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RESEARCH ARTICLE

STUDY OF HEART RATE VARIABILITY CHANGES IN SMOKERS

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ABSTRACT

Background: Heart rate variability (HRV) is an objective and sensitive measure of integrated physiological functioning reflective of heart rhythm responsivity to internal and external demands. Reduced HRV is associated with vulnerability to stress, while increased HRV is associated with a favorable treatment response and recovery from various medical and/or psychiatric conditions.
Cigarette smoking has been shown to adversely affect heart rate variability (HRV), suggesting dysregulation of cardiac autonomic function.
Objectives: To determine the frequency and time domain measures of heart rate variability in smokers and thereby assessing the cardio vascular status.
Materials and methods: 50 smokers and 50 normal male subjects between the age group of 20-50 years were selected. Computerized ECG system with Niviqure Software was used for the study. Frequency domain measures such as very low frequency, high frequency and LF/HF ratio and time domain measures such as mean RR intervals, mean HR, SDNN, RMSSD, were assessed to observe both sympathetic and parasympathetic nerve function status.
Statistical analysis was done by Student's unpaired t-test will be used to compare different parameters between study and control groups.
Results: Frequency domain parameters like low frequency and LF/HF ratio were significantly (< 0.001) higher and HF was reduced, Time domain parameters like SDNN, RMSSD, PNN 50% and mean RR were reduced significantly in smokers compared to normal.
Conclusion: Impaired cardiac autonomic nerve function characterized by sympathetic over activity and reduced vagal activity were found in the absence of any cardiac disease in smokers.

INTRODUCTION

Tobacco consumption has many worse health outcomes. Tobacco consumption is the single most cause of the preventable deaths globally. Tobacco is consumed in many forms and one such form is cigarette smoking. Its use leads to heart attacks, chronic obstructive pulmonary disease, cancer, peripheral vascular disease, hypertension and the list is endless (Ockene *et al*., 1997). It contains nicotine which causes physical and psychological dependencies. Cigarette smoking contributes to the loss of over 5 million life years annually in the United States. Cigarette smoking increases the relative risk of coronary artery disease by 2.8-fold and 3.1-fold in young (35–64 years) men and women, respectively (Prasad DS *et al*., 2009). Changes in cardiovascular autonomic control are often assessed using measures of heart rate variability (HRV) which is the beat-to-beat variability of the R-R interval of successive normal beats on an electrocardiogram (ECG). Lower levels of HRV are strong predictors of mortality especially in cardio-compromised patients (Kennedy 1997).

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HRV is an index of vagal tone and reflects the balance between parasympathetic and sympathetic maneuvers. Sympathetic nervous system activation accelerates heart rate (HR) thereby decreasing HRV, whereas parasympathetic nervous system activation decelerates HR and increases HRV. Elevations in HRV are a sign of healthy cardiac function, whereas reductions in HRV leave the heart vulnerable to arrhythmia and sudden death (Hermansen *et al*., 2008).

A growing body of cross-sectional data has shown that smokers, compared to nonsmokers, exhibit dysfunctional cardiac autonomic function, as evidenced by lower HRV indices. This has been shown to be the case when HRV is measured in both the time domain and the frequency domain. Additionally, duration of smoking has been found to be inversely associated with HRV (La Rovere *et al*., 2003). Hence, nicotine and other components of cigarette smoking produce profound changes in the heart which can be assessed by doing HRV, which is the easiest and the cheapest method for assessing cardiovascular abnormalities. Maintaining abstinence from smoking as early as possible can prevent further damage. This study was aimed at creating an awareness among people and thus preventing morbidity and mortality.

MATERIALS AND METHODS

The present study was conducted in the Department of Physiology, J.J.M Medical College, Davangere. In this study a total of 50 smokers, 50 non-smokers of age matched controls from general population of Davangere satisfying the inclusion criteria were included in this study.

Inclusion criteria

- Smokers of age group 20-50 years are selected as per World Health Organization (WHO) 10th revision of International Statistical Classification of Diseases and related health problems (ICD-10) criteria of harmful use. (Diagnostic criteria for research. ICD-10 WHO Geneva 1993)
- Non-smokers and non-alcoholics of age matched subjects as control group.
- Males are included.

Exclusion criteria

- Subjects below 20 years and above 50 years.
- Both smokers and alcoholics.
- Medical H/O any diseases known to affect the autonomic cardiac function such as Cardiovascular, neurological and endocrine diseases.
- Renal, Hepatic and thyroid disease.
- Obese, Diabetics and hypertensive.
- Patients on medications.
- Females.

Methods of collection of data

Prior to enrollment, an explanation of the protocol was given to the subjects. Before starting the study, written consent was taken from the subjects. Ethical clearance for the study was obtained from Ethical committee of our college. Clinical history of the subject was obtained. A general physical examination was done. Vital signs were recorded including Pulse rate, Respiratory rate and Temperature. Examination of the respiratory system and cardiovascular system was conducted using stethoscope. All subjects who were clinically fit were recruited for the study. Following parameters were recorded in each subject. All the data of individual subject were entered in Proforma for each subject.

Recording of Anthropometrical Parameters

- Height (Ht in cms) measured with subject, standing without shoes, nearest to 0.1 cm error by using a Standard Height measuring Scale.
- Weight (Wt in kg) measured with subject, wearing minimum clothing, nearest to 0.1 kg error by using a standard weighing machine.
- Body Mass Index (BMI) in kg/m^2: It is calculated using a Quetelet's index.(Park K. 2007)

Body mass index = Weight(kg)/Height(m^2)

Recording of Physiological parameters

- Pulse Rate: beats per minute (bpm) - Left Radial Artery is partially occluded.
- Systolic Blood Pressure (SBP) in mmHg: By using mercury sphygmomanometer.
- Diastolic Blood Pressure (DBP) in mmHg: By using mercury Sphygmomanometer. SBP and DBP are recorded in the lying down position by both Palpatory and Auscultatory methods.

Heart rate variability

Resting heart rate and Heart rate variability in supine position was measured using Niviqure computerised ECG system. ECG was acquired using digital ECG system, an instantaneous heart rate at RR intervals were continuously plotted using Niviqure software on a Microsoft window based computer. The digital ECG system to save multiple records and provided with additional filter settings, calculation tools, automated analysis and auto report generation facilities. A normal one cycle ECG signal is made up of several waves. The peak with the highest amplitude is called the R wave. An R-R interval is the time elapses between two successive R waves.

Acquiring R-R intervals

To analyse HRV, we should obtain the R-R intervals.

Process of acquiring R-R intervals HRV analysis methods

- R-R intervals
- Preprocessing
- Time domain
- Frequency domain
- Nonlinear measures

Linear measures of HRV

Linear measures of HRV includes various time and frequency domain indices. Time domain indices provide information on total variability over a period of time. The time domain indices could be derived from direct measurements of the R-R intervals or from the differences between R-R intervals. Time domain indices include heart rate, SDNN (standard deviation of all NN intervals), SDANN (standard deviation of average NN intervals during 5 min monitoring), RMSSD (root mean square value of square differences between neighboring NN intervals), SDNN index (mean standard deviation of all NN intervals from 5 min segments), SDSD ms (standard deviation of neighboring NN interval differences), NN 50 (count of coupled neighboring NN intervals differing more than 50 ms in length), p NN 50 (NN 50 divided by the total count of NN intervals). Frequency domain parameters were analyzed by power spectral analysis of the data. Power spectral density analysis (PSD) divides the heart rate signal into its frequency components and quantifies them in terms of their relative intensity termed as power. Frequency domain indices provide information on both total variability as well as its distribution as a function of frequency.

The RR interval duration is plotted against the number of RR intervals (tachogram). This method projects the entire range of fluctuations into different frequencies. Spectral analysis of R-R intervals derived from short term recordings of 2-5 min yields 3 separate bands.

- A very low frequency (VLF) band located in the less than 0.04Hz.
- A Low frequency (LF) band located in the 0.04-0.15Hz range.
- A High frequency (HF) band with a very large range from 0.15-0.50Hz.

STATISTICAL ANALYSIS

The Student's unpaired t test was used to compare different parameters between study and control groups. The results are expressed as Mean and Standard Deviation (SD) for all the quantitative data.

- p Value > 0.05 is taken as ' not significant'.
- p Value < 0.05 is taken as 'Significant'.
- p Value < 0.001 is taken as 'Highly Significant'.

All the statistical methods were carried out through the SPSS for Windows (version 20.0).

RESULTS AND ANALYSIS

50 smokers, males and 50 normal males (controls) were analyzed for the results. The age of subjects ranged from 20-50 years. The results obtained were expressed as Mean ± Standard deviation. Anthropometric parameters of the 50 normal subjects and smokers were matched. There was significant increase in BMI of smokers compared to normal.

There was no significant change with regard to other parameters like Height, weight, pulse and Blood pressure. Our results shows that there was statistically significant increase in heart rate ($p<0.000$) in smokers. The frequency domain parameters like LF power (ms2) ($p<0.001$) and LF in normalized units ($p<0.001$) and LF / HF ratio ($p<0.001$) were significantly increased in smokers. There was statistically significant reduction in HF power (msec2) ($p<0.000$) and HF (nu) ($p<0.000$) in smokers compared to normal subjects. There was statistically significant reduction in Time domain parameters like SDNN, RMSSD, RR interval, PNN 50% in smokers showing decrease parasympathetic activity.

DISCUSSION

This study analyzes the effect of smoking on cardiac autonomic functions and to assess the cardiovascular disease risk. The differences in the mean value of Heart Rate Variability between normal and smokers were analyzed and discussed.

Very low frequency (VLF)

In our study there was no statistically significant change in very low frequency values between normal and smokers.

HEART RATE VARIABILITY IN SMOKERS FREQUENCY DOMAIN ANALYSIS

Low frequency (LF)

In our study, there was a statistically significant increase in the mean value of LF power (ms2) and LF (nu) in smokers compared to normal subjects. Similar findings were found in studies by Daniela Lucini *et al*. (1996); Karakaya O *et al*. (2007); Cagira *et al*. (2009); Alyan O *et al*. (2008); Pranay swarnkar *et al*. (2013).

Table 1. Comparison of Anthropometric Parameters, Pulse Blood Pressure between Normal and Smokers

Variables	Normal N=50		Smokers N=50		Statistical Analysis unpaired t test df= 98
	Mean	SD	Mean	S D	
Age (yrs)	35.14	7.67	35.22	8.04	F=0.13, NS
Height (m)	1.66	0.06	1.64	0.05	F=1.46, NS
Weight (kg)	60.74	5.1	62.36	4.49	F=1.67, NS
BMI	22.18	1.16	23.2	1.25	F=7.17, P<0.001
Pulse (bpm)	76.76	8.4	77.82	7.81	0.65 , NS
SBP (mmHg)	114.88	5.98	114.84	6.27	0.99 , NS
DBP (mmHg)	78.04	5.58	76.92	5.7	0.03 , NS

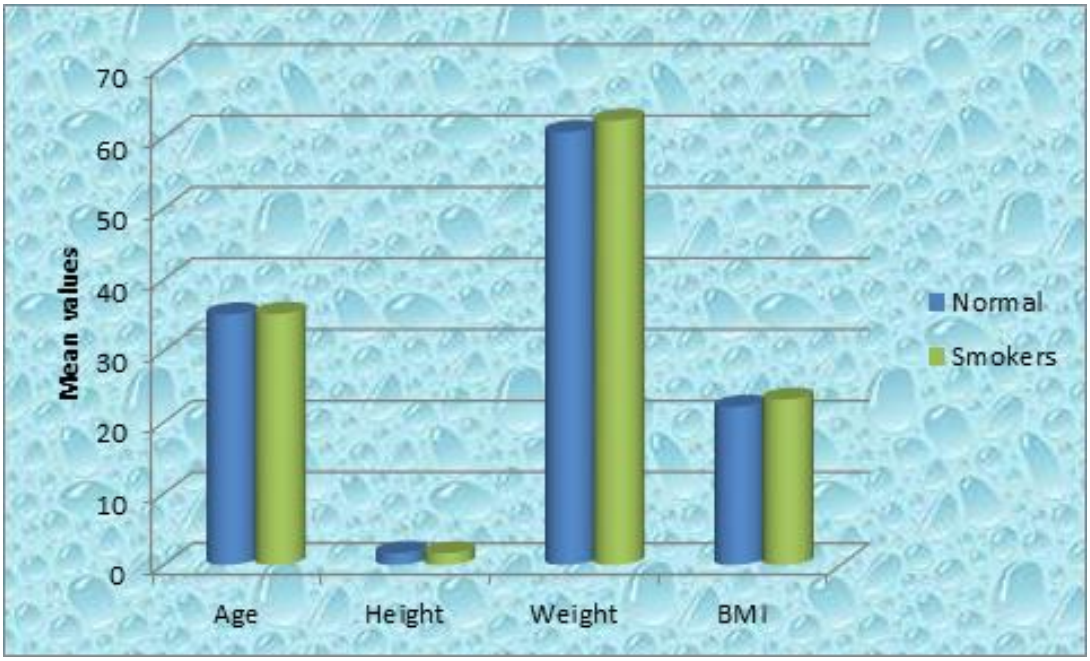
NS: Not significant

Table 2. Spectral Analysis of Heart Rate Variability Normal and Smokers

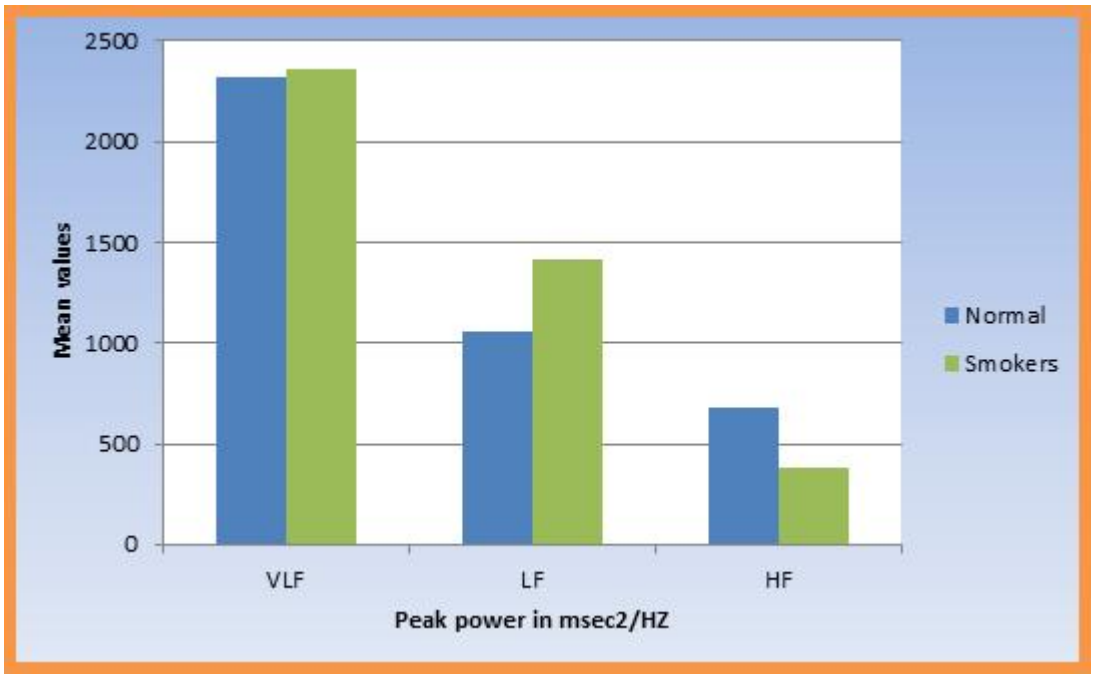
Variables		Normal N=50		Smokers N=50		Statistical Analysis unpaired t test df= 98
		Mean	SD	Mean	SD	
Peak Power in msec2/Hz	VLF	2317.68	397.82	2361.22	245.01	t=0.66, NS
	LF	1053.14	367.15	1416.6	381.09	t=4.85, P<0.001
	HF	681.36	359.28	381.58	202.23	t=5.14, P<0.000
Frequency in normalized unit	LF(nu)	44.53	13.3	71.07	9.49	t=11.49, P<0.001
	HF(nu)	55.15	13.53	29.52	9.34	t=11.02, P<0.000
LF/HF		0.19	0.47	2.64	0.09	t=11.96, P<0.001

Table 3. Time Domain Analysis of Heart Rate Variability between Normal and Smokers

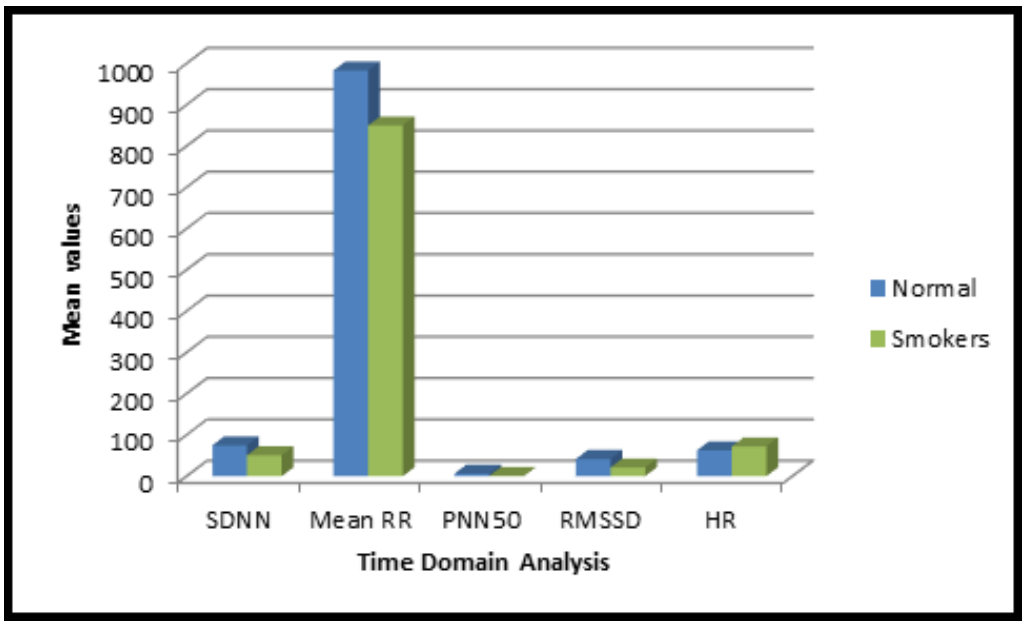
Variables		Normal N=50		Smokers N=50		Statistical Analysis unpaired t test df= 98
		Mean	Std Deviation	Mean	Std Deviation	
Time Domain Analysis	SDNN	74.76	10.93	50.82	9.85	t=11.95, P<0.000
	Mean RR	983.37	98.25	850.05	114.55	t=11.51, P<0.001
	PNN50	6.64	2	0.93	1.06	t=6.25, P<0.000
	RMSSD	41.9	12.72	21.29	7.75	t=17.83, P<0.001
	HR	62.72	4.6	72.45	7.75	t=9.87, P<0.000



Graph 1. Comparison of Anthropometric Parameters between Normal And Smokers



Graph 2. Comparison of Peak Power Frequency in Msec2/Hz between Normal and Smokers



Graph 3. Comparison of Time Domain Parameters Between Normal And Smokers

High frequency (HF)

In our study, there was statistically significant reduction in high frequency values (ms2) and HF (nu) in smokers compared to normal. Similar findings were found in studies of Cagira G *et al*. (2009); Alyan O *et al*. (2008); Pranay swarnkar *et al*. (2013). Increase value of HF was observed by Karakaya O *et al*. (2007).

LF/HF ratio

In our study there was a statistically significant increase in LF/HF ratio in smokers compared to normal. Similar findings were found in studies of Barutcu I *et al*. (2005); Cagira G *et al*. (2009); Alyan O *et al*. (2008); Pranay swarnkar *et al*. (2013).

TIME DOMAIN ANALYSIS

Heart rate (bpm)

In our study, there was significantly increased heart rate (mean) in smokers (72.45 bpm) compared to normal (62.72 bpm). Similar findings were found in studies of Sultana Ferdousi *et al*. (2014). Pranay swarnkar *et al*. (2013) found Heart rate increased significantly during smoking and came back to normal after 30 minutes.

SDNN (Standard Deviation of Normal to Normal intervals) (ms) RMSSD: (Root Mean Square Successive Differences)

In our study there was a statistically significant reduction in SDNN (ms) and RMSSD in smokers compared to normal. Similar findings were found in studies of Barutcu *et al*. (2005); Cagira *et al*. (2009); Alyan O *et al*. (2008); Karakaya O *et al*. (2007). Pranay swarnkar *et al*. (2013) found normal spectral parameters- SDNN, RMSSD in smokers.

RR interval (ms)

In our study RR (ms) interval was significantly reduced in smokers compared to normal subjects. Similar findings were found in studies by Cagira G *et al*. (2009); Karakaya O *et al*. (2007). Decreased values of SDNN, RMSSD indicating decreased HRV and lower RR interval are suggestive of decrease vagal modulation and higher sympathetic activity in our subjects.

PNN 50% (Percentage of differences between adjacent normal RR Interval > 50 msec)

In our study PNN 50% was significantly reduced in smokers compared to normal. PNN 50% is a sensitive measure of parasympathetic activity, it was lower among smokers indicating decreased vagal tone. The increase in heart rate in smokers could be due to stimulation of sympathetic ganglia and discharge of catecholamine from adrenal medulla (Venkatesh G 2010). Low frequency and High frequency measures sympathetic activity and parasympathetic activity respectively. LF/HF ratio measures the sympathovagal balance (Heart rate variability. Eur Heart, 1996). This study showed that sympathetic activity is more and reduction in parasympathetic activity in smokers. Our study showed there was sympathovagal imbalance in smokers compared to normal.

Conclusion

The following conclusions can be drawn from the results of this study. Our study shows that HRV is significantly reduced in smokers compared to controls. Since reduced HRV is associated with cardiac arrhythmias, suggesting that these people may have risk of occurrence of cardiac arrhythmias.

Our study concluded that, impaired cardiac autonomic function characterized by sympathetic over activity may occur in smokers and alcoholics and also showed sympathovagal balance in above two groups is towards higher sympathetic and lower vagal modulation. Our study results showed that smokers prone for cardiovascular risk. Therefore, earlier detection of ECG changes and HRV is useful in preventing the cardiovascular risk.

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