Original Research Article

Assessment of heart rate variability and reaction time in traffic policemen

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Abstract

Introduction: Air Pollution can have a deleterious effect on cardiovascular function and cognition. Heart rate variability (HRV), which is a non-invasive and objective measure of cardiac autonomic function, is a cardiovascular risk predictor. Reaction time is a simple method of assessing the perceptual-cognitive processing capability of the central nervous system. Hence, the aim of the study was to assess the heart rate variability and reaction time in traffic police officers of Puducherry. **Methods:** Fifty-five age and BMI matched traffic police and healthy controls were recruited. Basal cardiovascular parameters; basal heart rate, systolic and diastolic blood pressure (BHR, SBP, DBP) were assessed. Short term HRV analysis was done. Time and frequency domain indices were computed. Simple and Choice Auditory and Visual reaction time (SART, CART, SVRT, CVRT) were measured. **Results:** BHR and DBP were significantly increased in traffic police. Time domain indices (Mean RR, SDNN, RMSSD, pNN50) were significantly reduced in traffic police. In frequency domain, Total Power was significantly reduced. LF-HF ratio was increased, though not significant. SVRT was significantly delayed in traffic police. CVRT, SART and CART were delayed in traffic police though not significant. **Conclusion:** Traffic police have decreased HRV with increased sympathetic and decreased vagal tone, and delayed reaction time.

Key words: Traffic Police, Autonomic function, Heart rate variability, Cognition, Reaction time

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Introduction

Air pollution is a form of environmental degradation which has become rampant in recent times [1]. In 2010, as per the Global Burden of Disease study, around 3.1 million deaths of overall 52.8 million deaths had been attributed to air pollution [2]. Such is the burden and impact of air pollution on human health.

Vehicular emissions are the prime cause of air quality crisis in cities. Owing to the expanding economic base, use of motor vehicles increased with a subsequent increase in air pollution. Automobile exhaust causing health hazard are mainly oxides of nitrogen, sulfur and particulate matter (PM), with contribution from carbon monoxide and benzene [2,3].

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Along with environmental pollution, occupation is also a major determinant of health. In this aspect, traffic police officers are at a risk, since they are continuously exposed to emissions from vehicles. The relationship between air pollution and respiratory diseases, such as chronic obstructive pulmonary disease and asthma, is well established [3,4]. In fact, a study conducted in Puducherry has demonstrated obstruction and narrowing of airways in traffic police officers [5].

But recent studies also reveal the relationship between air pollution and cardiovascular (CV) morbidity [6,7]. Short-term particulate matter exposures, lead to acute CV events including myocardial infarction, cardiac arrhythmia while long-term exposure has been linked to increased development of atherosclerosis. Various postulated mechanisms include pulmonary and systemic inflammatory response, myocardial ischemic response, endothelial dysfunction, atherosclerosis and thrombosis [6,7]. Though the exact underlying link between PM exposure and CV outcomes is not yet clear, alterations in cardiac autonomic function have been suggested to be one of the pathophysiologic pathways [6,7].

Heart rate variability (HRV) is a non-invasive, independent and quantitative marker of cardiac autonomic control [8]. HRV is an indicator of autonomic control of the heart rate, and an alteration in HRV is associated with increased risk for cardiac events [8].

Air pollution can also have a deleterious effect on the central nervous system. Animal studies have shown that exposure to fine or ultrafine PM is associated with CNS inflammation and lipid peroxidation, neuronal degeneration, impairments in spatial learning and memory and behavioural changes with depressive-like responses [9,10]. To further potentiate, the CV effects of air pollution may lead to CNS dysfunction via the vascular brain pathology [9]. A possible manifestation of CNS dysfunction is cognitive decline. Studies have evidenced ambient traffic-related air pollution was associated with decreased cognitive function in middle-aged and older adults [11]. Reaction time (RT) is the time taken to respond to a sensory stimulus, which includes stimulus recognition, cognitive processing, and the motor response to the stimulus [12].

Since vehicular emissions are associated with increased cardiovascular risk and cognitive decline, understanding the underlying mechanisms for this association has significant public health relevance. With the paucity of literature on the heart rate variability (HRV) and reaction time in traffic police officers of Pondicherry, in this study, we plan to assess short-term heart rate variability in Traffic police officers in Puducherry.

Aim and Objectives

To assess the heart rate variability and reaction time in traffic police officers of Puducherry

Materials & Methods

It was an analytical cross-sectional study, conducted in Department of Physiology, IGMC & RI, Puducherry. Before commencement of the study, the approval from the Institute Research Committee and Human Ethics committee was obtained. After explaining the study to the participants, their written informed consent was obtained.

Participants: The study involved two groups with 55 participants in each group.

Inclusion criteria

Group 1: Traffic police officers (males) employed in Puducherry, aged between 25 to 45 years, employed for at least five years.
Group 2: Age, Gender, and BMI-matched healthy men.

Exclusion criteria

For both the groups: Participants who are smokers, chronic alcoholics, taking hormonal/drug therapy, diabetes mellitus, hormonal disorders, known hyper-tension, cardiovascular & pulmonary disease.

Methodology

The participants fulfilling the inclusion criteria were recruited. All the participants were asked to report at 9.00 a.m., two h after a light breakfast, and after emptying their bladder. Participants were asked to avoid any caffeinated beverage on the day of the trial. The recording was done in a quiet room with the ambient temperature maintained at 25°C (±2°C). The procedure was duly explained to them.

Parameters assessed

Anthropometric measurements- BMI was calculated by Quetelet's index. The Asian criterion for BMI was followed for grouping the subjects based on the level of BMI [13].

Basal Parameter- Basal heart rate (BHR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) were measured after 10 minutes of supine rest, by the oscillometric method using an Omron MX3 automated blood pressure monitor (Omron Healthcare, Kyoto, Japan).

Heart Rate variability analysis: Short-term HRV analysis

Recording of HRV-Lead II electrocardiogram (ECG) was recorded, following the standard procedure as per the recommendation of Task Force. The data acquisition was performed using INCO-NIVIQUIRE digital acquisition system, version 52.0, INCO systems, Ambala, India. The sampling rate was kept at 500 samples/s per channel. Raw ECG was filtered using a band pass filter (2–40 Hz). The RR tachogram obtained from the filtered ECG was then analyzed for time domain and frequency domain measures (power spectral analysis using fast Fourier transformation) using the software from the Biomedical Signal Analysis Group ver. 2.1 (Kuopio, Finland).

*HRV indices & their implications:*The frequency domain indices included low frequency (LF; 0.04–0.15 Hz), high frequency (HF; 0.15–0.4 Hz), total power (TP), LF in normalized units (LFnu), HF in normalized units (HFnu) and the ratio of LF to HF (LF-HF ratio). The LF and LFnu represent sympathetic tone. The HF and HFnu, represent the cardiac parasympathetic drive (vagal tone). The LF-HF ratio depicts the sympathovagal balance [8].

The time domain measures included mean RR (mean of RR interval), standard deviation of RR interval (SDNN), the square root of the mean of the sum of the squares of the differences between adjacent NN intervals (RMSSD), the number of pairs of adjacent NN intervals differing by more than 50 msec in the entire recording (NN50) and the percentage of NN50 counts, given by NN50 count divided by total number of all NN intervals (PNN50).

The SDNN, RMSSD, NN50 and PNN50 of HRV indices represent the cardiac parasympathetic drive (vagal tone) [8].

Reaction time assessmen- Reaction time is a simple and inexpensive method for indirectly measuring the perceptual-cognitive processing capability of the central nervous system.

The RT was recorded using RT apparatus supplied by Anand Agencies (Pune, India). The RT apparatus consists of an automated chronoscope with a four-digit display that can record the response time with an accuracy of 1ms. It is capable of providing an auditory input signal of two different tones namely beep and click, and likewise, visual input signals of two colors namely red and green.

Evaluation of RT to auditory and visual signals was done. The participants were instructed to use their self-reported dominant hand to record their response to the presented stimulus. Participants were instructed to release the response key as soon as they perceived the stimulus and the time interval between the stimulus and the response was recorded. The apparatus was in front of the participant to avoid lateralization of the stimuli to one side. Before recording the RT, three practice sessions were given to all the study participants to familiarize them to the RT apparatus as RT. Both simple and choice auditory and visual reaction times were assessed.

Simple Reaction time: Only one stimulus was presented, to which the participant was asked to respond. Simple Auditory Reaction Time (SART): The subjects were asked to respond to beep sound. Simple Visual Reaction Time (SVRT): The subjects were asked to respond to red light.

Choice Reaction time: Among the two stimuli (beep & click auditory stimuli / red & green color of visual stimuli), one will act as the “memory” stimulus for which the participant is instructed to respond by releasing the response switch, while the other will act as a “distractor” stimulus for which the participant is instructed not to respond.

Choice Auditory Reaction Time (CART): The subjects were asked to selectively respond to beep sound when intervened with the click sound.

Choice Visual Reaction Time (CVRT): The subjects were asked to respond to red light when intervened with the green light.

Sample Size Calculation and Statistical analysis: The sample size was calculated using the formula $4pq/L^2$. Considering proportion of people with decreased heart rate variability as 50% and taking allowable error as 30 % of p, with p = 50 and q = 100-p = 50, at 5% significant level with 95% confidence interval, sample size is calculated as follows: $4*p*q / (L)^2 = 4*50*50/15*15 = 10000/225 = 44$. Considering the drop out of 10% and no response of 10% total sample size has been calculated as 55 in each group.

Continuous data were tested for normality and expressed as mean ± SD or median with range. For intergroup comparison of continuous data, unpaired student’s t-test for parametric and Mann-Whitney-U test for non-parametric data was used. Statistical analysis was done at two-tailed significance and p-value of <0.05 was considered as significant.

Results

Age, anthropometric, basal cardiovascular parameters: Both the cases and control subjects were of comparable age (P=0.290) and BMI (P=0.236) (Table1). Among the cardiovascular baseline parameters, BHR and DBP were significantly high (P=0.034, P=0.007 respectively) in traffic police compared to that of controls. The SBP was found to be high in traffic police, though not significant.

Table-1: Comparison of anthropometric & basal cardiovascular parameters between Controls & Traffic Police.

Parameters	Controls (n=55)	Traffic Police (n=55)	P value
Age	30.76 ± 5.08	31.98 ± 6.81	0.290
BMI	23.60 ± 3.94	24.29 ± 1.75	0.236
BHR	70.24 ± 8.32	74.16 ± 10.70	0.034
SBP	113.69 ± 10.60	116.64 ± 10.37	0.144
DBP	67.76 ± 7.46	72.35 ± 9.92	0.007

Analysis done by Unpaired Student's t Test, Data expressed as Mean with SD. BMI, body mass index; BHR, basal heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Short-term HRV analysis: Time domain indices: All the time domain indices; mean-RR (P=0.004), SDNN (P=0.001), RMSSD, NN50 and pNN50 (for all P<0.001) were significantly decreased in traffic police compared to that of controls (Table 2).

Frequency domain indices: Among the frequency domain indices, total power (TP) was significantly reduced among the traffic police (P=0.001] (Table 2). When the absolute powers were expressed in normalized units, increased LFnu (P=0.177) and decreased HFnu (P=0.187) were observed in traffic police, though not significant. The LF/HF ratio was increased in traffic police (P=0.214) compared to the controls, but not significantly.

Table-2: Comparison of HRV indices between Controls and Traffic Police.

Time Domain Indices					
Parameters	**Controls (n=55)**		**Traffic Police (n=55)**		**P value**
	Median	**IQR**	**Median**	**IQR**	
Mean RR (ms)	865.50	154.40	777.29	234.67	0.004
SDNN (ms)	48.00	20.80	37.80	13.51	0.001
RMSSD (ms)	36.30	29.10	29.40	13.88	< 0.001
NN50	49.00	113.00	27.00	46.00	< 0.001
pNN50	15.60	36.40	7.71	13.62	< 0.001
Frequency Domain Indices					
Parameters	**Controls (n=55)**		**Traffic Police (n=55)**		**P value**
	Median	**IQR**	**Median**	**IQR**	
TP (ms^2)	1742.00	1216.00	1108.40	862.80	0.001
LF(nu)	52.80	19.90	56.14	22.11	0.177
HF(nu)	47.00	19.40	43.65	21.85	0.187
LF:HF	1.12	1.02	1.29	1.43	0.214

Analysis done by Mann Whitney – U test, Data expressed as Median with IQR. SDNN, standard deviation of NN intervals;. RMSSD, square root of the mean squared differences of successive NN intervals; NN50, number of pairs of adjacent NN intervals differing by more than 50 msec; pNN50, percentage of NN50; TP: total power; HF: high frequency; LF: low frequency; nu, normalized units.

Reaction time assessment: Simple Reaction time: The SART was increased in traffic police, though not significant (P=0.059). The SVRT is significantly increased in traffic police (P=0.014). Choice Reaction time: The CART and CVRT were increased in traffic police, though not significant (P=0.222, P=0.057) (Table 3).

Table-3: Comparison of Reaction time between Controls and Traffic Police.

Parameters	Controls (n=55)	Traffic Police (n=55)	P value
SART (ms)	163.8 ± 23.1	173.1 ± 27.6	0.059
SVRT (ms)	215.9 ± 31.3	229.2 ± 24.0	0.014
CART (ms)	235.7 ± 43.7	245.3 ± 37.8	0.222
CVRT (ms)	325.8 ± 43.0	340.6 ± 37.3	0.057

Analysis done by Unpaired Student's t Test, Data expressed as Mean with SD. SART: Simple auditory reaction time; SVRT: Simple visual reaction time; CART: Choice auditory reaction time; CVRT: Choice visual reaction time.

Discussion

In our study TP, the index of overall heart rate variability was significantly reduced in traffic police, indicating a decreased HRV. Decreased HRV depicts decreased cardiovagal modulation and is a potent risk for cardiovascular health [8].

Also the increased LFnu (P=0.0001) and lowered HFnu (P=0.0001) seen among the traffic policemen reflected the increased adrenergic drive and attenuated vagal activity. Subsequently, the LF-HF ratio, which is the marker of sympathovagal balance was elevated among them, though not significant (P=0.0016). This depicts the deviation of sympathovagal balance more towards the adrenergic system [8].

The time domain indices depict the high-frequency variations in short-term recording of HRV, which are due to vagal activity [8]. The time domain indices also revealed a significant reduction in traffic police. The reduction in these parameters reveals a decreased vagal modulation of cardiac functions consistent with the findings in frequency domain analysis.

Also, we found that the baseline cardiovascular parameters (BHR and DBP) were significantly higher in traffic policemen when compared to the controls (P<0.0001). The SBP was also higher in traffic police though not significant. Since HR is mainly under vagal modulation, an increased BHR in these patients could be attributed to the decrease in vagal activity [14]. The raised DBP observed in traffic police could be considered due to exaggerated adrenergic drive as maintenance of BP is mainly under sympathetic modulation [14].

Our findings corroborate with the findings of a previous study conducted in Brazil, depicting decreased HRV in traffic police, attributed to air pollution [15].

There are many theories postulated to explain the effects of air pollution on cardiovascular diseases. Among them are the increased levels of inflammatory markers, the ischemic response of myocardium to pollutants and endothelial injury. All of these can have a cause and effect relationship with autonomic dysfunction [16].

The cardiovascular system and HR are under the influence of the sympathetic and parasympathetic nervous systems. HRV reflects the autonomic modulation of the heart rate and has been used as a risk marker for arrhythmia and sudden death.

Decrease in HRV reflects the decreased capacity of the autonomic nervous system to adapt to a myriad of stimuli that we encounter in our daily life [8].

Hence, we hypothesize that cardiac autonomic dysfunction with decreased HRV could be the plausible mechanistic pathway in the causal of cardiovascular disease in traffic police.

The RT assessment revealed increased simple and choice reaction time in traffic police, indicating a delayed response. RT is the duration between application of a stimulus to the onset of response. It is the process by which human use their cognition to respond towards the sensory input; visual or auditory. RT acts as a reliable indicator of attention, rate of processing of sensory stimuli and its motor response by the nervous system [17].

RT is categorized according to the number of diverse stimuli in a task that need to be responded with a specific motor reaction viz; simple and choice reaction time. When the number of stimuli is equal to one, this kind of reaction time task is called simple RT task; if higher than one, it is defined as choice reaction time task. In simple reaction time task, there is only one particular stimulus and the same response is always required. In choice RT task, there are several different stimuli and response for a particular stimulus amidst different stimuli is required [18].

RT can get affected by many physiological and pathological parameters. Air pollution is a potential pathological factor that can have long term and considerable effects on cognition. Brains of individuals living in a highly polluted environment have higher inflammatory mediators, β-amyloid deposition, oxidative damage to DNA, as well as blood–brain barrier disruption, than those from a city with low levels. Further, it has been evidenced from animal studies that long-term exposure to PM at levels typical of cities in parts of the developing country such as India, would induce neuroinflammation and adjustments in neuronal morphology and behaviour and decreased cognitive abilities [9,10]. It is evident that chronic exposure to air pollution accelerates cognitive decline. In our study, though insignificant, we observed that the traffic police had delayed response time reaction time in comparison to controls. This suggests that the traffic police, due to constant exposure to PM, are at risk for cognitive derangement in the long term.

Conclusion

The traffic police have decreased HRV, with increased sympathetic and decreased vagal tone. Also, they are at risk of cognitive derangement. Based on the proposition that air pollution exposure may induce cardiovascular changes mediated by the autonomic nervous system and cognitive decline, the present study reinforces the effects of air pollution on heart rate variability, blood pressure and cognition in healthy traffic police in the city of Puducherry. Also, it stresses upon the need for appropriate precautionary measures at an early stage, to prevent cardiovascular and cognitive morbidity.

Limitations & future perspectives: The limitation of our study is that we did not control for occupational stress. Psychological stress can affect autonomic function.

So the effects of both pollution and stress on autonomic function could not be delineated. But, since we took traffic police officers with a work experience of more than five years, we expect adaptation to work environment, which could have mitigated the work stress.

In future, we recommend a complete battery of autonomic function tests to be performed, which would enable to arrive at a more certain proposition regarding the autonomic status. Also, the association with the inflammatory markers can be established.

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References

1. Estévez-García JA, Rojas-Roa NY, Rodríguez-Pulido AI. Occupational exposure to air pollutants: particulate matter and respiratory symptoms affecting traffic-police in Bogotá. Rev Salud Publica (Bogota). 2013 Nov-Dec; 15(6):889-902.

2. Newby DE, Mannucci PM, Tell GS, Baccarelli AA, Brook RD, Donaldson K, Forastiere F[7], Franchini M, Franco OH, Graham I, Hoek G, Hoffmann B, Hoylaerts MF, Künzli N, Mills N, Pekkanen J, Peters A, Piepoli MF, Rajagopalan S, Storey RF ESC Working Group on Thrombosis, European Association for Cardiovascular Prevention and Rehabilitation; ESC Heart Failure Association. Expert position paper on air pollution and cardiovascular disease. Eur Heart J. 2015 Jan 7;36(2):83-93b. doi: 10.1093/eurheartj/ehu458. Epub 2014 Dec 9.

3. Lee BJ, Kim B, Lee K. Air pollution exposure and cardiovascular disease. Toxicol Res. 2014 Jun;30(2): 71-5. doi: 10.5487/TR.2014.30.2.071.

4. Gupta S, Mittal S, Kumar A, Singh KD. Respiratory effects of air pollutants among nonsmoking traffic policemen of Patiala, India. Lung India. 2011 Oct;28 (4):253-7. doi: 10.4103/0970-2113.85685.

5. Pal P, John RA, Dutta TK, Pal GK. Pulmonary function test in traffic police personnel in Pondicherry. Indian J Physiol Pharmacol.2010Oct-Dec;54(4):329-36.

6. Shields KN, Cavallari JM, Hunt MJ, Lazo M, Molina M, Molina L, Holguin F. Traffic-related air pollution exposures and changes in heart rate variability in Mexico City: a panel study. Environ Health. 2013 Jan 18;12:7. doi: 10.1186/1476-069X-12-7.

7. Pope CA, Burnett RT, Thurston GD, Thun MJ, Calle EE, Krewski D, Godleski JJ. Cardiovascular mortality and long-term exposure to particulate air pollution epidemiological evidence of general pathophysiological pathways of disease. Circulation. 2004;109(1):71-7. Epub 2003 Dec 15.

8. Heart rate variability: standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Circulation. 1996 Mar 1;93(5):1043-65.

9. Power MC, Weisskopf MG, Alexeeff SE, Coull BA, Spiro A 3rd, Schwartz J. Traffic-related air pollution and cognitive function in a cohort of older men. Environ Health Perspect. 2011 May;119(5):682-7. doi: 10.1289/ehp.1002767. Epub 2010 Dec 20.

10. Fonken LK, Xu X, Weil ZM, Chen G, Sun Q, Rajagopalan S, Nelson RJ. Air pollution impairs cognition, provokes depressive-like behaviors and alters hippocampal cytokine expression and morphology. Mol Psychiatry. 2011;16(10):987-95. doi: 10.1038/mp.2011. 76. Epub 2011 Jul 5.

11. Gatto NM, Henderson VW, Hodis HN, St John JA, Lurmann F, Chen JC, Mack WJ. Components of air pollution and cognitive function in middle-aged and older adults in Los Angeles. Neurotoxicology. 2014 Jan;40:1-7. doi: 10.1016/j.neuro.2013.09.004. Epub 2013 Oct 19.

12. Sharma VK, Subramanian SK, Arunachalam V, Radhakrishnan K, Ramamurthy S, Ravindran BS. Auditory and visual reaction times in school going adolescents: effect of structured and unstructured physical training-a randomized control trial. Int J Adolesc Med Health. 2015 Nov. doi: 10.1515/ijamh-2015-0060. [Epub ahead of print].

13. Misra A, Chowbey P, Makkar BM, et al. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. J Assoc Physicians India 2009;57:163–70

14. Benarroch EE. Peripheral autonomic system: anatomy, biochemistry and physiology. In: Low PA, Benarroch EE, eds. Clinical autonomic disorders. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2008:29–42.

15. de Paula Santos U, Braga AL, Giorgi DM, Pereira LA, Grupi CJ, Lin CA, Bussacos MA, Zanetta DM, do Nascimento Saldiva PH, Filho MT. Effects of air pollution on blood pressure and heart rate variability: a panel study of vehicular traffic controllers in the city of São Paulo, Brazil. Eur Heart J. 2005 Jan;26(2):193-200. Epub 2004 Dec 3.

16. Chuang KJ, Chan CC, Su TC, Lee CT, Tang CS. The effect of urban air pollution on inflammation, oxidative stress, coagulation,and autonomic dysfunction in young adults. Am J Respir Crit Care Med. 2007 Aug 15;176(4):370-6. Epub 2007 Apr 26.

17. Solanki J, Joshi N, Shah C, Mehta HB, Gokhle PA. A study of correlation between auditory and visual reaction time in healthy adults. Int J Med Public health. 2012;2(2):36-8.

18. Ng AW, Chan AH. Finger response times to visual, auditory and tactile modality stimuli. InProceedings of the International Multiconference of Engineers and Computer Scientists 2012 (vol. 2, pp. 1449-1454).

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