**Borneo International Journal eISSN 2636-9826**; Vol. 1 (2); 2019; 1-4
Published by *Majmuah Enterprise*
www.majmuah.com

# Hearing Status Among Smokers Using Extended High Frequency Pure Tone Audiometry (EHFPTA) and Distortional Product of Otoacoustic Emissions (DPOAE)

Atiyah Ali[1], Noraidah Ismail[2], Afzarini Ismail[2]

1. *Department of Neuroscience, School of Medical Sciences, Universiti Sains Malaysia, Kelantan, Malaysia*

2. *Department of Audiology and Speech Language Pathology, International Islamic University Malaysia, Kuantan, Pahang, Malaysia*

Email: atiyahali90@yahoo.com.my | Tel: +60133153685 |

Received: March 7, 2019
Accepted: April 28, 2019
Online Published: April 29, 2019

## Abstract

**Objective:** The purpose of this study is to measure the hearing level among smokers using high frequency sensitive testing which are extended high frequency Pure Tone Audiometry (EHFPTA) and Distortional Product of Otoacoustics Emissions (DPOAE). This study focuses on four specific objectives which determine the hearing level of smokers at high frequencies, identifying amplitude of DPOAE in measuring damage level of hearing cell in cochlea, correlating the smoking duration on hearing and lastly, smoking quantity per day effects on hearing. **Methods:** 30 subjects participated in this study whereby they were divided into testing groups (smokers) and control groups (non-smokers). **Results:** The result of this study found that there are elevation of threshold at 16 KHz, 18 KHz and 20 KHz among smokers compared to non-smokers depending on duration (years) and quantity of smoking (per day). The higher the number of cigarettes being smoked per day, and the longer duration of smoking, the higher the potential of getting hearing loss. This study result also found that the longer the duration of smoking (years), it also may increase the chance of hearing elevation especially at high frequency. Mean amplitudes of DPOAE among smokers was significantly low compared to non-smokers except on 1.5 KHz and 8 KHz. **Conclusion:** This study implies that the damaging effects of smoking tend to reduce the hearing sensitivity at extended high frequency first which later can be progressively affected on other frequency range of hearing.

**Keywords:** smoking; hearing loss; audiology tests,

## 1. Introduction

According to Global Adult Tobacco Survey (GAST) conducted by World Health Organization (WHO) in 2011, there was 43.2% of smokers among Malaysian adults. Most people associated smokers with high tendency of having chronic diseases such as cancers and heart problems rather than hearing loss. It was discovered from numerous studies that cigarette smoking reduces the hearing threshold by damaging the high frequencies sound first which later progress towards the mid and low frequencies sound (Nomura et al. 2004). This pattern of hearing loss was due to anatomical functions of organ of hearing, cochlea whereby the high frequency coding part was located on the outmost part of organ known as basal part while low frequency coding part known as apical part was located in the inner part (Cunningham et al. 1983). The basal part will easily get damaged first due to the abundant of blood vessel surrounds the basal.

Toxic agents in cigarette such as nicotine and carbon monoxide (CO) give direct effect on cochlea by reducing the oxygenated blood flow surrounds the cochlea, thus depletion of oxygen in the hearing cell leads to cell damage (Dawes et al. 2014). Study done by Paschoal & Azevado (2009) mentioned on the hearing cell, Outer Hair Cell (OHC) which is sensitive to any noxious substances and gets damaged easily compared to Inner Hair Cell (IHC). This current study was conducted to study on the hearing status among smokers using clinical testing which are sensitive in high frequency loss. Extended High Frequency Pure Tone audiometry (EHFPTA) and Distortional Product of Otoacoustic Emissions (DPOAE) was used throughout this study to detect early hearing loss among smokers.

## 2. Methodology

Cross-Sectional study design was used in this study and 30 subjects was recruited using convenience sampling method. 15 smokers were recruited as the target group, while another 15 non-smokers as the control group. This gives out a total of 30 ears equal to 60 ears bilaterally and 60 data were used in data analysis as no significant difference was found between each ear. Two-way ANOVA statistical test was used in order to analyse on EHFPTA and DPOAE among smokers and non-smokers. Spearman's nonparametric correlation test to correlate the smoking quantity (per day) and smoking duration (years) with extended high frequency PTA.

## 3. Results and discussion

**Table 1:** Summary analysis of EHFPTA between smokers (S) and non-smokers (NS).

| KHz | *p*-value | Mean of Hearing threshold (dB HL) (S) | Mean (NS) | Std (S) | Std. (NS) |
|---|---|---|---|---|---|
| 10 | 0.717 | 10 | 10 | 12.57 | 13.43 |
| 12.5 | 0.206 | 10 | 5 | 16.65 | 9.46 |
| 14 | 0.469 | 15 | 15 | 19.38 | 10.05 |
| 16 | 0.006* | 20 | 10 | 17.31 | 15.80 |
| 18 | 0.001* | 25 | 10 | 12.90 | 15.30 |
| 20 | 0.004* | 20 | 15 | 10.98 | 14.56 |

**P<0.05 indicates significant different between variables*
*Based on estimated marginal means*
**. The mean difference is significant at the 0.05 level.*
*Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).*

Table 1 shows the summary analysis of mean hearing threshold between smokers (S) and non-smokers (NS) at 6 different frequencies: 10KHz, 12.5 KHz, 14KHz, 16KHz, 18KHz and 20KHz. It was found that there was elevation of hearing threshold up to mild hearing loss among smokers compared to non-smokers who had normal hearing mean threshold (refer Table 1). There were significant different of p-value at 16 KHz, 18 KHz and 20 KHz compared to the non-smokers. The mean threshold between these two groups were in normal hearing threshold except at 18 KHz, it was revealed that smokers had mild hearing loss compared to non-smokers who had normal mean hearing threshold. Paschoal &Azevado (2009) stated that smoking reduces oxygenated blood in the cochlea whereby it causes the OHCs tend to be ruptured and deoxygenated in which later reduces the hearing sensitivity at high frequency sound.

Meanwhile, Table 2 shows the summary analysis of mean DPOAE amplitudes for both smokers and non-smokers groups. The mean reading of DPOAE among smokers were significantly lowered than non-smokers except at 1.5 KHz and 8 KHz (refer Table 2). The highest DPOAE frequency tested which was at 8 KHz showed no significant difference between smokers and non-smokers and these results can be due to small numbers of subjects. Although the amplitudes were lowered among smokers than non-smokers, the mean amplitude of DPOAE for both groups was still in normal range of DPOAE amplitudes. These findings are in parallel to one of studies done by Oliveira & Lima (2009) in which they discovered that there was no significant difference of hearing threshold at extended high frequencies (i.e. 10 KHz – 16 KHz) among smokers and non-smokers, since both mean thresholds were within normal hearing threshold. The authors explain that the research was only done among smokers who smoked less than one pack within 6 years. Thus, limitation of subject populations in smoking quantity (per day) and smoking duration (years) can be the factors for non-significant differences observed at frequency tested.

**Table 2:** Summary analysis of DPOAE between smokers (S) and non-smokers (NS).

| KHz | *p*-value | Mean Amplitudes of DPOAE (dB SPL) (S) | Mean (NS) | Std. (S) | Std. (NS) |
|---|---|---|---|---|---|
| 1 | 0.015* | 12.02 | 13.92 | 8.28 | 6.24 |
| 1.5 | 0.169 | 19.99 | 20.82 | 6.55 | 6.62 |
| 2 | 0.001* | 18.29 | 22.28 | 6.24 | 5.65 |
| 3 | 0.001* | 16.13 | 20.47 | 9.67 | 4.12 |
| 4 | 0.001* | 17.71 | 21.44 | 6.01 | 5.17 |
| 6 | 0.001* | 18.53 | 20.88 | 8.77 | 11.16 |
| 8 | 0.997 | 18.12 | 18.21 | 15.01 | 12.51 |

**p-value <0.05 shows significant different*
*Based on estimated marginal means*
**. The mean difference is significant at the .05 level.*
*Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).*

Nakashini et al., (2000) also mentioned that the effects of duration and quantity of smoking towards hearing loss because of the toxic substance in cigarette may damage the OHC slowly and progressively within years. The damage induced by ototoxicity is permanent, irreversible and commonly gives bilateral effects of hearing damage. The smoking duration was categorised into 4 different groups of durations which were 0-5 years, 6-10 years, 11-15 years and 16-20 years. All the categories were correlated with the extended high frequency PTA (i.e, 10 KHz-20 KHz) and the r-value was 0.872 which indicated on strong correlation strength between the smoking duration and hearing sensitivity at extended high frequencies. In other words, these results show that the longer the smoking duration, the higher the potential of reduce hearing sensitivity across extended high frequencies.

Spearman's nonparametric correlation test correlate the smoking quantity (per day) and EHFPTA among smokers. The number of cigarette smoked per day were categorised into 3 groups which were 0-10 (cigarettes/day), 11-20 (cigarettes/day) and more than 20 (cigarettes/day). These three groups were correlated with the extended high frequencies (i.e, 10 KHz-20 KHz) and the correlation results were 0.976. The r- value showed very strong positive correlation between smoking quantity and hearing sensitivity at extended high frequency PTA. From the correlation test, it is revealed that as the number of cigarettes smoked per day increases, it will increase the potential of having defects on the hearing sensitivity at extended high frequencies.

## 4. Conclusions

It was shown in this study that smokers have potential to be affected with hearing loss at high frequencies and also may have permanent damage of hearing sensitivity advocated by outer hair cell. This is due to the effects of ototoxic substances which damage the outermost basal layer of cochlea. In this conducted study, there was a correlation of smoking quantity (per day) and smoking duration (years) to extended high frequency PTA. The higher the number of cigarettes smoked (per day) and the longer the smoking duration (years) which at the end it shall increase the potential of having hearing loss at high frequencies.

## Acknowledgments

The authors thank Dr. Sarah Rahmat and Dr. Ahmad Aidil for assisting in the data analysis.

## References

Cunningham, D.R., Vise, L.K., Jones, L.A. 1983. Influence of cigarette smoking on extra-high-frequency auditory thresholds. *Ear Hear.* 4(3):162-5.

Dawes, P., Cruickshanks, K.J., Moore, D.R., Edmondson, J.M., McCormack, A., Fortnum, H., Munro, K.J. 2014. Cigarette smoking, passive smoking, alcohol consumption, and hearing loss. *J Assoc Res Otolaryngol* 15(4):663-74.

Nakanishi, N., Okamoto, M., Nakamura, K., Suzuki, K., Tatara, K. 2000. Cigarette smoking and risk for hearing impairment: a longitudinal study in Japanese male office workers. *J Occup Environ Med*. 42(11):1045-9.

Nomura, K., Nakao, M., Morimoto, T. 2005. Effect of smoking on hearing loss: quality assessment and meta-analysis. *Prev Med*. 40(2):138-44.

Paschoal, C.P., Azevedo, M.F. 2009. Cigarette smoking as a risk factor for auditory problems. *Braz J Otorhinolaryngol* 75(6):893-902.

World Health Organization. 2011. Global Adult Tobacco Survey (GATS) Malaysia. http://www.who.int/tobacco/surveillance/survey/gats/malaysia_fact_sheet_2011.pdf?ua= [2nd Oct 2016]