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Heart Rate Variability among Long Distance Bus Drivers after a Night Shift

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Abstract

Introduction: Most of the fatal accidents were found to be due to fatigue among the drivers. Long distance bus drivers are more prone to fatigue following driving and hence increase in the risk of road traffic accident among them. Techniques such as Electroencephalography (EEG), Electrooculography (EOG) and Electrocardiography (ECG) were used to detect fatigue among the drivers during and after driving. Heart rate variability (HRV) assessment in drivers was found to be a useful tool to detect fatigue and drowsiness. Data on HRV and fatigue among bus drivers post night shift is scarce in the literature.

Method: HRV was assessed during resting state among 12 long-distance bus drivers immediately after their night shift. HRV was also assessed among non-bus drivers who were not involved in shift works. Obese, Hypertensive and diabetic patients were excluded from the study. Time domain and frequency domain measures of HRV were compared between bus drivers and non bus drivers.

Result: Baseline heart rate and blood pressure were normal in both the groups. All the time domain and frequency domain measures were found to be normal in both the groups. Though time domain measures such as SDNN, rMMSSD, NN50, pNN50 were increased and frequency domain measures such as LFnu and LF/HF ratio were decreased in study group, they were not statistically significant.

Conclusion: There seems to be an increase in parasympathetic activity among long-distance bus drivers probably due to fatigue because of prolonged driving overnight.

Keywords: *Heart rate variability; Long Distance Drivers; Fatigue*

Introduction

Driver fatigue has been found to be one of the major problem in road safety [1]. One of the factors of road traffic accidents is found to be fatigue and drowsiness among the long distance drivers [1,2]. Fatigue is the loss of efficiency of the driver to drive a vehicle due to prolonged driving, sleep deprivation and exhaustion. It is estimated by The Royal society for prevention of accidents that 20% of fatal accidents in Australia are due to fatigue among the drivers [3]. Several studies have included various methods such as Electroencephalography (EEG), electrooculography and Electrocardiography (ECG) for detection of fatigue [2]. Heart rate variability (HRV) is defined as the measure of beat to beat variation in heart rate due to the result of adaptive changes caused by the sympathetic and parasympathetic nervous system. It is calculated by analyzing the time series R–R intervals in ECG [4]. HRV can be evaluated using time domain measures and frequency domain measures. Time domain measures can be assessed with calculations from standard deviations from R-R intervals. Frequency domain analysis is

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based on Fast Fourier Transformations of the signals from time domain to frequency domain. Power spectral density (PSD) analysis provides the basic information of how power (i.e., variance) distributes as a function of frequency. Low frequency (LF) component of HRV power spectrum is influenced by both sympathetic and parasympathetic activity whereas high frequency (HF) component is influenced by parasympathetic activity. Thus, the LF: HF ratio is considered to be a measure of sympathovagal balance [4, 5].

Several studies have studied the changes in physiological parameters while driving to detect fatigue[6]. Verser el al studied the nocturnal effects of driving and reported that 2 hours of continuous nocturnal driving were sufficient to produce driving impairment [7]. Vehicle Crash rate was higher in drivers with excessive drowsiness compared to alert individuals [8]. A state of reduced mental alertness which affects the cognition and driving performance been found to be influenced by fatigue [2]. Inadequate sleep, sleep loss, disrupted sleep and disturbances in circadian rhythm were the attributed reasons for fatigue among long distance drivers [9,10]. Assessment of HRV for the detection of fatigue while driving were studied by several studies and were found to be an useful tool for the detection of fatigue while driving [4]. Assessment of HRV is found to be a cost effective tool to detect fatigue than other methods. While most of the studies have assessed the heart rate variability of drivers during driving, in this study we assessed the heart rate variability post night duty. We intended to study the influence of overnight driving for long distance bus drivers on HRV. We hypothesized that there would be decrease in HRV for drivers after an overnight shift of driving for more than 12 hours. The aim of our study was to assess HRV in bus drivers and to compare it with non-bus drivers.

Methodology

The study was approved by Institutional Ethics Committee. Participants between 30 and 55 years were included in the study. Twelve apparently healthy bus drivers were recruited who had at least one year experience of long distance bus driving. Twelve healthy subjects who were non bus drivers were recruited as control group. Obese (BMI $\geq$ 30 Kg/m^2), Hypertensive (SBP $\geq$ 140 mm Hg and /or DBP $\geq$ 100 mm Hg) and Diabetic patients were excluded from the study.

The study was conducted in a temporarily set lab in Pondicherry Road Transport Corporation (PRTC) office, Puducherry. Participants in study group were asked to report to the lab after their night shift. Participants in control group (non bus drivers) were asked to report to the lab when they come for regular work in the morning. They were instructed to come in fasting state and to refrain from tea or coffee before the test.

After obtaining the informed consent, their age, height and body weight were recorded. Body Mass Index (BMI) was calculated using Quetelet's index [11]. Baseline blood pressure of all the subjects was recorded in sitting posture using Omron (SEM 1 Model, Omron Healthcare Co. Ltd, Kyoto, Japan).

After 15 minutes of supine rest on a couch in AFT lab, ECG was recorded for 5 minutes for short-term HRV analysis following the standard procedures as practiced in the laboratory. HRV was recorded by using BioHarness AcqKnowledge 4.1 version and analyzed by Kubios HRV 2.00 software. Recommendation of the Task Force on HRV was followed for recording and analysis [8].

Following parameters were derived

Time domain measures:

a) Standard deviation of normal-to-normal RR intervals (SDNN)

b) Root mean square successive difference (RMSSD)

c) Number of pairs of adjacent N-N intervals differing by more than 50 ms (NN50 count)

d) The proportion of NN50 to the total number of NN intervals (pNN50)

2. Frequency domain measures:

a) Total power (TP)
b) Very low frequency power (VLF)
c) Low frequency power (LF)
d) Normalized low frequency power (LFnu)
e) Normalized high frequency power (HFnu)
f) Ratio of low frequency power to high frequency power (LF-HF ratio)

Statistical Analysis

All data were expressed as Mean and Standard Deviation. Comparison of HRV indices between bus

drivers and the control group using Mann Whitney U Test since they were non parametric data. Data was analyzed using SPSS 17.

Results

Subject Characteristics of bus drivers and control group are represented in Table 1. Subjects were between 30 and 50 years of age in study group and between 30 and 55 years of age in control group. 10 out of 12 subjects were found to be overweight (BMI $\geq$ 25 Kg/m^2) in both the groups. None of the subjects were obese. Baseline Heart rate and Blood pressure in all the subjects were found to be normal.

Table 2 shows the time domain measures of HRV in both the groups. All the time domain measure SDNN, RMSSD, NN50 and pNN50 were found to be in normal range in both the groups. Though not statistically significant, the time domain measures SDNN, rMSSD, NN50 and pNN50 show an increase in the bus drivers group.

Table 3 shows the frequency domain measures of HRV. Frequency domain measures such as TP, VLF, LF, HF and LF/HF were found to be within normal range in both the groups. There was no statistically significant difference in frequency domain measures TP, VLF, LFnu, HFnu and LF/HF ratio between the bus drivers and the control group. Though not statistically significant, LFnu and LF/HF ratio were reduced in the bus drivers. There was also an increase in TP and HFnu observed in the bus drivers.

Discussion

In this study, HRV indices seems to be within normal range in both the groups. Yet, the frequency domain indices, LF and HF values are comparatively higher in study group. LF component represents both the sympathetic and parasympathetic tone. HF component in specific represents the parasympathetic tone of the autonomic nervous system [12,13]. An increase in HF component has been observed in the study group. The LF/HF ratio seems to be decreased in the study group than the control group which may be contributed by the increased parasympathetic tone on the study group. Also increase in the time domain parameters such as RMSSD, SDNN, NN50 and pNN50 were also seen in bus drivers indicating an increase in the parasympathetic tone.

Sato et al [14] studied 24 hrs HRV on long distance driving truck drivers which revealed that there were parasympathetic predominance among the truck drivers. This parasympathetic predominance was attributed to the fatigability of the drivers due to prolonged driving overnight. Driving with increase in parasympathetic activity were also found to induce drowsiness and also deteriorate the attentiveness of the drivers [14]. Adverse events especially road traffic accident were reported to be high among long distance automobile drivers due to fatigue [15]. Many studies has used indices of HRV as a tool for detecting the fatigue and drowsiness in drivers[6,9].

Adams et al assessed ambulatory blood pressure and ECG before, during and after the night shifts among physicians working in emergency department, in which they reported that there was a significant decrease in LF/HF ratio which indicated an increase in vagal tone post night shift compared to pre night shift [16]. Freitas et al assessed the influence of day night shift on the circadian pattern on HRV and reported that LF/HF ratio was lowest during post shift work compared to pre and during shift work among nurses [17].

In this study, increase in parasympathetic tone among bus drivers could be due to the disturbance in circadian rhythm, irregular shift works or fatigue due to overnight driving in the study population [14]. This effect may due to the sleep debt due to the night shift work nature leading to physical and mental fatigue specifically leading to parasympathetic overdrive amongst the drivers denoting catchup of the lost sleep period. Our study is the first of its kind amongst drivers in Puducherry region.

We conclude that there seems to be a slight increase in parasympathetic activity after night shift among the bus drivers. There is a need to extend our understanding on driver fatigue by performing long term HRV during long distance driving along with other sensors such as Electroencephalogram (EEG) and electro oculogram (EoG).

Limitation: Assessment of their fatigue score and Sleepiness scale would have given us more insights regarding the contents of this study. We intend to continue this study in a larger population and have a better understanding so that this could alert the drivers to take adequate rest after driving.

Table 1: Subject Characteristics of Study and Control group. (Mean ± SD)

Subject Characteristics	Bus Drivers	Control
Age	40 ± 7	44 ± 8
BMI	27.34 ± 3.58	27.11 ± 3.11
Heart Rate	74.67 ± 11.84	75.58 ± 10.08
SBP	121.58 ± 11.60	122.75 ± 11.09
DBP	75.25 ± 7.02	75.75 ± 8.28

BMI - Body Mass Index (11), SBP – Systolic Blood Pressure, DBP – Diastolic Blood Pressure

Table 2: Frequency Domain parameters of HRV in study and Control Group. (Mean ± SD)

HRV Parameters	Bus Drivers	Control	P value*
Total Power	1244.33 ± 780.92	808.64 ± 471.01	0.149
VLF	676.05 ± 580.61	414.45 ± 378.04	0.184
LF	268.41 ± 147.02	219.91 ± 204.28	0.248
HF	299.19 ± 215.42	173.73 ± 96.48	0.133
LF/HF ratio	1.20 ± 1.01	1.35 ± 0.95	0.419
LF nu	49.03 ± 14.30	52.38 ± 12.15	0.236
HF nu	50.89 ± 14.28	47.37 ± 12.01	0.371

TP - Total power, VLF - Very low frequency power, LF - Low frequency power, LFnu - Normalized low frequency power, HFnu - Normalized high frequency power, LF-HF ratio - Ratio of low frequency power to high frequency power
* Mann Whitney U test was done to compare bus driver and control group.

Table 3: Time Domain Parameters of HRV in study and Control Group. (Mean ± SD)

HRV Parameters	Bus Drivers	Control	P value*
SDNN	38.71 ± 14.19	33.20 ± 13.55	0.298
RMSSD	32.04 ± 17.31	21.38 ± 6.02	0.112
NN50	40.67 ± 47.49	10.33 ± 9.50	0.139
PNN50	14.16 ± 17.36	2.88 ± 2.91	0.132

SDNN - Standard deviation of normal-to-normal, RMSSD -RR intervals Root mean square successive difference (RMSSD) , NN50 count - Number of pairs of adjacent N-N intervals differing by more than 50 ms, pNN50 - The proportion of NN50 to the total number of NN intervals

* Mann Whitney U test was done to compare bus driver and control group.

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Ethical Clearance: This study is approved by

Institute ethics committee (Human studies) of JIPMER, Puducherry. (Approval No: JIP/IEC/2016/26/859)

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