

Original research article

Effect of Partial Sleep Deprivation on Audio-Visual Reaction Time in Taxi Drivers of Bangalore City: A Pilot Study

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Abstract

Background and Aim: The human brain needs adequate sleep to recover from fatigue. Reaction time testing is a highly sensitive measure of sustained attention, which is a prerequisite for safe driving. In view of this, the study was planned to evaluate the effect of partial sleep deprivation (<3 hours of sleep-in night) on sleepiness, Auditory and Visual reaction time in taxi drivers of Bangalore city.

Methods: The study included 30 male taxi drivers in the age group of 18- 40 years. After obtaining informed consent from the subject participants sleepiness status was assessed using the Karolinska's sleepiness scale (KSS). Visual reaction time (VRT) for red, green & blue light & Auditory reaction time (ART) measurement was done by PC 1000 reaction timer. After the baseline measurements, taxi drivers departed for their 12-hour night shift. After the night shift when taxi drivers reported back all the parameters were rechecked ie KSS for sleepiness, VRT, and ART.

Results: There was a significant increase in KSS score after partial sleep deprivation when compared to the baseline values indicating higher levels of sleepiness after sleep deprivation. The mean values of ART & VRT for red, green & blue was prolonged after partial sleep deprivation when compared to before values and the difference was statistically significant.

Conclusion: The present study observed that partial sleep deprivation has a major effect on mental attention and prolongation of reaction time among Bangalore city Traffic drivers. Results of our study suggest that road users especially shift workers should be provided with education concerning the fatal risk of driving during the sleep-deprived condition, effective countermeasures, sufficient areas of staff sleeping areas for on-call workers, counselling against the ill effects of consumption of excessive tea/coffee, drug, alcohol or smoking to eliminate the effects of sleep deprivation.

Keywords: Karolinska sleepiness scale, Sleepiness, Partial sleep deprivation, Taxi drivers, Visual Reaction Time, Auditory Reaction Time

Introduction

Sleepiness is a primary cause of road crashes.^{1,2} Sleepiness is mainly induced by sleep deprivation.³ due to total sleep loss, partial sleep loss, extended wake duration, and sleep fragmentation or sleep disturbances. The sleep of a shorter duration than the average basal need of 7 to 8 hrs per night in adults causes sleep deprivation.⁴ Sleep deprivation has been shown to slow reactions to stimuli, decrease the accuracy of responses, and lead to long lapses in attention.⁵ All these have negative implications for safe driving. Seven to nine hours of sleep is recommended for young adults and 7-8 hours for older adults.⁶ National Sleep Foundation consensus working group of USA concluded that individuals who have slept for 2 hours or less in the past 24 hours “are not fit to operate a motor vehicle”.⁷ Failure to get enough sleep per night can produce a wide array of effects ranging from daytime sleepiness to clumsiness, to general decreased cognitive performance.⁸ Researchers have mainly studied the effects of total sleep deprivation but partial sleep deprivation is more common in daily life.⁹ Cognition involves the brain’s processing capability which can be assessed with various neurophysiological and or neuropsychological tests. Reaction time is the interval between the onset of a signal (stimulus) and the initiation of a movement response.¹⁰ Pioneer reaction time study was done by Donders. He showed that a simple reaction time is shorter than a recognition reaction time and that the choice reaction time is the longest of all.¹¹ The delayed or fast reaction time indicates deteriorated or improved processing capability of the central nervous system and or sensory-motor performance.¹² Sleep deprivation has deleterious effects on task performance in the form of audio-visual reaction time as it causes mental fatigue. The human brain needs adequate sleep to recover from fatigue.¹¹ Reaction time testing is a highly sensitive measure of sustained attention, which is a prerequisite for safe driving.¹³ Previous studies have compared the effect of sleep deprivation on cognitive performance.^{7, 12,14,15} However there is a paucity of such data for the taxi drivers of India. In view of this, this pilot study was planned to evaluate the effect of partial sleep deprivation on the reaction time of the Taxi drivers of Bangalore city.

Materials and Methods:

This comparative study included 30 male taxi drivers of Bangalore city. All the study participants were in the age group of 18 to 40 years and they were asked to sign an informed consent before inclusion in the study. Taxi drivers aged below 18 years and above 40 years, history of any ear disease, sleep disorders, mental or neurological disorders, history of smoking, drinking alcohol, consuming tea or coffee more than 4-5 cups a day, or ingesting any other central stimulant or suppressive drugs, sleep deprivation due to pain, drugs or medical diseases, history of major surgery in the recent past, subjects on chronic medication with any muscular disorder were excluded from the study. Ethical clearance to conduct the study was obtained from the institutional ethics committee. The health of the subject was assessed by noting the present, family, and personal history and also by a thorough general and systemic examination. The study involved non-invasive procedures and with no financial burden on the subjects. Sufficient time was given (15 min) for the subjects to mentally & physically relax before recording the parameters. Following parameters were recorded in each subject before the start of 12 hrs of partial sleep deprivation (<3 hours of sleep in the nighttime). All data of individual subjects were entered in proforma for each subject.

RECORDING OF ANTHROPOMETRICAL PARAMETERS:

- Height (Ht in cms) measured with the subject, standing without shoes, nearest to 0.1 cm error by using a Standard Height measuring Scale.

- Weight (Wt in kg) measured with the subject, wearing minimum clothing, nearest to 0.1 kg error by using a standard weighing machine.
- Body Mass Index (BMI) in kg/m^2 : It is calculated using a Quetelet's index.¹⁶
Body mass index = weight (kg)/Height (m)²

Karolinska sleepiness scale to measure participants' sleepiness¹⁷:

A 9-point Likert scale based on a self-reported, subjective assessment of the subject's level of sleepiness at the time. In this, a score = 1 indicates feeling extremely alert and a score = 9 indicates feeling very sleepy and the individual having to make a great effort to fight sleep and remain awake.

Reaction time Measurement:

Visual reaction time (VRT) and auditory reaction time (ART) were measured using a PC 1000 reaction timer.¹⁸ Before measuring RT subjects were made familiar with the apparatus. PC 1000 reaction timer has a soft key for start and stop function with 1000 Hz square wave oscillator. It consists of 2 components – examiner (E) and subject (S) component. The E component was controlled by the examiner and was out of the view of the subjects. Participants operated the S component which had Stop button. Participants were instructed to press the STOP button in the S component as soon as he sees the light in the instrument. VRT was recorded for red (VRT_R), green (VRT_G) & blue (VRT_B) light in Millisecond (ms) using Audacity software. 5 trials for different colors were given and after repeated practice readings were taken for each color. The lowest of 5 readings of VRT was taken as the final value for reaction time for that color. For measurement of ART, 1000 hertz tone was delivered through headphone as an auditory stimulus. Both E & S components were connected to the computer running audacity® software which is an open-source software that records the reaction time in wave format with accuracy in the range of 0.001 sec. Once the baseline measurements were taken taxi drivers departed for their 12-hour night shift. After the 12 hours of the night shift when taxi drivers reported back all the parameters were rechecked ie Karolinska sleepiness scale for sleepiness, VRT, and ART.

Statistical Analysis:

The Statistical software namely the SPSS 20th version was used for the analysis of the data and Microsoft Word and Excel have been used to generate graphs, tables, etc. Reaction time was reported as mean \pm Standard Deviation. Results were analyzed statistically using the Wilcoxon paired 't' test to compare reaction time of before & after sleep deprivation measurements. The minimum level of significance was fixed at $p < 0.05$

Results:

The demographic profile of the subject is shown in Table 1:

Table 1: Mean and SD of age, weight, height and bmi of the subjects studied

Variables	Sample (N=80)	
	Mean	SD
Age (years)	29.58	7.49
Weight (Kg)	80.54	6.37
Height (m)	1.6	0.08
BMI (kg/m^2)	22.39	2.47

Effect of partial sleep deprivation on sleepiness:

There was a significant increase in KSS score after partial sleep deprivation when compared to the baseline values ($p < 0.001$) indicating higher levels of sleepiness after sleep deprivation.

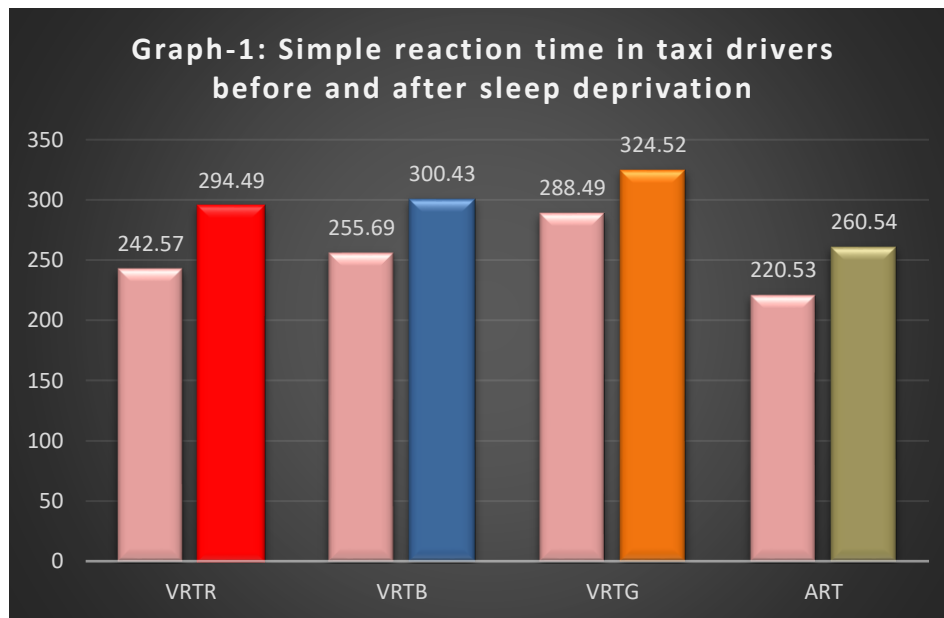
Table 2: Mean and SD of karolinska sleepiness scale before and after sleep deprivation

Karolinska sleepiness scale	Sample (N=30)	
	Mean	SD
Before sleep deprivation	2.5	0.5
After sleep deprivation	6.4	0.7

Effect of partial sleep deprivation on Reaction time:

In Graph-1 visual reaction time for red, green, and blue colors, and auditory reaction time, before & after 12 hrs of sleep deprivation has been shown. Simple VRTR before sleep deprivation was 242.57 ± 17.59 and after 12 hrs of sleep deprivation was 294.49 ± 18.47 ms. This difference was statistically significant. The mean VRTB (ms) before & after sleep deprivation were 255.69 ± 14.54 & 300.43 ± 20.43 respectively ($p < 0.05$). The mean value of VRTG was slower after sleep deprivation when compared to before values & the difference was statistically significant. The mean ART of subjects was significantly slower after sleep deprivation (260.54 ± 14.47 ms) than the before values (220.53 ± 14.32 ms) ($p < 0.0001$).

These results indicated a statistically significant increase in VRT & ART after the 12 hrs sleep deprivation.

**Discussion:**

The present study was designed to explore the effect of partial sleep deprivation (< 3 hours of sleep during night time) on Auditory and Visual reaction time. The study observed a significant slowing in the reaction time following sleep deprivation. Similar results have been observed in previous studies where reaction time was slowed under total or partial sleep loss.^{19,20,21,22} In 2006, Van Den Berg and Neely found that sleep deprivation causes subjects to have a slower

reaction time and also to miss stimuli over a test period that lasted for 2 hrs.²³ Cote et al studied the effects of 2 days of restricted sleep on reaction time, and found that the more restricted sleep was the worse is the deterioration in reaction time. Also, subjects were compensating for this by more mental effort measured by high-frequency EEG waves. Similarly in 2004 Philip et al²⁴ found that 24 hrs of sleep deprivation lengthened the reaction time of 20-25-year-old subjects. Takahashi et al²⁵ studied workers who were allowed to take a short nap on the job and found no effect on choice reaction time though the workers thought the nap had improved their alertness. Study done by Adrienne et al (2010) demonstrated that sleep deprivation did not affect the executive components of the task ie working memory, scanning efficiency, and proactive interference but it did affect the non-executive component.²⁶ Mental fatigue especially sleepiness has the greatest effect on reaction time. Study done by Welford²⁷ showed that reaction time gets slower when the subject is fatigued. The mechanism behind sleep deprivation leading to slower reaction time and alertness is still controversial.^{28,29,30} One hypothesis suggested that sleep deprivation has domain-specific effects that target specific 'top-down' brain areas mainly the prefrontal cortex functions which include flexible thinking, verbal fluency, and memory. Another hypothesis suggested that sleep deprivation influences 'bottom-up' attention and arousal processes mediated by wake state instability.³¹ An integrative approach suggests that sleep deprivation mainly negatively impacts prefrontal cortex functions influencing both top-down and bottom-up processes.³²

Limitations of our study:

Additional studies involving more sample size, a more controlled environment, different variety of physical and cognitive tests are needed to make conclusions about a larger population.

Conclusion:

The present study observed that partial sleep deprivation has a major effect on mental attention and prolongation of reaction time among Bangalore city Traffic drivers. Results of our study suggest that road users especially shift workers should be provided with education concerning the fatal risk of driving during the sleep-deprived condition, effective countermeasures, sufficient areas of staff sleeping areas for on-call workers, counseling against the ill effects of consumption of excessive tea/coffee, drug, alcohol or smoking to eliminate the effects of sleep deprivation. The most vital goal of our finding was to bring awareness that sleep deprivation is a major problem that should be addressed by every organization involving shift workers.

Acknowledgment:

We acknowledge the contribution of Supriya, Statistician, Assistant professor, Dept of Community Medicine, VIMS&RC, Bangalore – 560066

Conflict of Interest: None

Funding: None

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