Effects of Oral pH Changes on Smoking Desire

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ABSTRACT
Background: Nicotine addiction is associated with nicotine absorption from buccal mucosa and it is stated that the main factor that determines the nicotine absorption is saliva pH. In the literature, the effects of changes in saliva pH values after eating and drinking on smoking desire in the smokers were not questioned.
Aim: The main purpose of this study was to show the effect of saliva pH changes on smoking desire. The secondary aims were to show the effects of coffee and water drinking on saliva pH and the effects of smoking on oral-dental health (oral hygiene, gingival bleeding).
Study Design: Case-control
Methods: A questionnaire was administered that included "Sociodemographic Data Form" and smoking history and Fagerström Test for Nicotine Dependence (FTND). Oral and dental examinations were performed with mirror sonds and using oral hygiene standard Silness and Leöe plaque index and DMFT Index (Index of Decayed Missing or Filled Teeth). Untreated saliva samples were taken and baseline saliva flow rate and pH values were measured. To assess

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pH changes, saliva pH was remeasured after sugar-free instant coffee and water consumption. Smoking desire was evaluated with Visual Analog Scale (VAS).

Results: There were 24 (55.8%) female and 19 (44.2%) male among the 43 smoking and 39 nonsmoking cases. Smoking was significantly associated with poor oral hygiene (in smokers 4.71 (1.40), in nonsmokers 2.30 (1.59); p<0.01). DMFT Index was higher in smokers than in nonsmokers (in smokers 6.45 (3.69), in nonsmokers 3.87 (2.67); p<0.01). Gingival bleeding was more prevalent in smokers (0.68 (0.76)), than nonsmokers (1.20 (0.90); p=0.009). Salivary flow rates were lower in smokers (in smokers 2.56 (1.34), in nonsmokers 3.00 (1.22), p=0.06). In both groups, pH values increased after coffee consumption and decreased after water; in smokers basal:6.67 (±0.41), pHcoffee: 6.93 (±0.36), pHwater: 6.85 (±0.33); in nonsmokers pHbasal: 6.84 (±0.37), pHcoffee: 7.02 (±0.37), pHwater: 6.97 (±0.31), p<0.01. The VAS values of smokers at basal 4.73 (±3.21); p<0.01, after coffee consumption 4.91 (±3.08); p<0.01 and after water 3.15 (±2.72); p<0.01.

Conclusion: The saliva pH increased after coffee consumption and decreased after drinking water. Besides VAS values decreased significantly after drinking water. The results suggest that a simple behavior such as drinking water may be used in conjunction with behavioral and cognitive therapies in the pursuit of smoking cessation.

Keywords: Caffeine, Nicotine, pH, water drinking

Introduction

Nicotine addiction is the most common disease of our societies and it can be treated with medical methods like other diseases (1). Pharmacotherapy with proven scientific efficacy as well as cognitive and behavioral treatments play an important role in reducing smoking (2). In this context, it is recommended to question the daily behavior patterns along with ensuring the motivation of the person, to identify the factors that trigger the desire to smoke, to develop methods to combat them, and to organize them in ordinary activities including eating and drinking.

It can be observed that there is an increase in the desire to smoke during drinking tea and coffee and after meals. Consumption of acidic foods makes the oral pH acidic, and saliva increases to neutralize it. Caffeine is another psychostimulant found in varying proportions in coffee and tea, and its stimulating effects on the locomotor system are antagonistic at the level of adenosine receptors (3). It has been reported that smokers consume more caffeine than nonsmokers (4). However, this effect may not be solely due to the pharmacological effects of caffeine, but also that the desire to smoke is caused by a change in pH in the mouth. In a study by Parvinen et al. the pH of saliva was shown to be lower in smokers than nonsmokers (5). It was also reported that saliva secretion capacities were decreased as well.

The amount of nicotine and the absorption rate from the buccal mucosa significantly affect the risk of addiction. In addition to oral pH, other factors such as local blood flow, moisture of product and size of the surface area of the tobacco mixture, pH constant holding capacity, and nicotine content of tobacco may affect nicotine absorption. Various absorption enhancing substances have been investigated to facilitate the absorption of nicotine from the buccal mucosa. It has been shown that increased pH (alkaline) increases the absorption and physiological effects of nicotine by buffering moist snuff products and nicotine gums to alkaline pH. Although other factors may affect the nicotine absorption rate in the mouth, the main factor that determines the absorption rate of nicotine is stated to be pH (6-8).

There are studies comparing nicotine products containing different amounts of nicotine. However, the effects of changes in saliva pH values after eating and drinking on smoking desire in the smokers were not questioned. Until now, the relation between pre- and post-coffee/water

saliva pH and smoking desire has not been investigated. In this study, the main aim was to investigate the effects of changes in the saliva pH values on smoking desire and the effects of water drinking action on the desire to smoke. The secondary aims were to show the effects of coffee and water drinking behavior on saliva pH and the effects of smoking on oral-dental health (oral hygiene, gingival bleeding).

Methods

Design

This study was a case-control study. After obtaining approval from the Clinical Studies Ethics Committee (2018/09-01), smokers and nonsmokers volunteers invited to the study.

Sample size was calculated as follows. In the preliminary evaluation made before starting the study, saliva samples were taken from 5 non-smoker and 5 smoking volunteers and pH was measured. Estimated saliva pH for the control group: 7.00, estimated saliva pH for the case group: 6.75, standard deviation 0.29; when 0.05 margin of error and 0.9 power and possible drop out rate were considered as 10%, it was planned to enroll 35 volunteers for each group (9).

The inclusion criteria were as follows: not having an active disease, being between the ages of 18 and 45, not using antibiotics in the past two weeks, not using inhaler treatments, not having oral and salivary gland diseases, to be in the week after the menstrual bleeding period in women. In the control group, individuals without smoking history and any secondary smoke exposure included. Exclusion criteria were presence of an active disease, less than 18 years or greater than 45 years of age, antibiotic use in the past two weeks, use of inhaler treatments, oral and salivary gland disease, menstrual irregularities in women, being in the luteal phase, pregnancy, and using hormonal therapy (10, 11).

Data Collecting

A questionnaire was administered that included "Sociodemographic Data Form" and smoking history and Fagerström Test for Nicotine Dependence (FTND). The scores were classified as low (0 - 4 points), medium (5 -7 points) and high (8 - 10 points) according to Turkish Ministry of Health, Fighting Tobacco Addiction Handbook for physicians (12-14).

Oral and Dental Examinations

Oral and dental examinations were performed with the mirror sonds. The oral hygiene standard was estimated using the Silness and Löe plaque index (15). DMFT Index (Index of Decayed Missing or Filled Teeth), a method for measuring present (decayed teeth) and past (missing and filled teeth) caries experiences in permanent dentition was evaluated and also, debris, calculus, and also gingival bleeding were evaluated (16).

Saliva Collection and pH Measurement Procedure

Measurements were made at room temperature (22-25°C), in a standard environment, and in the same place. Oral and dental examinations of all the participants were performed and saliva samples were taken 3 times; the first sample, the second sample after coffee (pH: 5.5), and the thirth sample after water (pH: 6.34), in a total of 30 minutes. Saliva flow rates and pH values were measured by taking saliva samples from all cases at least 1 hour after breakfast and simultaneous VAS (Visual Analog Scale) smokers' actual smoking desire was measured (Figure 1). pH measurements were made with the table device "InoLab pH 720" (WTW, Germany). Device calibrations were made at the beginning of each measurement day and when deemed necessary.

Visual Analog Scale

Visual analog scale (VAS) - used to assess the current smoking desire. Participants put a vertical mark on a 100mm line with "no desire to smoking" on the far left and "excessive desire to smoking" on the far right. Measurements were made with the help of a ruler and evaluated with numbers between 0-10. The signs put by the participant at baseline, after coffee and after

drinking water were evaluated as increased or decreased according to whether they were on the right or left and with numerical values (17, 18).

Statistical Analysis

In this study, assuming a 0.05 margin of error and 0.9 power and a possible drop-out rate of 10%, 35 volunteers were planned for each group. Forty-three volunteers in the case group and 39 volunteers in the control group were included. Continuous variables according to distribution analysis mean ± standard deviation (SD) or median-interquartile range (IQR); categorical variables were presented as numbers and percentages. Students' T-test was used to analyze the significance of independent continuous variables within and between groups. In binary analysis, Chi-square and Mann-Whitney U test were used depending on distribution of data. p-value <0.05 was considered statistically significant.

Results

Forty-three smokers were included in the case group and 39 nonsmokers were included in control group (Table 1). The most common reason for starting smoking was stress (22%). The second most common causes were curiosity (13.4%) followed by wannabe (12.2%). When the factors triggering smoking requests were questioned, the most frequently stated factor was after meals (37.8%). In addition, stress (29.3%), ambience (27.9%), alcohol (22%), coffee (19.5%) and tea (18.3%) were other trigger factors.

The oral hygiene scores, DMFT values, debris and calculus scores and gingival bleeding values of the case and control groups are summarized in Table 2. Smoking was significantly associated with poor oral hygiene (p<0.01). DMFT values were higher in smokers than in nonsmokers (p<0.01). "M" datas indicating missing teeth were analyzed and it was observed that there was more tooth loss in the smoker group compared to the nonsmoker group (in smokers 2.62 (3.08), in nonsmokers 0.58 (1.18), p<0.01). Also, debris and calculus values were higher in smokers than in nonsmokers, and gingival bleeding was more prevalent in nonsmokers than in smokers (p=0.009).

The saliva flow rates, saliva pH values and changes in the case and control groups, and the changes in VAS values in smokers are summarized in Tables 3 and 4. Although it was not statistically significant, salivary flow rates were lower in smokers (p=0.06). The basal saliva pH values of the smokers were found to be lower than nonsmokers but it was not statistically significant (p=0.104). In both groups, pH values increased after coffee consumption and decreased after water and this is shown in Figure 2. The changes between pH_{basal} (pH1) and pH_{coffee} (pH2) (p<0.01), pH_{coffee} (pH2) and pH_{water} (pH3) (p=0.019) were significant as summarized in Table 4. The VAS values of smokers at basal 4.73 (3.21) (VAS1), after coffee consumption 4.91 (3.08) (VAS2) and after water 3.15 (2.7) (VAS3) Figure 3). The change between basal - VAS1 and after coffee - VAS2 was not statistically significant, but the change between after coffee - VAS2 and after water – VAS3 was statistically significant (p <0.01) (Table 4).

Discussion

In this study, it was observed that the basal saliva pH values of the smokers were lower than nonsmokers, and the pH of saliva increased after drinking an acidic beverage (pH: 5.5) such as coffee, and the pH of saliva decreased after drinking water in both groups. The changes between pH1 and pH2, and the changes between pH2 and pH3 were significant. Changes were observed in the VAS values that we used to evaluate the smoking desire. Changes were observed in the VAS values we used to evaluate the smoking desire. The change between VAS1 and VAS2 was not observed significantly, but the change between VAS2 and VAS3 was statistically significant. Also it was observed that salivary flow rates were lower in smokers. As a result of evaluations for oral health, it was observed that smoking was significantly associated with poor oral hygiene. DMFT values were higher in smokers than in nonsmokers. Debris and calculus

values were higher in smokers than in nonsmokers, and gingival bleeding was more prevalent in nonsmokers than in smokers.

Nicotine absorption was studied in various commercial products with different nicotine concentrations and different pH values, and it was found that higher pH products gave more nicotine than low pH products. It has been shown that nicotine is in the non-ionized form at alkaline pH and is more easily absorbed in the buccal mucosa and is not sufficiently absorbed in the ionic form at acidic pH values (9, 19, 20). In saliva, pH has been reported to show a rapid and temporary increase after smoking. Other studies report that the pH value is relatively lower in smokers compared to nonsmokers (21). However, the correlation between smoking desire and saliva pH has not been extensively studied. In our study, it was observed that saliva pH increased after drinking coffee, but there was no significant change in smoking desire.

There was no statistically significant change between VAS1-basal and VAS2-after coffee, but there was a statistically significant decrease in VAS3 values after drinking water suggested that smoking desire was decreased. Actually smoking desire was assesed with VAS which was previously described in literature. VAS is a method that has been used in previous studies to evaluate smoking desire and is considered valid (17, 18). As indicated in Table 4, although VAS scores did not change with coffee consumption, significant change was observed after water consumption as decrease in VAS score which suggests decrease in smoking desire. These findings suggest that water consumption may decrease smoking desire in smokers however this finding merits more research in this area. In our study, it was shown that there was an increase in saliva pH values after caffeine, and at the same time, an increase in VAS values was found, but it was not found statistically significant. Participants associated this situation with their traditional preference for tea. The factors that trigger nicotine use include stress, daily routine, eating and drinking habits, and especially caffeine. Caffeine and nicotine interactions can be explained by neurochemical mechanisms. Caffeine is a non-selective antagonist at the level of A1 and A2A receptors. Chronic caffeine exposure has been shown to produce a change in the number and function of central adenosine receptors. Acting as an agonist at A1 and A2 receptors, adenosine inhibits the mediated effects of D1 and D2 dopamine receptors (4, 22). Use of nicotine with caffeine provides potential for stimulation via dopaminergic pathway (23). There are studies reporting that there is no interaction between caffeine and nicotine, and studies reporting that caffeine consumption increases the number of cigarettes smoked, although there are also epidemiological studies that relate co-consumption of caffeine and nicotine after meals and between meals rather than pharmacological effects. It has been reported that smokers consume more caffeine than nonsmokers (24, 25). In a study by Emurian et al., it was shown that there is more smoking in the 20 minutes after coffee consumption compared to the 20 minutes before. In other studies, it was reported that there is no interaction between caffeine and nicotine, and between co-consumption of caffeine and nicotine after meals and between meals rather than pharmacological effects. And also, it was tested that increased dosage of caffeine may alter nicotine intake in smokers. As a result, it has shown an upward trend in cigarette consumption during caffeine consumption and a trend toward higher plasma nicotine levels in the low-dose caffeine group compared to the decaffeinated group (26, 27).

Although our results were not statistically significant, smokers were found to have lower saliva flow rates than non-smokers, similar to the literature, (28, 29). In addition, it was shown that smokers' had poor oral hygiene than nonsmokers and and tooth loss was higher in smokers than non-smokers. Also that gingival bleeding was lower in smokers than nonsmokers. Furthermore, previous studies have shown that smokers show more symptoms of periodontal disease than nonsmokers (30, 31) Similar to our results, it was reported that bleeding was reduced in young adult smokers, regardless of plaque and calculus distribution (32).

Conclusion

Although pH of saliva increased after drinking coffee, its effect on smoking desire could not be shown statistically. However, it can be seen that drinking water lowers saliva pH values and the desire to smoke after drinking water decreases. Drinking the appropriate amount of water during the day is a recommended healthy behavior, and regulations in our daily eating and drinking habits are thought to be an important support for smoking cessation treatments. Based on our results, it can be said that quitting smoking is necessary for better oral and dental health. The fact that the results of this cross-sectional study we obtained in our single-center cannot be generalized for all smokers is the limitation of this study.

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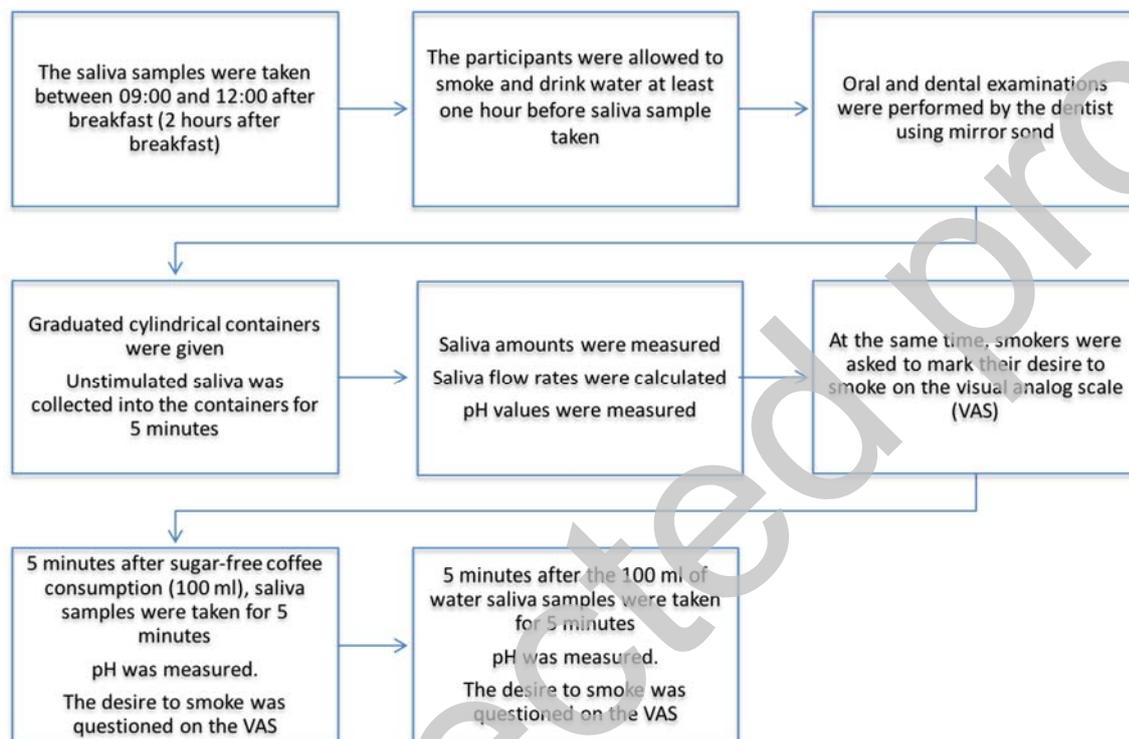
Figure 1: Saliva Collection and pH Measurement Procedure

Table 1: General demographic features of patient population		Smokers n, (%)	Nonsmokers n, (%)	p
Age, year, mean (SD)		32.76 (9.38)	28.74 (9.55)	0.056
Gender, n (%)	Female	24 (55.8)	29 (74.4)	
	Male	19 (44.2)	10 (25.6)	0.079
Married, n (%)		20 (46.5)	15 (38.5)	0.462
Education, n (%)	Primary education	10 (23.3)	5 (12.8)	
	High school	15 (34.9)	18 (46.2)	
	University	11 (25.6)	7 (17.9)	
	Master degree	7 (16.3)	7 (17.9)	
	PhD	-	2 (5.1)	0.326
Occupation, n (%)	Cleaning Staff	7 (16.3)	3 (7.7)	
	Patient Care Staff	7 (16.3)	2 (5.1)	
	Management Staff	3 (7)	4 (10.3)	
	Nurse	6 (14)	3 (7.7)	0.307

	Physician	6 (14)	8 (20.5)
	Student	10 (23.3)	16 (41)
	Other	4 (9.3)	3 (7.7)

Table 2: Oral hygiene, DMFT, debris, calculus and gingival bleeding in smokers and nonsmokers					
	Oral hygiene	DMFT	Debris	Calculus	Gingival bleeding
Smokers, mean (SD)	4.71 (1.40)	6.45 (3.69)	2.86 (0.93)	1.79 (0.77)	0.68 (0.76)
Nonsmokers, mean (SD)	2.30 (1.59	3.87 (2.67)	1.52 (1.13)	1.06 (0.98)	1.20 (0.90)
p	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*0.009*

Table 3: Saliva flow rate and pH values of smokers and nonsmokers					
	Saliva flow rate	pH basal saliva	pH after coffee	pH after water	*p*
Smokers, mean (SD)	2.56 (1.34)	6.67 (0.41)	6.93 (0.36)	6.85 (0.33)	*<0.01*
Nonsmokers, mean (SD)	3.00 (1.22)	6.84 (0.37)	7.02 (0.37)	6.97 (0.31)	*<0.01*
p	*0.06*	*0.104*	*<0.01*	*<0.01*	

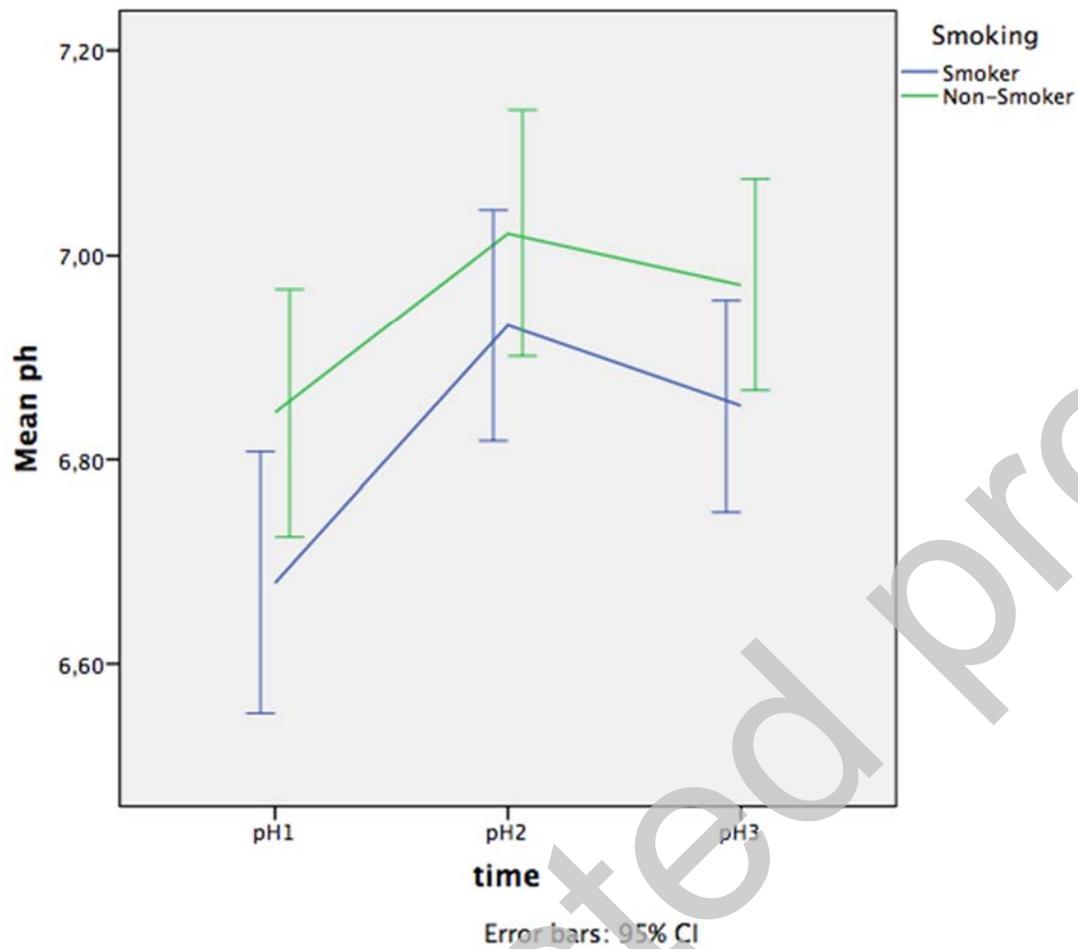| Table 4: pH and VAS changes in smokers		
	Mean (SD)	*p*
pH basal – pH after coffee	6.67 (0.41) - 6.93 (0.36)	*<0.01*
pH after coffee - pH after water	6.93 (0.36) - 6.85 (0.33)	*0.019*
VAS basal - VAS after coffee	4.73 (3.21) - 4.91 (3.08)	*>0.05*
VAS after coffee - VAS after water	4.91 (3.08) - 3.15 (2.72)	*<0.01*

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Figure 2: The changes of pH values; basal - pH1, after coffee - pH2 and after water - pH3, in smokers and nonsmokers
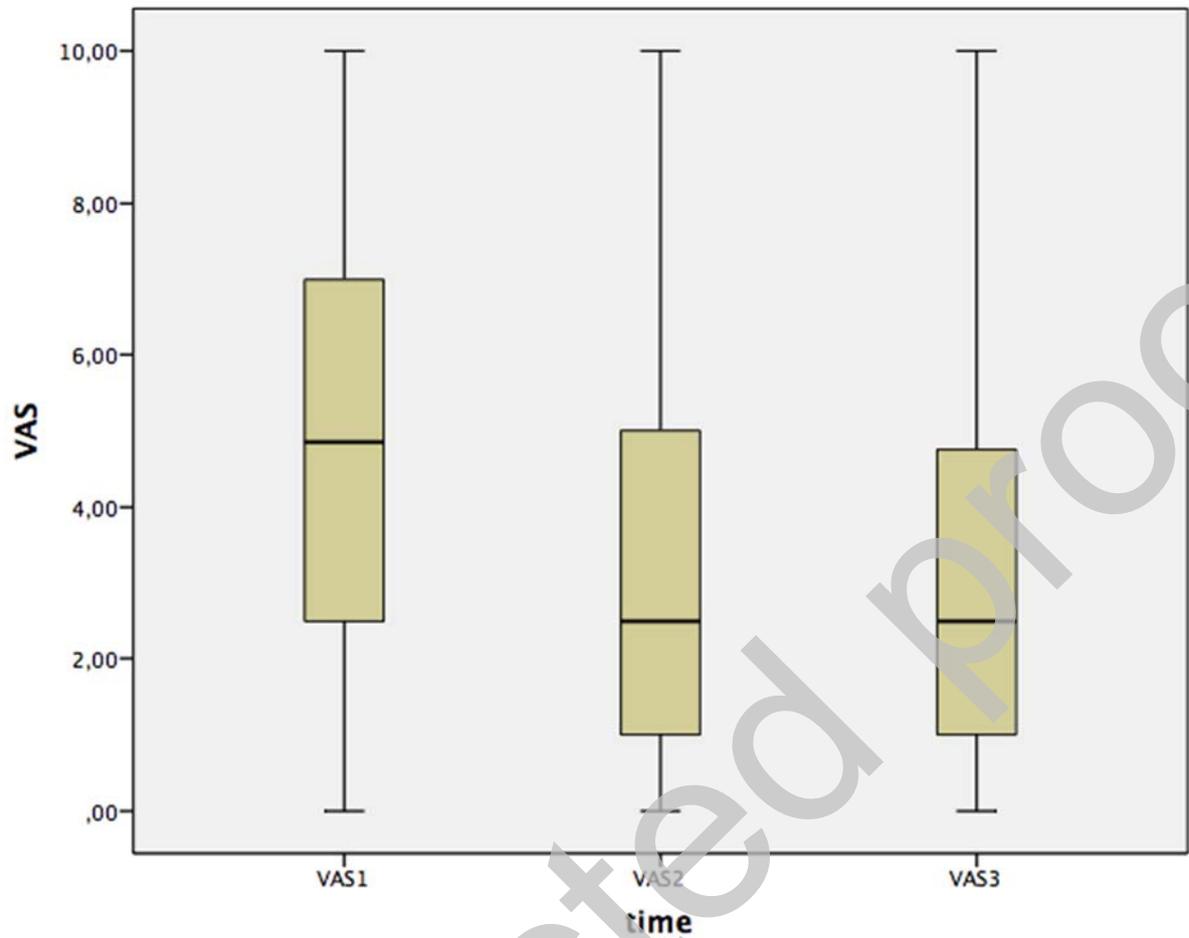
Figure 3: The changes of VAS values; basal - VAS1, after coffee consumption - VAS2 and after water - VAS3, in smokers