Research article

Evaluation of cognition using neurophysiological and neuropsychological tests in rotating night shift workers: a pilot study

Hemamalini Ramasamy Vajravelu[1], Prabhavathi Krishnan[1], Saravanan Ayyavoo[1], Krishnamurthy Narayanan[2]

[1]Department of Physiology, SRM Medical College & Research Center, Kattankulathur, Chennai, Tamil Nadu, India.
[2]Department of Physiology, Pondicherry Institute of Medical Sciences, Puducherry, India.

Correspondence to: R.V. Hemamalini, E-mail: hemaaghil@gmail.com

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Abstract

Background: The modern lifestyle is changing the circadian rhythm of the body especially in rotating shift workers. The impact of this might impair cognitive performance of the rotating shift workers who are frequently exposed to unstable circadian rhythm. **Aims and Objective:** To evaluate cognitive functions using neurophysiological and neuropsychological methods in rotating night shift and day workers and to compare cognition between the two groups. **Materials and Methods:** Forty healthy male security guards (25–35 years) who did rotating night shifts at least for 6 months and 40 day workers (25–35 years) who did not do night shift in last 2 years were involved in the study. A battery of neuropsychological tests, latency, and amplitude of P300 were recorded. **Result:** Kolmogorov–Smirnov test for normalcy showed the latencies and amplitude of P300 to be normally distributed. Student's unpaired *t*-test showed significant difference ($p < 0.05$) in the various neuropsychological tests and in the latency of P300 between night- and day-shift workers. There was no significant difference in the amplitude of P300. **Conclusion:** Night-shift workers who are prone to circadian rhythm alteration will have impaired cognitive performance.

KEY WORDS: Circadian rhythm; Shift workers; Sleep deprivation; P300

Introduction

Disruption of the normal sleep is inevitable in shift work particularly where night work is involved. Rotating-shift workers change from one shift schedule to another each week. In such a situation, the body's sleep–wake schedule is continually desynchronized and the body cannot adjust quickly enough to the differing external cues each week. Moreover, when the circadian rhythm gets disrupted so frequently, the body cannot adequately rest and rebuild. The earlier study confirmed that the visual-evoked potential (EP) of these workers were affected.[1] The study was further continued in the same group of subjects to find if the impact of this might also affect their cognitive performances, which can be assessed using a battery of neuropsychological tests and P300, a well-established neurophysiological approach.

Many of the studies did not show any significant difference in the cognitive performances of their shift workers.[2–4] Results have been controversial in few other studies. Certain studies have documented that the shift workers are prone to changes in cognitive performances.[5]

P300 is the event-related potential (ERP) appearing at about 300 ms following the task-related stimuli. These are long latency EPs that are related to cognitive processing and are referred to as cognitive EPs.[6] It depicts the various cognitive

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domains such as attention, discrimination, and working memory. Recent studies suggest that any change in the alertness or circadian rhythm of a subject would affect P300.[7]

There had been controversies in the results of cognitive assessment by neuropsychological method and P300 method of evaluation of cognition has not been done in male rotating night-shift workers.

So this study was carried out to assess and compare various neuropsychological tests and the ERP changes between shift workers and day workers.

MATERIALS AND METHODS

The study was carried out in the Department of Physiology in Pondicherry Institute of Medical Sciences, Puducherry, India, after getting institutional ethical clearance. This is a cross-sectional study. Thorough history regarding drug intake, smoking, alcohol consumption, and diseases such as seizures, hypertension, and psychiatric problems were obtained. Forty security guards who did rotating night shift for at least 6 months and 40 day workers who did not do night shift were involved in the study. Informed consent was obtained from all the participants before performing the test. This study was conducted for a period of 2 months following the earlier study, which was completed within 1 month. In the previous study, we assessed the visual EP in the same group of subjects.

Inclusion Criteria

Apparently healthy males within the age group of 25–35 years were involved.

Exclusion Criteria

Subjects with clinical evidence of auditory impairment due to any cause, those with chronic alcoholics and smokers, those with psychiatric disorders, those consuming antidiabetics, anti-psychiatric, anti-convulsant drugs, and those who are hypertensives and obese were excluded.

PROCEDURE

The day workers, who were taken as controls were asked to maintain sleep dairy for 1 week. This was to confirm whether they had critical 6–8 h of sleep and those with sleep disturbances were excluded. All workers were instructed not to consume any caffeinated beverages 2–3 h prior to the recording.

Event-Related Potential

The recording procedure, adapted from that of Aminoff[8] was carried out in light and sound minimized Physiology Research Lab maintained at 24 ± 1°C, at same time of the day for each of the subjects.

In sitting position, the sound stimulus that consists of rare tone (2000 Hz) and frequent tone (1000 Hz) was delivered binaurally through headphone to the patient 340 times at 0.9 Hz at 60 decibel. The rare stimulus formed 20% of the total 340 stimuli and was given randomly. The EP was recorded from the vertex of skull by using Ag–AgCl electrode with electrode paste. The common reference electrode was obtained by connecting two Ag–AgCl electrodes fixed on both side mastoid processes with the electrode paste. Ground electrode was fixed in the forehead. The response was recorded between 2 and 100Â Hz in the, EP, EMG, NC machine (Aleron, Recorders and Medicare System, Chandigarh, India).

Two averaged traces of 340 trials each was the final form of ERP. The latency and amplitude of ERP was tabulated.

Auditory and visual reaction time was done by the standard method followed by Nikam and Gadkari[9] by the reaction time apparatus (Anand Agencies, Pune, India)

Visual Reaction Time

The subject was seated comfortably on a stool. He was then asked to keep pressing the response button with the index finger of his dominant hand. He was instructed to remove his finger as soon as a light is flashed. The quickness with which he does so was measured in milliseconds, which was the measure of his visual reaction time.

The subject was familiarized with the procedure before the actual recordings commenced. Three sets of three recordings each were performed and the average thus obtained was taken as the visual reaction time of the subject.

Auditory Reaction Time

The subject while seated was asked to keep the index finger of his dominant hand pressed on the response button. The subject was told to remove his finger as soon as he heard a sound emitted by the apparatus. The time taken to remove his finger was noted in milliseconds. After familiarizing the subject with the procedure, three sets of three recordings were measured and the average was calculated.

Digit Vigilance Test

Numbers 1–9 were randomly arranged with 30 digits per row and 50 rows on the sheet of paper. The subject was asked to cancel out the digits 6 and 9 as fast as possible without missing the target digits. The time taken to complete the test gives the score that assesses the sustained attention levels of the individual.[10,11]

Stroop Test

The names of the color such as blue, green, red, and yellow were printed in 16 rows and 11 columns in capital letters on a sheet of paper. The color of the print most of the time does not match with the color designated by the word. The subject was asked to read all the words column-wise as fast as possible. The time taken to read all the 11 columns was noted in seconds. Then, the subject was asked to name the color in which the word was printed. The time taken to name all the colors in all columns were noted down in seconds. The reading time was subtracted from the naming time to get the test score.[11]

Statistical Analysis

Analysis of data was carried out with the help of SPSS version 19. Data were represented as mean ± standard deviation. Normalcy of data was tested by Kolmogrov–Smirnoff test. Unpaired Student's *t*-test was used to compare the various cognitive tests between the study groups. $p < 0.05$ was considered for statistical significance.

Results

Tables 1 represents demographic characteristics of shift workers. Tables 2 shows significant difference in various neuropsychological tests between night shift workers and day workers. Tables 3 shows the comparison of the latency and amplitude of P300 of both the groups. There was significant prolongation in the latency of P300 and significant decline in amplitude of P300 among night shift workers when compared to day workers.

Discussion

The circadian rhythm is an endogenously driven biochemical, physiological, and behavioral process in the body that functions like a biological clock regulating sleep and wake cycle. Rotating shift workers are exposed to unstable sleep pattern due to frequent disruption of circadian rhythm. Previous study have determined the prolongation in the latency of visual EV of these workers when they work against their natural sleep cycle[1] and this study which was carried out in the same group of subjects confirm that their cognitive performances also gets deteriorated.

The effects of cognition on varying durations of sleep deprivation have been the focus of interest and subject of many studies.[1–3] It has been considered in certain studies that night shift work affects their cognitive performances.[12] In this study its effect on rotating shift workers have been assessed using both neurophysiological and neuropsychological methods.

Rotating night shift workers performed poorly when compared to day workers in the various neuropsychological tests done for assessing their cognition. Reaction time provides an indirect index of the processing capability of central nervous system.[12] It assesses the information processing speed. McCarthy and Waters[13] revealed significant effects of sleep deprivation on both cognitive and physiological measures including reaction time, which is supportive of this study. Another study also shows that sleep deprivation increases reaction time.[14] In contrast, study carried out by Namita et al. suggests that there is no significant difference in the reaction times in shift workers,[15] which could be due to variation in individuals' adaptability to shift work pattern.

Table 1: Demographic characteristics of night (NSW) and day shift workers (DSW)

Characteristics	NSW	DSW
Age (years)	28.68 ± 3.9	27.88 ± 3.4
Height (cm)	165.38 ± 5.28	168.63 ± 6.10
Weight (kg)	61.55 ± 9.32	71.18 ± 8.52
BMI (kg/m^2)	21.84 ± 1.06	22.37 ± 1.04

BMI, Body mass index.

Table 2: Comparison of neuropsychological tests between NSW and DSW

Neuropsychological tests	NSW	DSW	*p*-Value
Visual reaction time (ms)	264.5 ± 30.6	182.8 ± 14.9	0.001
Auditory reaction time (ms)	227.4 ± 36.6	153.2 ± 17.6	0.000
Digit vigilance test (s)	550 ± 60.70	320 ± 40.32	0.000
Stroop test	196.30 ± 34.47	141.10 ± 11.85	0.000

NSW, night shift workers; DSW, day shift workers.

Table 3: Comparison of P300 latency and amplitude between NSW and DSW

	NSW	DSW	*p*-value
P300 Latency	323.5 ± 26.1	278.4 ± 35.3	0.000
P300 Amplitude	5.33 ± 2.74	9.52 ± 3.57	0.000

NSW, night shift workers; DSW, day shift workers.

Digit vigilance test is a measure of sustained attention. Attention was found to be impaired in shift workers in a study done by Saricaoglu et al.[16] which coincides with this study. McCarthy and Waters[13] indicated that sleep deprivation decreased the subject's attentional responsivity to new information and simultaneously reduced the efficiency of their cognitive processing. Among the BPO employees who did shift duties for 6 months did not show any deterioration in their attention.[11] This finding contradicts with our observation which suggests impairment in the attention of shift workers. This indicates the shift workers do not get adapted with their longer duration of shift work instead they are more affected.

In this study, the executive function was assessed by Stroop test. There was decreased response in rotating shift workers. Sleep deprivation in rotating shift workers interfere with the functioning of frontal brain areas which is important for executive function of the brain.[17,18]

P300 latency reflects the time needed for the cognitive process and P300 amplitude is considered to reflect the amount of attentional resources.

In this study, P300 latency of rotating shift workers were prolonged significantly and amplitude were found to be decreased significantly. Similar findings have been reported by Morris et al.[3] He reported reduced P300 amplitude and increased latency during 18 h of sleep deprivation. In the most recent and most comprehensive study of EV effects of sleep deprivation, Gosselin et al.[19] confirmed that 36 h of sleep deprivation causes decline in P300 amplitude. Certain studies have documented that prolongation in P300 latency occurs when there is difficulty in differentiating between the stimuli.[16]

This latency increase suggests the longer time taken for stimulus evaluation when discriminations are difficult.[20]

In contrast, Cote et al.[21] found no changes in P300 following two nights of sleep fragmentation. Kingshott et al.[22] found reduced P300 amplitudes following a night of sleep fragmentation at some frontal, central, and temporal scalp sites but not over parietal areas where P300 is most prominent. The probable reason for contradicting results could be due to the adaptation of the individuals.

In the work place, individual's ability to cope up with the specific shift work pattern must be assessed and those who can withstand can be allowed to continue and others must be shifted to day work. This study indicates that cognition gets adversely affected for those who cannot adapt with longer duration of same shift work pattern.

Limitation of the Study

Small sample size was considered in our study. Larger sample size would assess the sensitivity and specificity thereby the validity of the neurophysiological method – auditory ERP P300 in assessing cognitive deterioration in shift workers.

Conclusion

Cognitive performances of the rotating shift workers are significantly affected. Cognitive deteriorations induced by circadian rhythm alteration are consequences of neurophysiological changes in brain processes that lead to decreased amplitude and longer latency in the P300.

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