THE EFFECT OF SMOKING ON THE AUTONOMIC HEART REGULATION IN YOUNG "HEALTHY" MALE SMOKERS

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Summary:

The aim of our study was to compare the autonomic nervous system (ANS) activity between young "healthy" male smokers and non-smokers via the method of heart rate variability (HRV).

Pulse oximetry, blood pressure, time and frequency domain and non-linear HRV parameters were measured in 21 healthy non-smoker males aged 28.0 ± 7.4 (mean±SD) and fourteen "healthy" smoker males aged 28.1±4.3 with 9.2±5.6 pack-years resting in supine position. Smokers were instructed to refrain from smoking at least 2 hours before the test.

There was no difference between smokers and non-smoker, regarding oxygen saturation (96.3±1.6 vs 96.8±1.2% p=0.330) and blood pressure (117.4±9.4/75.5±7.1 vs 119.5±6.4/77.2±7.1 mmHg p=0.312) but smokers had higher heart rate at rest (76.3±14.2 vs 65.2±9.0 b/min p=0.008). Smokers had decreased standard deviation of normal-to-normal interval (SDNN) (40.3±16.3 vs 62.0±32.1 ms p=0.013) and root mean square of the successive differences (RMSSD) (24.9±12.5 vs 59.3±32.8 ms <0.001). Frequency domain analysis showed that smokers had decreased total power (lnTP) (7.0±0.8 vs 7.7±1.1 ms^2 p=0.046), but higher LF/HF index (2.3±0.9 vs 1.4±0.8 p=0.004). Sample entropy was higher in non-smokers (1.4±0.3 vs 1.6±0.2 p=0.049).

Cigarette smoking altered autonomic nervous function measured by HRV in young "healthy" males in the absence of subjective clinical signs or symptoms. The method may be applied in the clinical practice to detect early changes in the ANS activity.

Key words: smoking, heart rate variability, autonomic nervous system.

INTRODUCTION:

Smoking is one of the most widely spread bad habits especially in Eastern Europe. Latest research data show that more than half of the male Bulgarian population aged 20-44 smoke cigarettes [1]. It is well known that habitual cigarette smoking affects the respiratory and cardio-vascular systems and it is one of the strongest contributors to coronary artery disease, stroke, sudden death, chronic obstructive pulmonary disease, etc. The pathogenesis of some of the mentioned conditions includes impairment of the autonomic nervous system (ANS) caused by tobacco smoke [2]. Nicotine is known to increase sympathetic activity and circulating catecholamines causing tachycardia and it is a major risk factor for cardiovascular morbidity [3, 4].

Heart rate variability (HRV) is a commonly used method for non-invasive assessment of the autonomic nervous system and it may be applicable in the assessment of early pre-clinical alterations in the autonomic regulation in smokers. Research data show that heavy smokers have decreased HRV parameters [5].

The aim of our study was to compare the ANS activity between young "healthy" male smokers and non-smokers via the method of HRV.

MATERIAL AND METHODS:

Twenty-one healthy non-smoker males aged 28.0 ± 7.4 (mean±SD) and fourteen "healthy" smoker males aged 28.1±4.3 (9.2±5.6 pack-years) were included in the study. A signed informed consent was received from all the subjects prior to inclusion in the study and a questionnaire about their physical status was filled in. During the experimental day, the participants did not take any medications, drink coffee or alcohol. They were instructed to refrain from smoking at least 2 hours before the test. A physical examination, including an electrocardiogram (ECG) reviewed by a cardiologist to exclude cardiovascular abnormalities or any rhythm or conductive disorders was carried out.

The subjects were situated in supine position in a comfortable bed, placed in a quiet, well aerated room with constant light and ambient temperature and absence of any distracting factors. They were instructed to keep calm without excessive voluntary movement or speaking. The subjects spent 15 minutes in that position. Four-channel ECG (H3+, Mortara Instruments, Milwaukee, USA) and pulseoxymetry (CMS50F, Contec Medical Systems, Qinhuangdao, China) were recorded during the whole visit. Blood pressure was measured manually before the test (Boso, Bosch and Sohn, Germany).

ECG recordings were reviewed, R-R intervals were extracted automatically by H-Scribe 5 software (Mortara Instruments, Milwaukee, USA). Last five minutes from each recording were selected for HRV analysis. After removing trends, data were analyzed using Kubios HRV software [6] and time, frequency and non-linear parameters were calculated. Prior to the spectral estimation by Fast Fourier Transform, beat-to beat RR series were transformed to evenly sampled time series using a cubic spline interpolation.

The following parameters were derived from the RR

data: Total power (TP) and standard deviation of normal-to-normal inter-beat interval (SDNN) as measures of overall autonomic regulation; absolute power and normalized units (nu) of high frequency (HF; 0.15-0.40 Hz) and low frequency (LF; 0.04-0.15 Hz) spectral components, respectively reflecting parasympathetic nervous system (PNS) activity and combined sympathetic (SNS) and PNS activities. The LF/HF ratio was also calculated as an index of sympatho-vagal balance. Root mean square of successive RR interval difference (RMSSD) is a time domain parameter associated with the PNS activity [7]. In addition to linear methods described above, three commonly used nonlinear parameters were computed. These include standard deviations SD1 and SD2 of the Poincare plot – SD1 related to fast beat-to-beat variability in data and SD2 describing longer-term variability of R-R [5]. Sample Entropy was also computed and provides a simple index for overall complexity of HRV time series [8].

The statistical analysis was performed using Independent sample T-test (SPSS v.17.0). Skewness of distribution in absolute spectral powers was normalized by natural logarithmic transformation.

RESULTS:

There was no difference between smokers and non-smoker regarding oxygen saturation (96.3±1.6 vs 96.8±1.2 % p=0.330) and blood pressure (117.4±9.4/75.5±7.1 vs 119.5±6.4/75.5±7.1 mmHg p=0.312) but smokers had higher heart rate at rest (76.3±14.2 vs 65.2±9.0 b/min p=0.008). The results from the HRV analysis are presented in table 1.

The group of smokers had diminished time domain and non-linear HRV parameters (Fig. 1). Frequency domain analysis showed decreased Total power and high frequency but increased LF in normalized units and respectively LF/HF index.

Table 1. HRV comparison between young,"healthy" smokers and non-smokers

Parameter	Smokers	Non-smokers	p
SDNN (ms)	40.3±16.3	62.0±32.1	0.013
RMSSD (ms)	24.9±12.5	59.3±32.8	<0.001
lnTP (ms2)	7.0±0.8	7.7±1.1	0.046
lnLF (ms2)	6.0±1.0	6.9±1.1	0.015
lnHF (ms2)	5.3±1.1	6.5±1.5	0.013
LF (nu)	66.8±11.0	54.2±14.6	0.010
HF (nu)	33.2±11.0	45.3±14.6	0.010
LF/HF	2.3±0.9	1.4±0.8	0.004
SD1 (ms)	19.4±12.4	41.8±23.2	0.001
SD2 (ms)	53.3±19.2	93.8±39.9	<0.001
SD1/SD2	0.34±0.10	0.43±0.10	0.018
SampEn	1.4±0.3	1.6±0.2	0.049

Legend: SDNN – standard deviation of normal-to-normal intervals, RMSSD – root mean square of the successive differences, TP - Totalpower, LF- Lowfrequency, HF - Highfrequency, SD1- Standard deviation of Poincareplot-1, SD2- standard deviation ofPoincareplot- 2, SampEn – Sample entropy.
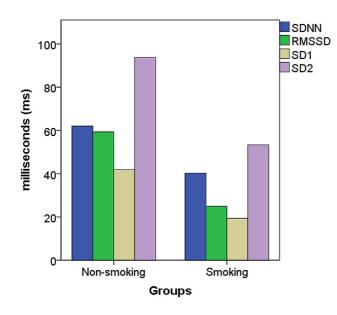

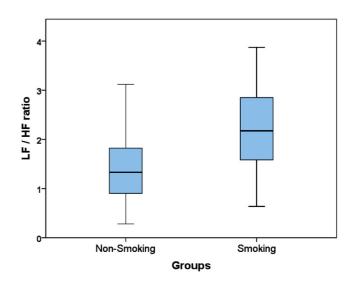**Fig. 1.** Time domain and non-linear HRV parameters in smokers and non-smokers.

DISCUSSION:

The results from our study show that at rest smokers have normal oxygen saturation but increased heart rate and altered HRV. Therefore, smoking leads to decrease in the overall variability (lowered Total power and SDNN), vagal withdrawal (lowered RMSSD, HF and standard deviations of the Poincare Plot), sympathetic predominance (increased LF (nu) and LF/HF) and decreased complexity of the time series (lowered SampEn).

The idea for the altered autonomic regulation in smokers has been previously studied. Manzano et al. have found that smoking a cigarette leads to acute modifications of the autonomic control associated with sympathetic activation and vagal withdrawal and these changes are present for 30 minutes after the smoking [9]. Therefore we tried to eliminate the acute effect of smoking by instructing the subjects to refrain from smoking at least 2 hours before the test and we assessed the long-term effects caused by cigarettes.

Results from our research are supported by other studies who have established significant decrease in HRV with increased LF/HF in heavy smokers with more than 15 pack-years [10, 11]. Even though we have measured HRV in younger patients with less pack-years, the same pattern of autonomic function alteration is present. Although there were no clinical symptoms in the smokers group there was evidence for sympathetic predominance assessed by LF/HF ratio (Fig. 2). It could be associated with the attenuated baroreflex in smokers which normally decreases the sympathetic activation [12, 13]. Therefore measuring HRV could be a very useful screening test for detecting ANS alterations in smokers long before the clinical signs appear.

Fig. 2. Comparison of LF/HF ratio between young "healthy" smokers and non-smokers.

CONCLUSION:

Cigarette smoking altered autonomic nervous function measured by HRV in young "healthy" males in the absence of subjective clinical signs or symptoms. The method may be applied in the clinical practice to detect early changes in the ANS activity.

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