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Effect of acute and chronic nicotine consumption on reaction time

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Abstract: *Objective:* To record the effect of acute and chronic nicotine usage on visual and whole body reaction time which is the indicators of cognition. *Background:* Nicotine intake in the form of cigarette smoking does affect cognition. Even though the effect of nicotine on cognition is interesting, knowledge regarding this is inconsistent due to lack of much research. *Methods:* This study done on 50 male subjects (smokers) in the age group of 30-50 year, equal number of age and sex matched individuals were taken as controls. Cognition is evaluated by following parameters: (a) Simple and choice visual reaction time. (b) C1 of whole body reaction time. Student t test was used to compare the reaction time between smokers and non smokers. *Results:* The difference between simple and choice visual reaction time which is the indicator of cognition is significantly lower in smokers when compared to that of non smokers. (p=0.02) C1 of whole body reaction time is significantly lower in smokers when compared to that of non smokers (p=0.04). *Conclusion:* acute and chronic effect of nicotine consumption improves cognition and there by decreases reaction time.
Keywords: Intellectual activity, Nicotine, Response latency.

Introduction

Tobacco contains various chemicals like nicotine, carbon monoxide and tar. Various forms in which nicotine is taken are by tobacco smoking (bidi, cigarette), chewing (pan). In India, tobacco consumption is an important risk factor for development of various cardiovascular diseases and chronic obstructive pulmonary diseases [1-2]. Nationally representative and reliable prevalence data on tobacco consumption are scarce. However some of the regional wise work for the prevalence of smoking is done like Venkat Narayan et al (1996) on a Population based representative study in Delhi urban sample showed that 45% (43.8–46.2%) of men and 7% (6.4–7.6%) of women were smokers [3].

Nicotine which is found in the tobacco is acts as mimetic of the neurotransmitters acetylcholine at nicotinic-cholinergic receptor sites. Nicotine effects on behavior and brain electrophysiology are quite complex because it not only binds to cholinergic nicotinic receptors, but causes increased release of acetylcholine, nor epinephrine, dopamine, GABA, and glutamate [4-5]. It also appears to increase the release of prolactin, adrenocorticotropic hormone (ACTH), b-endorphin, b-lipotropin, growth hormone, vasopressin, and neurophysin [6]. Nonetheless, a substantial amount of evidence suggests that chronic administration of nicotine causes changes in the fundamental properties of cholinergic neurotransmission and hence produces changes in synaptic efficacy that result in modified behaviors.

Cognitive function can be defined as the person's capacity to acquire and use information to adapt to environmental demands and the process involves many skills including attention, creativity, memory, perception, problem solving, thinking, and the use of language [7]. We can study cognitive function by using simple and choice visual reaction time(SVRT and CVRT) and whole body reaction time(SWBRT and WBRT) using the instrument with chronoscope. The difference between the simple and choice time indicates cognitive ability [8]. Ichaporia RB and his colleagues have shown that reaction time decreases after cigarette smoking [9]. While Monique Ernst et al have worked on effect of nicotine on cognitive functions and demonstrated that non smoker’s cognitive functions were better [10]. Within the scope of these interactions, nicotine effects on cognition have been interesting but inconsistent. So the objective of the study is to record the Effect of acute and chronic nicotine consumption on simple and choice visual and whole body reaction time.

Material and Methods

The study was conducted in the Department of physiology, SDMCMS&H, Dharwad after obtaining the permission of the institutional Ethical committee. The details of the procedure were explained and written informed consent was obtained from the participants. The present study includes 50 smokers in the age group of 30-50 years and age and sex matched 50 non smokers as controls. Inclusion criteria: Smokers, who smoke more than 10 Cigarettes/day for more than 5 yrs and non-alcoholic.

Exclusion criteria: Those with the history of diabetes, hypertension, lung disorders, color blindness were been excluded from the study. The subjects were instructed to come to department of physiology at 9.00am after having a light breakfast. They were also instructed not to consume tea, coffee or cola. Data on Name, age, occupation, personal history& personal habits of the subjects are taken. Smoking history was taken in detail. Smoking index [11] was calculated as the average number of cigarettes consumed per day multiplied by the duration of smoking in years. The average number of cigarette smoked per day was calculated by summing up the smoking indices and dividing the whole by the duration of smoking in days. That is,

$$\frac{D}{n_1d_1+n_2d_2+n_3d_3+\ldots\ldots\ldots\ldots\ldots n_{50}d_{50}}$$

Where;

- n = Average number of sticks smoked per day during life time
- d = Average Duration of smoking in each day
- D = Total duration of smoking

The following parameters were recorded in all the participants.

- Simple and choice visual reaction time
- Whole body reaction time

The reaction time of all the participants were recorded by using the instrument – reaction timer Anand agencies, 1433/A, Pune.

Recording of Simple and choice Visual reaction time: The visual stimulus is used to determine simple reaction time and choice reaction time. The simple reaction involved the stimulus in the form of red light which glowed after a brief adjustable fore period (1.5 milliseconds). On perceiving the stimulus (i.e., the red light) the subject was instructed to press a button with right finger. The timer starts recording just after the fore period and stops when the button is pressed. The reaction time is displayed on a led screen measured in milliseconds.

Similarly, the choice reaction involved two stimuli- one red and another green light. Either of the two light glow randomly as controlled by operator. On perceiving the green light, the subject was asked to press the right button and if the red light was seen to glow, he is asked to press button on left.

Recording of Whole body reaction time: Here the operator manually presses on a button on the control box, which makes the LED arrow which points to the right to glow on the stimulus board. As soon as the subject perceives the red arrow pointing to the right, he is instructed to step on the right stepping board with the right leg.

The controller provides the operator with two different values on 2 separate LED displays. The first one called chronoscope reading 1 (C1) which we are measuring measures the time taken between the stimulus presentation (i.e., red light) and the lifting of the foot from the starting board. This reading gives the time taken for cognition. To record acute effect of smoking- The subjects (smokers) were asked to come to the department of physiology again next day of their recording of reaction time. On their arrival they were made to smoke one cigarette and after 3 min reaction time was measured by the similar procedure as mentioned above.

Estimation of sample size: [12]

$$n = 2(Za+Z1-\beta)^2\,{}_{\sigma}^{2}/\Delta 2$$

With $p<0.05$ as acceptable and a study with 80% power; following values were: $Z_{\alpha,}$ is 1.96. $Z_{1-\beta}$ is 0.8416. The standard deviation would be approximately 1.8($_\sigma$) calculated from the previous studies. The value of Δ is 1.0

$$n=2(1.96+0.8416)^2(1.8)^2/(1.0)^2$$
$$n=50$$

Statistical analysis: This is a case- control study. All the values were expressed in terms of mean±SD. student t test was used to compare the reaction time between smokers and non smokers. The same test also used to compare the acute effect of smoking with non smoking. Statistical analysis was done by using Statistical Package for the Social Sciences Version 20. Significance level was set as $p < 0.05$: significant, $p < 0.01$: highly significant, $P < 0.001$: very highly significant

Results

Table1 shows the demographic characteristics of the smokers and non smokers. Out of 50 non-smokers (n=50) 56% were in the age group of 30-40 years and 44% were in age group of 40-50yrs with the mean age of 38±4.5 years .Out of 50 (n=50) smokers 32% were in the age group of 30-40 years and 68% were in age group of 40-50yrs with the mean age of 40±5.9 years. The smokers have a smoking history of 15.4±5.6years with a smoking index of 8.4

Table-1: Shows the characteristics of smokers and non smokers

	Smokers (n=50)	Non Smokers (n=50)
Age(years)	40±5.9	38±4.5
Duration of smoking(years)	15.4±5.6	
Number of cigarette smoked per day	12±4.0	
Smoking index	8.4	

Values expressed as mean±SD.

Student t test was used to compare the reaction time between smokers and non smokers. Table 2 shows the values of various reaction times measured between smokers and non smokers. Simple visual reaction time is 240.20 ± 18.46 ms in smokers and 242.36±16.78 in non smokers which is lower in smokers but not statistically significant. (p=0.08). Choice visual reaction time is 317.36 ± 81.99 ms in smokers and 340.56±70.89 ms in non smokers, Which is significantly lower in smokers when compared to that of non smokers (p=0.04).The difference between simple and choice visual reaction time which is the indicator of cognition is 77.16±63.53 ms in smokers and 98.20±54.11 ms in non smokers Which is significantly lower in smokers when compared to that of non smokers. (p=0.02) C1 of whole body reaction time is 381.80 ± 81.92 ms in smokers and 400.76±65.98 ms in non smoker, which is significantly lower in smokers when compared to that of non smokers (p=0.04).

Student t test was also used to compare the effect of acute smoking with the non-smokers. Table3 shows the comparison of reaction time between smokers (acute effect/ immediate effect after smoking) and non smokers. Simple visual reaction time is 220.20 ± 18.46ms in smokers and 242.36±16.78 in non smokers which is statistically significantly lower in smokers. (p=0.04) choice reaction time is 300.28 ± 80.90ms in smokers and 340.56±70.89 ms in non smokers which is significantly lower in smokers when compared to that of non smokers (p=0.01).the difference between choice and simple visual reaction time which is the indicator of cognition is significantly lower in smokers when compared to that of non smokers. (p=0.01) C1 of whole body reaction time is significantly lower in smokers when compared to that of non smokers (p=0.03).

Table-2: Shows the comparison of reaction time between smokers and non smokers. (Chronic effect)

Parameter	Smokers(n=50)	Non smokers(n=50)	Z value	P value
Simple visual reaction time (msec)	240.20 ± 18.46	242.36±16.78	1.48	0.08
Choice visual reaction time (msec)	317.36 ± 81.99	340.56±70.89	2.39	0.04*
Choice-simple visual reaction time (msec)	77.16±63.53	98.20±54.11	2.71	0.02*
C1 whole body reaction time (msec)	381.80 ± 81.92	400.76±65.98	2.39	0.04*

$p < 0.05$: significant*, $p < 0.01$: highly significant**, $p < 0.001$: very highly significant***
Values expressed as mean±SD

Table-3: Shows acute effect of smoking on reaction time between smokers and non smokers

Parameter	Acute Smoking(n=50)	Non smokers(n=50)	Z value	P value
Simple visual reaction time (msec)	220.20 ± 18.46	242.36±16.78	2.48	0.04*
Choice visual reaction time (msec)	300.28 ± 80.90	340.56±70.89	3.70	0.01**
Choice-simple visual reaction time (msec)	80.08±62.56	98.20±54.11	3.68	0.01**
C1 whole body RT (msec)	340.50 ± 68.89	400.76±65.98	2.39	0.03*

p < 0.05: significant*, p < 0.01: highly significant**, p < 0.001: very highly significant***

Discussion

The results of present study confirmed that reaction time is significantly lower in smokers when compared to that of non smokers. Our study demonstrated nicotine improves the cognition.

Study showed that choice visual reaction time; difference of simple and choice visual reaction time and C1 of whole body reaction time is significantly higher in non smokers when compared to smokers. Higher the reaction time signifies lower the cognitive function. Similar findings of decreased reaction time in smokers were demonstrated in the study done by Ichaporia and his colleagues. The acute effect of smoking one cigarette was also studied in the same group of smokers and a statistically significant reduction was found, as compared to their basal VRT and ART [9].

Froeliger.I found that smokers who were abstaining from cigarettes had faster reaction times when they were wearing a nicotine patch, and even nonsmokers had increased accuracy when they were wearing nicotine patches [13]. Bates T recorded reaction time in two smoking conditions: sham smoking (denicotinised cigarette) or regular smoking (0.8 mg nicotine cigarette), smallest reaction times being recorded under the high nicotine condition [14]. The same investigator also recorded reaction time task with four levels of choice-task complexity under non-smoking, sham smoking, and low, medium and high nicotine cigarette conditions. Nicotine reduced decision time, while sham smoking increased decision time [15].

Atzori G assessed the efficacy of nicotine (4-mg lozenge) versus placebo on aspects of cognitive and psychomotor performance, mood, and withdrawal symptoms in male and female established smokers and found that Compared with placebo nicotine (4 mg) significantly improved vigilance, divided attention, executive functioning, working memory, and sensor motor performance in abstinent volunteers (P < or = 0.05) [16].

Two models explain the relation between smoking and improved cognitive changes. The pharmacological model and models of that genre propose that smoking is equivalent to nicotine addiction and that smoker's smoke to maintain nicotine, or one of its metabolites, at a level that prevents the onset of unpleasant withdrawal symptoms [17]. In contrast, the psychological tool or functional models by Warburton and Wesnes focus on the behavioral effects of smoking and derive support from data indicating short-term improvements in psychological well-being, selective attention, vigilance performance, and rapid information processing [18].

Study was done by Harris and others on 20 schizophrenics among whom 10 were smokers, and 10 nonsmokers. The Repeatable Battery for the Assessment of Neuropsychological Status was administered following the administration of nicotine gum and placebo gum. Nicotine affected only the Attention Index; there were no effects on learning and memory, language, or visuo spatial/constructional abilities [19]. Studies conducted in a variety of neuropsychiatric populations [e.g. attention-deficit hyperactivity disorder (ADHD), Alzheimer's disease, schizophrenia] have collectively suggested that nicotine may be efficacious in remediating selected cognitive deficits associated with these disorders [20-21].

Limitations of the study: As it was difficult to get all the female participants in the same phase of menstrual cycle we dropped them out to avoid the confounding effect of feminine hormones on cognition.

Conclusion

The potential benefits of nicotinic agents for therapeutic use in various neuropsychiatric disorders like schizophrenia, ADHD; Alzheimer's disease were been demonstrated. The present study, showed that acute and chronic intake of nicotine in the form of cigarette smoking improves the cognitive ability even in normal individuals. Nonetheless, it appears highly likely that several novel nicotine Acetyl choline Receptor -based pharmacological treatments for cognitive dysfunction in neuropsychiatric disorders could become available within the next 5–10 years.

References

1. Gupta R, Prakash H, Gupta VP. Prevalence and determinants of coronary health disease in a rural population in India. *J Clinl Epidemiol* 1997; 50:203-9.
2. Padmavati S. Prevention of heart disease in India in the 21st century, Need for a concerted effort. *Indian Heart J* 2002; 54:99-102.
3. Venkat KM, Chadha SL, Hanson RL. Prevalence and patterns of smoking in Delhi: cross sectional study. *BMJ* 1996; 312:1576-9.
4. Ochoa EL, McNamee MG. Desensitization of central cholinergic mechanisms and neuroadaptation to nicotine. *Mol Neurobiol* 1990; 4:251-7.
5. Herzig KE, Callaway E, Halliday R, Naylor H, Benowitz NL. Effects of nicotine on information processing in nonsmokers. *Psychopharmacology* 2009; 135:127-32.
6. Gilbert DG, Meliska CJ. Individual differences in and reliability of electroencephalogram, cortisol, beta-endorphin, heart rate, and subjective responses to smoking multiple cigarettes. The biology of nicotine: current research issues. *Psychopharmacology* 1998; 23:56-64.
7. Hamid J, Amal KM, Hasmiza H, Wan MR. Effect of Gender and Nutritional Status on Academic Achievement and Cognitive Function among Primary School Children in a Rural District in Malaysia. *Mal J Nutr* 2002; 17:189-200.
8. Jakobsen LH, Sorensen JM, Rask IK, Jensen BS, Validation of reaction time as a measure of cognitive function and quality of life in healthy subjects and patients. *Nutrition.* 2011; 27:561-70.
9. Ichaporia RB, Kulkarni SP, Malthi A, Parulkar VG. Study of reaction time in smokers. *JPGM* 1991; 37(4):209-12.
10. Monique MD, Stephen JH, Loretta BS, Edythe D. Smoking History and Nicotine Effects on Cognitive Performance. *Neuro psycho pharmacology* 2001; 25:313-9.
11. Ahuja RC, Singhal S, Srivastava AN, James P, Kesarwani D, Sing A. case-control study of bidi smoking and bronchogenic carcinoma. *Ann Thorac Med* 2010; 5(4): 238-41.
12. Prashant K, Supriya B. Sample size calculation. *Int J Ayurveda Res* 2010; 1(1):55-7.
13. Froeliger B, Gilbert D, McClernon. Effects of nicotine on novelty detection and memory recognition performance: double-blind, placebo controlled studies of smokers and nonsmokers. *Psychopharmacology* 2009; 205(4):625-33.
14. Bates T, Mangan G, Stough C, Corballis P. Smoking, processing speed and attention in a choice reaction time task. *Psychopharmacology* 1995; 120(2):209-12.
15. Bates T, Pellett O, Stough C, Mangan G. Effects of smoking on simple and choice reaction time. *Psychopharmacology.* 1994; 114 (2):365-8.
16. Atzori G, Lemmonds CA, Kotler ML, Durcan MJ, Boyle J. Efficacy of a nicotine (4 mg)-containing lozenge on the cognitive impairment of nicotine withdrawal. *J Clin Psychopharmacol* 2008; 28(6):667-74.
17. Schachter S, Silverstein B, Perlick .Studies of the interaction of psychological and pharmacological determinants of smoking: Vs. Psychological and pharmacological, explanations of smoking under stress. *J Exp Psych* 1997; 106:31-40.
18. Warburton DM, Rusted JM, Fowler J. A comparison of the attention and consolidation hypotheses for the facilitation of memory by nicotine. *Psychopharmacology* 1997; 108:443-7.
19. Harris JG, Kongs S, Allensworth D, Martin L, Tregellas J, Sullivan B et al. Effects of nicotine on cognitive deficits in schizophrenia. *Neuro psycho pharmacology.* 2004; 29(7):1378-85.
20. Kristi AS, Katie LB, Tony PG. Nicotinic receptor mechanisms and cognition in normal states and neuropsychiatric disorders. *J Psychopharmacol* 2004; 18(4):457-74.
21. Levin ED, Rezvani AH. Nicotinic treatment for cognitive dysfunction. *Curr Drug Targets CNS Neurol Disord.* 2002; 1(4):423-31.

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