

=== SHORT COMMUNICATION ===

## Acute effects of electronic cigarette smoking on heart rate variability

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**SUMMARY.** Heart rate variability (HRV) refers to a temporal variation between consecutive heart beats and is considered a measure of the balance between the sympathetic and the parasympathetic nervous system. HRV is also one of the few methods which can evaluate the acute effects of smoking on the autonomous nervous system. The aim of our study was to evaluate and compare HRV parameters during regular cigarette and electronic cigarette smoking. The study was performed on 15 regular cigarette smokers and 15 electronic cigarette smokers, and time-domain, frequency-domain and nonlinear parameters of HRV were recorded. When smoking regular cigarettes, the subjects had lower values of HRV parameters than before smoking, whereas electronic cigarette smokers described higher HRV parameters values for all HRV parameters. Our results regarding the behavior of HRV parameters during regular cigarette smoking are consistent with the literature, but the evaluation of the sympathovagal balance during electronic cigarette smoking was performed for the first time in our study.

**Keywords:** electronic cigarette, heart rate variability, smoking.

### Introduction

Heart rate variability (HRV) refers to the variation in consecutive R-R intervals on the electrocardiogram (ECG) and represents a sensitive and non-invasive measure of the autonomic nervous system (ANS) function and balance (Henry *et al.*, 2010;

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Tsai *et al.*, 2014). HRV is usually evaluated by visual methods (the R-R intervals tachogram and the Poincaré plot) and, more accurate, by time-domain, frequency-domain and nonlinear parameters (Acharya *et al.*, 2006).

Long-term cigarette smoking is reported as a major and independent risk factor for cardiovascular morbidity and mortality, especially by sympathetic mediation (Karakaya *et al.*, 2007). However, only a few studies focused their investigations on short-term (acute) effects of smoking, i.e. the effects of smoking on fast-changing parameters. HRV is a method of assessing acute effects of cigarette smoking on the ANS balance (Gondim *et al.*, 2015).

The aim of the study was to evaluate the acute effects of electronic cigarette smoking on HRV.

## Materials and methods

The study included 15 healthy habitual smokers (20-22 years old, 8 females, all smokers for at least 2 years, both electronic and regular cigarettes), and HRV was continuously recorded for 25 minutes: 5 minutes without smoking (the control period), 5 minutes the subject was asked to smoke from an electronic cigarette and 15 more minutes after the smoking of the cigarette; this last period was divided into three 5-minutes periods, for statistical purposes. The first 5-minutes period was considered control and Student *t* test was used for value comparison. A  $p < 0.05$  was considered statistically significant.

ECG traces used for HRV analysis were performed using a Neurosoft Poly-Spectrum-8 device, which interfaces a personal computer *via* an USB port. Leads were placed on both arms and legs and the ECG was performed in 6 derivations (DI, DII, DIII, aVL, aVR and aVF). R-R intervals were calculated using Poly-Spectrum integrated software and HRV parameters were computed using Kubios HRV, a freeware academic tool for HRV analysis developed by University of Kuopio, Finland.

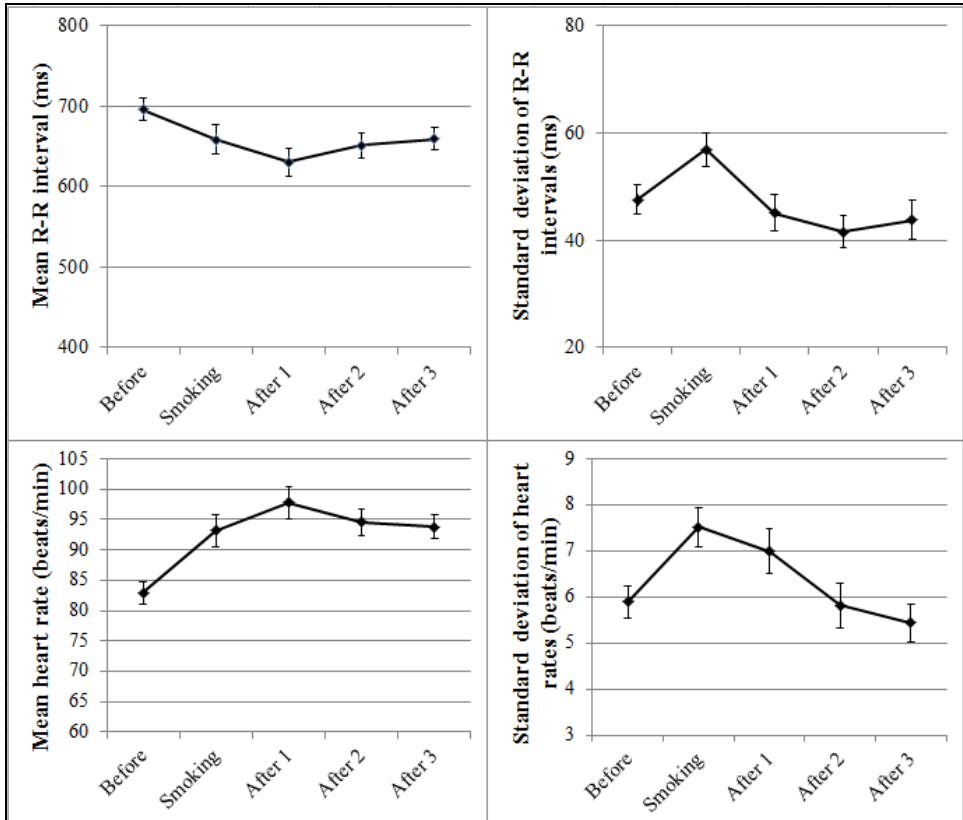
**Table 1.**

HRV parameters included in the study

<b>Time-domain parameters</b>		
Mean R-R interval	ms	Average of all R-R intervals
Standard deviation of RR intervals	ms	Standard deviation of all R-R intervals
Mean heart rate	beats/min	Average heart rate
Standard deviation of heart rates	beats/min	Standard deviation of all momentarily heart rates
<b>Frequency-domain parameters</b>		
LF/HF		Ratio between low frequency and high frequency power in the fast Fourier transform
<b>Nonlinear parameters (descriptors of the Poincaré diagram)</b>		
SD1	ms	The short radius of the Poincaré plot
SD2	ms	The long radius of the Poincaré plot

## Results and discussion

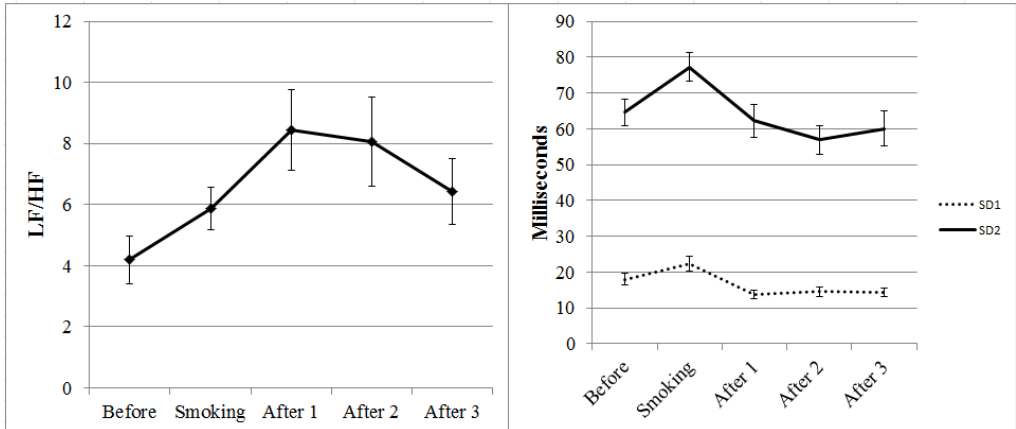
Time-domain parameters expressed discordant values. Heart rate increased during smoking and in the first 5-minutes interval after smoking ( $p < 0.05$ ), with a decrease in the following 5-minutes interval. On the other hand, SDRR increased during smoking compared to the control interval ( $p < 0.05$ ) and returned or the control values in the next 15 minutes (Fig. 4).



**Figure 4.** Time-domain parameters in subjects smoking electronic cigarettes.

LF/HF had a similar behavior to the regular cigarette users, returning to the control values in the next 15 minutes ( $p < 0.05$  when comparing the smoking interval to the control interval and the three 5-minutes intervals with the smoking interval) (Fig. 5-Left).

The Poincaré plot statistical descriptors are in accordance with the variation of SDRR: both SD1 and SD2 expressed an increase during smoking and a decrease in the next 15 minutes (Fig. 5-Right).



**Figure 5.** Left – LF/HF and Right – statistical descriptors of the Poincaré diagram in subjects smoking electronic cigarettes.

## Conclusions

While the vast majority of the studies assayed the effects of long-term smoking on the heart and autonomic balance, our study premierly compared the acute effects of electrical cigarette on the autonomic balance, by the means of HRV. Despite the reduced number of volunteers, we clearly demonstrated that smoking has a direct influence on HRV parameters.

While HRV expressed an overall decrease in regular cigarette smoking, suggesting a sympathetic prevalence during smoking and 5 minutes after, the situation concerning electronic cigarette was different. The differences between the two types of smoking habits were pronounced in those parameters that are considered independent descriptors of HRV (SDRR, SDHR, SD1 and SD2), which were increased in electronic cigarette smokers.

Very few studies have been performed on the acute effects of smoking on HRV and none concerning the effects of electronic cigarette smoking. Nevertheless, our results are consistent with the literature, HRV parameteres decreasing during smoking (Karakaya *et al.*, 2007). Other studies (Middlekauff *et al.*, 2014; Gondim *et al.*, 2015 focused on the comparison between HRV parameters in smokers and non-smokers, not taking into consideration the acute effects.

The decrease in HRV described by regular cigarette smokers was expected, considering the fact that nicotine and carbon monoxide triggers adrenalin and noradrenalin release, which increase the activity of the sympathetic nervous system (Karakaya *et al.*, 2007; Henry *et al.*, 2010; Middlekauff *et al.*, 2014; Gondim *et al.*, 2015).

Unexpected results were found concerning HRV parameters in electronic cigarette smokers. They were found to have increased values during smoking, which is unexplainable on the knowledge of current data about the effect of nicotine (even in pure solution) on the nervous system.

The limitations of the current study are the small number of subjects and their young age.

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