ORIGINAL RESEARCH PAPER
Volume - 14 | Issue - 01 | January - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

COGNITION DUE TO LESS SLEEP DURATION: AFFECTED OR NOT AFFECTED

Neuroscience

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KEYWORDS

INTRODUCTION:

Sleep is a multifaceted physiological and behavioral process that plays a crucial role in determining quality of life, influencing both longevity and overall well-being. It is a state of rest for the otherwise active nervous system. It is defined as a state of unconsciousness from which a person can be aroused by appropriate sensory or any other stimulus (1). Sleep duration varies with gender, age and also according to one's daily routine. A lack of sleep, or sleep deprivation (SD), is a widespread phenomenon that can induce adverse changes in cognitive performance. Sleep duration is very important but sleep quality is often ignored factor. Sleep is very essential for learning, memory, attention, alertness, judgement, and overall health of an individual.

Two processes that affect the amount of sleep obtained are the circadian and homeostatic processes. The circadian process theory suggests that an internal circadian clock regulates sleep by controlling the timing of its onset and offset. This facilitates the wake and sleep cycles as well as the secretion of different hormones (2). The homeostatic process is influenced by periods of wakefulness and sleep, with sleep demands increasing when sleep duration is insufficient.

In today's fast age getting one nights restful sleep has become a challenge. Due to lack of sleep there occurs excessive daytime sleepiness. Sleep deprivation (SD) is a major health concern not just physically but mentally as well. The impact of sleep disorders on cognitive performance has become a major concern as it affects the quality of life. Sleep deprivation not only involves physiological changes throughout the entire body but is also considered to be critically related to the decline of a range of cognitive functions(3,4,5). Hence,in this study we will assess the effect of sleep quality and duration on cognitive function.

MATERIALS & METHODS:

A cross sectional study was conducted on 40 young adults. A written informed consent was taken prior and participation was purely voluntary. There were no potential risk to the subjects in this study as there were no interventions involved.

Exclusion Criteria:

1. Age less than 18 years.
2. Those who are taking any medication.
3. Any history of Major physical illness.
4. Any history of Neuro-muscular /neurological disorder
5. Any history of Psychological disorder.
6. Any history of Substance abuse, smoking, alcohol abuse.
7. Any history of Head trauma.

Methodology:

Participants were given prior information regarding the nature of the study and those who were willing to participate were asked to come for a single contact session. On the study day, written informed consent was taken from each participant. Study was conducted in a quiet isolated room with adequate light. Subjects were asked to fill a case record form. Detailed history regarding sleep duration and quality were obtained by Pittsburgh sleep quality index (PSQI - ANNEXURE A), a questionnaire, that assesses sleep quality and quantity over a 1-month period (6). History of day time sleep was obtained by Epworth sleepiness scale (ANNEXURE B) (7). The following cognitive functions were performed on the study participants.

Cognitive Function Tests:

1. Stroop Test:

The Stroop colour word test is a neurophysiological test extensively used to assess the ability to inhibit cognitive interference that occurs when the processing of a specific stimulus feature impedes the simultaneous processing of a second stimulus attribute, well known as the Stroop effect (8). We performed the stroop test using Psychopy Demo Software version 1.83.01(9).

A colour word stimulus is a compound stimulus consisting of colour of ink of the word and text of the word. In this test subject was instructed to press the laptop keys assigned for particular colour. Subject was asked to ignore the word appearing on the screen and give the response according to the colour of the letters. Instructions were as follows:

Keys to press	Colours of the letters
Left	Red
Down	Green
Right	Blue

At the end of the test, the Reaction time for the given responses and number of errors made were recorded.

Data Recording And Analysis: Reaction Times and any errors in the responses were measured. Increased in Reaction times and errors rates are suggestive of cognitive interference.

2. Trail-making test (ANNEXURE C):

It was conducted in two parts, both parts of the Trail Making Test consist of 25 circles distributed over a sheet of paper. In Part A, the circles are numbered 1 – 25, and the participant had to draw lines to connect the numbers in ascending order. In Part B, the circles include both numbers (1 – 13) and letters (A – L); as in Part A, the participant had to draw lines to connect the circles in an ascending pattern, but with the added task of alternating between the numbers and letters (i.e., 1-A-2-B-3-C, etc.). The subject was instructed to connect the circles as quickly as possible, without lifting the pen or pencil from the paper. Time taken by the participant was recorded as he/she connected the "trail." If the patient made an error, it was immediately pointed out and the patient was allowed to correct it. Errors affect the patient's score only in that the correction of errors gets included in the completion time for the task. The test was not counted if the participant did not complete both parts after five minutes had elapsed(10).

Scoring:

Results for both TMT A and B are reported as the number of seconds required to complete the task; therefore, higher scores reveal greater impairment.

	Average	Deficient	Rule of Thumb
Trail A	29 seconds	> 78 seconds	Most in 90 seconds
Trail B	75 seconds	> 273 seconds	Most in 3 minutes

Trail making test (ANNEXURE C) (11)

Stastical Analysis: Data was analysed by using SPSS 16 statistical software. Chi-square test was used to find out the association between

the variables.

To Assess The Sleep Quality And Excess Daytime Sleepiness Following Scales Were Used:

1. The Pittsburgh Sleep Quality Index (PSQI):

It is an effective instrument used to measure the quality and patterns of sleep in the older adult. It differentiates "poor" from "good" sleep by measuring seven domains: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction over the last month. The client self rates each of these seven areas of sleep. Scoring of the answers is based on a 0 to 3 scale, whereby 3 reflects the negative extreme on the Likert Scale. A global sum of "5"or greater indicates a "poor" sleeper. Although there are several questions that request the evaluation of the client's bed-mate or roommate, these were not scored, nor reflected in the attached instrument.(6)

2. Epworth Sleepiness Scale (ESS):

Daytime sleepiness was assessed using the ESS, which is a well-validated questionnaire consisting of eight items that quantify the likelihood of dozing in eight different situations. The total ESS score ranges from 0 to 24, and daytime sleepiness was considered excessive in this study if the score was >10 (12).

Observations:

Descriptive Statistics :

Sleep quality measured by PSQI(>5) was good among 12 (30%) study participants. Among the participants 4 (10%) slept less than 5 hours; 14 (35%) slept for 5 hours; 11(27.5%) slept for 6 hours and the rest 11 (27.5%) participants slept for 7 hours or more.

Table I:

Table I :CROSS TABULATION (done using Chi square test)							
GENDER	category of EPROSCORE					Total	P value
		Average day time sleepiness	Mild sleepy	Moderate sleepy	Excessive sleepy		
F	Count	5	9	2	8	24	0.927 Two variables are not significantly associated
	% within GENDER	20.8%	37.5%	8.3%	33.3%	100%	
M	Count	2	6	2	6	15	
	% within GENDER	13.3%	40.0%	13.3%	40.0%	100%	
Total	Count	7	15	3	14	39	
	% within GENDER	17.9%	38.5%	7.7%	35.9%	100.0 %	

In the above table according to EPROSCORE, it has been observed that 33.3% of females & 40% of males are experience excessive sleepiness, whereas 37.5% of females & 40% of males exhibit mild sleepiness.

Table II:

		AGE	HSD (Hrs)	STROOP TIME	ST - CONGUR	ST IN CONGUR	STRO OPERROR	TMTTIMEA	TMTAERRORS	TMTTIMEB	TMTBERROR
PSQI	Pearson Correlation	0.094	-0.3	-0.076	-0.25	0.02	0.219	0.108	0.285	0.011	0.041
	Sig. (2-tailed)	0.837	0.069	0.645	0.126	0.906	0.186	0.513	0.079	0.948	0.802
EPROSCORE	Pearson Correlation	0.019	0.017	-0.249	-0.151	-0.158	0.204	-0.064	0.117	-0.274	-0.014
	Sig. (2-tailed)	0.908	0.917	0.126	0.359	0.337	0.22	0.697	0.479	0.092	0.935
	N	39	39	39	39	39	38	39	39	39	39

Using Pearson correlation the following results were obtained. Correlation between PSQ Index with HSD (r = -0.3), Stroop Time (r = -0.076) and ST- CONGUR (r = -0.25) are negatively correlated which indicates that as PSQ Index increases then HSD, Stroop Time and ST - CONGUR decreases followed by correlation between PSQ Index with ST INCONGUR (r = 0.02), STROOP ERRORS (r = 0.219), TMT TIME A (r = 0.108), TMT A ERRORS (r = 0.285), TMT TIME B (r = 0.011) and TMT B ERROR (r = 0.041) are positively correlated which indicates that as PSQ Index increases then ST INCONGUR, STROOP ERRORS, TMT TIME A, TMT A ERRORS, TMT TIME B and TMT B ERROR increases. However, these factors are not significantly correlated.

Correlation between EPROSCORE with Stroop Time (r = -0.249) and ST-CONGUR (r = -0.151) , ST INCONGUR (r = - 0.158), TMTTIMEA (r = -0.064) , TMT TIME B (r = -0.274) and TMT B ERROR (r = -0.014) are negatively correlated which indicates that as EPRO SCORE increases then Stroop Time and ST - CONGUR, ST INCONGUR, TMT TIME A, TMT TIME B and TMT B ERROR decreases followed by Correlation between EPRO SCORE with HSD (r =0.017) , STROOP ERRORS (r = 0.204), TMT A ERRORS (r = 0.117), are positively correlated which indicates that as EPRO SCORE increases then HSD, STROOP ERRORS, TMT A ERRORS increases. However, these factors are not significantly correlated.

DISCUSSION:

Sleep deprivation and lack of good quality sleep, is very common in today's modern society and many studies are being conducted to prove its effect on cognitive performance. While there is broad consensus that insufficient sleep leads to increase in reaction time, variability in performance, decreased alertness, attention and vigilance, but there is less agreement about the effects of sleep deprivation as well as bad quality sleep on many higher level cognitive capacities, including perception, memory and complex problem solving. The effect of sleep deprivation affects all domains of cognition central to this debate has been the question of whether sleep deprivation affects nearly all cognitive capacities in a global manner through degraded alertness and attention, or whether sleep loss and bad quality sleep specifically impairs some aspects of cognition more than others.

As per our findings (Table 1), shows 33.3% of females & 40% of males experience excessive sleepiness whereas 37.5% of females & 40% of males exhibit mild sleepiness. A research study by Angelone et al (13) and Lund et al (14), showed results contrary to our findings, that female students have higher prevalence of daytime sleepiness than male students. Another study by, El Hangouche et al (15) also found that, female students are having more daytime sleepiness than males and which was statistically significant.

In our study, we correlated PSQI with habitual sleep duration, stroop test (Congurent and incongurent), stroop test errors, Trail mainking test A and B time, Trail making A & B errors. PSQI scale measure the quality and patterns of sleep. We also evaluated all the above cognitive tests with Epworth sleepiness score. Epworth sleepiness score assess daytime sleepiness. We found that, the Correlation between PSQ Index with Habitual Sleep Duration (r = -0.3), Stroop Time (r = -0.076) and ST-CONGUR. (r = -0.25) are negatively correlated, meaning that as PSQ Index increases then Habitual Sleep Duration, Stroop Time and ST-CONGUR score decreases. An increased PSQI score indicates poor sleep quality, so as per our findings, habitual sleep duration and reaction time decreases with poor sleep quality. Study conducted by Anderson et al (16) , showed that people with less sleep perform better with lesser reaction time and answered more accuretly in stroop test. In a study done by Sen B, Kurtaran NE, Ozturk L (17), the Stroop test showed improvement in cognitive flexibility after sleep deprivation. Both the above studies are in accordance with our findings.

We also found,Correlation between PSQ Index with ST INCONGUR (r = 0.02), STROOP ERRORS (r = 0.219), TMT TIME A (r = 0.108), TMTAERRORS (r = 0.285), TMTTIMEB (r = 0.011) and TMT B ERROR (r = 0.041) are positively correlated which indicates that as PSQ Index increases then ST INCONGUR, STROOP ERRORS, TMT TIME A, TMT A ERRORS, TMT TIME B and TMT B ERROR increases. However, these factors are not significantly correlated. So with poor sleep quality, reaction time and attention span, visual search and scanning, sequencing and shifting, psychomotor speed, abstraction, flexibility, ability to execute and modify a plan of action, and ability to maintain two trains of thought simultaneously , increases. Our study proves, Poor sleep quality affects cognition. As per study done by Virta JJ et al (18), poor sleep quality is major risk factor for the poorer cognitive functions. Koutsonida et al (19) concluded that, increased PSQI scores, implying low sleep quality, predicted higher scores in TMT A, indicating slower processing speed and increased response time. Another study done by K.M. Mullins & A.M Reynold (20) done on undergraduate students showed participants made fewer errors with increased sleep, but, unexpectedly, reaction times also increased with more sleep. They quoted fatigue may have played a role in this relationship. Contrary to this, a study done by Holding et al (21) proved that there is no effect of sleep deprivation on the Stroop test. There were variations in attention and arithmetic test performance across different times of day. The effect of sleep deprivation on all cognitive tests was also found to vary at different times of day.

When Epworth sleep score correlated with various cognitive function test, we found that Correlation between EPRO SCORE with Stroop Time (r = -0.249) and ST- CONGUR (r = -0.151) , ST INCONGUR (r = - 0.158), TMT TIME A (r = -0.064) , TMT TIME B (r = -0.274) and

TMT B ERROR (r = -0.014) are negatively correlated which indicates that as EPRO SCORE increases then Stroop Time and ST-CONGUR, ST INCONGUR, TMT TIME A, TMT TIME B and TMT B ERROR decreases. Increase epworth sleepiness score indicates excess daytime sleepiness. So as per our findings, as daytime sleepiness increases reaction times for both congurent and incongurent, trail making time as well as trail making test B errors are getting better. Our study showed positive correlation between epworth score and HSD (r =0.017) , STROOP ERRORS (r = 0.204), TMT A ERRORS (r = 0.117) meaning that, as daytime sleepiness increases habitual sleep duration as well as errors of stroop test and trail making test A increases. However, these factors are not significantly correlated. Shilpa Khullar et al (22), in her study observed no significant association between Epworth sleepiness score and parameters of the stroop test, they further found that reaction time of the incongruent trial was significantly higher as compared to the congruent trial in the Stroop Task. A study done by El Hangouche et al (15), revealed that poor sleep quality and excessive daytime sleepiness as accessed by PSQI and Epworth sleepiness score are significantly associated with low academic performance in medical students.

As sleep is one of the most dependant and important factor for memory, any changes in sleep time , sleep deprivation will affect the academic performance in medical students. A study done by Samoel O Adeoson et al. (23), showed that habitual night reading may affect academic performance, possibly due to the reduced sleep and poor sleep quality of habitual night readers. Similar results are seen by Dixit and Mittal study on medical undergraduate students, in which they quoted that, high demanding professsions like medical and armed forces etc. where people work more than 24 hrs at a stretch showed decline in cognitive functions (24).

Conclusion :

Our study conclude that, not only sleep duration but sleep quality is also very important factor to be considered. We found that, poor sleep quality affects different components of cognition. Sleep hygiene education and techniques to implement it would be beneficial to the population.

REFERENCES:

1. Guyton and Hall. Textbook of Medical Physiology. 3rd South Asia Edition. Chapter 123, page no. 889.
2. Kim T, Kim S, Kang J, Kwon M, Lee SH. The Common Effects of Sleep Deprivation on Human Long-Term Memory and Cognitive Control Processes. Front Neurosci. 2022 Jun 2;16:883848. doi: 10.3389/fnins.2022.883848. PMID: 35720688; PMCID: PMC9201256.
3. Durmer JS, Dinges DF. Neurocognitive consequences of sleep deprivation. Semin Neurol. 2005 Mar;25(1):117-29. doi: 10.1055/s-2005-867080. PMID: 15798944.
4. Ratcliff R, Van Dongen HP. Sleep deprivation affects multiple distinct cognitive processes. Psychon Bull Rev. 2009 Aug;16(4):742-51. doi: 10.3758/PBR.16.4.742. PMID: 19648462; PMCID: PMC2797337.
5. Lo JC, Ong JL, Leong RL, Gooley JJ, Chee MW. Cognitive Performance, Sleepiness, and Mood in Partially Sleep Deprived Adolescents: The Need for Sleep Study. Sleep. 2016 Mar 1;39(3):687-98. doi: 10.5665/sleep.5552. PMID: 26612392; PMCID: PMC4763363.
6. Shahid et al.(eds.), STOP THAT and One Hundred Other Sleep Scales, 279 DOI 10.1007/978-1-4419-9893-4_67.
7. Available from: https://nasemso.org/neuro-epworthsleepscale
8. Scarpina F, Tagini S. The Stroop Color and Word Test. Front Psychol. 2017;8:557. doi: 10.3389/fpsyg.2017.00557.
9. Stroop JR. Studies of interference in serial verbal reactions. J Exp Psychol. 1935;18:643-662.
10. Bowie CR, Harvey PD. Administration and interpretation of the trail-making test. Nat Protoc. 2006;1:2277-2281.
11. Available from: http://apps.usd.edu/schieber/psyc423/pdf/TrailMakingTest.pdf
12. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep. 1991 Dec;14(6):540-5. doi: 10.1093/sleep/14.6.540. PMID: 1798888.
13. Angelone AM, Mattei A, Sbarbati M, Di Orio F. Prevalence and correlates for self-reported sleep problems among nursing students. J Prev Med Hyg. 2011;52(4):201–208.
14. Lund HG, Reider BD, Whiting AB, Prichard JR. Sleep patterns and predictors of disturbed sleep in a large population of college students. J Adolesc Health. 2010;46(2):124–132. doi:10.1016/j. jadohealth.2009.06.016.
15. El Hangouche AJ, Jniene A, Aboudrar S, Errguig L, Rkain H, Cherti M, Dakka T. Relationship between poor quality sleep, excessive daytime sleepiness and low academic performance in medical students. Adv Med Educ Pract. 2018;9:631-638 https://doi.org/10.2147/AMEP.S162350.
16. Anderson S, Becker T, Flannery A, Gustafson L, Sarmiento G, Sreeram A. The effects of sleep deprivation on cognitive function. J Adv Stud Sci 2017;1:1-13.
17. Buket Sen, Nurcan Erdogan Kurtaran, Levent Ozturk, The effect of 24-hour sleep deprivation on subjective time perception, International Journal of Psychophysiology, Volume 192, 2023,Pages 91-97, ISSN 0167-8760, https://doi.org/10.1016/j.ijpsycho.2023.08.011.
18. Virta JJ; Heikkilä K; Perola M; Koskenvuo M; Räihä I; Rinne JO; Kaprio J. Midlife sleep characteristics associated with late life cognitive function. SLEEP 2013;36(10):1533-1541.
19. Koutsonida M, Aretouli E, Kosmidis MH, Ioannidis P. Emotional Memory in Patients with Neurodegenerative Disorders [Master's]. Thessaloniki, Greece: Aristotle University of Thessaloniki, Aristotle University of Thessaloniki; 2018.
20. K M Mullins, A M Reynolds, 0123 Sleep Duration and Cognitive Performance on the Stroop Color-Word Task and Simple Reaction Time Task, Sleep, Volume 43, Issue Supplement_1, April 2020, Pages A48–A49, https://doi.org/10.1093/sleep/ zsaa056. 121.
21. Holding BC, Ingre M, Petrovic P, Sundelin T, Axelsson J. Quantifying Cognitive Impairment After Sleep Deprivation at Different Times of Day: A Proof of Concept Using Ultra-Short Smartphone-Based Tests. Front Behav Neurosci. 2021 Apr 13;15:666146. doi: 10.3389/fnbeh.2021.666146. PMID: 33927603; PMCID: PMC8076531.
22. Khullar, Shilpa; Singh, Mitasha1; Das, Suman2; Kamya, . To Study the Association between Daytime Sleepiness and Cognition as Tested by Stroop Test in Indian Medical Students. Journal of the Scientific Society 48(1):p 33-37, Jan–Apr 2021. | DOI: 10.4103/jss.jss_89_20.
23. Adeosun, Samuel O. et al. "Effects of night-reading on daytime sleepiness, sleep quality and academic performance of undergraduate pharmacy students in Nigeria." Sleep and Biological Rhythms 6 (2008): 91-94.
24. Dixit A, Mittal T. Executive functions are not affected by 24 hours of sleep deprivation: A color-word stroop task study. Indian J Psychol Med 2015;37:165-8.