of time. Scoring was given based on the correct cancellation and time taken to finish the task[11].

Response inhibition was tested by stoop tasking. Stimulus sheet had 16 rows and 11 columns containing words "RED" "GREEN", "BLUE" & "YELLOW" printedin capital letters. The scoring was done by the time taken to read words minusthe time taken to read color in which word was printed.[11].

Learning and memory was measured by Complex figure test by visuospatial construction using Ray-Osterrieth complex figure test. The complex figure image was placed in front of the subject and was asked to observe. Later the subject had to recreate the complex figure first at three minutes and later after 30 minutes. Scoringwas given based on accuracy and placement of lines.[11]

Statistical Analysis: Descriptive statistics were done. Data were expressed as mean ± SD. Independent "t" test was done to compare the means of two groups. P value less than 0.05 was considered statistically significant.

Results

A total of 56 young adults were enrolled in study. The baseline characteristic like age and gender were measured. The subjects were aged between the age group 18-25 years. There were 27 men and 29 women in the study. There was no significant difference in the age and gender between both the age groups.

Table 2 shows that the sleep deprived group had significant Epworth sleep score than the group with normal sleep duration indicating higher daytime sleepiness in the sleep deprived group.

In table 3 mean±SD for cognitive parameter of digit vigilance test scoring was significantly lower in the partially sleep deprived group than subjects with normal

sleep duration. Time taken for completion of Stroop tasking was higher in partially sleep deprived group than the group with normal sleep duration but not statistically significant. Scoring of learning and memory was lower in partially sleep deprived group than the subjects with normal sleep duration.

Table 1: Age and gender distribution in sleep deprived group and group with normal sleep duration.

	Sleep Deprived Group (n=30). [Study group] Mean ±SD. n=30	Normal Sleep Duration (n=26). [Control Group] Mean ±SD. n=26	P – Value
Age	18.48±0.82	18.48±0.71	0.56
Male: Female	15:15	12:14	0.95

Table 2: Comparison of Epworth sleep scale between the partially sleep deprived group and those with normal sleep duration.

Epworth Sleep Scale	Sleep Deprived Group (n=30). [Study Group] Mean ±SD.	Normal Sleep Duration (n=26). [Control group] Mean ±SD.	P-Value*
Score	11.41±1.78	9.8±3.17	0.0391*

*P value less than 0.05 is considered statistically significant.

Table 3: Comparison of digit vigilance, Stroop task and complex figure test between study group and control group.

Domains	Test	Sleep Deprived Group (n=30). [Study group]. Mean ±SD.	Normal Sleep Duration (n=26) [Control group] Mean ±SD.	P - Value*
Sustained Attention [Score]	Digit vigilance test.	49.93±10.90	58.6±15.95	0.0268*
Executive Functions [in seconds]	Stroop task.	19.27±5.35	18.92±3.06	0.7621
Learning and Memory [Score]	Complex figure test.	49.93±10.90	56.96±16.73	0.7985

*P value less than 0.05 is considered statistically significant.

Discussion

Sleep deprivation is an emerging pandemic. Numerous health risks have been associated with sleep deprivation. Partial sleep deprivation can be a potential cause for various metabolic disorders. Obesity has strong association with sleep deprivation which in turn can lead to various metabolic disorders like diabetes mellitus and metabolic syndrome. This study was done to assess the immediate effects of partial sleep deprivation on cognition in young adults.

Sustained attention was measured by digit vigilance test which is based on the activity of the prefrontal cortex. Table 3 showed that the scores of the partially sleep deprived group were significantly lesser in the study group than the control group. This is in agreement with study done by BP. Alhola et al. that partial sleep deprivation affects cognitive performances that depend on the prefrontal cortex[12]. Attention and working memory being linked to frontal lobe of the brain and this regions of brain areas is greatly vulnerable to partial sleep deprivation therefore it can be hypothesized that both attention and working memory are impaired during prolonged wakefulness. Functional-MRI showed increased activity and blood flow in associated regions of brain in sleep deprived subjects indicating that sleep deprived subjects had to work harder to accomplish the task[12].

Brain imaging techniques including magnetic resonance imaging (MRI) imaging, functional magnetic

resonance imaging (fMRI) and positron emission tomography (PET) have shown that there are two main areas in the brain that are involved in the processing of the Stroop task is 1) Cingulategyrus-The posterior part of anterior cingulate cortex is responsible for what decision is made (i.e. whether you will say the incorrect answer [written word] or the `correct answer [ink color] and anterior part of cingulate cortex is involved in response evaluation—deciding whether the answer is correct or incorrect[13] 2) Dorsolateral prefrontal cortex is also involved in Stroop tasking. The color perception and not those involved in word encoding is controlled by left dorsolateral prefrontal cortex and right dorsolateral prefrontal cortex aims to reduce the attentional conflict and is activated after the conflict is over[13]. Stroop tasking in this study shows time taken for sleep deprived group was slightly longer than non-sleep deprived group. According to Yusuf Patrick et al young student population may be more effective at dealing with acute sleep deprivation[7]. The time taken to complete the task was slightly longer but not significant due to better tolerance to lack of sleep in young adults.

Complex figure test involves visual perception. It has been found that there are a series of alterations in the visual perception that might have contributed for damages in the visuospatial skills, such as failures in the discrimination between close or similar visual stipulations, identification of visual information and mistakes in detection or omission of present visual stimulation in the sleep deprived population. From Table 3. Learning and memory is lesser in subjects with partial sleep deprivation duration but not statistically significant. Among compensatory mechanisms adults have more developed cognitive skills due to their age, which allows them to acquire the capability to search other resources more efficiently and perform better[14.]

Limitations: A computerized cognitive function test would have been better at eliciting the defects in cognitive performance in the sleep deprived. The study would have been better if the sample size had been more. Epworth sleep scale is a self-administered questionnaire which leads to increased subjective error. In order to demonstrate effect of sleep deprivation the task should be complex, new and interesting.

Conclusion

The study shows that partial sleep deprivation in young adults showed significant decrease in attention. Attention being linked to the frontal regions of the brain are first to be affected, whereas the other regions remain active until the effects of sleep deprivation become more severe. This cognitive decline increases the chances of error at workplace or and risk of losing at academics. Hence, it is important to incorporate sleep hygiene measures to have adequate sleep duration like turning off mobile phone few hours before sleep, having a regular sleep pattern, actively involving in lifestyle modification like walking and exercise which further decrease the intensity of diseases like DM, HTN.

Ethical Clearance: Taken

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