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Original Research Article

Efferent System Activation Using Contralateral Suppression of Distortion Product Otoacoustic Emissions in Individuals with Normal Hearing

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ABSTRACT

Efferent system can be activated using a non invasive technique named as contralateral suppression of distortion product otoacoustic emissions (DPOAEs). The present study was taken to estimate the amount of suppression noticed in three different age group (Young, middle & older) individuals in the age range of 17-70 years. The results of the study revealed that there are significant differences for distortion product otoacoustic emission amplitude observed between younger and older age group individuals in absence and presence of noise. However, similar differences were not evident between middle and older age group individuals. Further, there were differences in amount of suppression across different age groups only at 1.5 kHz and 2 kHz. Hence, present study highlights efferent system activation could be partially alike across different age groups.

Keywords: Otoacoustic Emission, Noise, Efferent system, Outer Hair cells.

INTRIDUCATION

Otoacoustic emissions (OAEs) are the sound energy propagating from cochlea (outer hair cells) first reported by Kemp in 1979. It is believed to arise from the action of outer hair cells (Kemp, 1986). Distortion product otoacoustic emissions (DPOAE) are measured with the presentation of two simultaneous pure tone stimuli (primaries) to the ear. When both the primaries are reasonably close in frequency, their interaction takes place on the basilar membrane which gives output of energy at other discrete frequencies (e.g., f2-f1, 2f1-f2, 3f1-2f2 etc.). Conventionally DPOAEs are recorded at 1 to 2 frequencies per octave i.e., audiometric frequencies. The DPOAE amplitudes can be measured at a variety of primary frequencies. So, the resulting DP gram can be obtained with the different resolution of the primary frequencies in different DPOAE systems.

Evidence suggests that the efferent suppression of otoacoustic emissions is mediated by the olivocochlear bundle. The medial olivocochlear (MOC) reflex had been studied in humans and other animals while recording DPOAEs simultaneously with the presentation of noise to the contralateral ear (Collet et al., 1990; Moulin, Collet & Duclaux., 1993). MOC activation leads to change in amplitude, usually reduction in different types of OAEs including DPOAEs (Mott, Norton, Neely & Warr, 1989; Moulin, Collet & Morgon, 1992; Micheyl & Collet, 1996). DPOAE is usually reduced by a small amount (0.5 to 2 dB), with large intersubject variability in the presence of contralateral sound (Moulin et al., 1993; Williams & Brown, 1997).

There are several studies tried to explore the effect of aging on efferent system measuring contralateral suppression of otoacoustic emissions (Castor, Veuillet, Morgon & Collett, 1994; Kim, Frisina & Frisina, 2002; Quaranta, Debole, & Girolamo, 2001). Castor et al. (1994) revealed that the suppressive effect decline with ageing using contralateral suppression of DPOAEs. Similar finding is also reported by Kim, Frisina and Frisina (2002) using DPOAEs. Further later study also reported frequency specific decline where more declines in emission noted at 4 to 6 kHz region in comparison to 1 to 2 kHz region. However, Quaranta et al. (2001) studied the effect of ageing on efferent system using contralateral suppression of TEOAE. They reported no significant effect of aging on contralateral suppression of TEOAEs.

The contralateral suppression of otoacoustic emissions enjoys less clinical popularity among clinicians since the magnitude of suppression is very small with large inter- and intra-subject variability (Moulin et al., 1992; Sun & Kim, 1999). There are studies which have stated the hypothesis that the efferent olivocochlear bundle (OCB) starts degenerating before any observed hearing impairment due to presbycusis (Kim, Frisina, & Frisina 2002; Fu et al., 2010).

DPOAE measurement for the effect of MOCB with and without noise can give the index of MOCB functioning. It is thought to be produced by the active nonlinearities of the outer hair cells activity to amplify basilar membrane motion which in turn are innervated by the MOC fibers (Kim, 1980, Brownell, 1990). Guinan (2006) stated that the activation of the efferent system alters the outer hair cell function thereby affecting otoacoustic emissions. From review of literature, it can be concluded that there are studies in the area of contralateral suppression of DPOAE and TEOAEs in individuals with normal hearing. However, there is a discrepancy in outcome of different study. Hence, present study tried to assess efferent system in different age groups using contralateral suppression of DPOAEs.

MATERIALS AND METHODS

There were 40 participants in the age range of 17-70 years in three different age (young, middle & old) groups. There were 16 participants in young (17-30 years), 14 participants in middle (40-50 years) aged and 10 participants in older age (60-70 years) group. They were randomly selected from the southern part of India. All the above participants were having hearing sensitivity within normal limits for both air conduction as well as bone conduction thresholds. The audiometric thresholds for the young and middle aged were considered as ≤ 15 dBHL up to 6 kHz whereas for old aged individuals the audiometric thresholds was considered as ≤ 25 dBHL up to 6 kHz. All participants had “A” type tympanogram with acoustic reflexes present at 500, 1000, and 2000 Hz. The detailed case history was taken to rule out factors like ototoxicity, long term noise exposure, family history of hearing impairment etc. Those participants who had above symptoms were not considered for the study. Written/Oral consent was obtained from all the participants.

A calibrated two channel Audiometer MAICO MA-53 was used for estimating the pure tone thresholds and presenting white noise for contralateral suppression of DPOAEs. Pure tone hearing thresholds were measured using modified Hughson Westlake procedure (Carhart & Jerger, 1959). Threshold was obtained across octave frequencies 250 Hz to 8000 Hz for air conduction using TDH-39 headphones and 250 Hz to 4000Hz for bone conduction using Calibrated Radio B-71 bone vibrator. A calibrated GSI-Tympstar Middle ear Analyzer was used for tympanometry and acoustic reflexes. Tympanometry was carried out with a probe tone frequency of 226 Hz. Ipsilateral and contralateral acoustic reflexes thresholds were measured for 500, 1000, and 2000 Hz.

DPOAEs measurements were done using calibrated ILO (Version 6) in a sound treated room. All participants were comfortably seated on an armchair throughout the test session, which lasted for approximately 15 minutes. Each test session consisted of two initial DPOAE measurements without noise and two measurements in the presence of the contralateral white noise presented at 30 dBSL. The noise threshold was measured for each individual with insert earphone of calibrated MAICO MA-53 audiometer and further presented through same audiometer.

A standard DPOAE probe tip was positioned in the participant's ear canal. Throughout the measurement the ratio (f2/f1) was constant i.e., 1.22. The stimulus intensity levels were held constant at L1 = 65 and L2 = 55 dB SPL. The level of the 2f1-f2 DPOAE were depicted as a function of frequency as a DPgram at 2 points per octave from 1000 Hz to 6000 Hz. DPOAE were considered to be present when they were at least 3 dB above the corresponding noise level (Moulin et al., 1993). The contralateral white noise was generated by the MAICO MA-53 audiometer at 30 dBSL as it does not evoke the middle ear reflex as well as it is in good agreement with the previous studies (Guinan, 2006). All the testing was carried out in an acoustically and electrically shielded room where the noise levels were within the permissible limits (ANSI S 3.1; 1991).

RESULTS AND DISCUSSION

All the data were tabulated and analyzed using SPSS (version 16). The statistical procedure includes descriptive statistics and non-parametric test (Kruskal-Wallis test, Mann Whitney U test, and Wilcoxon sign rank test) was used. Distortion product otoacoustic emissions were recorded in the absence and presence of contralateral noise in three age groups (Younger, middle and older). The mean and 95% confidence interval (CI) of without and with noise DPOAEs amplitude obtained at different frequencies mentioned in figure 1. From Figure 1, It is very clear that the mean DPOAE amplitude of without and with noise is higher (more) for low and mid frequency and lesser (low) for higher frequencies i.e. above 3 kHz. Further, Figure 2 shows at different age groups irrespective of different frequencies, overall DPOAEs amplitude is lesser (low) for older age group in comparison to younger age group individuals with normal hearing.

Mann Whitney U test was to done to check the difference between different age groups for DPOAEs amplitude measures in presence and absence of noise. The results revealed that there were significant differences in DPOAEs amplitude in both with and without noise condition between younger and old age groups at all the frequencies. Further, significant differences were also observed between younger and middle aged group individuals in presence of noise at all frequencies. However, significant differences did not observe in quiet condition between younger and middle aged groups at all frequencies. In addition, significant differences did not noticed between middle aged and older age group individuals too (Table 1).

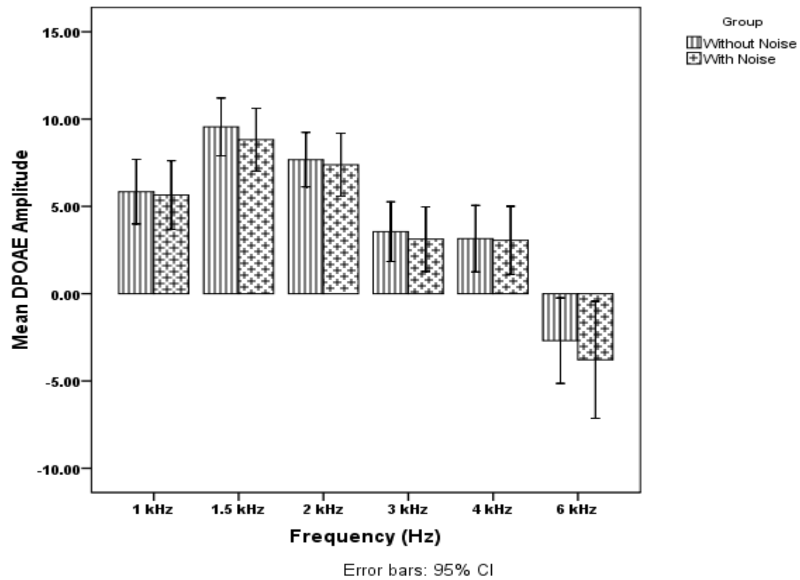

Figure 1: Mean and 95% CI of DPOAE amplitude without and with noise across frequencies

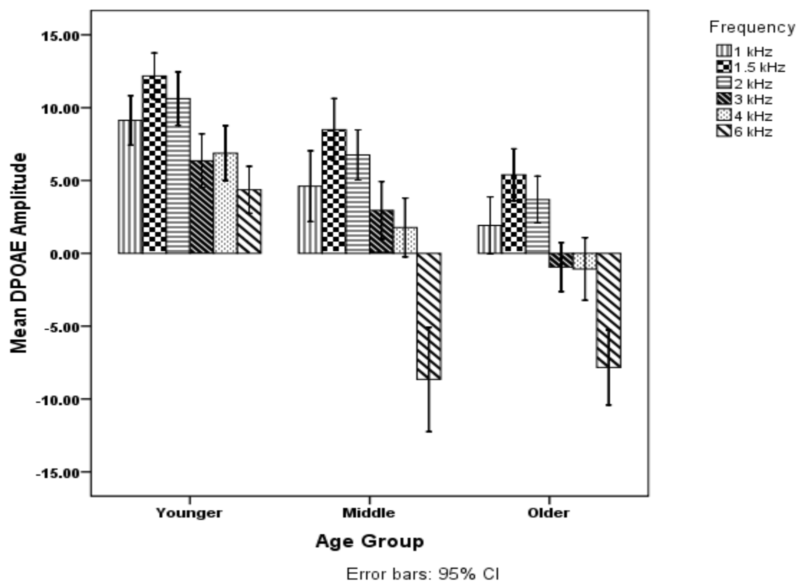

Figure 2: Mean and 95% CI of DPOAE amplitude for different age group individuals across frequencies

Table 1: Comparison between different age groups in quiet and noise conditions across different frequencies

Age group	Younger Vs Older		Younger Vs Middle		Middle Vs Older	
Frequency	Quiet	Noise	Quiet	Noise	Quiet	Noise
1 kHz	-3.05**	3.40***	-2.32*	-2.24*	-1.23#	-1.20#
1.5 kHz	-2.92**	3.37***	-1.53#	-2.05*	-1.37#	-1.11#
2 kHz	-2.95**	3.26***	-1.82#	-2.24*	-1.64#	-1.43#
3 kHz	-3.05***	-3.26**	-1.70#	-1.89*	-1.90#	-1.72#
4 kHz	-3.47***	-3.05**	-2.78**	-2.05*	-1.52#	-1.49#
6 kHz	-3.87***	3.84***	-3.80***	-3.63**	-0.14#	-0.20#

#p>0.05; *p<0.05; **p<0.01; ***p<0.001

Kruskal-Wallis test was done to check the changes in DPOAE amplitude in presence and absence of noise at each frequency across different age groups. The results revealed that there was a statistically significant difference at all the frequencies across different age groups in both presence and absence of noise conditions (Table 2).

Table 2: Chi-square values of Kruskal-Wallis test at different frequencies

	Quiet Condition	Noise Condition
Frequency (Hz)	χ^2-value	χ^2-value
1 kHz	11.15**	12.29**
1.5 kHz	8.58*	11.42**
2 kHz	9.87**	12.08**
3 kHz	10.51**	11.54**
4 kHz	15.16**	10.69**
6 kHz	20.76***	19.64***

*p<0.05; **p<0.01; ***p<0.001

Contralateral suppression of DPOAE amplitude

Mann-Whitney U test was done for contralateral suppression of DPOAE amplitude to check whether there are differences between younger, middle and older age group individual. The results revealed contralateral suppression of DPOAEs was statistically significant only at 1.5 kHz (Z= -2.03; $p<0.05$) and 2 kHz (Z= -2.03; $p<0.05$) between younger and older as well as younger and middle age group individuals at 1.5 kHz (Z= -2.23; $p<0.05$) and 2 kHz (Z= -2.76; $p<0.05$). However, significant differences were not noticed for other frequencies between any age groups except 1.5 kHz and 2 kHz. Further, Kruskal-Wallis test was done to check whether there are any differences in DPOAEs amplitude considering different age groups together. The results revealed that there were no statistically significant differences observed for contralateral suppression of DPOAE amplitude at any frequencies except 1.5 kHz (χ^2 = 6.48; $p<0.05$) and 2 kHz (χ^2 = 8.44; $p<0.05$). Hence, the above finding in the present study revealed there is no effect of age on contralateral suppression of DPOAE amplitude.

The present study finding show no effect of ageing on efferent system since the contralateral suppression of DPOAE amplitude at different frequency did not show significant reduction with age. The present study findings are in agreement with the finding of other studies (Quaranta, Debole & Girolamo, 2001; Badariya & Maruthy, 2010). However, both studies measures contralateral suppression of TEOAEs amplitude rather DPOAEs and revealed no effects of age on efferent system.

Present study finding is in contrast with other studies on DPOAE suppression effect as noticed by Kim et al. (2002), Jacobson et al. (2003) and Varghese et al. (2005). However, present study too observed significant differences comparing different age groups in absence and presence of noise for DPOAEs amplitude though the differences in amplitude between two conditions did not show decline with age. Similarly differences in DPOAEs amplitude across different frequencies were well evident. There was lesser (low) amplitude at higher frequencies in both presence and absence of noise in comparison to low and mid frequency. The above finding is in agreement with Kim et al. (2002) study. They measured age related changes of the medial olivocochlear system by comparing DPOAEs with and without contralateral white noise stimulation. They notice decline in the contralateral suppression with age for the middle aged and old aged groups. In addition, they also found contralateral suppression was greater at lower frequencies than higher frequencies. Hence, they conclude that there is a functional decline of the medial olivocochlear system with age. Similar finding was observed even in animals by Jacobson et al. (2003) and Varghese et al. (2005). In addition to that, Castor et al. (1994) also reported a decrease in the amount of suppression with age. However, Castor et al. noted that their finding might had been confounded by the peripheral hearing loss. Hence, recently Abdala et al. (2009) and Sun (2008) advocated measurement of contralateral suppression at only the peaks of the DPOAEs fine structure rather than dips, and reported much more instances of suppression. However, present study could not able to explore DPOAEs fine structure which could have been a better option to document minimal changes in suppression effect on MOC system; this could be the limitation of the present study.

CONCLUSION

Efferent system can be assessed while recording DPOAEs amplitude simultaneously with the presentation of noise to the contralateral ear. The results revealed significant difference in DPOAEs amplitude in presence and absence of noise across different age groups. In spite of differences, contralateral suppression of DPOAEs amplitude was not significant for most of the frequencies for different age group individuals. Absence of ageing effect for contralateral suppression of DPOAEs probably suggests lack of degeneration of efferent system up to the age of 70 years. However, researchers must be cautious while considering the above finding because of small sample size.

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