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Distortion Product Otoacoustrc emission (OPOAE)

Latencies:Normative Data

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Abstract :

Otoacoustic emissions were first introduced by Kemp in 1978. Since then, there have been numerous investigations exploring the relations between OAE parameters and measures of audition in humans.

Distortion products otoacoustic emissions(DPOAEs) have been used as screening tool for hearing and monitoring of cochlear function. DPOAE amplitude and input/ output function (I/O) have been extensively studied but very little research on the DPOAE latency has been done to the author best knowledge.

This research aimed at studying, the DPOAE latency for f2 frequencies of 0.5,1,2,,4& 8 kHz in sixty normal hearing subjects . The stimulus used were pure tones f1&f2, with a ratio of f1:f2 of 1:1.21 and an intensity of L1:L2 of 65 and 55 dB HL respectively.

Sixty subjects were examined ,31 were male with a mean age of 41.45 years ; and 29 were females with a mean age of 33.66 years .Males showed a mean air conduction threshold of 12.90 dBnHL in the right ear and 12.52 dBHL in the left. Females showed a mean air conduction threshold of 12.45 dBHL in the right ear, and 11.17dBHL in the left .These findings were within the internationally adopted criteria with no significant difference in threshold between males and females or right and left ears. The results showed that:

- DPOAE latencies decreased as the frequencies tested increased.
- DPOAE latencies ranged from 8.76 ms at 1 kHz to 3.48 ms at 8 kHz and were highly consistent. They differed by less than one ms for both males and females and right and left ears, across the 0.5 –8kHz range . Thus the DPOAE latency is a sensitive indicator that could be used as a diagnostic and research tool for hearing screening and monitoring of cochlear function .

Key words: Distortion product otoacoustic emmission, Latencies,Thresholds,Normative data.

Introduction

Otoacoustic Emission (OAEs) are acoustical signals that can be detected in the ear canal. They occur spontaneously as narrow – band tonal signals, and during stimulation of the ear. They are thought to be due to vibrations produced at various locations within the cochlea . Though Gold (1948) postulated such sound as long ago as 1948 , they were only first detected 30 year later by Kemp (1978) who demonstrated that sounds produced by the cochlea can be recorded in the ear canal using special methods .

Probst & Hauser (1990) defined otoacoustic emission as " any sound that is produced by the cochlea and which can be recorded in the ear canal ". Kemp defined them as sound found in the external auditory meatus that originates from physiologically vital and vulnerable activity inside the cochlea. There is abundant experimental evidence that this activity is intimately associated with the hearing process. They are created by motion of the ear drum driven by the cochlea through the ear chain. Thus closing of the ear canal is an essential part of the otoacoustic emission technique and enables any oscillatery movement of the ear drum to more efficiently compress and rarefy the air that other wise would flow silently in and out of the ear canal ,without creating sound,(Burch-Sims &Ochs,1992; Kemp,1997) .

This research aimed at studying the DPOAE latency for f2 frequencies of 0.5,1,2,4&8 kHz in sixty normal hearing subjects. The stimulus used were pure tones f1&f2 ,with ratioof f1:f2 of 1:1.21 and an intensity of L1:L2 of 65and55dB HL respectively

Material & Methods

Sixty healthy normal hearing subjects constituted the study group .The sample consisted of physicians ,nurses ,clerks , laboratory technicians, porters and patiens' relatives who agreed to participate in the study .Both females and males were included in the study .The females were not pregnant .They all fulfilled the inclusion and exclusion criteria of the study .

Subject Selection Criteria :

- Both sexes were included in the research.
- Subjects age between 20 & 60 years.
- No congenital or acquired facial anomaly.
- No family history of hearing loss
- No past history of ear surgery
- No active or chronic ear disease
- Normal middle ear function.this was ascertained by tympanometry .
- Both Saudis and non-Saudis were accepted into the study
- No past or present history of ototoxic drug intake.

- No past history of physical trauma like road traffic accidents (RTA), single blast noise injury or traumatic ear perforation
- No past or recent history of epileptic fits
- No history of stroke or ischaemic heart disease
- No past history of suppurative otitis media
- No history of neurosis, psychosomatic disorder or related drug use.
- Subjects who showed abnormal tympanograms e.g type B , C& A_D (Margolis and Shanks 1985) were excluded.

Equipments:

1. Audiometric booth ,amplisilence modular 'G' ,double walled patient's room and single walled control room; with an acoustic attenuation of 42 dB at 1000Hz as demonstrated by Galilio Ferraris ,National Electromechanical Institute of Turin ,according to ASA S 31 standards (1960) .
2. Clinical audiometer interacoustics AC-40, calibrated to IEC 645 –1 1992 ,IEC 665-2 1993 ,ISO 389-2,ISO 389-3,489-4; with TDH 39 headset and B 71 bone conductor.
3. Tympanometer Ineracoustics AZ 26 ,calibrated to ANSI S 3.39-1987,IEC 1027-1991
4. Otodynamic otoacoustic emission analyzer model ILO 92 , DPOAE software version

Methods

- A comprehensive history was taken for each subject regarding any present or past ,medical problem , any ENT disease or ototoxic drug intake.
- ENT examination was performed at the clinic using ATMOS 1996 set machine –otoscopy ,nasal examination ,throat and larynx inspection.
- Pure tone air and bone conduction test were carried out in the 500-6000Hz range .Effective masking was used when indicated .
- Tympanometry was carried out on all subject to verify the status of the middle ear, and to fulfill the inclusion /exclusion criteria .All subjects had bilaterally normal type A-tympnograms
- Distortion products otoacoustic emission latency measurement were carried out on all subjects at F_2 frequencies 0.5 ,1,2,4 and 8 kHz with F_1 :F_2 ratio 1:1.21 and L1 :L2 of 65 and 55 dB respectively .The

subjects were asked to sit quietly during the test .Their ear canals were inspected for wax and debris .A foam earpiece was introduce to fit snugly into the external ear canal.

Pilot Study

Since was no agreed time limit for a good line fit for a DPOAEs detection, a time difference of 20, 30 & 40 sec run on 1,2& 4 kHz was used to determine the best possible fit

Five normal hearing subjects were selected. Each F_2 frequency (1,2 and 4 kHz) latency was tested three times at 20, 30 and 40 sec run .The mean latency test showed that a good line fit was attained at 30 & 40 sec . .Since there was no significant latency difference between the 30 & 40 run ,the 30 sec time run was adopted (figs 1-A& 1-B) .With the 30 sec time run each ear was tested twice .If the Two DP latency readings were within one ms ,then the average was taken as that f_2 DP latency , if the difference was more than one ms then a third run was performed and the average of the nearest two was taken as the DP latency reading.

The whole battery of test i.e pure tone audiogram , tympanogram and DPOAE testing took about forty five minutes.The results would be statistically treated using the ANOVA ,Bonferroni ,and the student' t-tests.

Results :

Sixty subjects were studied, 31 (51.75%) were males with a mean age of 41.45 years and SD of 11.35. Twenty –nine (48.3%) were females with a mean age of 33.66 years and a SD of 7.66.(Table1-1&1-2)

- **Pure Tone findings :**

The pooled data (right & left ears) showed a mean air conduction threshold of 12.27 dBHL with a SD of 3.739 .Men had a mean air conduction threshold of 12.90 dBHL with a SD of 3.20 in the right ear ,and 15.52 dBHL with a SD of 3.88 in the left ear .Females had a mean air conduction threshold of 12.45 dBHL with a SD of 3.29 in right ear ,and 11.17dBHL with a SD of 4.44 in the left .These findings were within the internationally adopted criteria , with no significant difference between air conduction ,bone conduction thresholds , or between right and left ears in each sex .(Table 2 & Figs.1-C & 1-D).

- **DPOAEs findings**

In the male group the DPOAEs ltency finding showed a mean latency of 8.76 ms at 1kHz ,6.11ms at 2 kHz ,4.90 ms at 4 kHz and 3-90ms at 8 kHz in the right ear. In the left ears the DPOAE latencies were 8.20 ms at 1kHz ,6.06 ms at 2 kHz ,4.76 ms at 4 kHz and 3.50 ms at 8kHz respectively .(Table-3)

The female group showed a mean DPOAEs latency of 8.22 ms at 1 kHz ,6.19 ms at 2 kHz ,4.75 ms at 4 kHz .and 3.48ms at 8 kHz in the right ear .In the left ears, they showed a mean DPOAEs latency of 8.32 at 1kHz ,6.48 ms at 2kHz ,4.75 ms at 4 kHz ,and 3.68 ms at 8 kHz .(Table –3)

DISCUSSION

Prevalence of DPOAEs

None of the males showed a DP emission at 0.5 kHz , both right and left ears . In females only two right ears , and one left ear showed emissions at 0.5 kHz .This finding agrees with the literature that DPOAEs are scaresly detected at 0.5 kHz . (Mahoney (1993), Mahoney & Kemp 1995) .

Twenty -nine males, –out of thirty -one showed DP emissions at 1kHz- both ears, with an occurrence rate of 94% . All males showed emissions at 2 & 4 kHz ; twenty - nine right ears showed emissions at 8 kHz ,and twenty -eight left ears showed emissions at 8 kHz .

In the female group twenty- six right ears and twenty -eight left ears gave emissions at 1 kHz . All ears in females showed emissions at 2&4 kHz with a 100% occurrence rate. Twenty-eight right ears, and twenty – seven left ears showed emissions at 8 kHz.

.These finding agreed with those of kemp et al (1986) who reported DPOAE in all 14 normal ears tested along the 0.5 –10 KHz f2 range . Similarly Lonsbury –Martin et al (1990) detected acoustic distortion products in all the 44 ears tested along the 0.5-10 kHz f2 range, while Harris & Glattake (1988) detected DPOAEs in 20 years from 20 subjects examined unilaterally .Roede et al.1993 studied the DPOAEs along the f2 range of 0.8-8 kHz in six women and 8 men with normal middle ear status . They recorded DPOAEs from all normal hearing ears during each test session with no significant intrasubject variability .

These published data , and the additional experience of Probst ,Antonelli & Pieven (1989), in testing 113 normal ears , indicate that DPOAEs can be recorded in essentially all normal hearing ears.

DPOAEs Latency:
In our study there was no significant latency difference between right and left ears .These findings agree with those of kimberley et al (1993), and Mahoney&Kemp (1995).
Kimberely et al (1993) used distortion product emission phase response to measure human cochlear travelling wave delay in 18 adult female ears (9 women) and 18 adult male ears (9 men) across the frequency range 10 kHz to 500Hz . They found that the travelling wave delay in ms , increases as the frequency of the f2 decreases .
Elberling (1974) suggested a latency of approximately 1.5 ms at the 10 kHz place rising to 5 ms at the 500 Hz place.
Mahoney 1993 studied the DPOAEs latency in 12 normal , and 11 ears with known cochlear pathology. In the normal ears , she found the DPOAEs latency ranging from 8 ms at 1 kHz to 3.5 ms at 6 kHz . In the abnormal ears she found significant lower DPOAEs latencies at 2 and 4 kHz in one left ear.and at 4 kHz in one right ears
Thus it could be concluded that as the DPOAEs detection implies normal cochlear function and normal peripheral hearing, the DPOAEs latency might equally be a senstive index for normal cochlear function, normal hearing threshold evaluation, and site of lesion testing..

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Table (1-1) Distribution of the study group according to Gender

	Sex				
	Males		Females		
	No	%	No	%	Total No
Study Group	31	51.7	29	48.3	60

Table (1-2) Distribution of the study group according to Gender and age (Mean ± Standard Deviation)

	Sex				
	Males		Females		
	Mean	S.D.	Mean	S.D.	Total No
Study Group	41.45	11.35	33.66	7.60	60

Table - 2 Distribution of pure tone air conduction thresholds for the 0.5-8 KHz range of the study group according to Gender and the ear tested.

Intensity in dB HL / Frequency in kHz	Males						Females				
	Right			Left			Right		Left		
	Mean	S.D.	No.	Mean	S.D.	P-Value*	Mean	S.D.	Mean	S.D.	P-Value*
0.5	14.84	3.53	31	13.39	5.06	0.196	14.66	3.76	12.93	5.43	0.166
1	13.55	3.91	31	12.58	4.06	0.343	12.59	4.36	10.69	6.08	0.178
2	10.48	4.72	31	11.94	5.11	0.250	10.69	3.95	10.17	5.75	0.691
4	11.13	4.02	31	10.81	5.64	0.706	9.48	3.62	10.69	5.63	0.336
8	14.36	4.79	31	13.55	5.20	0.527	14.14	5.19	10.35	4.81	0.005
Average	12.90	3.20	31	12.52	3.88	0.670	12.45	3.29	11.17	4.44	0.219

Total number of Males =31
Abbreviations:
kHz: Kilohertz

Total Number of Famales = 29
* Student T-test

Table – 3: DPOAEs latency as a function of f_2 frequency for the study group according to side and sex, showing Frequencies, Percentage, Means and standard deviations.

Intensity in dB HL / F_2 Frequency in kHz	Males									Females									
	Right				Left					Right				Left					
	No	%	Mean	S.D.	No.	%	Mean	S.D.	P-Value*	No.	%	Mean	S.D.	No.	%	Mean	S.D.	P-Value*
0.5	-	-	-	-	-		-	-	-	2	7	5.24	1.81	1	3	8.15	-	0.414
1-	29	94	8.76	1.89	29	94	8.20	1.73	0.244	26	90	8.22	1.18	28	97	8.32	1.69	0.813
2-	31	100	6.11	1.56	31	100	6.06	1.53	0.889	29	100	6.19	1.25	29	100	6.48	1.36	0.41
4-	31	100	4.90	0.86	31	100	4.76	0.97	0.562	29	100	4.75	1.16	29	100	4.75	1.30	0.992
8-	28	90	3.90	1.09	28	90	3.50	1.60	0.178	28	97	3.48	0.64	27	93	3.68	0.98	0.328

Total number of Males =31

Total Number of Females = 29

* Student T-test

Abbreviations:

Ms: Milliseconds

kHz: Kilohertz

No.: Number

S.D.: Standard Deviation

Fig (1-A) Time Difference of DP Latency measurement using a 40 sec. Run.

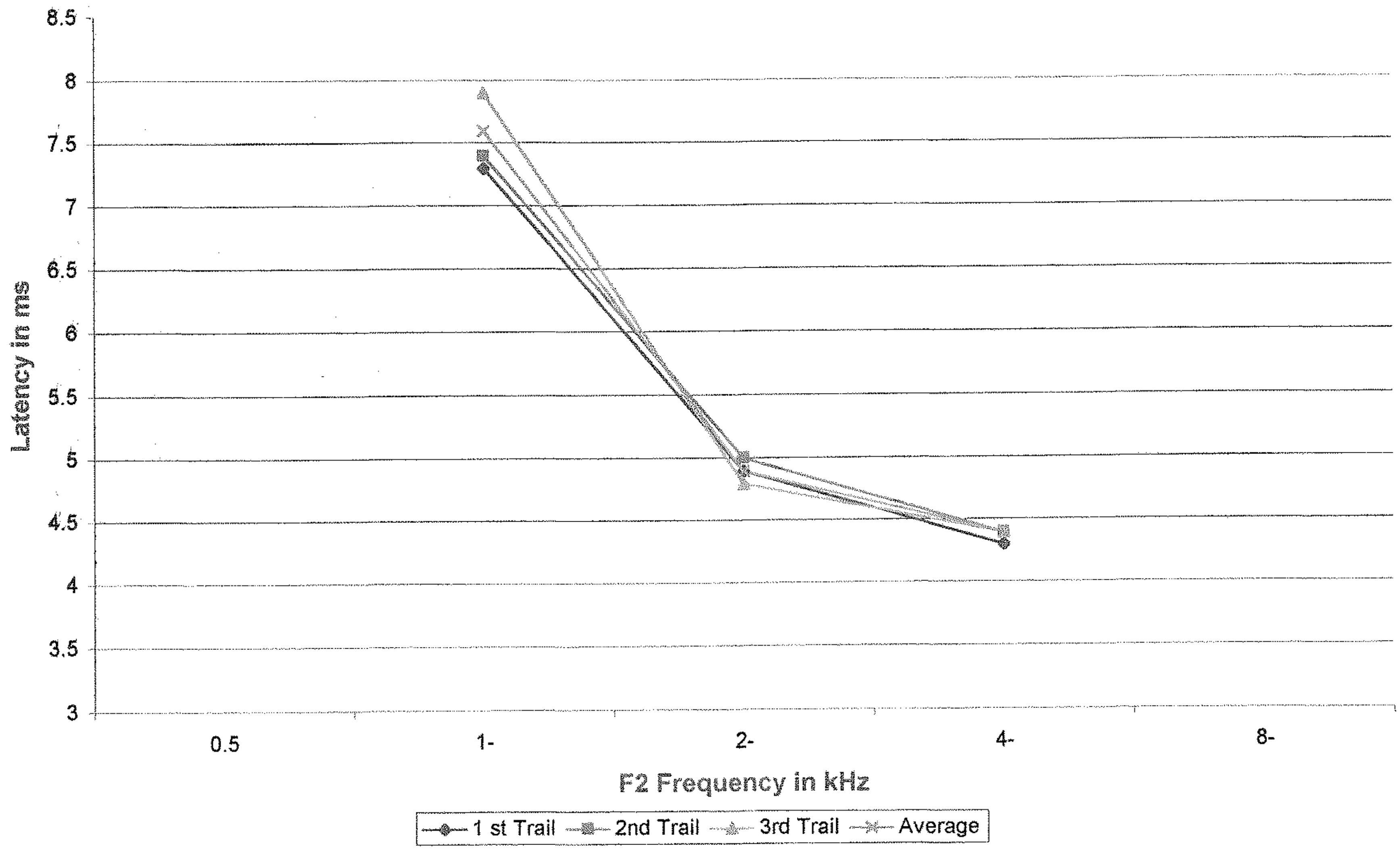

Fig (1-B) Time Difference of DP Latency measurement using a 30 sec. Run.

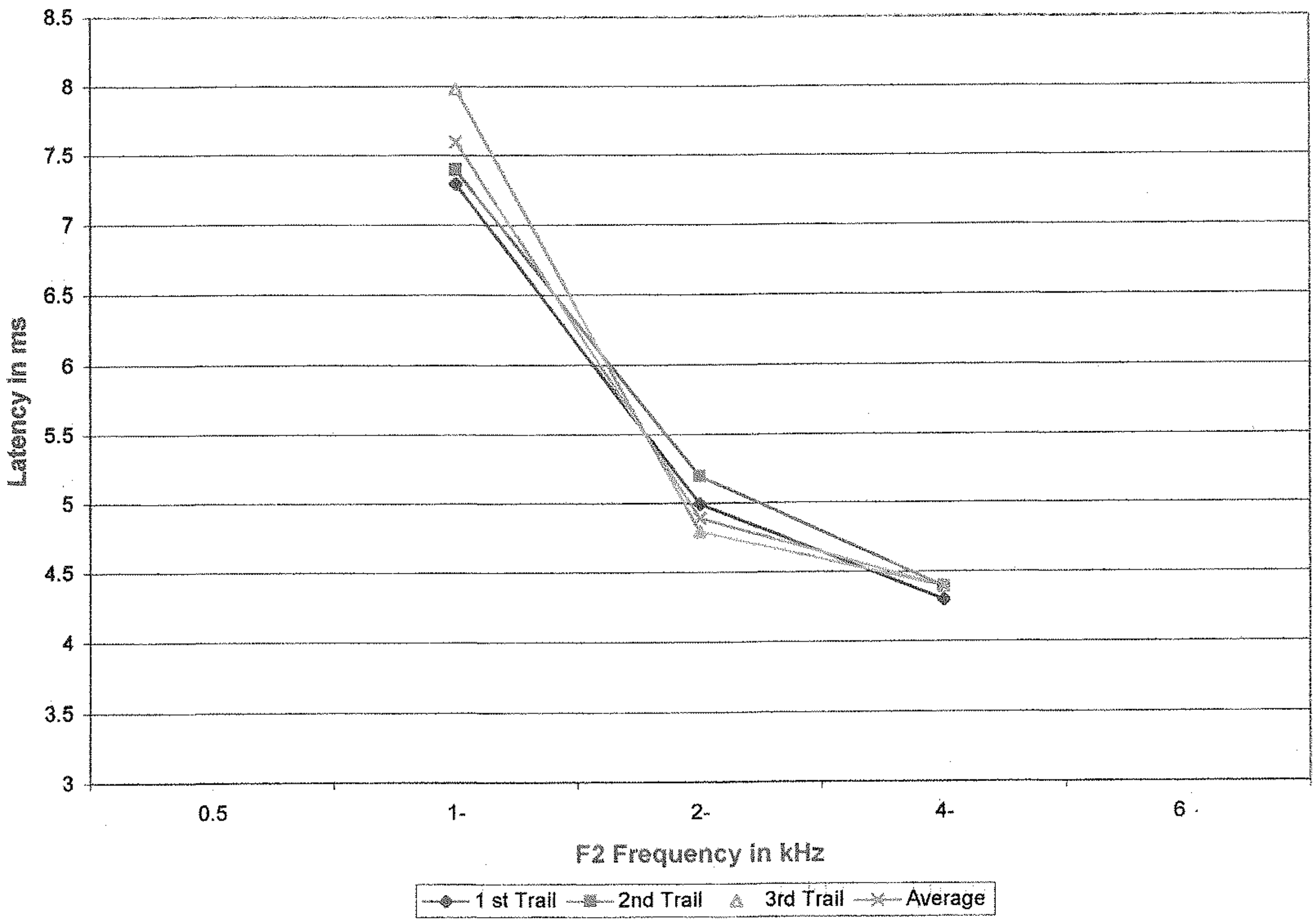

Fig (1-C) Mean of pure tone air conduction thresholds for the 0.5 - 8 KHz of the study group.

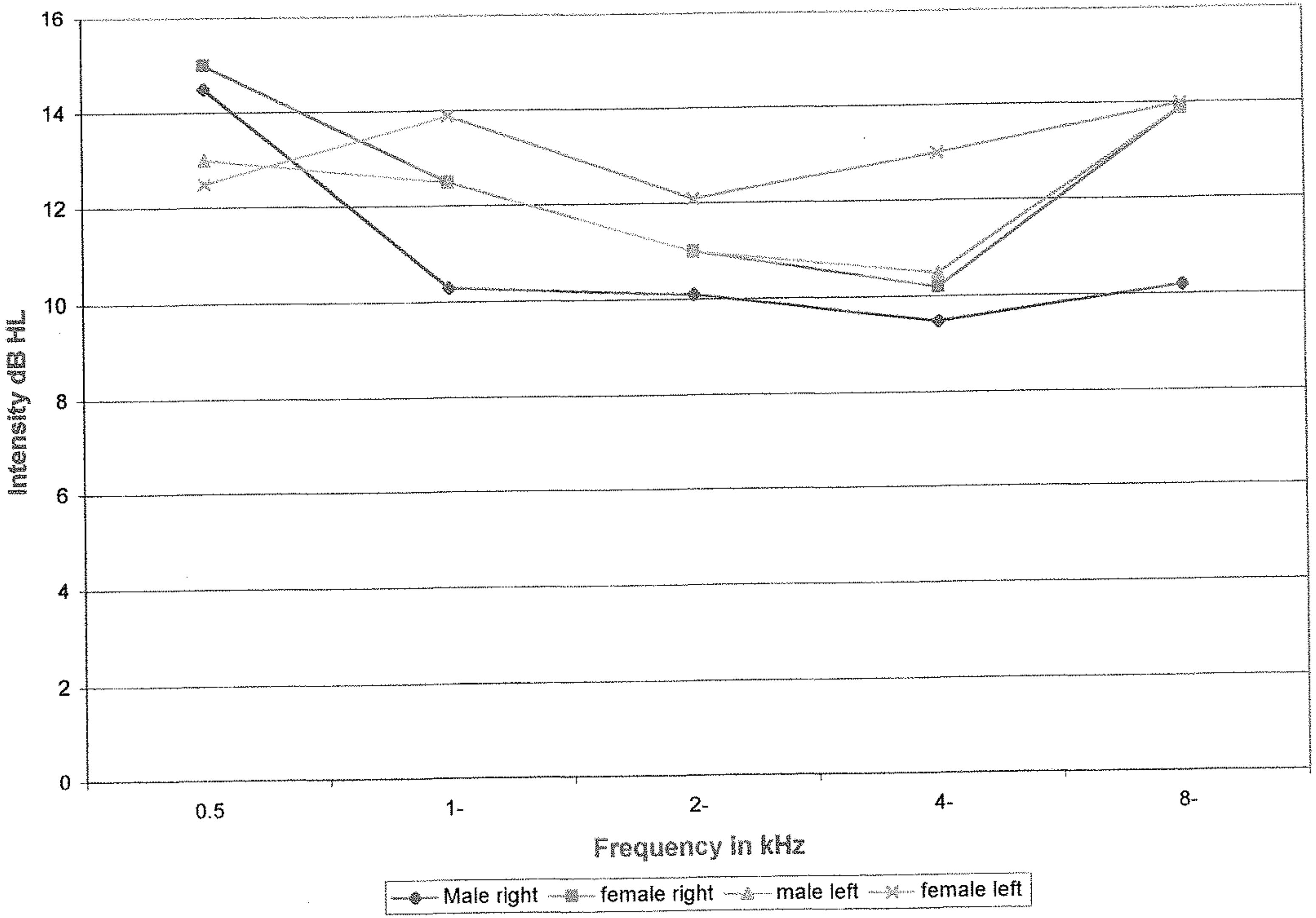

Fig (1-D) Mean of pure tone bone conduction thresholds for the 0.5 - 8 KHz of the study group.

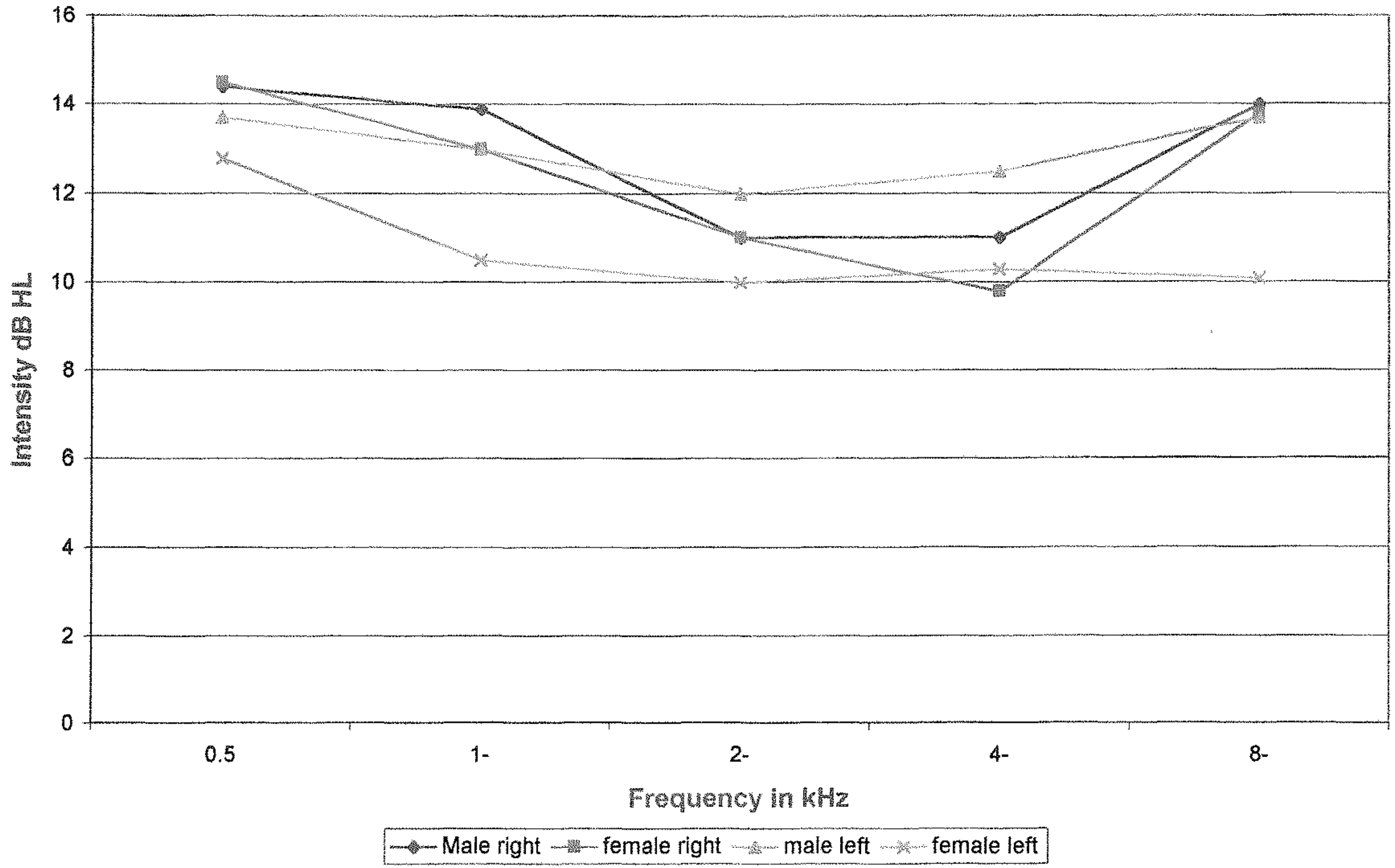

Fig (1-E) Mean of DPOAEs latency as a function of f2 frequency for the study group.