Original Article

The influence of community on Transient evoked otoacoustic emissions (TEOAEs) in Iraqi subjects with normal hearing.

Munir S. Al-Namir* BSc, MSc
Falah N. Al-Doori** BSc, PhD
Maha A. Essa*** BSc, MSc

J Fac Med Baghdad
Vol. 51, No.4, 2009
Received: April 2009
Accepted: June 2009

Summary:

Background: The purpose of this study was to compare the parametric measurements of transient otoacoustic (TEOAEs) in normal hearing subjects between two clinical centers in Iraq and to examine the community effect on TEOAEs characteristics.

Patients and Methods: Transient otoacoustic emission (TEOAEs) were obtained from eighty subjects (160 ears)-males and females aged (10-20 years), with Forty (40) subjects in Baghdad audiology center and forty subjects in Sulaimania audiology center (North of Iraq)[Kurdistan-Iraq], in standard, non-linear "Fast Screen" mode. Hearing thresholds, tympanometric, and TEOAE-parameters were recorded between two clinical center groups.

Results: The cross correlation (wave reproducibility) was constant between two groups. The mean Signal to noise ratio (SNRs) for all (160 ears) were well above 3 dB at frequencies 1K, 2K, 3K, 4K and 5 KHz. The Sulaimania –subjects group showed the lowest SNR in low frequency (1 KHz) and middle frequency (3 KHz) than the Baghdad-subjects group. No statistical difference was observed in other frequency bands, and in overall mean SNRs between two groups.

Conclusions: The observed differences of SNRs at low and middle frequency bands are most likely related to differences in ear canal volume and/or to differences in cochlear mechanisms. The values obtained in the present study can be used as normative data for screening and diagnostic purposes in Iraqi subjects aged (10-20 years).

Key words: Transient evoked otoacoustic emissions, Reproducibility, Signal to noise ratio, Baghdad – subjects group, Sulaimania subject group.

Introduction:

Otoacoustic emissions are sounds thought to be generated by the cochlear outer hair cells in response to an external sound stimulus (1). Normal hearing threshold is achieved by a cochlear mechanism, though to reside in the healthy hair cells, which magnifies the stimulus internally. When this mechanism loses the peak of its performance, OAEs diminish and hearing threshold is raised.TEOAEs, are currently though to be the most clinically useful OAEs, as they are detectable in 98% of people with normal hearing, regardless of age or sex, and the two ears of any individual produce similar TEOAEs (2,3). Signals used to generate TEOAEs consists of a click or tone burst. TEOAEs in response to click stimuli consists of a delayed, nonlinear, frequency-filtered echo of the stimulus (1). Healthy ears typically demonstrated several regions of strong response for TEOAEs between 0.4 and 6 KHz (4, 5). TEOAE can be measured in frequency-specific regions, which is helpful for audiogram predication in patients. Regions of normal and abnormal outer hair cells function can be predicted by patterns of OAE response. There are currently no universally accepted methods for determining when an OAE is present and clearly discernible from the background noise (6,7). OAE equipment will provide measures of "OAE amplitude", background noise, and often "signal to noise ratio" which is a comparison of two. TEOAE recording systems generally provide a "reproducibility" index as well, which essentially determines how well the response will produce when measured twice. All this information must be considered when determining if a response is present. Kemp, et al, (6) recommended a minimum of 50% reproducibility for determining response presence, while Prieve, et al, (8), found 70% to reasonable expectation, along with an overall amplitude (wide band) of 6 dB SPL. For narrow frequency bands, amplitude of 3 dB above background noise may give reasonable assurance of a TEOAE response for that frequency region alone (9).There are

**Dept. of Medical physics, College of Medicine, Baghdad University*
*** Dept. of Medical physics, College of Medicine Baghdad University*
****Dept. of hearing and Speech*

many factors may affect TEOAE-screening, such as, external and middle ear conditions Maxon, et al, (10) age, gender, and race (10,11,12,13). Gender is a factor in TEOAE measurement, at least in audiometrically normal adults. TEOAE amplitude is significantly larger for females than males (14). In any event, the extent of the gender difference argues for separate normative data for males and females , at least for young adults.The objective of this study is to compare TEOAE occurrence and characteristics between two clinical centers in Iraq.

Materials and Methods:

Transient evoked otoacoustic emissions were recorded in both ears of forty (40) subjects living in Baghdad (20 males, 20 females) and forty (40) subjects living in Sulaimania (North of Iraq)(20 males , 20 females). All subjects included in this study had ages ranging from 10 – 20 years (mean age = 15.4 years ± 3.1). Subjects were divided into two groups: Group-I (Baghdad-audiology center) and group-II (Sulaimania - audiology center). All subjects had a negative history of hearing problems, and did not take any drugs that were thought to affect hearing or OAE amplitude.

Each subject was seated in a quite room for routine pure-tone audiometry and tympanometry. Pure tone audiometry was tested in both ears of all subjects at octave intervals from 250 Hz to 8 KHz. All ears included in this study had pure-tone thresholds of 15 dB HL or less at all frequencies tested.All OAEs and tympanometric measurements were performed by (Madsen Capella's-OAE/middle ear analyzer-GN Otometrics, Danmark) in both groups. Tympanometric measurements in all (160 ears in both groups confirmed an (A-type) of tympanogram curve.

Transient Otoacoustic Emissions recording:The probe was retained in the subject's ear and TEOAE measure were made. The evoked stimuli used were 80 µs clicks presented at 75-85 peak SPL (Peak sound pressure level). Non-linear "Fast Screen-mode" click stimuli were used. The presence of a TEOA response was primarily determined by analyzing the reproducibility of the resultant waveform, emission strength and signal-to noise ration (SNR). In analyzing the TEOAEs, the Madsen Capella's-software Version-2 broke down all the recording into their component frequencies in five equal bands on (1, 2, 3, 4, and 5 KHz). A band reproducibility of greater than 60% or signal to noise ration of >3 dB was considered indications of true TEOAE responses in any frequency band.

Statistical analysis: For statistical analysis of the measured data, paired 2-tailed t-test was used. Averaged data are presented in the form of mean ± standard deviation [SD]. In all statistical analysis, only p-value < 0.05 were considered significant.

Results:

The results showed that the mean values of the reproducibility in Group-I (Baghdad Center) and in group-II (Sulaimania Center) were 86.3% ± 15.8 and 84.7%± 13.4 respectively. No significant difference was found in the whole wave reproducibility between the two groups using an t-test (t= -0.67 , P > 0.05). Figure (1) shows the means reproducibility at each frequency band in the group-I and group-II. There is a trend for Baghdadi subjects (Group-I) to have higher reproducibility in all frequency components of the TEOAEs than the Kurdistan subjects (group-II). No significant differences were found between the two groups in all frequency bands.

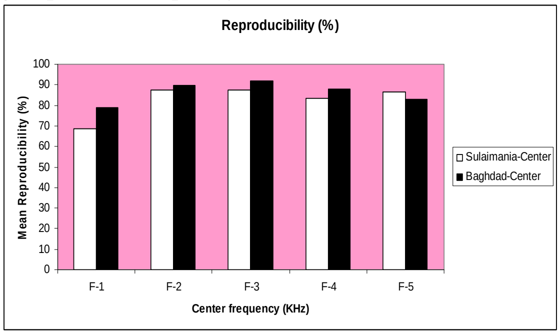

Fig 1: Mean reproducibility of TEOAEs from Sulaimania and Baghdad subjects at five frequency bands.

To study the effect of community on the TEOAE responses at different frequency bands, SNR at frequency bands centered around 1,2,3,4, and 5 KHz were recorded. Table -1 shows the means at each frequency band in the Baghdad and Sulaimania subjects. An analysis of variance further indicated statistically significant differences in the SNRs across frequencies of 1 KHz , p<0.0001. There were also significant differences in SNR across frequencies of 3 KHz , p<0.0001. No significant differences across frequency interaction occurred. Although the mean SNR of the overall frequency band in Baghdad center was higher than that in Sulaimania center, pair wise comparisons between the two groups did not reveal significant differences. Figure 2)

Table 1: Statistical analysis of the mean SNRs between two groups.

Sulaimania -Center		Baghdad-Center		
Frequency band	Mean SNR ± SD	Mean SNR ± SD	t-value	P-value
1 KHz	9.18 ±5.53	16.74± 6.29	-8.40	0.0001
2 KHz	15.36± 7.08	16.71 ± 6.00	-1.40	0.166 (NS)
3 KHz	13.75 ± 5.63	17.5±5.95	-4.21	0.0001
4 KHz	13.11± 5.76	15.24±5.52	2.35	0.0212
5 KHz	13.58 ± 5.17	12.93±5.44	0.80	0.4233 (NS)
Whole frequency bands	12.79± 4.58	13.42± 4.43	-0.86	0.3798 (NS)

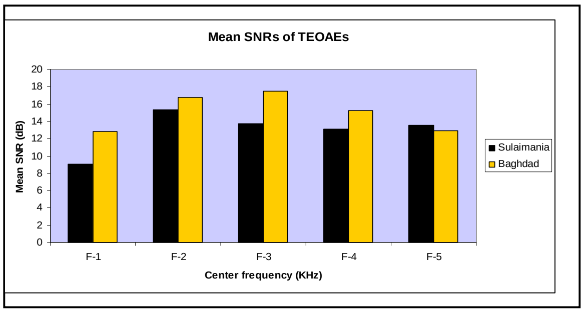

Figure 2: Mean SNRs of TEOAEs from group-I and group-II at five frequency bands.

For the overall responses of the TEOAEs recorded from both groups, data was expressed in terms of SNR in dB. The Baghdad subjects data ranged from (-0.70 dB to 21.80 dB (Mean = 13.42 dB; median = 14.50 dB) and the Sulaimania subjects data ranged from 4.90 dB– 22.4 dB (Mean= 12.79 dB; median = 13.8 dB). No statistically significant difference was found between the two groups using t-test (t = -0.86 , p >0.05). Table 2 ; shows the effect of gender on TEOAE responses at different frequency bands. The results showed that the mean SNRs in females were higher than that in males in both groups. Significant difference of the mean SNRs between the females and males were observed in Baghdad group in almost frequency bands.

Table 2: Mean SNRs between the females and males in both groups at different frequency bands.

Sulaimania audiology center				
Females		Males		
Frequency Bands	Mean ± SD	Mean ± SD	t-value	P-value
1 KHz	9.08 ±5.14	9.59 ±5.43	-0.50	0.618 (NS)
2 KHz	16.38 ±7.28	14.34 ±6.8	1.55	0.128 (NS)
3 KHz	14.58 ±4.78	12.97 ± 6.38	1.49	0.145 (NS)
4 KHz	14.12 ±5.56	12.11 ±5.84	1.94	0.059 (NS)
5 KHz	14.32 ±5.15	12.76 ±5.08	1.56	0.121 (NS)
Over all Frequency	13.50 ±4.67	12.07 ±4.43	1.65	0.108 (NS)
Baghdad audiology center				
Females		Males		
Frequency Bands	Mean ± SD	Mean ± SD	t-value	P-value
1 KHz	15.79 ± 6.31	10.81± 6.21	3.13	0.0033
2 KHz	19.08 ± 5.82	14.45 ±5.87	3.12	0.0034
3 KHz	19.16 ± 5.71	15.86 ± 5.73	2.37	0.0226
4 KHz	16.84 ± 4.74	13.79 ±6.10	2.40	0.0214
5 KHz	13.99 ± 4.13	11.80 ±6.15	1.83	0.0750 (NS)
Over all Frequency	15.20 ± 3.50	11.65 ± 4.54	3.36	0.0017

SD: standard deviation
NS: not significant

All the subjects (males and females) in Sulaimania-group revealed lower SNRs than that in Baghdad –group. However, significant lower of the mean SNRs were observed in the Sulaimania females at frequency bands of 1 KHz and 3 KHz , p,0.01.While in males, no significant difference of the SNRs was found between the two groups (table-3).

Table-3: Mean SNRs between the females in two groups and between the males in both groups at different frequency bands.

Sulaimania audiology center		Baghdad Clinical center		
Females		Females		
Frequency Bands	Mean ± SD	Mean ± SD	t-value	P-value
1 KHz	9.08 ± 5.14	15.79 ± 6.31	-5.27	0.0001
2 KHz	16.38 ± 7.28	19.92 ± 5.82	-1.89	0.0661 (NS)
3 KHz	14.58 ± 4.78	19.06 ± 5.75	-3.89	0.0004
4 KHz	14.12± 5.56	16.84 ± 4.74	-2.33	0.0253
5 KHz	14.32 ± 5.15	13.99 ± 4.13	0.32	0.7542 (NS)
Over all Frequency	13.5 ± 4.67	15.20 ± 5.63	-1.91	0.0633 (NS)
Sulaimania audiology center		Baghdad Clinical center		
Males		Males		
Frequency Bands	Mean ± SD	Mean ± SD	t-value	P-value
1 KHz	9.59 ±5.43	10.81 ±6.21	-0.83	0.4131 (NS)
2 KHz	14.34 ±6.80	14.45 ±5.87	-0.06	0.9358 (NS)
3 KHz	12.91 ±6.30	15.86 ±5.73	-2.15	0.0381(NS)
4 KHz	12.11 ±5.84	13.79 ±6.1	-1.16	0.2461 (NS)
5 KHz	12.76 ±5.08	12.80 ±6.15	0.76	0.4390 (NS)
Over all Frequency	12.07 ±4.43	12.67 ±4.54	0.36	0.7044 (NS)

SD: Standard deviation
(NS): Not significant

Discussion:

TEOAEs are present in ears with normal cochlear ear function and typically are absent or reduced in ears with cochlear and/or disorders of even mild degree. No difference in TEOAE prevalence was noted between the two groups. It was found that the TEOAE responses from the Baghdad-subjects (Group-I) had significantly higher SNRs in the low frequency components than sulaimania subjects (Group-II).In this present study, the TEOAEs showed larger levels in females particularly in group-I (Baghdad- audiology center). This fact was observed by other authors (15, 16, 17, 18, and 19). The hearing sensitivity is stronger in females (14) and that this gender differences emerge early in development. The higher outer hair cells count in females 20), gender with a higher prevalence of TEOAE (21) whereas, in group-II (sulaimania-audiology center), this difference was slightly difference in spite of there were nearly the same age-subjects and the same equipment. This might be due to the community effect. The demonstrated community difference in frequency distributions for TEOAEs was an interesting finding. It has been suggested in previous study that may be related to middle ear conduction properties (22, 23). According to this model, any difference in the physical properties of the middle ear ossicles, tympanic membrane and external auditory meatus can affect the OAEs recorded. Since tympanometric results represent preliminary data in considering middle ear functions, statistical comparisons of the estimated ear canal volume between the two groups were carried out. Statistically significant difference was found in the ear canal parameter between the two groups using dependent two-tailed t-test ($t = -2.14$, $p= 0.035$). Accordingly, canal volume was smaller in Sulaimania group (1.68 ml ±0.43) than in Baghdad group (1.82 ml±0.40). It is possible that the community differences in the canal volume are at least one of the underlying reasons for the different frequency distributions of OAEs found. In spite of these differences in TEOAEs responses between the two groups, the results indicated that the TEOAE-responses in both clinical centers were within the normative base line (8, 9). The finding of the present investigation may contribute toward future improvements in neonates, infants, children, and adults hearing screening in Iraqi population.

Conclusion:

TEOAEs can be used to identify hearing loss in subjects (10-20years) under routine clinical conditions. TEOAE-tests accurately identified auditory status at middle and high frequencies but performed more poorly at lower frequencies. The decrease in performance as frequency decreases may be a result of increased noise at lower frequencies but also may be due to properties of measurement paradigm " Fast Screen", which would not be ideal for recording energy around 1 KH-band (24,25). The improvement in test performance when SNR was used and the interaction of this effect with frequency, however, would be consistent with the view that test performance in lower frequencies is at least partially influenced by the level of background noise.

Limitations:

The main limitation of our study were the age range of our subjects. Due to the limited age range of our study population, our results are not applicable to subjects older than 20 years. We suggest further study included different ages (neonatal, infants, adolescents, adults and old subjects) that will give us a complete picture to the race effect on the TEOAEs for the Iraqi population.

References:

1. *Kemp,DT.: Stimulated acoustic emission from within the hearing system. J Acoustic Soc Am. 1978; 64: 1386 -1391.*
2. *Probst,R.: Advances in otorhinolarynology. Basel; Karger, 1990; 44: 1-91.*
3. *Probst, R; Lonsbury-Martin, BL; Martin, GK. A review of otoacoustic emissions. J Acoust Soc Am. 1991 ; 89: 2027 -2067.*
4. *Lonsbury-Martin,BL: Clinical applications of otoacoustic emissions. J Speech Hearing Res; 1991;34:964-81*
5. *Sutton,Gj. : Suppression effects in the spectrum of evoked otoacoustic emissions. Acustica. 1985, 58:57-63.*
6. *Kemp, DT; Ryan, S; Bray ,P . : Aguide to the effective use of otoacoustic emissions. Ear Hearing. 1990 ; 11: 93-105.*
7. *Norton, SJ; Gorga, MP ; Widen, JE; Folsom, RC; Siniger, Y; Cone-Wesson,B; Vohr, BR; Fletcher, KA. Identification of neonatal hearing impairment: Summary, and recommendations. Ear Hear. 2000: 529-585.*
8. *Prieve, BA; Gorga, MP ; Neely ST; et al: Analysis of transient-evoked otoacoustic emissions in normal hearing and hearing impaired ears. J Acous Soc AM. 1993: 93: 3308 – 3319.*
9. *Harrison,WA; Norton, SJ.: Characteristics of transient evoked otoacoustic emissions in normal hearing and hearing impaired children. Ear Hear. 1999; 20:75-86*
10. *Maxon, AB,White,KR; Gulpepper,B; Vohr,BR.: Maintaining acceptably low referral rates in TEOAE-based newborn hearing screening programs. J Commun Disord. 1997 : 30: 457-75.*
11. *Fukai, N; Shyu, J: Driscoll,C; Kei, J. : Effects of body position on transient-evoked otoacoustic emissions: the clinical perspective. Int J Audio. 2005 ; 44: 8-4.*
12. *Newmark, M: Merlob , P; Bresloff, I: Olsha, M; Attias, J. : Click-evoked otoacoustic emissions: Inter-aural and gender differences in newborns. J Basic Clinc Physioly Pharmacol. 1997: 8: 133-9.*
13. *Saitoh, Y: Sakoda, T: Hazama, M: Funakoshi,H; Ikeda, H,Shibano,A:et al.: Transient-evoked otoacoustic emissions in newborn infants: effects of ear asymmetry ,gender, and age. J Otolaryngol. 2006: 35: 133-8.*
14. *Kannan, PM: Lipscomb, DM. Bilateral hearing a symmetry in a large population. J. Acoust.Soc.Am.1974: 55,1092-1094.*

15. Namyslowski, K; Lisowska, G; Misiolek: Scierski, W; Orecka, B; Czeciore,E.: The influence of gender on otoacoustic emissions in normally hearing subjects.Otolaryngol Pol.2007: 61 (5): 792-5

16. McFadden,D.Sex differences in the auditory system. Dev Neuropsyhol. 1998: 14: 261-98

17. Ferguson, MA; Smith,PA: Davis, AC; Lutman, ME: Transient-evoked otoacoustic emissions in representive population sample aged 18 to 25 years. Audiolog. : 2000; 39 (3): 125-34

18. Johanseen, Ms, Arlinger, SD.; Otoacoustic emissions and tympanometry in a general adults population in Sweden. Int J Audiol. 2003: 42 (8): 448 - 64

19. Kapoor, R : Panda, NK. : Transient evoked otoacoustic emissions. Indian J Pediatr. 2006 : 73 (4); 283-6.

20. Wright, A: Davis, A: Bredberg, G: Ulehlova, L: Spencer, H. : Hair cell distribution in normal human cochlea. A report of a European working group. Acta otolayngol (Stockholm). 1987 : 436 : 15-24.

21. Cassidy, JW; Ditty, KM. Gender differences among newborns on a transient evoked otoacoustic emissions test for hearing. J.Music therapy. 2001 : 38: 28-35.

22. Dreisbach, LE: Kramer, SJ: Cobo, Cowart, K. Racial and gender effects on pure-tone thresholds and distortion-product otoacoustic emissions (DPOAEs) in normal-hearing young adults. In J Audiol. 2007: 46 (3) : 419 -26.

23. Navid, S. : Transient evoked otoacoustic emissions (TEOAEs) in Caucasian and Chines young adults. International Journal of Audiology. 2008 : 47 : 67-83.

24. Vohr, Br White, KR; Maxon, AB: Johnson, MJ. Factors affecting the interpretation of transient evoked otoacoustic emission results in neonatal hearing screening. Semin Hear : 1993: 14: 57-72.

25. Nelch, D; Greville, KA: Thome, PR : Purdy, SC. Influence of acquisition parameters on the measurement of click-evoked otoacoustic emissions in neonates in a hospital environment. Audiology. 1996: 35: 143-57.