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# Sleep restriction may lead to disruption in physiological attention and reaction time

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ABSTRACT

Sleepiness is the condition where for some reason fails to go into a sleep state and will have difficulty in remaining awake even while carrying out activities. Sleep restriction occurs when an individual fails to get enough sleep due to high work demands. The mechanism between sleep restriction and underlying brain physiology deficits is not well assumed. The objective of the present study was to investigate the mental attention (P300) and reaction time [visual (VRT) and auditory (ART)] among night watchmen, at subsequent; first (1st) day, fourth (4th) day and seventh (7th) day of restricted sleep period. After exclusion and inclusion criteria, the study was performed among 50 watchmen (age = 18–35 years) (n = 50) after providing written informed consent and divided into two group. Group I-(Normal sleep) (n = 28) working in day time and used to have normal sleep in night ($\geq$ 8 h); Group II-(Restricted sleep) (n = 22) - working in night time and used to have less sleep in night ($\leq$ 3 h). Statistical significance between the different groups was determined by the independent student '*t*' test and the significance level was fixed at $p \leq 0.05$. We observed that among all normal and restricted sleep watchmen there was not any significant variation in Karolinska Sleepiness Scale (KSS) score, VRT and ART, along with latency and amplitude of P300 on 1st day of restricted sleep. However at subsequent on 4th day and 7th day of restricted sleep, there was significant increase in (KSS)score, and prolongation of VRT and ART as well as alteration in latency and amplitude of P300 wave in restricted sleep watchmen when compare to normal sleep watchmen. The present finding concludes that loss of sleep has major impact in dynamic change in mental attention and reaction time among watchmen employed in night shift. Professional regulations and work schedules should integrate sleep schedules before and during the work period as an essential dimension for their healthy life.



## 1. Introduction

Sleep restriction occurs when an individual fails to get sufficient sleep [1]. It mainly refers to the reduced number of hours of sleep that individuals experience from day-to-day or week-to-week. Normally it is suggested that adults should obtain about 8 h sleep per night [2]. The amount of sleep varies considerably from one person to another [3], but on average most adults need about 7–8 h of sleep each night to feel alert and well rested [1,4]. A person's quality of life can be disrupted due to many different reasons [5]. Lifestyle and occupational factors such as long hours of work, commuting, shift work, family and social commitments [5–7]. Due to high work demands, sleep restriction is becoming common in modern societies. Extended time awake and/or sleep restriction increase sleep pressure and generate cumulative sleepiness and impair neurobehavioral functioning [8]. Disruption of alertness and risk of professional errors is a major issue, when working under sleep restriction [9,10]. The nature of brain functioning underlying these behavioral changes remains poorly understood. Because of these conflicts understanding sleep restriction are becoming key issues. Event related potentials; especially the P300 can be used to study information processing during wake and sleep [11]. P300 (also referred to as P3b), is a centro-parietal distribution [12] and wave phenomenon that reflects conscious processes [13,14]. It is a slower, sustained posterior positivity elicited at around 300 ms [15]and considered as a high-level prediction error signal associated with conscious novelty detection. Event-related potential (ERP) or P300 are neurophysiological measures of arousal and information processing in the brain which may be capable of compensation during sleep loss and it that may be used to investigate the CNS nature of performance during

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sleepiness [16] by determining the timing of cognitive processes in the order of milliseconds using ERP. The global novelty response, associated with a P300 on EEG, depends on a conscious appraisal of the auditory sequence [17]. It arises from recurrent interactions in a broad set of interconnected areas, including fronto-parietal cortices [18]. The previous research has been done using ERP techniques to examine the neural basis of performance deficits during sleep loss under extreme conditions of total sleep deprivation [16,17,19,20]. The mechanism between sleep restriction and underlying brain physiology deficits is not well assumed among night watchmen. The objective of the present study was to investigate the mental attention and reaction time (auditory and visual) among night watchmen, at subsequent at first (1st) day, fourth (4th) day and seventh (7th) day of restricted sleep period by using electrophysiological techniques.

## 2. Method

### 2.1. Inclusion and exclusion criteria

All Participants (watchmen) employed in Peoples University and nearby Community were recruited for the study. Participants meeting the following criteria were included, healthy, good sleeper, non-smoker, and free from medications, no history of depression, neurological disease, or chronic pain and underwent a medical interview to ensure that they had a regular sleep/wake schedule. After signing consent, they were also evaluated for a visual and hearing test to ensure that their visual and hearing range was within an acceptable level for reaction time and to perform auditory ERP tasks. Initially 70 participants volunteer to participate, 20 were eliminated due to exclusion criteria or inability to follow schedule and medical factor. The remaining 50 participants completed the one-week protocol. The study was approved by the research advisory committee of People College of Medical Science and Research Center (PCMS/OD/2015/1056). The participants were divided into two groups. The study was performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from each subject before the start of the study.

The participants were divided randomly into two groups.

Group I-(Normal sleep) (n=28) – Twenty-eight watchmen (age=18–35 years) working in day time and used to have normal sleep in night ( ≥ 8 h).

Group II-(Restricted sleep) (n=22) – Twenty-two watchmen (age=18–35 years) working in night time and used to have less sleep in night ( ≤ 3 h).

### 2.2. Sleep schedule

The participants were instructed to maintain a regular sleep–wake schedule and were monitored. No stimulant of any kind was allowed during the study. For the tests obtained in the normally rested condition, instructed to the subjects to maintain normal sleep in night every day. The participants in the sleep restricted group also had a regular sleep schedule (8 h/night) before the beginning of the experiment and later on participants were instructed to sleep in night less than three hours ( < 3 h) for one week of their night shift schedule. All the participants were not allowed to sleep in day time. Participants slept at home and completed scheduled sleep diaries, regularly while at home, the duration of sleep was self-monitored. Total time in bed was recorded with a click button by the subject when getting into and out of bed. Participants reported less sleep during study duration which was also confirmed by monitors. After completion of one week study period, participants visited to the laboratory on the morning at 09:00 a.m. for assessment of electrophysiology and RT tasks performance. Each participant was tested after a normal sleep night and after a restricted sleep night in random order. The study was conducted in the department of physiology, Peoples College of medical science and research center, Bhopal, India. All the measurement was assessed at first (1st) day, fourth (4th) day and seventh (7th) day of restricted sleep period. Laboratory assessment of electrophysiology and reaction time took place three times at the end of study period.

### 2.3. Sleepiness measurement

Participant sleepiness was assessed using a modified version of the Karolinska Sleepiness Scale (KSS) [21]. The Karolinska Sleepiness Scale (KSS) is a 9-point Likert scale based on a self-reported, subjective assessment of the subject's level of drowsiness at the time. These descriptors varied from 1="very alert" to 9="very sleepy, fighting sleep, an effort to keep awake".

### 2.4. Mood measurement

Participant mood was assessed using the University of Wales Institute of Science and Technology (UWIST) mood adjective checklist [22], which measures three domains of mood: energetic arousal, hedonic tone and tense arousal. Both the KSS and UWIST mood adjective checklist are state assessments and were given prior to reaction time and ERP measurement.

### 2.5. ERP recording (P300)

The Site-specific changes in the P300 waveform with sleep restriction were examined. P300 was measured in a standard audiometric, sound proof room of neurophysiology laboratory at temperature of 26–30 °C by using Neuroperfect-2000. The "oddball" or "P300" task is commonly used in assessments of sleep restriction, deprivation, and sleep apnea [23–25]. In common, the task engages attention and generates changes in brain activity across the scalp, especially at central and parietal sites. A simple auditory oddball paradigm was used with 20% rare high tones (40 dB 2 kHz) and with 80% normal low tones (40 dB 1 kHz). The stimulus frequency was 0.5 Hz. Tone frequency (i.e., high vs. low) was used to denote the infrequent and frequent stimuli. Each participant was instructed that they would hear a series of tones. Participant had to press a button when they heard the rare "target" tones. Rare tones were at random mixed with the frequent tones. After the forced awakenings only 200 stimuli were offered in one trial in order to prevent the participant from falling asleep. Signals were derived from Fz, Cz and Pz with linked ears as reference electrode. Signals were averaged with a band pass of 0.1–50 Hz and with an analysis time of 1 s. Responses of the participants were recorded by Neuro machine (Evoked potential measuring system).

### 2.6. Reaction time (RT) recording

Visual and Auditory RT was measured by Borker and Pednekar [26] by using a simple electrical setup as explained previously by our research group [27].

### 2.7. Statistical analysis

Data are expressed as Mean ± Standard deviation (SD). All data were analyzed with the SPSS for windows statistical package (version 20.0, SPSS Institute Inc., Cary, North Carolina. Statistical significance between the different groups was determined by the independent student '*t*' test and repeated measured analysis was performed. The significance level was fixed at $p \leq 0.05$.