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RESEARCH ARTICLE

Effects of overnight sleep deprivation on autonomic function and perceived stress in young health professionals and their reversal through yogic relaxation (Shavasana)

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ABSTRACT

Background: Extensive research has been done to demystify the effects of sleep deprivation on cognitive functions, memory, and reasoning ability. However, there is a lacuna in regard to the effects on autonomic function and perceived stress as well as its modulation through yogic relaxation. Healthcare professionals often work at night, and the effect of acute overnight sleep deprivation on their performance is crucial. **Aims and Objectives:** The present study was undertaken to study the effects of overnight sleep deprivation on autonomic function and perceived stress in health-care professionals and to determine its modulation through yogic relaxation (Shavasana). **Materials and Methods:** A total of 35 healthcare professionals, aged between 20 and 25 years, were recruited from emergency services wing (casualty) of MGMC and RI, Puducherry, and taught yogic relaxation. Heart rate (HR), blood pressure (BP), and HR variability (HRV) were recorded and Cohen's perceived stress scale (PSS) administered before the commencement of day duty. Parameters were again recorded after overnight sleep deprivation due to night shift work and then after they practiced yogic relaxation (Shavasana). As data passed normality testing, Student's paired t-test was used to compare the changes after sleep deprivation and then after yogic relaxation. **Results:** Overnight sleep deprivation resulted in statistically significant ($P < 0.05$) increases in systolic BP (SBP), low frequency (LF), LF/high frequency (HF), diastolic BP (DBP), PSS, and mean HR. This was coupled with significant decreases in mean RR, SDNN, pNN50, HF, and RMSSD. Following yogic relaxation, these changes were reversed, and significant decreases were witnessed in LF, LF/HF, SBP, mean HR, DBP, and PSS with significant increases in mean RR, pNN50, HF, RMSSD, and SDNN. **Conclusion:** The findings of our study reiterate the negative effects of sleep deprivation on cardiac autonomic status. Such deleterious effects may be partially reversed by practicing yogic relaxation (Shavasana). Such conscious relaxation may be able to help correct imbalance of autonomic nervous system by enhancing parasympathetic tone and reducing sympathetic overactivity.

KEY WORDS: Overnight Sleep Deprivation; Heart Rate Variability; Perceived Stress Scale; Yogic Relaxation; Shavasana

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INTRODUCTION

A person's quality of life can be disrupted due to many different reasons, and one important yet underestimated cause for that is sleep loss.[1] Professions such as health care, security, and transportation often require working at night, and the deleterious effect of acute overnight sleep

deprivation on performance is crucial. Increased blood pressure (BP), heart rate (HR), and urine catecholamine levels have been associated with acute sleep deprivation, and it has been linked to potentially serious changes to emotion, mood states, and their regulation.[2-4] It has been reported that sleep deprivation increased subjective stress, anxiety, and anger ratings with elevated negative mood by lowering the psychological threshold for the perception of stress.[5] It is also well known that sleep deprivation may increase the incidence of cardiovascular events, with a high incidence of sudden death, myocardial infarction, and stroke in the early morning attributed to sympathetic overstimulation.[6-9] Although extensive research has been done to demystify the effect of sleep deprivation on cognitive functions, memory, and reasoning ability, there is a lacuna in its effects on autonomic function and perceived stress as well as the modulation of such responses to yoga.

Yoga is the best lifestyle ever designed and is increasing in popularity worldwide with a recent report suggesting that 15 million Americans have practiced yoga at least once in their lifetime.[10] Yoga facilitates psychosomatic relaxation, and earlier studies have shown that Shavasana and Savitri pranayama in trained subjects cause a significant decrease in oxygen consumption, HR, and diastolic BP (DBP) while Shavasana alone has been shown to be effective in the treatment of hypertension.[11-13] It is also known that sleep duration in long-term experienced meditators is lower than in non-meditators and general population norms, with no apparent decrements in vigilance.[3]

HR variability (HRV) is non-invasive and well-established physiological parameter used to assess sympathovagal balance, an index of cardiac autonomic function.[14] Increase in HRV is associated with decreased sympathetic and increased vagal tone influence on the sinoatrial SA node of heart while decreased HRV and sympathovagal balance have been reported to be associated with cardiovascular morbidity and mortalities.[15,16]

Yogic relaxation (Shavasana) is known to induce psychosomatic relaxation and enhance one's ability to combat stress.[11,12] However, to the best of our knowledge, no study has been done to determine the effectiveness of yogic relaxation (Shavasana) of short duration on physiological functions, especially on mitigating the effect of overnight sleep deprivation.

With the above background in mind, the present study was designed with the following aims and objectives:

1. To study the effect of overnight sleep deprivation on autonomic function test and perceived stress in young healthy volunteers.
2. To provide evidence for the same through:
   a. HRV measures (time and frequency domain),
   b. HR and resting BP (systolic BP (SBP) and diastolic DBP), and
   c. Perceived stress scale (PSS).
3. To compare the differential effect of overnight sleep deprivation and normal sleep on the above-mentioned parameters.
4. To study the effect of Shavasana on overnight sleep-deprived subjects.

MATERIALS AND METHODS

Before commencement of the study, the Institute Research Committee (IRC) and IHEC approval were obtained. A total number of 35 healthcare professionals in the age group between 20 and 25 years were recruited from casualty and ICU unit of Mahatma Gandhi Medical College and Research Institute, Puducherry. All parameters were recorded in the Research Laboratory of the Department of Physiology, MGMCRI. Subjects were explained about the method of recording and were familiarized with the laboratory environment. Recordings were obtained between 8 and 10 am without any stimulants in pre-recording period. The laboratory temperature was maintained at a comfortable level with subdued lighting.

Basal recordings were done before the commencement of day duty. In the same subjects, all parameters were again recorded after overnight sleep deprivation due to night shift work. Yogic relaxation (Shavasana) was performed by the subjects on the day after overnight duty and parameters recorded post-relaxation phase.

Technique of Yogic Relaxation (Shavasana)[12]

The subjects were asked to lie down in a calm and quiet room in the supine position with the hands and legs fully extended. The feet were kept side by side with the toes directed outwards. The arms were kept close to the body at an angle of approximately 15 with the trunk, keeping the forearms in mid prone position and fingers relaxed. The eyes were closed lightly, and the subjects were asked to perform slow rhythmic breathing. They were instructed to keep their attention to the sensation of breathing at the nostrils only. The devitalization of group of muscles was carried out in the following order: First, the lower limbs, then the upper limbs, neck, face, and finally, the trunk. During this, the subjects were suggested to feel that a particular group of muscle is completely relaxed and has become non-impressional to both the afferent and efferent stimuli. The subjects were asked to retain this posture for about 30 min, after which the revitalization is done in the same order in which the muscles were devitalized. Then, they were asked to sit up for a minute before standing.

Recording of HRV

Subjects were asked to relax in a supine position on the couch and allowed to relax for 10 min. Lead II ECG and

respiration were recorded at the 500 samples per sec using INCO Polyrite-D for 5 min. R-R interval data were extracted by RMS Polyrite software, and then, HRV was analyzed from R-R interval by Kubios HRV, version 2.0, Department of Physics, University of Kuopio, Finland. HRV data analysis and signal processing followed guidelines defined by "Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology"

Time domain components are mean HR, mean RR, standard deviation of RR intervals SDNN, square root of the mean of the sum of the squares of differences between adjacent RR intervals RMSSD, adjacent RR interval differing more than 50 ms (NN50), and NN50 counts divided by all the RR intervals (pNN50).

Frequency domain components consisted of very low-frequency (VLF) component (0.003–0.04 Hz), LF component (0.04–0.15 Hz), and high-frequency (HF) component (0.15–0.5 Hz) and LF/HF ratio; the ratio of LF power to HF power, LF power in normalized units (LF nu) = (LF × 100)/(TP-VLF), and similarly HF nu was calculated. HF, HF nu, SDNN, RMSSD, NN50, and pNN50 reflect cardiovagal tone; LF reflects both the sympathetic and parasympathetic tones; VLF component's interpretation is not clear, and it cannot be interpreted using short-term HRV recordings; LF nu and HF nu represent a relative tone of sympathetic and parasympathetic nervous system PSNS.

Recording of BP

After 15 min of rest in supine, SBP and DBP were obtained from the subjects using sphygmomanometer. The average of three trials with 5 min interval was taken for calculation.

Cohen's PSS Questionnaire

It is most widely used psychological questionnaire for subjects' perception of stress. A 10-item Cohen's PSS questionnaire was used to score feeling and thoughts during last month in this study. All the questions were explained to the subjects and requested to answer. PSS scores were obtained by reversing responses (e.g., 0 = 4, 1 = 3, 2 = 2, 3 = 1, and 4 = 0) to the four positively stated items (items 4, 5, 7, and 8) and then summing across all scale items. A short 4-item scale is made from questions 2, 4, 5, and 10 of the PSS 10-item scale.

Statistical Analysis

After obtaining the study data, it was statistically analyzed using SPSS version 16.0. All data passed normality testing by Kolmogorov–Smirnov Test, and then, Students paired t-test was used to compare the differences in the subjects before and after the relaxation.

RESULTS

The results are given in Tables 1 and 2. Comparison of BP, PSS, and HRV recordings before day duty and post night duty revealed significant increases in SBP, LF, and LF/HF ($P < 0.05$) and DBP, PSS, and mean HR ($P < 0.01$), with

Table 1: Comparison of BP, PSS, and HRV parameters recorded before day duty and post night duty in 35 young healthcare professionals

Parameters	Before day duty	Post night duty
SBP (mmHg)	112.16±7.22	116.16±7.48*
DBP (mmHg)	75.44±8.48	79.38±7.36***
PSS	18.30±3.44	20.36±3.76***
Mean HR	73.88±3.85	76.13±4.65**
Mean RR	874.24±115.43	841.91±106.3*
SDNN	56.31±8.51	49.47±9.46*
RMSSD	53.43±12.70	45.32±13.66**
pNN50	26.62±8.50	21.20±4.57*
LF (ms2)	495.54±59.28	522.62±44.15*
HF (ms2)	214.07±43.23	165.94±60.28*
LF/HF	2.31±0.45	3.14±0.32*

Values are given as mean±SD. *P<0.05 **, P<0.01 ***, P<0.001 by students paired t-test comparing parameters before day duty and post night duty. SD: Standard deviation, BP: Blood pressure, PSS: Perceived stress scale, HRV: Heart rate variability, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, LF: Low frequency, HF: High frequency

Table 2: Comparison of BP, PSS, and HRV parameters before and after performance of yogic relaxation (Shavasana) after post night duty in 35 young healthcare professionals

Parameters	Before yogic relaxation (post night duty)	After yogic relaxation (post night duty)
SBP (mmHg)	116.16±7.48	112.83±8.16**
DBP (mmHg)	79.38±7.36	74.55±7.24***
PSS	20.36±3.76	17.44±3.50***
Mean HR	76.13±4.65	72.67±3.56**
Mean RR	841.91±106.3	862.02±90.22*
SDNN	49.47±9.46	59.63±10.04 ***
RMSSD	45.32±13.66	52.98±10.4 **
pNN50	21.20±4.57	25.97±7.01 *
LF (ms2)	522.62±44.15	489.78±49.43 *
HF (ms2)	165.94±60.28	202.16±54.14 *
LF/HF	3.14±0.32	2.78±0.45 *

Values are given as mean±SD. *P<0.05, **P<0.0,1 ***P<0.001 by students paired t-test comparing parameters before and after yogic relaxation done following night duty. SD: Standard deviation, BP: Blood pressure, PSS: Perceived stress scale, HRV: Heart rate variability, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, LF: Low frequency, HF: High frequency

significant decreases in mean RR, SDNN, pNN50, and HF ($P < 0.05$) and RMSSD ($P < 0.01$). Comparison of BP, PSS, and HRV taken before and post Shavasana after the night duty revealed significant decreases in LF and LF/HF ($P < 0.05$); SBP and mean HR ($P < 0.01$); and DBP and PSS ($P < 0.001$) with significant increases in mean RR, pNN50, and HF ($P < 0.05$); RMSSD ($P < 0.01$); and SDNN ($P < 0.001$).

DISCUSSION

It has been well documented that sleep is an important cause of disruption of the individual's quality of life. This is, especially, true in those professions that have extensive night duty where increased HR and BP as well as urine catecholamine levels have been associated with acute sleep deprivation.

Yoga facilitates psychosomatic relaxation and Shavasana has been suggested to be an antidote to the stress response by previous studies.[11,12] However, most of the previous studies are based on training of longer duration, and to the best of our knowledge, no study has been done to determine the effectiveness of yogic relaxation (Shavasana) training of short duration on overnight sleep deprivation in medical profession. This study was planned to determine if yogic relaxation (Shavasana) training of short duration can modulate cardiac autonomic activity and cardiovascular response to stress caused by overnight sleep deprivation.

In the present study, comparison of parameters before day duty and post night duty showed significant decreases in mean RR, SDNN, pNN50, HF as well as RMSSD. It was also found that there were significant increases in SBP, DBP, mean HR, LF, LF/HF as well as PSS. These findings give evidence that overnight sleep deprivation produces increased sympathetic activation coupled with a decreased vagal tone as well as an increased perception of stress. The decrease in time domain parameters of HRV and increase in the frequency domain parameters (except HF) can be attributed to the same increased sympathetic activation as a result of the overnight sleep deprivation. Our results are in tune with those of Tockikubo *et al*., who found that overnight sleep deprivation increased BP,[17] while Kato *et al*. found a heightened sympathetic nervous system activation due to sleep restriction.[18]

On the other hand, comparison of parameters before and after the practice of yogic relaxation showed the reversal of this unhealthy trend. There were significant increases of mean RR, pNN50, HF, RMSSD as well as SDNN, coupled with significant decreases in LF, LF/HF, SBP, mean HR, DBP as well as PSS. These findings provide valuable evidence of the de-stressing effect of yogic relaxation. It is also interesting that such a positive effect can be evidenced even with just 30 min of yogic relaxation. This may be attributed to the induction of the relaxation response as postulated by Benson.[19] This is further evidenced through increases in time domain parameters with decreases in frequency domain parameters (except HF) of HRV. This study correlates with the findings of Vasanthan *et al*, who reported that yogic practices decrease BP indices and increase HRV except LF shows enhancement of parasympathetic activity on the heart.[20,21]

Our findings are collaborated by earlier reports from Streeter *et al*. who proposed that yoga may reduce allostatic load in stress response systems, thus restoring homeostasis.[22] They hypothesized that stress causes an imbalance of autonomic nervous system with decreased parasympathetic and increased sympathetic activity.

Similarly, Innes *et al*. postulated two interconnected pathways through which yoga may reduce cardiovascular and metabolic risk.[23] They suggested, in this paper and a subsequent report, that this was through parasympathetic activation coupled with the decreased reactivity of sympathoadrenal system and hypothalamic-pituitary-adrenal axis.[24,25]

As the yogic relaxation (Shavasana) is performed with conscious deep rhythmic breathing, this may be reducing sympathetic arousal, thus bringing about a fall in HR and SBP as reported in the previous study.[26,27] It is well known that slow deep breathing stimulates the stretch receptors in the lungs that induce the Hering–Breuer inflation reflex. This in turn causes a withdrawal of sympathetic tone leading to vasodilatation and reduced DBP.[28]

The enhanced parasympathetic activity and reduction in sympathetic arousal may be probably due to the influence of yogic relaxation at the level of reticular formation of the brain stem. There are three feedback mechanisms which are said to influence the activity of reticular formation: I) from cerebral cortex, ii) from peripheral receptors and iii) from adrenal medulla. From peripheral receptors, pain and proprioceptive impulses are said to be more important than others. In yogic relaxation, the marked relaxation of muscles may be reducing the numbers of proprioceptive impulses to a certain extent. As the subject is asked to concentrate on the breath flowing through the nostrils into the chest, such a mindful and conscious focus may help the subject to momentarily forget their usual stresses during the relaxation period, thus providing mental relaxation. Due to these two factors, probably undue activity of reticular formation during awakened condition might be reduced, and as a result of this, de-stressing manifests in the subject after overnight sleep deprivation.

CONCLUSION

The findings of the present study reiterate the negative effects of sleep deprivation on cardiac autonomic status. It is also seen that such deleterious effects may be partially reversed through yogic relaxation (Shavasana) of 30 min.

This finding has a great potential in those who are working night shifts on a regular basis as increased allostatic load in stress response systems can lead to chronic cardiovascular and metabolic disorders such as coronary artery disease and metabolic syndrome. By reducing allostatic load and restoring normal homeostasis, yogic relaxation (Shavasana) may be able to help correct the imbalance of autonomic nervous system by enhancing parasympathetic tone and by reducing sympathetic overactivity. Further studies with larger populations and with longer duration of training may be useful in helping us to understand the mechanism by which these changes are brought about in such a short time.

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