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Research Report

The correlation between pH and flow rate of salivary smokers related to nicotine levels labelled on cigarettes

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ABSTRACT

Background: *Saliva is a biological fluid in oral cavity that plays a role in maintaining the environmental balance and oral commensal. Nicotine of cigarettes has been reported as a predisposing factor for changing of pH and salivary flow rate, thereby changing in biological salivary components.* ***Purpose:*** *This study aimed to analyze the correlation between salivary pH and salivary flow rate in smokers with nicotine levels labeled on cigarettes.* ***Methods:*** *Purposive sampling was conducted involving 40 male smokers. Before participating, they filled a questionnaire related to the history of their smoking habit. Using a spitting method for 5 minutes their saliva was collected.* ***Results:*** *Result of Pearson correlation test showed that there was a significant correlation between smoking intensity and salivary flow rate of those smokers ($r = -0.486$ and $p<0.001$). The results also indicated that there was a significant correlation between smoking intensity and salivary pH ($r = -0.376$ and $p<0.017$). On the other hand, there was no significant correlation between nicotine levels levels labeled on cigarettes with salivary pH of those smokers ($r = -0.107$, $p>0.512$). There was no correlation between nicotine levels labeled on cigarettes and salivary pH of those smokers ($r = -0.216$, $p>0.181$). Nevertheless, there was a significant correlation between salivary flow rate and salivary pH of those smokers ($r= 0.686$, $p<0.00$,).* ***Conclusion:*** *There is a strong correlation between the intensity of smoking with salivary flow rate and its pH. However, there is no correlation between nicotine levels labeled on cigarettes and both salivary flow rate as well as salivary pH.*

Keywords: *intensity of smoking; nicotine levels; salivary flow rate; salivary pH*

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INTRODUCTION

Smoking is one of the major health problems in the world, especially in developing countries.[1] Based on World Health Organization (WHO) data in 2012, there are 1 billion smokers in the world with a global smoking prevalence of 21%, 790 million of whom are from countries with low and middle-income economies, including Indonesia on the fourth rank with the largest number of smokers in the world after China, Russia and America.[2] The age of 13-17 is also known to be a transition period to be active smokers in Indonesia.[3]

Smoking is an attempt to burn tobacco, inhale, and suck back smoke containing harmful substances, such as nicotine using both cigarettes and cigars.[4] Oral cavity is a part of the body mostly exposed to cigarette smoke.[5] The exposure to cigarette smoke then can affect saliva, biological liquid, functioning to maintain the balance of the oral cavity.[6]

Nicotine in cigarette smoke will be absorbed through the lungs and mucous membranes, then circulated through the bloodstream, and distributed to the brain and tissue in all organs of the body.[7] Nicotine circulating to the bloodstream can affect the blood vascularization to the salivary glands, resulting in decreased function and morphology of glandula.[8] Nicotine even reaches the brain within 10-20 seconds.[9] Nicotine then can work on certain cholinergic receptors in the brain that affect central nervous system activity triggering changes in salivary secretion.[10,11]

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The changes in salivary secretion can affect salivary flow rate in the group of smokers.[10] The salivary flow rate is a modulator of salivary acidity (pH), thus, if the salivary flow rate is small, a small amount of bicarbonate then will be produced, resulting in low salivary pH.[12] Consequently, salivary flow rate and salivary pH can be considered as factors that play an important role in maintaining oral health.[13]

In addition, the changes in salivary pH and salivary flow rate are influenced by the duration of smoking and the level of nicotine labeled on the cigarette.[14] The smoking intensity is derived from the average number of cigarettes smoked daily multiplied with smoking duration in a year.[1] The concentration of nicotine in the salivary gland of smokers is different due to both the number of cigarettes smoked per day as well as the level of nicotine contained the cigarettes.[15] Therefore, this study aimed to analyze the pH profile and salivary flow rate in association with the labeled nicotine level.

MATERIALS AND METHODS

This study has passed ethical clearance No. 031/KE/FKG/2016 from the Faculty of Dentistry, Universitas Syiah Kuala, Indonesia. This study used cross-sectional design. In this research, risk factors were smoking frequency and nicotine levels labeled on cigarettes related to salivary pH and salivary flow rate.

There were forty subjects in this study, consisted of active male smokers who smoke at least one cigarette per day. Those research subjects were determined by using a purposive sampling technique.[16] Data of those smokers' profile were taken by using an interview approach with referenced questions that had been prepared by the researchers.

Furthermore, saliva of those smokers was collected without stimulation at 09.00-12.00 WIB. Those subjects then were asked not to eat, drink, and brush their teeth 60 minutes before taking saliva. Those subjects were also asked to sit on an upright back with the head slightly bowed, but facing forward, and their right hand holding a measuring cup.[11] Saliva then was collected using spitting method i.e saliva was collected in the mouth with closed lips. Afterwards, it was spitted out into the measuring cup every 1 minute for 5 minutes. During collecting saliva, those subjects were not allowed to speak, to move their tongue and to swallow. Salivary flow rate was calculated by dividing the collected salivary volume with the time used to collect saliva.[17,18]

Salivary pH then was measured using a pH meter. The electrode tip of the pH meter detector was washed with deionized water (ion free water), dried, and then calibrated to a standard pH value (7.0). Meanwhile, the electrode tip was dipped into prepared saliva. The values of the salivary pH tested then were displayed on the screen. Each repetition of another salivary pH examination, the electrode tip of the pH meter had to be calibrated to the standard pH.[18]

The correlation between salivary pH and salivary flow rate was analyzed using a Pearson test. The correlation strength analysis was interpreted as a follow: 0.00-0.199 (very weak), 0.20-0.399 (weak), 0.40-0.5999 (medium), 0.60-0.799 (strong), 0.80 to 1.000 (very strong).[19]

RESULTS

Tables 1, 2, 3, 4, and 5 generally illustrate the correlation between the age of the research subjects and the distribution of the research subjects based on nicotine levels labeled on cigarettes with respect to salivary pH and salivary flow rates. Table 1 shows the distribution of the research subjects by age. Table 2 describes the distribution of the research subjects based on nicotine levels labeled. Table 2 indicates that twenty-six research subjects (65%) had the highest nicotine levels, 1 mg/trunk. Table 3, illustrates that there were twenty-nine research subjects (72.5%) with a salivary

Table 1. Distribution of the research subjects by age

Age (years)	Number of the research subjects (n)	Percentage (%)
17-25	9	22.5
26-35	10	25.0
36-45	11	27.5
46-55	10	25.0
Total	40	100

Table 2. Distribution of the research subjects based on nicotine levels labeled on cigarettes

Nicotine levels labeled on cigarettes (mg)	Number of the research subjects (n)	Percentage (%)
1	26	65.0
1.1	4	10.0
1.8	1	2.5
2.2	1	2.5
2.3	7	17.5
2.5	1	2.5
Total	40	100

Table 3. Distribution of the research subjects based on salivary flow rates

Salivary flow rates (ml/minute)	Number of the research subjects (n)	Percentage (%)
0.1-0.25	29	72.5
0.25-0.35	11	27.5
>0.35	0	0
Total	40	100

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flow rate of 0.1-0.25 ml/min (good), while eleven research subjects (27.5%) had a salivary flow rate of 0.25-0.35 ml/min (medium). None of the research subjects experienced a salivary flow rate of > 0.35 ml/min (bad). Table 4 shows the distribution of the research subjects based on the salivary pH. In Table 4, there were twenty-seven research subjects (67.5%) with a salivary pH of <6.7, while eleven research subjects (27.5%) had a salivary pH of 6.7-7.4 and, none of the research subjects had a salivary pH of >7.4. Results of the statistical tests then showed that there was a significant correlation between salivary flow rate and salivary pH of those smokers (r= 0.686, p<0.00). Result of Pearson correlation test showed that there was a significant correlation between smoking intensity and salivary flow rate of those smokers (r = -0.486 and p<0.001). The results also indicated that there was a significant correlation between smoking intensity and salivary pH (r = -0.376 and p<0.017). There was a significant correlation between the intensity of smoking and changes in both salivary flow rate and salivary pH (p<0.01) (Table 5). On the other hand, there was no significant correlation between nicotine levels levels labeled on cigarettes with salivary pH of those smokers (r = -0.107, p>0.512). There was no correlation between nicotine levels labeled on cigarettes and salivary pH of those smokers (r = -0.216, p>0.181).

DISCUSSION

Oral cavity and salivary liquid are important parts of the mouth mostly exposed to cigarette smoke. On the other hand, nicotine is considered as a predispose factor to structural and functional changes of salivary glands that may interfere with salivary flow rate and salivary pH.[20] Based on the researchers' analysis, the prevalence of smoking behavior increased by age. This correlates with nicotine contained in cigarettes as an addictive substance that can cause dependence and make cigarettes as a daily necessity at adult age (36-45 years), reaching 27% (Table 1). The highest prevalence of smoking behavior was in the age group of 35-45 years, and then decreased in the age group of 45-64 year due to the increased awareness of the danger of smoking.[21]

The insignificant correlation between nicotine levels labeled on cigarettes and salivary flow rate had very weak correlation strength of 1.1%. It means that 98.9% of them were influenced by other factors. Similarly, there was no significant correlation between nicotine levels labeled on cigarettes and salivary pH with weak correlation strength of 4.7%. This indicates that 95.3% of them were affected by other factors as well (Table 5). This is because the number of research subjects who consumed cigarettes with a variety of nicotine levels was not controlled due to the random sampling. Another assumption is that nicotine can cause stimulation and sedation in the central nervous system depending on the amount of exposure and the duration of exposure.[22]

Each brand of cigarettes has a different nicotine level that causes the different levels of nicotine consumed by everyone even though the number of smoked cigarettes is the same.[23] Nicotine can work on certain cholinergic receptors in the brain that affect nerve activity triggering changes in salivary pH and salivary flow rates.[10] Clove cigarettes have a strong role to decrease salivary pH more than non-clove cigarettes.[24]

In general, nicotine from cigarette smoke had no effect on salivary flow rate (Table 3). It means that the values of the salivary flow rate obtained were still in good and medium categories with a negative correlation (r) of -0.486 (Table 5) and a correlation coefficient (R2) of 0.236. In other words, the correlation between smoking intensity and salivary flow rate was only 23.6% with a significance probability of <0.01. The results of this research were in line with a research conducted by Dyasanoor that showing that the more cigarettes consumed daily for long period can generate a greater risk of decreased salivary flow rate.[25] A

Table 4. Distribution of the research subjects based on salivary pH

Salivary pH	Number of the research subjects (n)	Percentage (%)
<6.7	27	67.5
6.7-7.4	13	32.5
>7.4	0	0
Total	40	100

Table 5. The correlation analysis between the intensity of smoking, the levels of nicotine labeled on cigarettes, salivary flow rate, and salivary pH

Correlation	Coefficient of correlation (r)	Coefficient of determination (R^2)	*P* Values
Smoking intensity salivary flow rate	-0.486*	0.236	0.001**
Smoking intensity salivary pH	-0,.376*	0.142	0.017**
Nicotine levels labeled on cigarettes salivary flow rate	-0.107	0.011	0.512
Nicotine levels labeled on cigarettes salivary pH	-0.216	0.047	0.181
Salivary flow rate salivary pH	0.686*	0.470	0.000**

* R Significant at 0.01 *level 2-tail*; ** Significant (p<0.01)

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steady heat that blows continuously into the oral cavity also may cause changes in blood flow and a decrease in salivary secretion.[26] This is because smoking habits, involving a large number of cigarette intakes per day over a long period of time, can lead to a decrease in sensitivity to oral receptors, resulting in a decrease in salivary reflex.[11]

Consuming 10-15 cigarettes per day for more than 6 months may lower salivary flow rate into 0.20 ml/min (low category).[12] A significant correlation between smoking duration and salivary flow rate, as a result, both stimulated and non-stimulated salivary flow rates decreased as the smoking duration increased, but the decreased salivary flow rates was not significant compared to the number of cigarettes consumed daily.[27]

Furthermore, Table 4 shows that there were twenty-seven research subjects had a salivary pH of <6.7 (67.5%), while eleven research subjects had a salivary pH of 6.7-7.4 (27.5%). The results also showed that there was a negative significant correlation between smoking intensity and salivary pH (r = -0.376) with a correlation coefficient (R2) of 0.142 and a significance correlation (p) of <0.01 (Table 5). It suggests that 85.8% of the salivary pH detected from the research subjects was influenced by other factors, such as type of food consumed which is rich of carbohydrates. Consequently, the salivary pH will decrease since carbohydrates contained can be utilized by acidogenic bacteria for fermentation, and yield as the product of the bacterial fermentation is acidic, making the oral cavity become acidic.[28] In addition, changes in salivary pH may also be affected by changes in bicarbonate structures in saliva and biological rhythms.[29] As a result, changes in salivary pH in smokers is usually triggered by changes in electrolytes and ions in saliva, especially bicarbonate structures.[10]

In addition, smokers who consumed 10-15 cigarettes per day over 6 months had acidic salivary pH of 6.3.[12] The average salivary pH in smokers was lower at 6.75 (± 0.11) than in non-smokers with an average salivary pH of 7 (± 0.28), however, there was no significant correlation.[30] Salivary flow rate is actually considered as a modulator of salivary acidity (pH).[10] In this research, there was a positive and significant correlation between salivary flow rate and salivary pH with a correlation strength of 47%. Generally, the high salivary flow rate was followed by the low salivary pH of 47% (Table 5). The increased salivary secretion can lead to an increase in the number and composition of salivary contents, such as bicarbonate which can increase salivary pH.[14] Changes in salivary flow rate and salivary pH are actually not only influenced by smoking habits and nicotine levels labeled on cigarettes, but also greatly affected by age, drug consumption, disturbed general state, stress level, circadian rhythm, alcohol consumption and others.[31]

In conclusion, there is a correlation between smoking intensity and both salivary pH as well as salivary flow rate in smokers. There is also a correlation between nicotine levels labeled on cigarettes and salivary flow rate. However, there was no correlation between nicotine levels labeled on cigarettes and salivary pH.

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