RESEARCH ARTICLE

Study of the Incidence and Impact of Chronic Sleep Deprivation in Indian Population with Special Emphasis on Neuropsychology Testing

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Abstract

The present study assesses the effect of such chronic sleep deprivation on brain functioning with special emphasis on frontal lobe functions. Chronic sleep deprivation is common in the modern society. Deficits in daytime performance due to sleep loss are experienced universally and associated with significant social, financial, and human cost. The objective way to assess effect of chronic sleep deprivation on various brain functions such as sustained attention, planning, and memory is to conduct the neuropsychology test battery. The general public was recruited as volunteers. Volunteers were asked to wear Actiwatch and/to fill sleep diary for 7 consecutive days. The neuropsychology test battery utilized included psychomotor vigilance task, forward digit span, Iowa gambling task, tower of London, Wisconsin card sorting test, Stroop, and Rey auditory verbal learning test. Results show that chronic sleep deprivation has the most significant effect on the younger generation as compared to older adults. There was no significant effect on the elderly population. Future large cohort studies are underway to substantiate the findings of this study.

Keywords: Chronic sleep deprivation, Excessive daytime sleepiness, Neuropsychology test battery.

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Introduction

Chronic sleep deprivation is common in the modern society. People are working longer than ever, and sleeping less. A recent Nielsen study on sleep habits around the world underlines these changing rhythms. According to the study, 64% of India's urban population wakes up before 7 am the highest in the world and 61% sleeps for less than 7 hours a day.[1] Indians are affected by what William C Dement, father of sleep medicine who pioneered the sleep study laboratory at Stanford University, called "one of the biggest epidemics in the world". For most adults, 7–8 hours are considered the right amount of sleep but modern lifestyles and work pressures have shrunk this to abnormal levels. In fact, the effects of lack of sleep on physical and mental health are just starting to be realized. In addition, there is a burden of sleep disorders—insomnia and sleep apnea being the two most giant condition.[2–12]

Brain benefits from sleep, which improves memory, ideas, and concentration. Whereas those who suffer from sleep debt function at only 80% of their capability. Deficits in daytime performance due to sleep loss are experienced universally and associated with significant social, financial, and human cost. The objective way to assess the effect of chronic sleep deprivation on various brain functions such as sustained attention, planning, and memory is to conduct the neuropsychology test battery. The research or data in Indian population is lacking. There is a need to evaluate neurocognitive functions in real-life setting sleep deprivation. The current study aims to evaluate the effect of chronic sleep deprivation in general public on various neuropsychology functions mainly involving prefrontal brain lobe. The outcome of the study will determine the incidence of chronic sleep deprivation and its daytime neurocognitive effects, which people generally ignore. The long-term goal of the study is to provide appropriate nonmedication interventions to sleep-deprived population.

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Materials and Methods

Study Population

Cohorts from different public locations such as the University of Mumbai, Corporate companies, and Rotary clubs were identified for conducting current studies wherein volunteers were recruited. The cohort comprised a population of 321 volunteers—166 males and 155 females, who belonged to the 16–70 age group.

Questionnaires

Epworth sleepiness scale (ESS) and sleep quiz were filled by all the participants, for determining daytime sleepiness and screening for sleep disorder/problems.

Demographic Inputs

Basic demographic data were collected from each participant that included parameters such as age, sex, education level—school/college, weight, and height.

Actiwatch/Sleep Diary

For recording sleep patterns, participants were asked to fill sleep diary for at least a week, who also wore Actiwatch to record average sleep hours within that week. The individuals with average sleep hours less than 6 per day within the study period were categorized as sleep-deprived population.

Neuropsychology Test Administration

All the participants were administered a neuropsychology test battery selected with the help of earlier studies[11–23] on sleep deprivation and considering the effects on the prefrontal lobe. The test battery includes seven tests which are described in NIMHANS specifications[24] as follows:

Psychomotor Vigilance Test

It is a sustained-attention, reaction-timed task that measures the speed with which subjects respond to a visual stimulus. Quantitative-dependent variables involve omission and commission errors, reflecting fluctuations in endogenous cognitive condition. The study utilized the PEBL software version 0.13 for conducting psychomotor vigilance test (PVT). The participant was seated comfortably; the level of a computer screen and subject head was kept parallel. The participants were asked to respond, as soon as possible, to a red circle appearing in the center of the screen, by pressing the "Space Bar" button. Each response was accompanied by displaying reaction time in milliseconds (ms). The variables used were average reaction time (ART), number of lapses (RT >500 milliseconds), number of too fast responses (errors of commission), and number of sleep responses (RT >30 seconds). The test duration was 10 minutes.

Forward Digit Span Test

This is a standard digit span task. It had a visual presentation of number strings. The participant was asked to type the list of digits exactly in displayed order. Starting with a 4 digit number, the length increased on correct recall and decreased on incorrect recall. The average memory span was the only variable utilized here. The study utilized the PEBL software version 0.13 for conducting the digit span test. The test duration was an average of 7 minutes.

IOWA Gambling Task

Four decks are given; the participant must draw cards from whatever deck they choose. On each selection, a reward and/penalty is given. The penalty/reward structure is identical to that in Bechara et al. with 40 cards per deck, and the identical reward structure. When 100 cards have been selected, the task is complete. Two decks are net positive and two are a net negative. The variable used in this case the difference in the number of good decks selected from the bad decks. The average duration of this test was 5 minutes.

Wisconsin Card Sorting Task

Wisconsin card sorting task (WCST) examines concept formation, abstract reasoning, and the ability to shift cognitive strategies in response to changing environments. The test consists of 128 cards. Stimuli of various forms are printed on the cards. The stimuli vary in terms of three attributes: color, form, and number. The stimuli are geometrical figures of different forms (triangle, star, cross, and circle), in different colors (red, green, yellow, and blue) and in different numbers (one, two, three, and four), which are presented on each card. The pack of 128 cards consists of 2 sets of 64 cards each. In addition to these 128 cards, there are 4 stimulus cards. Out of those four stimulus cards, the first card consists of one red triangle, the second consists of two green stars, the third consists of three yellow crosses, and the fourth consists of four blue circles. The subject is instructed to study the cards and match each successive card from the pack to one of the four stimulus cards. The subject is told only whether each response is right or wrong and is never told the correct sorting principle. The participant has to guess the concept based on the examiner's feedback and continue with the test. After the participant places 10 consequent cards correctly, the tester changes the concept without the subject's knowledge. The subject's capacity to form a mental set is measured by how quickly he/she attains the concept and retains it for 10 consecutive trials. The subject's capacity to perceive a change in the concept when the next sorting principle is introduced is a measure of the set-shifting ability. The test is terminated after the subject attains all the 9 concepts or after all the 128 cards have been used. Cards placed according to the sorting principle are correct responses. If the subject places a card according to the principle that was previously in operation but which has been changed in the current trial, then it qualifies as a preservative response. Errors that do not match the previous sorting principle in operation are nonpreservative errors. The variables utilized are the number of trials to complete the first category, the number of perservative errors, and the number of categories finished. The test duration is 10 minutes.

Tower of London Test

Planning is tested using tower of London (TOL). The test evaluates the subject's ability to plan and anticipate the results of their actions to achieve a predetermined goal. The goal is to move a pile of disks from their original configuration to the configuration shown on the top of the screen. There were a total of 12 problems. The variable here is the total number of problems solved with minimum moves. The test duration is 10 minutes.

Stroop Test

It assesses response inhibition. The color names "Blue", "Green", "Red," and "Yellow" are printed in capital letters on a paper. The color of the print occasionally corresponds with the color designated by the word. The words are printed in 16 rows and 11 columns. The subject is asked to read the text in the first trial and colors in the second trial. The difference in timings is taken as the Stroop effect score.

Auditory Verbal Learning Test

It consists of words designating familiar objects like vehicles, tools, animals, and body parts. There are 2 lists, A and B, with 15 different words in each list. The number of words correctly recalled in each of the 5 trials of list A as well as the total numbers of words recalled over all the 5 trials forms the learning score. The number of words recalled correctly in the immediate recall trial, delayed recall trial, and the recognition trial forms the memory score. In the recognition trial, the Hits are scored separately. Omissions and commissions form the errors. The other score is the long-term percent retention.

The present study utilized the PEBL software[26,27] to administer the above test battery on all participants.

Results

About 365 volunteers were recruited for the study. The population was divided into three age groups as 16–30, 31–50, and 50 above. The detailed demographics are depicted in Table 1. Each age group

Table 1: Demographic details of the study population

Age group	*16–30*	*31–50*	*>50*	*Total*
Population size (*n*)	120	144	101	365
Mean age	22.8	40.5	55.6	39.6
Mean BMI	21.79	26.33	26.8	24.9
Males	56	70	74	200
Females	64	74	27	165
Education—school	1	9	17	27
Education—college	119	135	84	338
Average sleep hours <6	38	69	30	137
Average sleep hours >6	82	75	71	228
Incidence of sleep deprivation	31.66%	47.91	29.7	37.5

Table 2: The 16–30 age group sleep hours and detail demographics data

16–30 age group	*>6 hours sleep (not sleep deprived)*	*<6 hours sleep (sleep deprived)*	*Total*
Total	82	38	120
Mean hours of sleep	7	5.1	6.05
Males	35	21	56
Females	47	17	64
Mean BMI	21.79	22.4	22.09
Mean age	22.2	24.4	22.8
Mean epworth sleepiness score	6.4	7.8	6.4
Mean sleep quiz Score	3.3	3.2	3.2

Table 3: The 16–30 age group population statistical analysis group I: sleep-deprived group; group II: not sleep deprived

Test		*Mean value*	*t value*	*p value, one tailed*	*Null hypothesis*	*p value, two tailed*	*Null hypothesis*
Psychomotor vigilance task lapses	Group I	4.2	0.69	0.24	Not rejected	0.49	Not rejected
	Group II	3.54					
Psychomotor vigilance task error of commission	Group I	2.39	1.10	0.13	Not rejected	0.27	Not rejected
	Group II	1.78					
Psychomotor vigilance task ART	Group I	362.97	1.29	0.099	Not rejected	1.98	Not rejected
	Group II	347.29					
Digit span	Group I	6.58	−1.82	0.036	Rejected	0.072	Not rejected
	Group II	7.03					
Iowa gambling test	Group I	−1.26	−2.10	0.019	Rejected	0.038	Rejected
	Group II	6.73					
Wisconsin card sorting test perservative errors	Group I	23.71	2.3	0.012	Rejected	0.024	Rejected
	Group II	18.24					
Tower of London number of problems solved with minimum moves	Group I	6.58	−1.82	0.036	Rejected	0.072	Not rejected
	Group II	7.03					
Stroop	Group I	86.76	−1.96	0.026	Rejected	0.053	Not rejected
	Group II	92.48					
Rey auditory verbal learning test immediate recall	Group I	36.60	−2.31	0.011	Rejected	0.023	Rejected
	Group II	50.85					
Rey auditory verbal learning test delayed recall	Group I	43.05	−1.73	0.043	Rejected	0.086	Not rejected
	Group II	53.83					

volunteers were further divided into two groups as sleep deprived and not sleep deprived. The sleep-deprived group had average hours of sleep as less than 6 hours/night for a week, whereas not sleep deprived had more than 6 hours of sleep/night for a week as observed in Actiwatch and/sleep diary.

In the 16–30 age group as depicted in Table 2, the average hours of sleep in the sleep-deprived group is 5.1, whereas in the other not sleep-deprived group, it is 7 hours average.

It is clear from Table 3 depicting statistical analysis for the 16–30 age group population, chronic sleep deprivation has significant effects on memory span, decision making, executive function, planning, social cognition, and verbal learning. However, the effects are observed in sustained attention in the mean values though statistically not significant. The baseline score for sustained attention is very low possibly due to various reasons, the most common being chronic sleep deprivation but not acknowledged by the person.

The average number of sleep hours in the 31–50 age group population was 6.79 and 5.28, respectively, in not the sleep-deprived and the sleep-deprived group. The other demographics are shown in Table 4. As depicted in Table 5, ART, memory span, social cognition, and verbal learning are significantly affected by chronic sleep deprivation in this age group. Table 6 depicts the demographic details as well as the average number of hours of sleep in above 50 age group population. The detail scores for this age group are depicted in Table 7.

Table 4: The 31–50 age group population details

31–50 age group	*>6 hours sleep (not sleep deprived)*	*<6 hours sleep (sleep deprived)*	*Total*
Total	75	69	144
Mean hours of sleep	6.79	5.28	6.03
Males	38	37	75
Females	37	32	69
Mean BMI	25.32	24.37	24.84
Mean age	39.37	41.03	40.2
Mean epworth sleepiness score	5.83	5.42	5.62
Mean sleep quiz score	2.71	3.8	3.25

Discussion

The incidence of sleep deprivation was the highest in the 31–50 age group as 47.91%. Although the incidence rate is very high as 31.66% in the 16–30 age group which indicates chronic sleep deprivation among Indian youth possibly due to changing life style. The subjective sleepiness scores are observed to be low in all the age groups which clearly depict the denial state of Indian population about sleep deprivation and also lack of awareness regarding the importance of sleep and its disorders.

In the earlier study by Suri et al.[10,11] on the prevalence of sleep disorders in Delhi population, approximately more than half of the population under the study was observed to be sleep-deprived (sleep time <8 hours per day); and 29.3% of them slept for less than 7 hours. About one-fourth of the population (26%) that slept for less than 8 hours per day had perceptible symptoms of excessive daytime sleepiness (EDS).

Several factors that may be responsible for sleep deprivation include conditions like poor sleep hygiene, improper sleeping environment, illness, work (shift work and frequent traveling), other sleep disorders (sleep apnea, PLMS and snoring), medications, personal choice, parenting of babies, etc.

There was no difference between the sleep-deprived and the not sleep-deprived group in the above 50 age group of population, except in the number of perservative errors in Wisconsin card sorting task and number of problems solved with minimum moves in the tower of London test. Although the scores were very low in the not sleep-deprived group which indicates poor baseline cognition. Earlier studies have reported sleep deprivation effects

Table 5: 31–50 age group population statistical analysis

Test		*Mean value*	*t value*	*p value, one tailed*	*Null hypothesis*	*p value, two Tailed*	*Null hypothesis*
Psychomotor vigilance task lapses	Group I	6.91	0.77	0.22	Not rejected	0.44	Not rejected
	Group II	5.76					
Psychomotor vigilance task error of commission	Group I	1.79	1.42	0.08	Not rejected	1.65	Not rejected
	Group II	1.32					
Psychomotor vigilance task ART	Group I	387.26	1.92	0.02	Rejected	0.05	Not rejected
	Group II	363.17					
Digit span	Group I	5.64	−3.33	0.001	Rejected	0.001	Rejected
	Group II	6.4					
Iowa gambling test	Group I	−2.44	−0.97	0.167	Not rejected	0.334	Not rejected
	Group II	1.44					
Wisconsin card sorting test perservative errors	Group I	23.66	1.27	1.65	Not rejected	0.20	Not rejected
	Group II	20.52					
Tower of London number of problems solved with minimum moves	Group I	5.30	−1.26	1.65	Not rejected	0.20	Not rejected
	Group II	5.97					
Stroop	Group I	74.72	−3.09	0.001	Rejected	1.97	Rejected
	Group II	85.64					
Rey auditory verbal learning test immediate recall	Group I	39.11	−2.12	0.018	Rejected	0.036	Rejected
	Group II	975.28					
Rey auditory verbal learning test delayed recall	Group I	34.53	−2.98	0.002	Rejected	0.003	Rejected
	Group II	50.01					

Table 6: Demographic details of above 50 age group population

Above 50 age group	*>6 hours sleep (not sleep deprived)*	*<6 hours sleep (sleep deprived)*	*Total*
Total	30	71	101
Mean hours of sleep	5.21	7.26	6.23
Males	19	55	74
Females	11	16	27
Mean BMI	27.9	25.73	26.8
Mean age	56	55.35	55.6
Mean epworth sleepiness score	5.5	5.8	5.6
Mean sleep quiz score	3.6	2.6	3.1

Table 7: Neuropsychology test scores in above 50 age group population

Test	*Sleep deprived*	*Not sleep deprived*
Psychomotor vigilance task—lapses	11.26	12.29
Psychomotor vigilance task—error of commission	2.7	1.5
Psychomotor vigilance task—ART	424	433
Digit span	5.94	5.64
IOWA gambling test	3.26	−0.97
Wisconsin card sorting test—perservative errors	26	22.9
Tower of London—number of problems solved with minimum moves	4.74	5.7
Stroop	73.9	73.21
Rey auditory verbal learning test—immediate recall	39	30.8
Rey auditory verbal learning test—delayed recall	37	32.5

as more prevalent among the younger population than the elderly, this study confirms the same.

Utilization of Neuropsychology Test Battery

Most of the earlier studies on sleep deprivation have focused on a sustained attention task of the psychomotor vigilance test.[25,26] This study utilizes a variety of neuropsychology tests to assess different frontal lobe functions such as set-shifting ability, decision making, planning, and memory. These functions have real-life applications which if deteriorated can unbalance the social, mental, economic, and health of an individual. The issues with these tests are lack of administration understanding, e.g., as experienced in the Wisconsin card sorting test, an executive function test; people were unable to understand initial conceptualization. Some modification is warranted to administer these tests in Indian population.

Conclusion

The incidence of sleep deprivation is very high as approximately 50% of the population which is comparable to an earlier questionnaire-based study conducted by Suri for Delhi population. It is clear from the above data analysis that chronic sleep deprivation has the most significant effect on the younger generation as compared to older adults. There is no significant effect on elderly population possibly due to age-related neurocognitive deterioration. The timely measures should be undertaken to curtail this neurocognitive lowering of the young generation. The most important step toward this goal can be making the population aware of sleep disorders as well as developing economical strategies to check for undiagnosed sleep disorders. Also, suitable manpower and sleep science education added in the medical curriculum can be helpful to address the issue of sleep deprivation which has an impact on the social, mental, physical, and economic health of the society.

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