Does chronic smoking affect induced-exercise catecholamine release?

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ABSTRACT: Introduction and objectives: This study was performed to investigate the acute effect of the submaximal aerobic exercise upon epinephrine and nor-epinephrine levels in chronic smokers and non-smoker. The study was carried out upon 10 regular (≥15 cigarettes/day) smoker untrained male along five years and 10 never smoker untrained male. Methods: Subjects performed an endurance exercise that continues 40 minutes at 70% maximal heart rate. There were 15cc venous blood samples extracted from the forearm pre-exercise (PRE), post-exercise (POST), post-exercise 2 hours (2h), post-exercise 24 hours (24h) to measure of epinephrine and nor-epinephrine levels. Results: The plasma level of each hormone increased after exercise and the tendency of rise was similar between groups as it seen in which 55.6% and 54.68% for epinephrine and 27.1% and 35.7% for norepinephrine. In this respect no group-time relationship has been found (p>0.05). But in between-group analyses, basal and after exercise levels were different (p<0.05). Discussion and conclusion: The study revealed the fact that, smokers have higher plasma levels of epinephrine and norepinephrine before and after exercise. The results demonstrate that long-term smoking induces elevate baseline and post-aerobic submaximal exercise plasma epinephrine and nor-epinephrine levels. The sympato-adrenal activity appears to be disrupt with long-term smoking which effect the glycolytic and fat metabolism during exercise.

KEY WORDS: smoke, epinephrine, nor-epinephrine, aerobic exercise, catecholamines

INTRODUCTION
Tobacco kills approximately 6 million people which includes about 600,000 are also estimated to die from the effects of second-hand smoke [1] and causes more than half a trillion dollars of economic damage each year [2]. In total, tobacco use is responsible for the death of about 1 in 10 adults worldwide. Smoking is often the hidden cause of the disease recorded as responsible for death. Even though notable progress has been made in raising awareness of cigarettes in relation to cardiovascular and lung diseases approximately 21.1%(36.9% males; 7.3% female) of the world population still smoke. For Europe this rate is 29.6% according to report [1]. Although both male and female athletes were less likely to have
ever smoked regularly compared to their nonathletic counterparts, there is no sharp difference between them [3]. Besides even if the studies show different results, it is seen that the use of smokeless nicotine is common in athletes [4, 5] as well as tobacco smoking. This epidemic hazard points to the importance of cigarette use and exercise-performance relationship. Smoking cessation have important improvements on athletic performance. For example oxygen cost of breathing decrease between %13-79 and hearth rate lower %5-7 with smoking abstinence for habitual smokers after one day [6] and air resistance increases three-fold after 15 puffs [7]. During graded exercise testing on treadmill seven days smoking abstinence produce significant reduction in hearth rate and increase performance by the time to exhaustion [8]. In the long run, chronic cigarette smokers tend to have lower fitness levels and sedentary lifestyles than counterparts [9]. Smoking enhances dependence on carbohydrate substrate for energy supply in exercise for some reason and decreases lung capacity [10]. All these findings reveal that while one day of abstinence decrease the cost of breathing and enhance performance [10], it is well documented that there are several important negative adaptations of long-term tobacco smoking including lipid profiles, immune function, central adiposity, bone mineral density and reproductive function [11]. Because of these adverse effects, the response during exercise accumulated stress may be expected to react differently in smokers than in non-smokers. In exercise many of hormones are regulated via various regulatory axes including the hypothalamic–pituitary–adrenal axis, the hypothalamic–pituitary–gonadal axis and the hypothalamic–pituitary–thyroid axis as the body transitions from resting to an active state with the increase in metabolism. A major component in the autonomic control during exercise is the adrenergic activity [12]. Adrenergic means the nervous system that uses epinephrine or norepinephrine as its neurotransmitter. The adrenal medulla is the innermost part of the adrenal gland which is responsible for epinephrine, norepinephrine and peptide F secretion with the stimulation of sympathetic nerves [13] and neuronal terminals of the preganglionic sympathetic nerves are mostly responsible for secretion of nor-epinephrine [14]. In basal and homeostatic state these hormones usually stay fixed. Although there are different responses in chronic and acute use, cigarette smoking affects the release of hormones acting in these axis for a variety of reasons. When smoke is inhaled it enters the blood stream, crosses the blood–brain barrier, reaches the central nervous system and peripheral nervous system where it acts as a stimulant [15]. For example activation of nicotinic receptors in chromaffin cells and neurons allows secretion of catecholamine from postganglionic sympathetic neurons and adrenal medulla [16]. During smoking, due to an increase in plasma nicotine levels, neurotransmitter and neuroendocrine disturbances occur. Correlative hormonal response and the increase in catecholamine is also emerge due to the exercise-induced metabolic stress. Based upon these findings it is hypothesized that during submaximal aerobic exercise this chronic negative effect of tobacco smoking will turn into a different and abnormal hormonal response in chronic users compared to non-smoking counterparts.

METHODS

Ten regular smokers (27.7 ± 6.4 age, 184.2 ± 6.6 cm, 82.5 ± 11.6 kg) for five years (>15 cigarettes per day) and ten non-smokers (30.7 ± 4.6 age, 178.0 ± 6.8 cm, 82.7 ± 12.0 kg) participated in this study. The subjects with any symptoms (hypertension, thyroid, diabetes, cardiac etc.) and those involved any training program was not included in study.

Subjects performed an endurance exercise on treadmill (Dunlop EL900) that continues 40 minutes in 70% maximal heart rate – (approximately%55-63 MaxVO2) (Pollock et al., 1998). To verify and record the duration and intensity of exercise, participants wore a heart rate monitor (Polar RS400, Polar, Kempele, Finland). There were 15 cc venous blood samples extracted from the forearm pre-exercise (PRE) and post-exercise (POST) to measure plasma epinephrine and nor-epinephrine levels. The blood samples were first centrifuged at a rate of 5000 revolution/minute and the upper phases were transferred to eppendorf tubes and kept at -80 C until the use [17]. Serum epinephrine and nor-epinephrine levels of all subjects were analyzed PRE-POST. Concentrations were studied with the immuno chemiluminescence method using the DiaSorin Liaison auto analyzer kit. The participants were given detailed information about the objectives of the study in accordance to the Helsinki Medical Declaration and they gave their full content. This study was carried out according to the approval of Selçuk University Faculty of Sports Science Non Enterprising Ethical Committee.

Distributions of the variables according to the groups were analyzed and the normality of the distribution and the homogeneity of the variances were determined with the Mauchly’ Sphericity Test and Levene test. Within-group and smoking-effect analysis were carried out with the repeated measures ANOVA and between-group analysis were carried out with Mann-Whitney U tests, level of significance was accepted as 0.05.

STATISTICAL RESULTS

Descriptive statistics of non-smoker and smoker groups has been given in the table above. The equality of variances and anthropometric differences between groups analyzed with Levene test and independent samples t-test. According to results which is not shown in table there is no between group difference in any measured data (p>0.05) (Table 1).

The plasma level of each hormone increased after exercise and the tendency of rise was similar between groups as it seen in which 55.6% and 54.68% for epinephrine and 27.1% and 35.7% for norepinephrine. In this respect no group-time relationship has been found (p>0.05). But in between-group analyses, basal and after exercise levels were different (p<0.05). Smokers have higher plasma levels of epinephrine and norepinephrine before and after exercise (Table 2).
Table 1. Descriptive statistics for smokers and non-smokers.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
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<td></td>
<td></td>
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<tr>
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<td>37,0</td>
<td>30,7</td>
<td>4,6</td>
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<tr>
<td>Weight (kg)</td>
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<td>107,2</td>
<td>82,7</td>
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<td>192,0</td>
<td>178,1</td>
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<td>BMI</td>
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<td>19,7</td>
<td>31,0</td>
<td>25,9</td>
<td>3,4</td>
</tr>
<tr>
<td>BFP (%)</td>
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<td>18,5</td>
<td>4,9</td>
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<tr>
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<td>38,0</td>
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<td>Weight (kg)</td>
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<td>BMI</td>
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<td>BFP (%)</td>
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<td>20,8</td>
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Table 2. Between-group and within-group comparisons of pre-post endurance training epinephrine and nor-epinephrine values

<table>
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<tr>
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<th>Pre Mean</th>
<th>Pre sd</th>
<th>Post Mean</th>
<th>Post sd</th>
<th>Difference Mean</th>
<th>Difference sd</th>
<th>time*group</th>
<th>p</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Non-Smokers</td>
<td>10</td>
<td>0,175</td>
<td>0,066</td>
<td>0,273</td>
<td>0,172</td>
<td>0,098*</td>
<td>0,172</td>
<td>55,644</td>
<td>0,462</td>
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<td>Smokers</td>
<td>10</td>
<td>0,268</td>
<td>0,054</td>
<td>0,414</td>
<td>0,139</td>
<td>0,147*</td>
<td>0,139</td>
<td>54,685</td>
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<td>-1,965*</td>
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<th>Pre sd</th>
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<th>Difference Mean</th>
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<td>Non-Smokers</td>
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<td>0,581</td>
<td>2,509</td>
<td>0,778</td>
<td>0,535*</td>
<td>0,778</td>
<td>27,102</td>
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<td>3,982</td>
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<td>1,049*</td>
<td>1,049</td>
<td>35,765</td>
<td>0,171</td>
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<td></td>
<td>-3,326*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>p</td>
<td></td>
<td>0,001</td>
<td></td>
<td>0,001</td>
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</table>

*: within group difference is significant p<0,05 sd: standard deviation, diff: difference

**DISCUSSION**

Pre-exercise basal plasma epinephrine and nor-epinephrine levels were high in untrained smokers than smokers. Likewise, post-exercise plasma hormone levels are also higher in smokers. Smoking appears to induce increased sympathetic discharge and leads to an increase in plasma levels of both the adrenomedullary hormone epinephrine and the sympathetic neurotransmitter norepinephrine [18, 19, 20]. At the cellular level nicotine acts by binding to and activating the nicotinic acetylcholine receptors in the brain and in the adrenal medulla which leads to increased catecholamine levels with corresponding cardiovascular and metabolic responses [15]. In another study, it was explained by effect of long-term cigarette smoking on beta-adrenoceptor density and catecholamine response. The density of beta-adrenergic receptors was 40% lower in the lymphocytes of smoking
twins compared with their nonsmoking cotwins [19]. In another study beta-
adreno receptor blockade significantly reduced oxygen consumption in
nonsmokers but not in smokers who also incurred a significantly greater
oxygen debt and had higher serum lactate levels [21]. These findings
explain the mechanism which leads to have more secreted plasma
catecholamine in smokers.

In the present study, both hormones elevated post-exercise for both groups.
The increment in plasma catecholamine levels with both aerobic [22, 23, 24, 20] and anaerobic exercise [25, 26] has been demonstrated in many
studies. In the present study, the duration of the exercise was 40 minutes or
until exhaustion with the intensity of %70 HRmax which was almost equal to
65-70% of VO2max for untrained subjects [27]. Studies with similar
intensity show parallel catecholamine responses [22, 23, 28].

On the other hand, the relationship of catecholamine increment with
exercise in terms of tobacco smoking has not been well studied. The plasma
increment tendency was similar for non-smokers and smokers respectively
55.6% and 54.68% for epinephrine and 27.1% and 35.7% for
norepinephrine during submaximal aerobic effort. Chronic smoking habit,
did not make a significant difference in the hormonal responses during
exercise. In a previous study epinephrine and nor-epinephrine did not
significantly elevated with exercise for smokers and non-smokers but the
total catecholamine level, expressed as epinephrine plus norepinephrine,
was significantly elevated in smokers compared with nonsmokers at rest in
the basal state and at peak heart rate (85% of age-adjusted maximal heat
rate) [19]. In the present study the total amount of epinephrine and
norepinephrine also did not make a significant difference between smokers and
non-smokers (not shown in statistical analyses). The exercise intensity
(increased in steps of 50 W to reach a heart rate corresponding to 85% of
the age-adjusted maximum, continued approximately 10 min in previous
study) or the statistical method used might be the conflict of these two
studies in catecholamine responses. Although the trend is similar, it was
seen that the level of catecholamine is higher in smokers. This suggests that
catecholamine sensitivity is decreased in smokers [19]. Catecholamine
effect on plasma free fatty acid circulation has been shown to decrease in
smokers [19] which may enhance dependence on carbohydrate substrate
for energy supply in exercise [10].

In summary, the present study shows that long-term smoking induces
elevate baseline and post-aerobic submaximal exercise epinephrine and
nor-epinephrine plasma levels. The sympa-tho-adrenal activity appears to
be disrupt with long-term smoking which effect the glycolytic and fat
metabolism during exercise.

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the authors have any potential conflicts of interest associated with this
research.

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