

Originals

## Effects of Tobacco Smoking on Frontal Lobe Function in Normal Healthy Volunteer

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### SUMMARY

To evaluate the efficacy of tobacco smoking on working memory of healthy normal volunteer, Computer-based-revised Keio type Wisconsin Card Sorting Test (WCST) was administered and analyzed.

Thirteen normal healthy nonsmokers and 10 normal healthy smokers had WCST, however, for smoker group WCST was administered immediately after tobacco smoking (1mg of nicotine and 12 mg of tar).

As the results, smoker group showed higher score in both Number of response card until the first category achieved (NUCA) and Perseverative errors of Nelson (PEN) ( $P < 0.05$ ). These results indicate that smokers have difficulty in changing and maintaining mental set, which means decrease in flexibility and adaptability of attention.

These data suggest that tobacco smoking may have acute effect on working memory of brain.

**Key Words** : nicotine, Wisconsin Card Sorting Test (WCST), frontal lobe, tobacco smoking

### INTRODUCTION

Pharmacologically, nicotine acts on cholinergic (nicotinic-specific) receptors on normal healthy people. Nicotinic receptors also interact closely with several neurotransmitters such as dopamine. Therefore, nicotine might have multiple effects on the brain. Since tobacco smoke contains a certain amount of nicotine and many publications have indicated that tobacco smoking is harmful, so no one should be encouraged to smoke. In addition, it has been proved that smoking is a risk factor of lung cancer, chronic obstructive pulmonary disease, coronary disease and cancer. Although, the smoking rate among Japanese the male is 46.9% and 13.2% among female<sup>9)</sup>. High smoking rate will lead to the increase in

tobacco related cardiovascular and pulmonary diseases. On the other hand, nicotine has many harmful side effects, it may have therapeutic value or at the very least be a useful tool for future drug development<sup>4,7)</sup>. Smith et al have indicated that people with schizophrenia have higher rate of smoking and they suggest that tobacco controls the symptom of the disease and tobacco increase blood flow of frontal lobe<sup>5)</sup>. Control of schizophrenia symptom by tobacco may be achieved by the effect on frontal lobe through working memory since working memory is one of the functions of frontal lobe<sup>2,6)</sup>. Although Wisconsin Card Sorting Test (WCST) is well known test battery that can be detect frontal lobe dysfunction, it is not easy to use for many subjects. However, recent development of computer-based-revised Keio type WCST enables us to analyze data with minimum human error and with minimum difficulties. In this study, we analyze effect of tobacco smoking on working memory of brain through the computer-based-revised Keio type WCST.

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## MATERIALS AND METHODS

Twenty-three normal healthy adult male volunteers who understood the purpose of this study were divided into smoker groups, who are currently smoking, and nonsmoker groups, who have never smoked before. Smoker groups consisted of 10 people and the nonsmoker groups consisted of 13 people and there were no age, sex and educational difference between two groups. Their mean ages were 22.7 for smoker group and 20.9 for nonsmoker group. Computer based revised Keio type WCST was administered by personal computers (Sony Vaio PGV505). In the waiting room, subjects were explained about this experiment. If they agreed to participate this experiment, they signed the informed consent and answered the questionnaire that contained information about history of smoking and amount of smoking. At this time, only smoker group smoked tar 12mg, nicotine 1mg tobacco. Afterwards, subjects were tested on WCST in a quiet room. We have analyzed following parameters such as categories achieved (CA), number of response card until the first category achieved (NUCA), total error (TE), perseverative errors of Milner (PEM), and perseverative error of Nelson (PEN).

## RESULTS

There was no significant difference between the smoker and nonsmoker groups (2.80 and 3.69) in CA. TE was 24.20 in smoker the group and 19.00 in nonsmoker group, and there was no significant difference. PEN was 8.40 in smoker and 5.46 in nonsmoker group, and there was also no significant difference. However, there was significant difference between groups in NUCA, smoker group showed 20.60, nonsmoker group showed 6.92 ( $P < 0.05$ ). In addition, PEM in smoker was 8.00 and 2.38 in nonsmoker group, and there was significant difference ( $P < 0.05$ ). In this study, smoker group showed higher score in both NUCA and PEM ( $P < 0.05$ ). The summary of results is shown in Table 1.

## DISCUSSION

It has been proved that smoking is a risk factor of lung cancer, chronic obstructive pulmonary disease, coronary disease and cancer. Therefore, it is well accepted that there will be an increase in the needs for the studies for investigating the relationship between smoking and sus-

**Table 1** Results of psychological tests

Category	CA	NUCA	TE	PEM	PEN
Smoker group	2.80	20.60	24.20	8.00	8.40
Nonsmoker group	3.69	6.92	19.00	2.38	5.46
	n.s	$P < 0.05$	n.s	$P < 0.05$	n.s

ceptibility for various diseases. Since tobacco smoke contains large amount of nicotine, there have been many publications related to the effect of nicotine. Even though, the relationships between frontal lobe function and nicotine have been controversial, Jacobsen et al have reported that administration of nicotine increase cognitive function in patients with schizophrenia<sup>2)</sup>. Although, there is a report that indicates nicotine enhance delayed memory in schizophrenic patients but it does not affect working memory<sup>8)</sup>.

In previous studies, most of reports utilized pure nicotine as a target substance but tobacco smoke contains large number of other substances. Therefore, it may have been inappropriate to discuss effect of tobacco smoking by administration of pure nicotine. However, pure nicotine or modified nicotinic receptor agonists are promising substance for a medicine of working memory and cognitive functions related diseases so there have been many reports related to pure nicotine. Smith et al indicated that the administration of pure nicotine and inhalation of tobacco smoke may have a different effect<sup>5)</sup>.

On the other hand, one possible cause for these controversial reports may seem to be a controversial is technical problems caused by human errors. To prevent these human errors, we have employed computer based WCST. One important feature of computer based WCST is that computer can reduce involvement of human role in administration of WCST.

In this study, smoker group has exhibited significant increase in NUCA, number of cards used until achievement of the category, and PEM, even a category has been changed an error reflecting stick to the category which have been achieved and tendency to continue to choose the category (perseveration). These results indicate that smoker has difficulty in changing and maintaining

mental set which mean decrease in flexibility and adaptability of attention. Also, chronic tobacco smokers decrease the working memory performance and the act of smoking does not recover the function of working memory. In adolescent study, daily smokers have showed decrease in performance in working memory and their performance did not recover by smoking<sup>1)</sup>. In contrast to the previous studies, there is a report that nicotine improved working memory and attention for healthy non-smoking males<sup>3, 8)</sup>. These controversial results indicate that tobacco smoke and nicotine have different effect on healthy male adult, and tobacco smoking may cause decrease in performance of working memory.

Since we have analyzed only WCST, there may be limitation to conclude any definite outcome but these data have suggested that tobacco may have acute effect on working memory of brain.

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