10.5958/2320-608X.2019.00137.9

A Comparative Study of Sleep Quality and Heart Rate Variability Index in Shifts and Non-Shift Working Population of Bengaluru

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Abstract

Background: Urban working population lead a busy stressful life with poor sleep quality and health. The present study targets working population including both Shift and Non-Shift (9am-6pm) workers to analyse their sleep quality and heart rate variability and to evaluate for association between them.

Objectives: This study aims to analyse Sleep quality and Heart Rate Variability (HRV) in working population of Bengaluru and to evaluate for association between these two parameters in the study group.

Materials and Method: 50 professional workers in the age group of 20-35yrs were subjectively analysed for their quality of sleep using Pittsburgh Sleep Quality Index (PSQI). HRV was recorded with finger photoplethysmograph using infrared light, placed on left index finger of subjects. The analog signals of the device were digitized and reported through Kubios HRV software.

Results: Sleep quality and HRV indices were found to be better in people working from 9am-6pm shifts (Non-Shift workers) compared to people working in other shifts. Significant correlation between Sleep quality and HRV indices was observed.

Conclusion: Non-shift workers have better Sleep quality and HRV indices compared to Shift workers in Bengaluru city.

Keywords: *Sleep quality, Pittsburgh Sleep Quality Index, Heart Rate Variability, Shift workers, Non-Shift workers, finger photoplethysmograph, Kubios HRV software.*

Introduction

17.9 million people die every year due to Cardiovascular diseases, which constitutes 31% of all global deaths[1]. The cardiovascular disease (CVD) burden is rising in developing countries like India. Additionally, CVD in Indians has been shown to occur at least a decade or two earlier than their counterparts in developed countries[2].

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In India, urban working population leads a busy stressful life and have poor sleep quality and health. Many people are seen to be working round the clock in different shifts divided within 24-hour span. It is said that, approximately 15% of healthy individuals do not adapt adequately to the effects of shift work, therefore regular night duties performed by them has an association with a relatively high health risk. Desynchronization of circadian clocks, resulting due to shift work, leads to higher risk of being prone to hypertension, dyslipidemia, insulin resistance and obesity[3].

Recently, Heart rate variability (HRV) analysis has been commonly performed for the assessment of the cardiovascular autonomic nervous system. The oscillations present in the beat-to-beat pacing intervals of heart rate are directly influenced by the sympathetic

and parasympathetic systems. Usually, time and frequency domain and nonlinear method are used to interpret the physiological information present within the HRV signal. The classical spectral analysis of the HRV signal, enables separation of power distribution in different frequency bands. The low frequency (LF) band corresponds mainly to sympathetic activity, the high frequency (HF) band is related to respiratory sinus arrhythmia mediated by parasympathetic activity and the LF/HF ratio indicates overall balance between sympathetic and parasympathetic systems.

Photoplethysmography (PPG) is a noninvasive technique for monitoring beat-to-beat relative blood volume changes in the microvascular bed of peripheral tissues using infra-red rays. The autonomic influences on spontaneous fluctuations in finger blood volume can be assessed by spectral analysis of the PPG signal. The PPG waveform characteristics such as amplitude, baseline and cycle period can be used for the study of autonomic control of the peripheral vascular tone[4].

Heart rate, cardiac autonomic activity shows circadian variation (i.e., under constant behavioral and environmental conditions). This knowledge of behavioral vs. circadian modulation of cardiometabolic function is of clinical relevance given the increased risk for the development of diabetes, obesity, and cardiovascular disease in shift workers[5].We aimed to analyse and evaluate the association between Sleep quality and Heart Rate Variability (HRV) in Shift and Non-shift working population of Bengaluru.

Method and Materials

After getting clearance from ethics committee, written informed consent was taken from all the participants and detailed clinical examination was done as per study protocol. Subjects were asked to arrive to the Department of Physiology, Bangalore Medical College and Research Institute. Detailed history was taken, and examination was done. It was a comparative study and the 50 subjects, included were grouped as Shift workers (25 in number, amongst whom 14 were males and 11 were females and worked in shifts of 11pm-8am /4pm-1am /5pm-2am /6pm-3am) and Non-Shift workers (25 in number, 13 males and 12 females and worked 9am-6pm) belonging to the age group of 21-36yrs.

Inclusion criteria

1. Professional workers
2. Education-Graduates

Exclusion criteria

1. BMI–$\geq$ 25 kg/m^2
2. Medical/Psychiatric Illness
3. Smoking, Alcohol intake
4. Substance abuse
5. Drug intake/Medications

Height & weight were measured by using stadiometer & digital weighing balance. BMI was calculated by using the formula Weight in Kg/Height in meter square. Blood Pressure and Heart rate were recorded by using automated B. P. apparatus.

All the subjects were asked to fill the PSQI assessment and were scored accordingly. PSQI questionnaire included 9 questions related to the sleep habits of past 1 month and each of the answers were scored (except for question no 1 and 3). Seven standard components were used to score the answers as per the protocol of the PSQI questionnaire and a total score of "5" or greater was indicative of poor sleep quality[6].

All the subjects were clearly instructed in prior to come to the lab before intake of food/beverage, after having a well-rested sleep (sleep timings varied in subjects of the test group). They were instructed to avoid caffeine/any beverage 2 hours before measurement[7]. Appropriate environment necessary for HRV recording was setup, with not too bright lights, sound proofing and temperature set at room temperature.

Each of the subjects were given 15 mins time to get accustomed to the new environment and to attain comfortable resting state. HRV was measured by Digital finger pulse plethysmography using infra-red light with wave length of 940 nm; placed on the right index finger of the subject. The output signal was digitalized by digital converter with a frequency of 100 Hz; which was connected to the computer and analyzed through Kubios software[8].

HRV measurement was done for 5 mins and during the process, it was ensured that the subject was comfortably seated. Subjects were instructed to keep their eyes open throughout the recording, breathing quietly and to not move or talk or fall asleep[7].

Statistical analysis: The measured HRV was compared between night shift and Non-shift employees.

All the parameters were expressed as mean ± SD. Student t test (two tailed, independent) was used to find the significance of study parameters on continuous scale between two groups. Significance was assessed at 5 % level of significance.

Results

Table No. 1: Comparison of PSQI scores and power distribution in different frequency bands between the Shift and Non-shift workers; **denotes p value is highly significant; *denotes p value is significant.

Variables	PSQI score	VLF (ms²)	LF (ms²)	HF (ms²)	Total Power (ms²)	LF/HF
Shift workers (n = 25)	7.5	61.08	278.2	196.84	537.32	1.477
Non-shift Workers (n = 25)	2.5	236.5	1146	1565.5	2950	1.137
p-value	<0.001**	<0.001**	<0.001**	<0.001**	<0.001**	0.02*

As shown in Table. No. 1, Mean PSQI score for the assessment of the Sleep quality are high in the Shift workers i.e., 7.5 when compared to the mean score of the Non-shift workers i.e., 2.5. A score of ≥5 denotes bad quality sleep and scores <5 denotes relatively good quality sleep [6]. Therefore, the sleep quality in Non-shift workers was found to be better than the sleep quality of the Shift workers.

The power distribution in different frequency bands were expressed as absolute values (ms^2) in both the groups as shown in the table. Low frequency (LF) and high frequency power (HF) components were defined by the power spectrum ranges of 0.04-0.15 Hz and 0.15-0.4 Hz, respectively [7]. It is clear by the table that the Shift workers had significantly lower values of VLF, LF, HF, Total power bands in comparison to Non-shift workers, whereas the LF/HF ratio was significantly higher in Shift workers.

Discussion

Autonomic nervous control of the cardiovascular system has a distinct circadian rhythm, and this may be an important mechanism underlying the diurnal distribution of cardiac events such as myocardial infarction and sudden cardiac death. A non-invasive technique used for investigating cardiovascular autonomic control is the analysis of HRV in the frequency domain[9]. Decrease of HRV is frequently associated with coronary artery disease (CAD), and the degree of this impairment is reported to be a predictor of mortality in such patients[10].

In mammals, two groups of circadian clocks have been described, namely central circadian clocks (located in the suprachiasmatic nucleus) and peripheral circadian clocks. Suprachiasmatic nucleus (SCN) generates 24-hour endogenous circadian rhythms that allow for the coordination of physiological, metabolic and behavioural activities with external light/dark cycles and anticipates daily environmental changes. Peripheral circadian clocks are found in almost all tissues, including the non-SCN cells in central nervous system. It is still not clear how these peripheral clocks are synchronised by the central SCN clock, although the involvement of neurohumoral stimuli cannot be ignored.

One of the significant characteristics of circadian rhythms is their ability to be synchronised by zeitgebers (external time cues). Light is the most potent stimulus for synchronizing endogenous rhythms of the body. Synchronisation depends on the timing, intensity, duration and the wavelength of light. Photic information is transmitted through the retinothalamic tract to the SCN.

In conditions where there is abrupt change in an individual's habit of sleeping, resynchronization of rhythms can be achieved by a brief nap during the day or a transient nocturnal awakening. Thus, short term desynchronization in sleep rhythm would never cause a change in the body's endogenous clock. Such short-term desynchronization leads to sleep disturbances, shift-lag syndrome, increased risk of errors and work related accidents. But when the desynchronization occurs over a prolonged period (approximately five days), a mismatch between the endogenous and exogenous components of the rhythm occurs. The long-term desynchronization results in disturbances of the cardiovascular and gastrointestinal systems, impaired glucose and lipid metabolism, reproductive difficulties and breast cancer.

Shift work also changes the diurnal variation of blood pressure. The normal daily circadian blood pressure rhythm is characterized by a nocturnal fall and diurnal rise. People who work in night shifts show limited or no nocturnal BP fall. Cardiovascular outcomes usually worsen in individuals who have an excessive morning BP surge and in those who lack the normal nocturnal BP fall[3].

In a study conducted by Kunikullaya et al., it was determined that sleepiness was significantly higher among night shift workers as measured by Epworth Sleepiness Scale ($p<0.001$). Night shift employees were found to have lower values of HF power (ms^2), and higher values of LF Power (ms^2) than day shift employees, unlike the present study. LF/HF power also showed higher values (%) suggesting decreased vagal activity and sympathetic over activity, when compared to day shift employees[2].

Hulsegge G et al conducted a study where shift workers had no significantly different HRV parameters than day workers, except for a lower VLF (B: 0.21; 95% CI: 0.36-0.05) in non-night shift workers ($p < 0.05$). Results differed significantly by gender (p for interaction < 0.10): among men, shift work was negatively associated with RMSSD (B: 7.83; 95% CI: 14.28-1.38), SDNN (B: 7.0; 95% CI: 12.27-1.78), VLF (B: 0.27; 95% CI: 0.46-0.09) and Total Power (B: 0.61; 95% CI: 1.20-0.03), while among women, shift work was only associated with the LF/HF ratio (B: 0.29; 95% CI: 0.54-0.03)[11].

Limitations: Although the present study was age and gender matched amongst the two groups, the sample size was very small (n=50; 25 Shift workers and 25 Non-shift workers).

Conclusion: Individuals working in night shifts tend to have more of sympathetic activity showing Sympatho-Vagal imbalance with higher LF/HF ratio values. Sleeplessness and disturbance in circadian rhythm could be the cause for the imbalance. Such people should be offered regular occupational health services which should include the screening of risk factors for cardiovascular diseases, such as: a history of shift work, smoking, high blood pressure, obesity, alcohol use, high blood lipid levels, physical inactivity and work stress.

Conflict of Interest: Nil

Source of Funding: Self

Ethical Clearance: Taken from the Ethical committee of the Institution

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