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Effect of Smoking on Autonomic Functions

Dr.Gurunath Birajdar[1], Dr.N.B.Prasad[2], Dr.V.R.Purandare[3]
[1]*P.G.student, Department of Physiology, Dr.D.Y.Patil Medical College, Hospital and Research centre, Dr.D.Y.Patil Vidyapeeth, Pune, India.*
[2]*Associate Professor,Department of Physiology, Dr.D.Y.Patil Medical College, Hospital and Research centre, Dr.D.Y.Patil Vidyapeeth,Pune,India.*
[3]*Professor,Department of Physiology, Dr.D.Y.Patil Medical College, Hospital and Research centre, Dr.D.Y.Patil Vidyapeeth,Pune,India.*

Abstract: *Cigarette smoking is major risk factor for the development of atherosclerosis, coronary heart disease, acute myocardial infarction and sudden cardiac death. Cessation of smoking is associated with reduced cardiovascular mortality and morbidity. Cigarette smoking alters baseline sympathetic and vagal modulation of thesinoatrial node(S-Anode) and peripheral sympathetic vascular control. A cross-sectional study on autonomic function tests was performed on 40 smokers of age range between 20-50 years. These smokers were compared with normal healthy 40 non-smokers age and BMI matched. Autonomic function tests(AFT) included were 30;15 ratio, valsalva maneuver(VR), Deep breath difference(DBD) ,orthostatic tolerance test(OTT),isometric hand grip test(IHG).Resting pulse rate and IHG was significantly lower ($p<0.01$,$p<0.001$) in smokers indicating decreased sympathetic reactivity in them. OTT was significantly increased (p value<0.001) in smokers compared to non-smokers. This is again suggestive of decreased sympathetic reactivity in them. The cardiovascular autonomic function tests are reliable non-invasive and easy to carry out. By using these simple tests we can detect the early involvement of the autonomic nervous system before the clinical symptoms appear. This study indicates that smoking has adverse effect on cardiovascular autonomic functions.*

Keywords: *autonomic function test, isometric hand grip test, orthostatic tolerance test, smoking ,valsalva ratio.*

I. Introduction

Cigarettes kill an estimated 5 million people annually worldwide.[1]The world health organization reported that tobacco smoking killed 100 million people worldwide in the 20th century.[2]By the early 2030, tobacco related death would increase to about 100 million a year.[3] Tobacco smoking rates have decreased in industrialized countries since 1975, but there has been corresponding 50% increase in smoking rates in low income countries.[4]

Cigarette smoking is major risk factor for the development of atherosclerosis[5], coronary heart disease[6], acute myocardial infarction[7] and sudden cardiac death.[8-9]Cessation of smoking is associated with reduced cardiovascular mortality and morbidity.[10]

Autonomic nervous system plays a pivotal role in the regulation of cardiovascular activities[11] and balance between its two components i.e. sympathetic and parasympathetic system is responsible for the efficient control of cardiovascular system.[12,13,14]

Heart rate variability measures the variation in the S-Anode due to sympathovagal change.[15]Smoking is said to increase arterial pressure and heart rate acutely.[16-21]The acute effect of smoking is mainly due to nicotine while reduction in cardiac vagal tone is responsible for chronic effects.[22].

Although smoking increases arterial pressure and heart rate acutely, the effect of smoking on sympathetic activity is not well understood. Smoking or nicotine infusions have been shown to decrease ,to not change ,to increase plasma norepinephrine levels and to decrease or not changedirectly recorded muscle sympathetic nerve activity.[23,24,25]

Classical autonomic function tests are simple non-invasive methods for determination of both sympathetic & parasympathetic divisions of cardiovascular autonomic control in clinical setting.[26,27]

The present cross –sectional study was therefore planned to assess the effects of cigarette smoking on sympathetic & parasympathetic activity on cardiovascular system.

II. Methods

40 healthy adult male cigarette smokers aged between 20-50 years, smoking for more than one year from local area were selected for study. They constitute the study group (cases).According to calculation of smoking index, our study group falls in Light smokers category(smoking index1-100).[28]

Autonomic function tests of these smokers were compared with 40healthy adult non-smokers males with age and BMI(Body mass index) matched. Who served as control group. Anthropometrical measurements

were taken along with preliminary clinical examination to exclude any systemic disorders affecting cardiovascular system for all the subjects.

Autonomic function tests were performed as follows on each subject in an environment with the room temperature ranging from 23^0C to 25^0C using computerized Polyrite-D (ModalDSMP0410,RMS,Chandigarh,India).[26,27]

Heart Rate Response ToPostural Change (30:15 Ratio)

The subject was asked to rest in lying down condition and then to stand up quickly unaided while the continuous recording of ECG was going on by Polyrite-D. The recording was taken for at least 30 seconds after the standing. The ratio of the longest R-R interval (around 30^{th} beat after standing) and the shortest R-R interval (around 15^{th} beat after standing) was efficiently measured by Polyrite-D and was presented as the result of the 30:15 ratio.

Heart Rate Variation During Controlled Deep Breathing Or Deep Breathing Difference (DBD)

After 5 minutes rest the subject sat quietly and breaths deeply at the rate of six breaths per minute for 1 minute. So, each inspiration took 5 seconds and same for each expiration also. The subject followed this rhythm of the controlled deep breathing by looking at the rhythmical up and down movement of the examiner's finger synchronized with the metronome. By this time a continuous ECG was being recorded by the Polyrite-D machine. The maximum and minimum R-R intervals in each breathing cycle were recorded and instantaneously converted to heart rate in beats per minutes. The mean of the differences between maximum and minimum heart rates for six respiratory cycles was expressed by the Polyrite-D software as the result.

Heart Rate Response To Valsalva Maneuver Or Valsalva Ratio(VR)

The subject was allowed to take rest for 5 minutes and then was asked to blow into a mouthpiece connected with a modified mercurial sphygmomanometer so that the mercury column is held at 40 mm Hg pressure for 15 seconds. A continuous ECG was recorded by the Polyrite-D and the ratio of the longest R-R interval after the maneuver (resulting from the overshoot bradycardia after release of the strain) and the shortest R-R interval during the maneuver (resulting from strain induced trachycardia) was expressed as Valsalva Ratio.

Blood Pressure Response To Postural Change Or Orthostatic Tolerance Test (OTT)

After taking rest for 5 minutes the resting systolic blood pressure (SBP) of the subject was recorded and then he was asked to stand up suddenly with the BP cuff in position. After standing again the SBP was recorded. The difference in these two readings due to fall in SBP on standing was recorded as the result of Orthostatic Tolerance Test.

Blood Pressure Response to Sustained Isometric Hand Grip (IHG) Test

At first the maximum capacity of voluntary contraction was noted by asking the subject to hold the handgrip dynamometer with the dominant hand at sitting position. Then after 5 minutes rest, the subject was told to maintain the handgrip at 30% of that maximum level for as long as possible, maximum up to 5 minutes. The diastolic blood pressure was recorded thrice before the procedure and at one-minute interval during the procedure. The difference between the highest recording during procedure and the mean of the three pre-procedure recording was recorded as the result of the test.

III. Results

In the present study 40 smokers of age range 20-50 years were compared with 40 healthy non-smokers of same age and BMI matched. The parameters studied were shown in Table 1&2.

Table 1: Age , anthropometric and basal cardiovascular parameters of smokers and non-smokers..

Parameters	(Non-smokers) Control	(Smokers)Cases	P Value
	Mean (S.D.)	Mean (S.D.)	
Age(in years)	30.23(6.59)	30.9(8.40)	0.69
BMI(in kg/m2)	24.04(3.20)	23.58(3.36)	0.53
Resting pulse rate(in beats/min)	71.95(1.24)	71.25(1.33)	0.02*
Systolic blood pressure (in mmHg)	117.4(3.82)	116.35(4.46)	0.26
Diastolic blood pressure (in mmHg)	79.85(0.70)	79.9(0.63)	0.74

Table 2: Distribution and comparison of Autonomic Function Tests (AFT)parameters between smokers & non-smokers.

AFT Parameters	Non-smokers (Control)	Smokers (Cases)	P value
	Mean (S.D.)	Mean (S.D).	
30:15 Ratio	1.24(0.12)	1.27(0.11)	0.27
DBD	24.18(8.04)	22.95(6.98)	0.47
VR	1.35(0.16)	1.36(0.16)	0.78
OTT	7.20(1.68)	11.65(1.75)	0**
IHG	18.23(2.52)	14.60(1.58)	0**

P value<0.05 is statistically significant.
P value <0.001 is statistically highly significant.
Resting pulse rate was significantly lower in smokers as indicated by p-value.
IHG was found significantly lower in smokers indicating by p-value. (p=0.00)
OTT was significantly increased in smokers as indicated by p-value. (p=0.00).
DBD was lower in smokers but statistically not significant. (p=0.47).
30:15 ratio and valsalva ratio showed no difference.

IV. Discussion

Smoking is one of the important lifestyle risk factor associated with increase morbidity and mortality from cardiovascular disease. Cigarette smoking is an established risk factor for coronary artery disease. A group of researchers observed that nicotine dependant inactivation of vagal cardiovascular control is one of the factorresponsible for hemodynamic changes in smokers.[29]

In our study, there was no significant difference in the mean physical parameters like age and body mass index on calculating the mean and the standard deviation in the smokers and non-smokers. A significant difference was observed in resting pulse rate, but no significant difference was found in systolic and diastolic blood pressure between smokers and non-smokers

Resting heart rate reflects the balance of parasympathetic and sympathetic influences at the sinoatrial node. It can be used for assessing both parasympathetic and sympathetic activity because of dual innervation of the heart.[12,30]Systolic blood pressure was also found to be low in smokers, although it was not statistically significant. These above results are suggestive of decreased sympathetic reactivity in smokers.

30:15 ratio was not statistically significant. This may be due to less sample size. Valsalva ratio was similar in smokers and non-smokers though not significant. As the procedure of valsalva ratio depends largely on subjective control, So one of the causes of this insignificance may be subjective variation to perfectly complete the maneuver. Another cause may be lesser sample size. DBD was lower in smokers though not significant statistically. Our finding were similar to the findings of Singh K. et al [31]whose study showed that there was no significant difference in DBD between smokers and non-smokers.

Out of all these parasympathetic function test, the deep breathing test is very easy to use and is considered as the most reproducible of the cardiac autonomic function tests .A decreased heart rate variation in response to deep breathing has been suggested as a primary indicator of decreased parasympathetic response.[32]
Orthostatic tolerance test(OTT) was statistically significant as indicated by p value=0.00 (highly significant).Fall in systolic blood pressure in smokers were more as compared to non-smokers suggesting decreased sympathetic reactivity. Similar fall in systolic blood pressure was observed byMotilal C. Tayade et al. in heavy smokers.[33]

Isometric handgrip test (IHG) was statistically significant as indicated by p value =0.00(highly significant).Mervi et al.(1994) also found that the rise in diastolic pressure was significantly less in smokers as compared to that in the non-smokers, thus suggesting a decrease in the sympathetic reactivity in them.[34]
Nicotine is the principle mediator of acute and chronic effects of smoking on neurocardiovascular regulation. These effects are mediated through central nervous system as well as afferent and efferent division of autonomic nervous system.[35]

Chronic cigarette smoking is associated with down regulation of beta adrenergic receptor density and catecholamine response in cigarette smokers. This may lead to decreased sympathetic reactivity in smokers.[36,33]

V. Conclusions

The cardiovascular autonomic function tests are reliable, non-invasive and easy to carry out. By using these simple tests we can detect the early involvement of the autonomic nervous system before the clinical symptoms appear. The results of this study are suggestive of decreased sympathetic reactivity in smokers.
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