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Influence of Rotating Roaster on Visual Evoked Potentials in Pink Collar Shift Working Nursing Personnel

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ABSTRACT
Sleep deprivation is common among nurses due to demanding schedules, potentially impacting cognition, and patient care. The effects of sleep deprivation on visual evoked potentials (VEPs) in nurses remain unclear. ***Materials and Methods:*** *This study included 30 rotating-shift nurses and age-matched day-shift controls. Participants completed the Epworth Sleepiness Scale and underwent visual evoked potential (VEP) testing (checkered pattern reversal) word after their shifts. VEP parameters, including N75, P100, N145 latency, amplitude, and waveform morphology, were analysed to assess the impact of sleep deprivation on visual processing.* ***Results:*** *The results revealed Epworth sleepiness scale values of (10.8±2.89) in shift workers as compared to their controls (7.2±3.1), significant alterations in VEP parameters following sleep deprivation. Nursing staff posted on rotatory night shifts exhibited prolonged latencies of N75, P100, N145 waves (82±5.13,107 ±7.02, 149± 6.91) respectively and reduced amplitudes of N75-P100, P100-N145 waves (5.515±1.91, 4.213±5.73) as compared to the day time controls indicative of compromised visual neural processing along with early sensory and higher order cortical processing.* ***Discussion and Conclusion-*** *Sleep deprivation exerts a detrimental influence on visual evoked potentials in nurses, indicating compromised visual neural processing. Addressing sleep-related factors is essential for maintaining cognitive function and ensuring high-quality patient care.*
Keywords: *Nurses, Pattern reversal, Sleep deprivation, Visual evoked potential*

INTRODUCTION

Sleep is a physiological circadian behaviour which is regulated by the supra-chiasmatic nucleus and sleeping at dark hours is an accompanying behaviour following it. Optimal health in individuals aged 18-60 necessitates a minimum of 8 hours of sleep nightly, as per prevailing literature. Sleep deprivation has been correlated with a spectrum of adverse health outcomes, encompassing diabetes, obesity, hypertension, coronary artery diseas, stroke, and elevated mortality rates.[(1)] In recent years, the healthcare sector has witnessed a surge in the demand for round the clock patient care, leading to an increased prevalence of rotatory night shifts among the paramedical health care professionals like nurses. However, this shift often disrupts the sleep wakefulness cycle leading to sleep deprivation. Such sleep deficits can adversely affect cognitive structures like the visual processes which are critical for nurses' efficiency and patient safety.

In nursing professionals, fatigue relates to a reduction in cognitive function, particularly in attention and vigilance. This condition is associated with decreased job performance and compromised patient safety.[(2)] Night-shift nurses typically experience a significant decline in vigilance, from the beginning to the end of their shift (3).A decrease in alertness was noted during work hours, believed to be attributable to extended working hours from the previous day and consecutive days of overtime.[(3)] Night shift workers especially the nurses are subjected to an altered biological clock. Exposure of the bodies to altered day and night cycles makes them prone to circadian rhythm disturbances namely in the form of decreased focus, attention and sensory disturbances in the form of visual and auditory disturbances.[(4)]
Visual event-related potentials (ERPs) are utilized to study fundamental neural processes, representing neural activity from the scalp. By analysing amplitude and latency, one can pinpoint the stage of information processing affected by sleep deprivation in behaviour(5). A study has found a statistically significant reduction in the amplitude and increase in latency of the P300 event related potential in response to sleep deprivation.[(6)]

Changes in attention and arousal levels can significantly influence early visual event-related potential (ERP) components. This is evident in the gradual decrease in early visual amplitudes when attention is diverted from the central point, indicating selective filtering of early sensory visual information.[(7,8)] Previous research has linked decreases in the P100 component, especially within the magnocellular visual system during early visual processing, with attention deficits. [(9,10,11,12)] This study addresses the perceived need of assessing the negative consequences of sleep deprivation in nursing staff which may affect their sensory health which may directly or indirectly affect their work performance. The study aims to explore the influence of sleep deprivation resulting from rotatory night shifts on nurses visual evoked potentials shedding light on neurological consequences of irregular sleep patterns.

MATERIALS AND METHODS:

- **Study Design**: A Comparative Study.
- **Sources of data:** 4th year nursing students doing rotatory night shifts for 15 days (8pm-8am) aged 21-23 years.
- **Venue:** Neurophysiology lab at Department of Physiology, KAHER" S JNMC,Belgaum

The study was granted IEC clearance (MDC/DOME/77). The entire purpose of the study was explained to the participants and a voluntary written informed consent taken from all of them prior to the study.

Participant characteristics:

- **Inclusion Criteria**:

Nursing students doing night shifts (8pm-8am) aged 21-23 years.
Both males and females were recruited.
H/O of at least 12 hours of sleep deprivation.

- **Exclusion Criteria:**

H/O prior sleep disorder
Visual Acuity<6/18
H/O diabetes or other major illness.
H/O alcohol consumption or tobacco chewing.
H/O any psychiatric illness or
H/O of consumption of any medication affecting sleep (eg: cetrizine).

- **Sample Size:** The sample size is determined by using this formula:

$$n = Z2\ pq/d2$$

Z2 = Standard score corresponding to a given confidence level. Example, at 95% Confidence Level or 5% level of significance (α = 0.05), Z = 1.96.
P = Prevalence of of disease is 5.36%
q = (1 – p) or percentage of failure which is 100 - 5.36= 94.64%.
d = Precision limit or proportion of sampling error which is usually 5% confidence limit.
Therefore, Sample Size=58, rounded to 60.

Protocol:

Our experimental group was posted for night duties at tertiary hospital for continuous 15 days. The examination of the sleep deprived sleep workers started on the third day of their posting. All the participants reported to the Neurophysiology lab at Dept. of Physiology for investigations. The study was approved by Institutional Human Ethical clearance
(MDC/DOME/77). The entire purpose and protocol of the study was explained to the participants and a written voluntary informed consent taken from all of them prior to the onset of the study. The participants had to refrain from caffeinated drinks and report to the lab at around 10 am. A proper medical history and, H/O of consumption of any medications like antidepressants, anticholinergic or any mydriatic/miotic eye drops was collected. The participants underwent anthropometric measurements followed by ophthalmological examination using Snellen and Jaeger's charts. The participants had to fill Epworth sleepiness scale followed by VEP recordings on Clarity Octopus software in a dark neurophysiology room.

Data Collection Tools:

1.Epworth Sleepiness scale [13]

The ESS is a self-administered questionnaire with 8 questions. Respondents were asked to rate, on a 4-point scale (0-3), their usual chances of dozing off or falling asleep while engaged in eight different activities.

0-5 Lower Normal Daytime Sleepiness
6-10 Higher Normal Daytime Sleepiness
11-12 Mild Excessive Daytime Sleepiness
13-15 Moderate Excessive Daytime Sleepiness
16-24 Severe Excessive Daytime Sleepiness

2. **Tests Used: VEP-**

VEP was measured after explaining the subject about the procedure to ensure full cooperation. Subjects were advised to avoid hair spray or oil after the last hair wash. Subjects with refractive errors were asked to put their usual glasses during the test. The scalp skin was prepared by abrading and degreasing. VEP was recorded using a PC based Clarity Octopus machine and electrodes made up of silver chloride. As per 10-20 International System of EEG placements, the reference electrode (Fz) was placed 12 cm above the nasion,recording electrode was placed at OZ approximately 2 cm above the inion and the ground electrode was placed at the vertex (Cz) using conducting jelly. The electrode impedance was kept below 5KΩ. The standardized methodology is recommended by the International Federation of Clinical Neurophysiology Committee and International Society for Clinical Electrophysiology of Vision. Low cut filters were set at 2 HZ and high cut filters at 100 HZ. The filters setting was kept constant throughout the study. The sweep duration was kept at 300ms. [14] The recording was done in a dark room. The visual stimulation was done using a checkered pattern which consisted of black and white checks whose phase would also reverse at a fixed rate of 2 reversals per second. The subject was asked to sit at a distance of 100 cm from the monitor and mono ocular stimulation was given. The participants were instructed to fix their gaze at red Colour dot in the centre of checkerboard pattern. Every time there is alteration in the checkerboard pattern, the subject's visual system will generate an electrical response which will be recorded and stored in the computer. The responses of 100 stimulations were averaged and two similar averages were considered for each eye. It was ensured that the patient did not sleep during the procedure. The VEP parameters recorded were latencies to N75, P100 and N145 waves, and peak to peak amplitude of N75-P100 and N100-N145 waves. [15] These values were then computed and expressed as mean ± SD at the assigned electrode sites.

Statistical analysis:

Descriptive data was entered onto Microsoft Excel and interpreted as Mean ± SD. IBM SPSS version.26 software was used to analyse the data. The differences between the groups were computed using Unpaired Students t test and p value was considered as statistically significant if <0.05.

Consort Diagram:

Nurses posted for night and day duties
(N=60)

Screened for Eligibility

Nursing students doing night shifts (8pm-8am) aged 21-23 years
Both males and females were recruited.
H/O of at least 12 hours of sleep deprivation

Recruitment

Experimental Group (n=30)
Sleep Deprived Shift workers

Control Group (n=30)
Day workers

Outcome Assessment:
Epworth sleepiness scale
VEP-N75, P100, N145

Data Analysis

RESULTS:
Table no 1-Socio-demographic Details-

Age	21-23yrs
Gender	Females(SD=18 and Controls= 18) and Males(SD=12 and Controls= 12)
Qualifications	Bsc Nursing students and PBBsc students doing night shift at KLEH and daytime working Nursing students at KLE's Hospital and Research Centre
Hours of actual sleep (SLEEP LOG)	Average 4-5 hrs of daytime sleep in shift workers (nurses) as compared to 8 hrs of night time sleep in control population working in day hrs.
Substance abuse like smoking, alcohol etc.	Nil
History of Social media usage(Hours)	Average 3±1.01
Start time- end time of shifts	8 pm-8 am

	Shift workers	Controls	T value	P value
Epworth Sleepiness Scale	10.8±2.89	7.2±3.1	8.33	0.0018*

Table 1 presents the socio-demographic details of the study participants. The age range was 21-23 years, with 18 female and 12 male participants in both the sleep-deprived (shift workers) and control groups. It also shows that Shift workers had significantly higher daytime sleepiness scores (10.8 ± 2.89) on the Epworth Sleepiness Scale compared to controls (7.2 ± 3.1), with a T-value of 8.33 and P-value of 0.0018, highlighting the negative impact of shift work on sleep quality.

Table no 2- Comparison of Anthropometric measurements in Males and Female Nurses.

	Sleep Deprived Shift Workers (Females) (n=18)	Control (Females) (n=18)	P value	Sleep Deprived ShiftWorker (Males) (n=12)	Controls (Males) (n=12)	P value
Height (cm)	150.3±2.31	152.9±4.079	0.08	168.11±5.13	167±4.47	0.67
Weight(Kg)	56±2.11	55±1.79	0.46	67.912±1.6	68±2.60	0.112
Head Circumference(cm)	52.33±2.8	51.69±1.27	0.55	54.6±7.3	55.11±6.11	0.07

***- Statistically significant, p<0.05**
Table 2 compares anthropometric measurements between sleep-deprived shift workers and controls, categorized by gender.

Table no 3- Comparison of Visual Event related potentials Amplitudes to Pattern reversals among Sleep Deprived shift workers and Controls.

	Sleep Deprived Shift workers(n=30_)	Controls (n=30)	**T Value**	**P value**
N 75- P100 Amplitude (µv)	5.515±1.91	6.06±3.20	6.16	0.0012*
P 100 –P 145 Amplitude (µv)	4.213±5.73	7.77±8.05	5.92	0.0043*

***- Statistically significant, p<0.05**

Table 3-compares the amplitudes of visual event-related potentials (ERPs) in response to pattern reversals between sleep-deprived shift workers and controls. Results show significantly lower N75-P100 and P100-P145 amplitudes in sleep-deprived shift workers compared to controls. The T-values and P-values indicate strong statistical significance (P < 0.05), suggesting that sleep deprivation negatively impacts neural responses in visual processing.

Table no 4- Comparison of Visual Event related potentials Latencies to Pattern reversals among Sleep Deprived shift workers and Controls.

	Sleep Deprived Shift workers Rt Eye(n=30)	Controls Rt Eye(30)	Sleep Deprived Shift workersLt Eye(30)	Controls Lt Eye(n=30)
N 75 Latency (ms)	81±6.04	72±3.31	83±7.22	71±1.507
	0.001*		0.071	
P 100 Latency (ms)	102±5.43	99±4.21	112±7.68	109±7.18
	0.003*		0.05*	
P 145 (ms)	150±9.36	138±5.51	148±6.487	142±5.74
	0.001*		0.086	

*- Statistically significant, p<0.05

Table 4 compares the latencies of visual event-related potentials (ERPs) to pattern reversals between sleep-deprived shift workers and controls for both eyes. Sleep-deprived individuals exhibit significantly longer latencies for N75, P100, and P145 in several comparisons, indicating delayed neural responses. Significant differences were observed for N75 latency in the right eye (p=0.001), P100 latency in both eyes (p=0.003 and p=0.05), and P145 latency in the right eye (p=0.001). These findings highlight the adverse impact of sleep deprivation on visual processing speed.

DISCUSSION-

The study was conducted to investigate the profound impact if any of sleep deprivation resulting from rotatory night shifts on nurses working at tertiary care hospital with a control group with consistent day time schedules on their visual cortical processing compromising their ability for accurately process stimuli increasing their susceptibility to errors. The Epworth sleepiness scale values of (10.8±2.89) in shift workers as compared to their controls (7.2±3.1) indicated that the rotatory night shift workers were more sleepy and had a poor quality of sleep as compared to their counterparts[Table 2] .The marker of visual processing used was Visual Evoked Potentials which consists of a series of waveforms: N75, P100 and N145wave where the latency are measured in (in milliseconds) and amplitudes of N75-P100 and P100-N145 (in microvolts).[16] These waves represent the electrical activity produced by series of neurons involved in the visual pathway in response to a visual stimulation. N75 wave which is the first negative wave reflects foveal stimulation and originates in Brodmann's area 17.The First positive wave P100 wave is due to discharge of thalamocortical nerve fibers and arises in the primary visual cortex and represents the spatial attentive processes[17,18]while the second negative wave N145 is due to stimulation of visual association area 18. [19]

Our study showed prolonged latencies in N75, P100 and N145 waves of both eyes in shift workers which was statistically significant (Table no 4) as well as reduced amplitudes of P 100 wave. Age apparently has a significant effect on P100 amplitudes following 50 years of age, which may be due to changes in the retina as well as rostral part of visual system [20] but the mean age group of our participants was around

22 years, to not confound the results. Studies have stated the presence of photosensitive melanopsin in the retinal ganglion cells (ipRGCs) which control the pupillary diameter [21] through which the supra chiasmatic nucleus gets entrained through retino-hypothalamic tract and regulates the sleep wakefulness cycle. The supra-chiasmatic nucleus provides impulses to the pineal gland for secretion of melatonin and other feedback loops which mediates clock information the peripheral tissues and affects pupillary diameter. [22]Studies have proven that a reduction in the pupillary diameter by 1.73mm reduces the P100 latency due to reduction in the area of retinal illumination.[23,24,25] Our results are similar to a study conducted where the researchers found sleep deprivation prolonged N 145 latency in both the eyes though statistically significant in the dominant eye. [26] The N 75-P 100 as well as P100- N 145 amplitudes showed a reduction in the shift workers as compared to the controls (Table no 3). Our results are similar to a study conducted by Jackson et al who suggested that slower rate of processing along the visual system along with sleep pruned cognitive dips as the reason of reduced amplitudes. [7]

Sleep loss affects functional connectivity within the visual system, leading to disruptions in the synchronized activity of cortical regions involved in visual processing. Sleep deprivation could involve impairments in processing spatial frequency, contrast sensitivity, colour perception, or motion detection, reflecting the diverse functional properties of visual sensory neurons. Our results show affection of higher order cortical processing system which are dependent on spatial attention and sleep deprivation increases the propensity towards microsleeps which may lead to such perceptual and visual deficits.

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cognitive processes, such as attention and meSleep deprivation disrupts neural processing along the visual pathway, leading to delayed latencies, reduced amplitudes, and altered waveform morphology of VEP. The above suggest a compromised transmission of impulses from the retina to the higher order cortical centres of the brain. These changes in VEP parameters reflect altered interactions among visual areas, impacting the integration and interpretation of visual processing of stimuli.

The findings highlight the deleterious effects of sleep deprivation on visual neural function in nurses, in the form of errors of omission which may have implications for patient safety and occupational performance. The observed alterations in VEPs underscore the need for interventions to mitigate the adverse effects of sleep deprivation on cognitive and perceptual abilities in healthcare professionals. Future research should explore strategies to optimize sleep quality and promote shift work scheduling practices that minimize the impact of sleep disruption on visual function to ensure better patient care.

CONCLUSION-

The influence of sleep deprivation in paramedical professions like nursing on visual processing underscores the close Gordian knot between sleep and sensorineural processing. Understanding the above shall provide insights into the mechanisms underlying the cognitive and perceptual impairments induced by rotating shift work and would help suggesting healthcare organizations and policy makers to implement evidence-based strategies aimed at mitigating sleep related impairments in nurses. Interventions such as optimized shift scheduling, targeted fatigue management programs would alleviate the burden and improve patient outcomes.

Implications: VEPs show recovery after sleep restoration, indicating reversible sleep deprivation effects and visual system neuroplasticity. Monitoring VEP changes could aid in diagnosing sleep disorders and improving interventions for occupations requiring prolonged wakefulness, such as nursing.

Author Contributions:

Study Conception and/or Design-NSA and RYS
Data Processing, Collection, Perform Experiment-NSA
Analysis and Interpretation of Results-NSA and RYS
Draft Manuscript Preparation, Visualization- BD
Critical Revision or Editing of the Article-NSA
Final Approval of the Version to be Published-BD

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