ORIGINAL ARTICLE ASIAN JOURNAL OF MEDICAL SCIENCES

Effect of smoking on visual evoked potential (VEP) and visual reaction time (VRT)

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Submitted: 13-12-2019 Revised: 26-01-2020 Published: 01-03-2020

ABSTRACT

Background: Nicotine in tobacco smoke causes demyelination. Again, hypoxia in long-term smokers is linked to neuropathy. Visual receptors are early sufferer of neuropathy. Visual-Acuity & other ocular tests often fail to detect subtle changes of neuropathy which, however, can be detected by VEP test. Literature review shows that changes in VEP come earlier than PFT changes in smokers. Ironically, smokers claim that smoking improves their reaction time, which can be assessed by VRT. **Aims and Objective:** To relate smoking status with VEP and VRT. **Materials and Methods:** Fifty-six subjects (smoker group = 28 & non-smoker group = 28), whose age & sex were matched, were included in the study. Their PFT, pattern VEP of both eyes & VRT were recorded. The data were compared between the two groups using unpaired t-test, considering statistical significance at $p<0.05$. **Results:** The FVC (4.35 ± 0.83 vs. 5.32 + 1.18 l, $p=0.022$), FEF 25% (7.40 + 2.38 vs. 8.74 + 3.90 l/s, $p=0.019$) & FEF 50% (6.11 + 1.52 vs. 7.74 + 2.57, $p= 0.010$) were significantly lower in smokers compared to nonsmokers. There was no significant difference in P100 wave latency of VEP. But, VRT of smokers were significantly shorter (431.69 + 60.29 vs. 441.14 + 123.54 ms, $p=0.010$). **Conclusion:** Smokers have shorter visual reaction time and similar visual evoked potential as compared to non-smokers.

Key words: Visual Evoked Potential (VEP); Visual reaction time (VRT); Smokers.

Access this article online

Website: http://nepjol.info/index.php/AJMS

DOI: 10.3126/ajms.v11i2.26689
E-ISSN: 2091-0576
P-ISSN: 2467-9100

INTRODUCTION

Tobacco smoke contains Nicotine and carbon monoxide. They harm peripheral nerves as well as central areas of brain.[1] Nicotine causes demyelination.[2,3] Again, long-term smokers who have already developed COPD suffer from hypoxia which is clearly linked to neuropathy.[4]

Visual receptors are early sufferer of resultant neuropathy.[5] Visual evoked potential (VEP) records intactness of visual pathway.[6] It is a non-invasive and sensitive tool to detect subclinical visual impairment. Whereas, visual-acuity and other ocular tests, commonly employed during clinical assessment of optic nerve, often fail to detect subtle changes of neuropathy before overt appearance of symptoms.

Visual reaction time (VRT) is time interval from exposure to visual stimulus to the subject's fastest response after proper instruction.[7] VRT depends upon the speed of processing capability of the brain. It is also a measure of sensory motor performance.[8,9]

This study was conducted to explore the effect of smoking on VEP and VRT as smokers claim that smoking increases their concentration, alertness, and overall mental performance. On the contrary, evidences have shown that smoking is associated with prolongation of P100 latency (VEP) which means smoking delays neural conduction. So far, studies that explore the effects of smoking in vision have not been conducted in Nepal. Since VRT is one of the very powerful means of relating mental events,[10] it is plausible to observe its effects as well.

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MATERIALS AND METHODS

The study was carried out on 28 apparently healthy smokers and 28 non-smokers in neurophysiology lab in the Department of Basic and Clinical Physiology of B.P Koirala Institute of Health Sciences (BPKIHS), Dharan, Nepal after receiving ethical clearance from institute's review board (IRB).

Male subjects within the age range of 20-40 years were selected from the subjects who visited the OPD in the Department of Internal Medicine, BPKIHS. The subjects recruited for the study were free from systemic diseases such as Diabetes Mellitus, Hypertension, (COPD), any lung diseases likely to cause hypoxia: Carcinoma of lung, Asthma, Tuberculosis and Chronic Obstructive Pulmonary Disease (COPD), or any eye diseases such as Retinopathy, Maculopathy, Glaucoma & Lesions of Optic nerve and Optic chiasma, refractive errors etc; psychiatric disease on medication; use of any mydriatic, miotic or sedative within 1 week which are likely to independently influence the study parameters either VEP/VRT or both. Subjects who did not have any clinical complaints were considered as apparently healthy. Their health status was assessed through questionnaires, which assessed their medical history and physical health status.

Recording procedure

After selection of a subject, the anthropometric variables were measured. The ambient temperature, pressure and humidity were also measured accurately and entered in CHESTGRAPH HI-101 spirometry system (Chest M.I., Inc, Tokyo Japan). The pulmonary function testing parameters Forced Vital Capacity (L), Forced expiratory volume in 1 second (L), FEV1/FVC ratio (FEV1%), forced expiratory flow 25% (L/s), forced expiratory flow 50% (L/s) and forced expiratory flow 75% (L/s)) were recorded. The procedure was fully explained and demonstrated in detail prior to the commencement of each test. Maximum effort on behalf of the subject was emphasized. All procedures were done in a sitting position with back of the subject facing the recording.

Pattern reversal VEPs were recorded using NeuropackS1 EMG/EP Measuring system MEB-9400, Nihon Kohden Machine (Japan). Subjects were seated comfortably in a dark room 100 cm away from the LED monitor of 12-inch screen (Samsung). Scalp electrodes were placed after cleaning the electrode placement areas as per the international 10-20 system. At our set up two channels recording i.e. CH-1 & CH-2 and montages were used (right- occipital (RO) = 5 cm right of Middle Occipital (MO) and left-occipital (LO) = 5cm left of MO) as active electrodes. Midline- frontal (MF) i.e. the reference electrode, was placed 12cm above the nasion and earthing electrode was placed on vertex (CZ). After 5 minutes of dark adaptation, they were instructed to gaze at a fixed point in the middle of the screen with one eye while the non-testing eye was covered. A chess board pattern reversal method was employed with checker size 8 (stimulus field size) at visual field angle 66 min of arc which was calculated by checker side length (38mm). The stimulation frequency was at a speed of 3 Hz with lightness of 90 cd/m^2 and contrast of 80%. The range of filters was 1-100 Hz, the sensitivity was 20 μV/div. In order to obtain reliable waveform, each subject was recorded two times and average of the two measurements was taken. The recording procedure was approximately 45 min duration. For VEP evaluation latency of wave P100 was taken.

For recording of Visual reaction time (VRT)**,** an electric circuit was made with 6 volt battery. A bulb of 0 watt, two pairs of morse keys ((1844, made in USA)), magnetic induction coil attached to a writing lever were connected in series circuit. A kymograph set at a speed of 500 mm/s was connected to the writing lever. The subject was instructed to press one of the morse keys continuously. When the instructor pressed another morse key simultaneously as the subject pressed the key, the bulb was lit. This produced a downward deflection of the writing lever which was recorded in a paper adjusted in a moving kymograph. As soon as the subject perceived the visual signal, he was instructed to release the key. This in turn, produced an upward deflection of the pen. Thus, the distance covered from the beginning of downward deflection to the beginning of upward deflection was recorded and visual reaction time was calculated from the obtained distance and speed of the moving kymograph (VRT= distance/ speed (ms))

Statistical analysis

The data obtained were entered into the Microsoft excel worksheet (2013) and their analysis was done using statistical package for social sciences (SPSS version 11, SPSS INC., Chicago, ILL USA). All study variables were normally distributed. Thus, unpaired t-test was applied to compare these variables. The data are expressed as mean ± SD. $P<0.05$ is considered as statistically significant.

RESULT

Comparison of anthropometric variables between smokers and non-smoker

Age, weight, height and BMI of smokers and nonsmokers were comparable (Table 1).

Comparison of pulmonary function test (PFT) variables between smokers and non-smokers

Smokers had significantly lower FVC, FEF_{25} and FEF_{50} (Table 2). The other PFT parameters were also reduced in smokers.

Comparison of visual evoked potentials (VEP) between smokers and non-smokers

The right eye VEP of smokers was comparable to the right eye VEP of nonsmokers and similar finding was documented between the left eyes irrespective of the smoking status.

Comparison of cognitive function (visual reaction time) between smokers and non-smokers

VRT was significantly lower among smokers compared to nonsmokers (Table 4).

Table 1: Comparison of anthropometric variables between smokers and non-smokers

Variables	Smokers (Mean±SD)	Non-smokers (Mean±SD)	P value
Age(yrs)	26.78±4.79	24.89±5.21	0.312
Weight (Kg)	65.63±9.36	63.48±7.15	0.139
Height (m)	1.72±0.07	1.67±0.05	0.133
BMI (Kg/m^2)	22.02±2.24	22.39±2.08	0.320

BMI: Body Mass Index, SD: standard deviation, P value <0.05 is statistically significant

Table 2: Comparison of pulmonary function test (PFT) variables between smokers and non-smokers

Variables	Smokers (Mean±SD)	Non=smokers (Mean±SD)	P value
FVC (L)	4.35±0.83	5.32±1.18	**0.022**
FEV_1 (L/s)	4.20±0.90	5.15±1.15	0.083
FEV_1%	91.91±20.83	96.81±2.75	0.050
FEF_{25}(L/s)	7.40±2.38	8.74±3.90	**0.019**
FEF_{50}(L/s)	6.11±1.52	7.74±2.57	**0.010**
FEF_{75}(L/s)	3.99±1.31	5.23±1.46	0.602

FVC: Forced Vital Capacity, FEV_1: Forced Expiratory Volume in one second, FEV_1%: Ratio of FEV_1 to FVC, FEF_{25}: Forced Expiratory Flow at 25%, FEF_{50}: Forced Expiratory Flow at 50%, FEF_{75}: Forced Expiratory Flow at 75%, P value <0.05 is statistically significant

Table 3: Comparison of visual evoked potentials (VEP) between smokers and non- smokersww

Variables	Smokers (Mean±SD)	Non-smokers (Mean±SD)	P value
Rt. Eye VEP (ms)	117.30±12.88	122.14±11.68	0.849
Lt. Eye VEP (ms)	116.84±12.47	123.85±12.66	0.878

Rt. Eye VEP: Right Eye Visual Evoked Potential, Lt. Eye VEP: Left Eye Visual Evoked Potential, P value <0.05 is statistically significant

Table 4: Comparison of cognitive function (Visual reaction time) between smokers and non-smokers

Variables	Smokers (Mean±SD)	Nonsmokers (Mean±SD)	P value
VRT (ms)	431.69±60.29	441.14±123.54	**0.010**

VRT: Visual Reaction Time, P value <0.05 is statistically significant

DISCUSSION

Smokers generally have a higher probability of respiratory symptoms which are often accompanied by pulmonary function abnormalities with a greater annual rate of decline in FEV1 and maximal expiratory flow volume as compared to non-smokers. Many studies done[11] on healthy tobacco smokers had found that spirometric parameters were significantly lower in all smokers (even mild smokers) than in non-smokers. Our study also showed similar results. This decline in PFT is even evident in teenagers who had smoked only for a few years. This indicates that smoking cause narrowing in the diameter of airways.[12,13] Hence, PFT is a useful tool to identify changes in lung volumes not only in symptomatic smokers but also in asymptomatic smokers. It helps to evaluate damage done to the lungs before any clinical features of COPD develop[14] and so can be used in early screening of pulmonary function. Airways constriction has been correlated with the duration of smoking instead of the quantity of smoking. And also giving up smoking at the earliest can help revert the PFT values to normal.[15] These findings thus reinforce on conducting PFTs early, even in asymptomatic smokers.[16]

In addition, lower pulmonary function test results may serve as evidence to help convince and increase awareness in the smokers to contemplate quitting the habit. And thus prevent long term morbidity and mortality due to smoking related illnesses and lead to an overall improvement in community health[17].

Studies done in chronic smokers with COPD yielded prolonged latencies in VEP.[18-21] In COPD there is ventilation- perfusion imbalance resulting in hypoxia, which is linked with peripheral and central neuropathy,[4] affecting the visual receptors more.[5] Tobacco smoke have been seen to produce demyelination at retrobulbar portion of optic nerve[22] and increase reactive O_2 species which decrease blood flow and thus affect nerve conduction[2,3] as well as modulate release of neurotransmitter. Thus, VEP can be considered a tool to detect changes in neuropathy before appearance of any symptoms.[6]

Whereas, in other studies[23-25] a decrease in P100 latency or VEP response was found in smokers. They had opinioned that it was the effect of nicotine which enhanced perceptual processing and response to execution.

In our study the VEP response between the smokers and non- smokers were comparable. Some of the PFT's were compromised in smokers but they were still asymptomatic. The hypoxic and other toxic effects of smoking might not have affected the optic nerves as yet.

Reaction time provides an index of speed of processing capability of CNS and is a simple means of determining sensory motor performance.[8,9] The VRT was shorter in smokers than in non- smokers in our study and also in a study done by Ichaporia et al 1991.[10] This could be due to stimulant action of nicotine which enhances the effect of visual attention. In general small doses of nicotine have stimulating and arousal action on CNS (whereas large dose suppress it) especially in cortical neurons, limbic system and reticular activating system.[25] Thus, smoking enhances response to preparation and execution.[23,24]

CONCLUSION

Smokers have P100 wave latency, VEP parameter, similar to a non-smoker, whereas, the visual reaction time is faster.

ACKNOWLEDGEMENT

The study team deeply appreciate the support of all the faculty members, colleagues, junior residents and post graduate students (especially Mr. Khirendra Chaudhary, Mr. Sailesh Chaudahary and Dr. Rekha Limbu). We would also like to thank Mr. Shyam Chaudhary for the technical support, Mrs. Manju Lamsal for computer assistance and Mrs. Sita Dahal and Mrs. Phula Devi Basfor for their help. Lastly, we would like to thank all the participants for participating and BPKIHS research grant for the financial support.

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KRP- Concept and design of the study, reviewed the literature, Data acquisition, Data analysis, Statistical analysis, manuscript preparation and critical revision of the manuscript; **DRP-** Definition of intellectual content, Literature search, Data analysis, Statistical analysis, Manuscript preparation, editing and review; **NL-** Definition of intellectual content, literature search, statistically analyzed and interpreted and critical revision of the manuscript; **BS-** Data acquisition and review of study; **KA-** Concept, review of literature and helped in Manuscript review.

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Source of Support: B.P. Koirala Institute of Health Sciences, Research Grant, **Conflict of Interest:** None.