Rhinology, 45, 224-228, 2007

Effects of smoking on odour identification in Japanese subjects*

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SUMMARY

Objectives: *Effects of smoking on olfaction appear to be well-known. However, there are not many studies that studied these effects on the basis of olfactory testing, and no studies on this topic have been performed so far in an Asian population. Thus, the aim of this study was to investigate the effects of smoking on odour identification.*

Methods: *Five hundred fifty seven Japanese subjects (368 men and 189 women) were given the cross-cultural smell identification test (CC-SIT). Their history was taken with special regard to nasal disease and smoking. Urine nicotine level was assessed in 107 subjects.*

Results: *The CC-SIT scores of current and previous smokers were lower than those of non-smoking subjects ($p < 0.05$). The Brinkman index (BI) and CC-SIT score were correlated even when controlling for the subjects' age ($r = -0.24$, $p < 0.001$). The time since quitting cigarette smoking did not exhibit a relation with the CC-SIT score ($r = -0.04$, $p = 0.76$). In addition, urine levels of nicotine and its metabolites exhibited no significant correlation with the CC-SIT score ($r = -0.08$, $p = 0.40$).*

Conclusion: *Smoking reduces olfactory function. Apparently, recovery of olfactory sensitivity after cessation of smoking appears to be exceptional.*

Keywords: smoking, olfaction, odour identification, CC-SIT, Brinkman index

INTRODUCTION

Cigarette smoking is generally thought to decrease olfactory sensitivity. Although this effect is typically believed to be a robust phenomenon, there is not much evidence to prove this point. In fact, modern olfactometry has been rarely applied for such investigations. In addition, some researchers reported a decrease in olfactory sensitivity [1-4] in smokers, but others did not find such changes in olfactory function [5].

Two types of olfactometric tests, the University of Pennsylvania Smell Identification Test [6] in North America and the "Sniffin' Sticks" [7] in European countries, are often administered in clinical studies. To study the effect of smoking on olfaction, Frye et al. [4] administered the University of Pennsylvania Smell Identification Test (UPSIT) to study the effect of smoking on olfactory function of employees in a chemical-manufacturing facility. The authors reported that olfactory identification decreased significantly in relation to smoking expressed as "pack years", but that it recovered after subjects quit smoking.

Most of the studies in the past have been performed in Caucasian and/or African-American subjects. Data on Asian subjects have not been provided so far. The present study aimed to investigate the relationship between the smoking history and the scores from the Cross-cultural Smell Identification Test (CC-SIT) [8] among a Japanese population, with the CC-SIT being an international short version of the UPSIT.

MATERIALS AND METHODS

Subjects

Five hundred and fifty-seven Japanese subjects (368 men and 189 women), with ages ranging from 18 to 75 (mean age, 46.9 ± 12.0), participated in the medical checkup program of Nanto General Hospital and Meiwa Hospital. Participants were asked not to smoke at the day of testing which was performed in the morning. All subjects agreed to participate in this study and signed a consent form. Ethnically, all subjects were native oriental Japanese.

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Parts of the results have been presented at the 25th International Symposium of Infection and Allergy of Nose (ISIAN) in Tampere, Finland (June 12, 2006).

*Received for publication: September 23, 2006; accepted: February 1, 2007

Methods

Subjects were interviewed with regard to the number of cigarettes smoked per day, the time since when subjects smoked, and previous nasal disease. If subjects had quit smoking, the interval since then was recorded.

The subjects' abilities to identify odours were obtained using the CC-SIT [8]. The test is based on lists of 4 items for each odour from which the odour had to be identified. The items on that list had been translated into Japanese. The Brinkman Index (BI: number of cigarettes consumed per day multiplied by years of smoking) was used as a measure for the dose of smoking.

Nicotine intake level was obtained in urine samples using the NicCheck 1® paper strip test (Mossman Associates Inc, Blackstone, MA, USA). Minimum concentrations at which a positive result is visible are 5 g/ml for nicotine, 2.5 g/ml for 3-hydroxycotinine, and 2.5 g/ml for cotinine. The nicotine intake level ranges from a minimum of 0 to a maximum of 14 (NicCheck® Index) and is related to self-reported cigarette consumption [9].

Statistics

The SPSSII® version 11.01.J for Windows (SPSS Japan Inc, Tokyo, Japan) was used for the statistical analysis of the results. Data were submitted to partial correlations (Pearson), Hochberg's GT2 test, and the Mann-Whitney test. The level of significance was set at 0.05.

RESULTS

Effects of nasal diseases on olfaction

Differences in CC-SIT scores among non-smoking subjects - those with and without nasal disease - were also investigated. In the 262 non-smoking subjects, 43 had nasal allergy and 3 had sinusitis; one subject had both sinusitis and nasal allergy. No significant difference of CC-SIT scores was observed between those subjects with (9.4 ± 1.3, mean ± SD) and without (9.5 ± 1.7, mean ± SD) nasal allergy and/or sinusitis (Mann-Whitney test, $p = 0.41$).

The influence of nasal allergy and sinusitis was also investigated in current smokers. Of 201 smoking subjects 18 had nasal allergy, whereas 7 had sinusitis; 2 subjects had both diseases. Again, no significant difference of CC-SIT scores was observed between those subjects with (9.1 ± 1.8, mean ± S.D.) and those without (8.6 ± 2.1, mean ± S.D.) nasal allergy and/or sinusitis (Mann-Whitney test, $p = 0.35$).

Differences in olfaction between sexes

The CC-SIT scores of male non-smoking subjects (9.4 ± 1.7, mean ± SD, $n = 102$) and those of their female counterparts (9.5 ± 1.5, mean ± SD, $n = 154$) were not significantly different (Mann-Whitney test, $p = 0.91$). In current smokers, 174 men and 23 women, the CC-SIT scores were 8.9 ± 1.8 and 9.7 ± 1.3 (mean ± SD), respectively, and no sex-related difference in CC-SIT scores were found (Mann-Whitney test, $p = 0.08$). Previous smokers were all male and their mean CC-SIT score was 8.8 ± 2.0 (mean ± SD).

Effects of aging on olfaction

The relationship between age and the CC-SIT score was investigated in non-smoking subjects ($n = 255$). One subject was dropped from the group of 256 subjects because there was no record of his age. Odour identification was found to decrease with aging (Pearson test, $r = -0.37$, $p < 0.001$, Figure 1).

CC-SIT scores of non-smokers, current smokers, and previous smokers

The CC-SIT scores in non-smoking subjects, current smokers, and ex-smokers were 9.5 ± 1.6 ($n = 256$), 9.0 ± 1.8 ($n = 197$), and 8.9 ± 2.0 ($n = 86$) (mean ± S.D.), respectively (Figure 2).

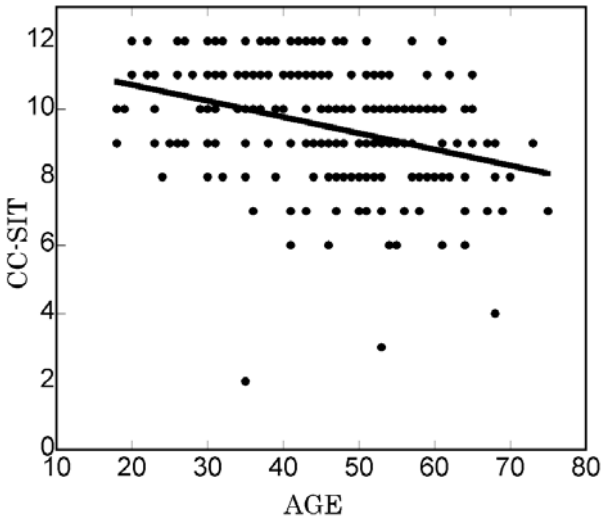

Figure 1. Relationship between age and CC-SIT scores in nonsmokers. CC-SIT scores significantly decreased with aging ($r = -0.37$, $p < 0.001$).

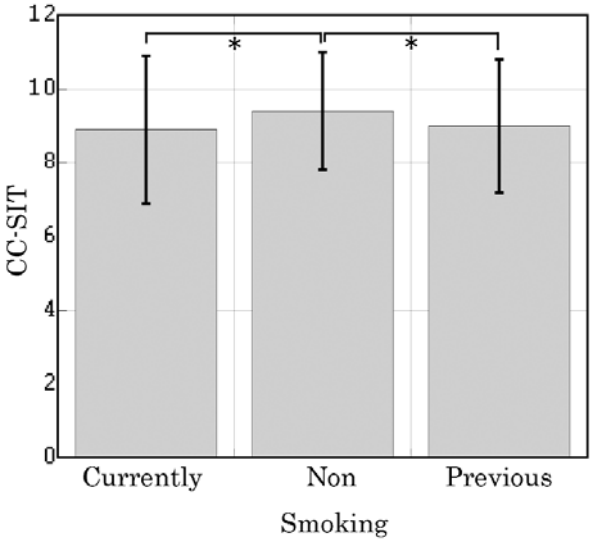

Figure 2. CC-SIT scores of nonsmokers, current smokers, and previous smokers.

There was a significant difference in CC-SIT scores (mean ± S.D.) as indicated by the asterisk ("*") (Hochberg's GT2, $p < 0.05$).

Eight subjects were dropped from 94 ex-smokers because of unclear details of their smoking history. The differences between non-smokers and current smokers ($p = 0.018$), and between non-smokers and previous smokers ($p = 0.037$) were significant (Hochberg's GT2) with non-smokers having higher scores.

Relationship between aging and BI

The relationship between age and BI was investigated in currently smoking subjects ($n = 189$). Eight subjects were dropped from the group of 197 subjects because of an unclear smoking history. BI increased significantly with age (Pearson test, $r = 0.56$, $p < 0.001$, Figure 3).

Relationship between BI and CC-SIT score

The relationship between BI and CC-SIT score was investigated in current smokers ($n = 183$) and non-smoking subjects ($n = 256$). Fourteen subjects were dropped from 197 smoking subjects because of unknown BI and/or CC-SIT score.

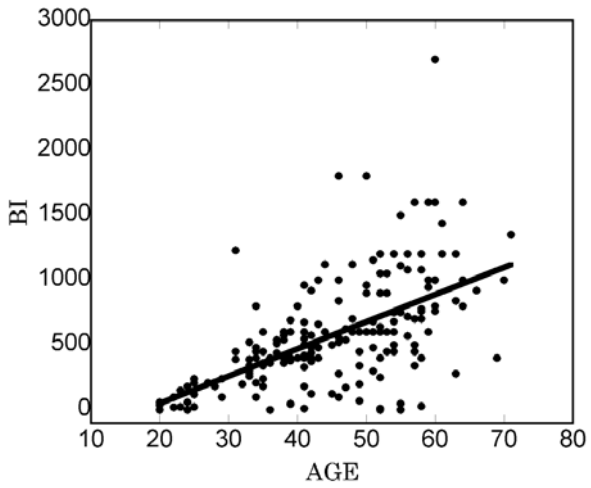

Figure 3. Relationship between age and BI in current smokers.
BI significantly increased with age ($r = 0.57$, $p < 0.001$).

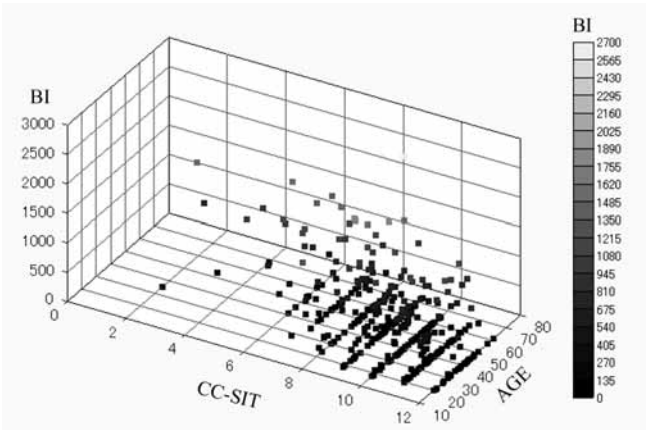

Figure 4. Relationship between age, BI, and CC-SIT scores.
CC-SIT score is influenced by both age and BI. The grey scale bar on the right also indicates BI.

Previous smokers were excluded in this analysis. The relationships among BI, age, and CC-SIT score are shown in Figure 4. CC-SIT scores decreased, depending not only on increasing BI but also on age. Results from a partial correlation analysis controlling for the subjects' age indicated that the decrease of the CC-SIT score was accompanied by an increasing BI ($r = -0.24$, $p < 0.001$).

Relationship between off-cigarette period and olfaction

The relation between CC-SIT score and the time since quitting smoking was studied in 55 of 86 previous smokers (Figure 5). The off-cigarette period was 11.6 ± 10.1 years (mean $\pm$ SD, $n = 55$). When submitting the data to a partial correlation analysis controlling for age and BI there was no significant correlation between cessation time and the CC-SIT score ($r = -0.04$, $p = 0.76$).

Relationship between NickCheck Index and olfaction

Urine nicotine and its metabolites levels, NickCheck Index, were examined in 107 of 557 subjects. A partial correlation analysis controlling for age revealed no significant correlation between CC-SIT score and urine nicotine and its metabolites ($n = 107$, $r = -0.08$, $p = 0.40$) (Figure 6).

DISCUSSION

The present study clearly indicated a correlation between smoking history and measured olfactory function. The present results are particularly important as age has been ruled out as a confounding factor.

The present investigations did not reveal a correlation between the time since cessation of smoking and olfactory function. In contrast, Frye et al. [4] reported that subjects exhibited some recovery after they stopped smoking. Although there were no major differences in the age of the investigated populations in

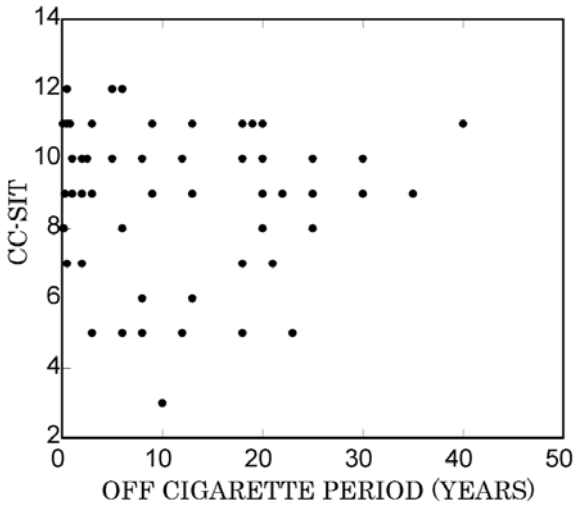

Figure 5. Relationship between cessation time and CC-SIT scores.
CC-SIT scores were not significantly related to the cessation time when controlling for age and BI (partial correlation, $r = -0.04$, $p = 0.76$).

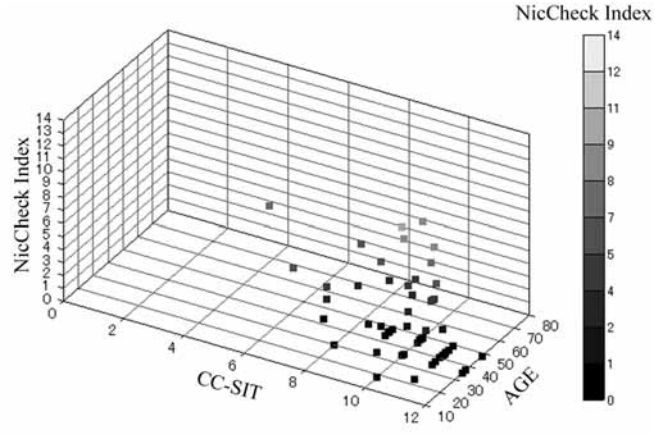

Figure 6. Relationship between urine nicotine and its metabolites level, age, and CC-SIT scores. Urine nicotine and its metabolites level (NicCheck Index) was measured by NicCheck 1® (see Methods). The CC-SIT score was not significantly correlated with urine nicotine level when controlling for age (partial correlation, $r = -0.08$, $p = 0.40$). The grey scale bar on the right also indicates urine nicotine level.

the present study and the work of Frye et al. [4], the latter investigators used a 40-item odour identification test while only a 12-item test was used in the present investigation. In other words, the currently used CC-SIT may not have been sensitive enough to detect recovery of olfaction. In the present study, the mean time since cessation of smoking was 11.6 ± 10.1 (mean ± S.D.) years. Frye et al. [4] did not mention this figure. The difference between the two studies may also be related to the different ethnicity of the two samples.

The relationship between NickCheck Index and CC-SIT score was not significant. Urine nicotine and its metabolites level reflected the amount of cigarettes smoked before testing within 24 h before testing [9] but not smoking history. This seems to suggest that the decreasing CC-SIT score in relation to smoking does not reflect acute but chronic effects of smoking.

The mechanism of smoking-induced olfactory loss has not yet been resolved. Animal research indicates that smoking damages the nasal epithelium [10]. In fact, it has been shown that the number of olfactory neurons is decreased by smoking [11]. Vent et al. [12] suggested that smoke-induced apoptosis would be responsible for the decrease of olfactory sensitivity. The effect of smoking on olfaction is known not only for active smoking but it has been suggested that passive smoking would also produce olfactory loss. Nageris et al. [13] reported that passive smoking also reduces olfactory ability in children. While the reason for this remains unclear, the authors suggested increased apoptosis or smoke-induced nasal congestion.

In the present study, smoking had a significant effect on olfactory function that appeared not to be reversible. It has to be kept in mind that the average reduction of the CC-SIT score was approximately 0.5 points. In fact, olfactory loss of smokers rarely reaches the level of anosmia. CC-SIT was used to measure olfactory function of Japanese subjects. Because this test was developed in the USA, some odourants used in this test were not familiar to Japanese subjects. Therefore, test scores were lower than those normally obtained in North American subjects [14]. However, with this test the influence of cultural differences appears to be negligible because this study was comparative assessment among the Japanese subjects [8]. Thus, especially when considering the relatively large sample size the CC-SIT was thought to be accurate enough to allow for comparisons between current smokers, ex-smokers, or non-smoking subjects.

Olfactory ability is typically decreased in subjects with sinunasal disease [15-17]. However, in the present study, there were no significant differences in CC-SIT scores between non-smoking subjects with and without nasal diseases. The reason for this may relate to the fact that we did not study patients with obvious complaints of sinunasal disease but subjects probably exhibiting some mild forms of rhinosinusitis or seasonal allergies which may not be accompanied by a significant loss of olfactory function.

We also investigated the presence of a sex-related difference in CC-SIT scores. There were 103 male and 154 female non-smoking subjects; the group of smoking subjects consisted of 173 males and 23 females. Because the percentage of female smoking subjects was much less than that for male subjects, it appeared not to be adequate to compare the CC-SIT scores in terms of presence and absence of smoking habits in men and women, respectively.

The current investigation also confirmed the effect of age on odour identification (see also [18]. The significant relationship between BI and age also suggested that the influence of aging on olfaction needs to be controlled when running investigations on the effect of environmental factors on olfactory function.

CONCLUSION

Smoking decreases odour identification. However, recovery of olfactory function is problematic even when quitting smoking. Based on the current investigations of urine nicotine levels it is concluded that the effects of smoking on olfaction are the result of long-lasting exposure to smoke and not just the acute effect of smoking.

ACKNOWLEDGMENT

The authors thank Dr. Jun-ichi Nei for providing the facilities for the health check-up program; Ms. Kazumi Tanimura and Ms. Fumiko Takata for their assistance with olfactory testing, and Ms. Fujiyo Mizuochi for her help in measuring urine nicotine levels. The authors also thank Professor Thomas Hummel for helpful discussions. This work was supported by a grant from the Smoking Science Research Foundation.

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