Developing Distortion product otoacoustic emissions Normative Data for the otometric Madsen Capella 2

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ABSTRACT

Objectives: To develop and establish a distortion product otoacoustic emissions normative data (DPOAEs) for normal hearing adults.

Methods: The right ear of 400 subjects of both sexes aged between 18-25 year old who are otologically normal were selected to participate in the present study which was carried out at the audiology department of King Hussein Hospital between August 2015 and December 2016. The right ear of the 400 subjects underwent otoscopic examination, pure tone audiometry , Tympanometry and distortion product otoacoustic emission , all measurements were performed in an isolated test booth with the same audiologist.

Results: The results of the present study showed significantly greater DPOAEs levels ($P<0.01$) in the adult subjects between the primary tone levels L1=75 to 65 dB and L2 =65 to 55 dB. The differences being in the vales of 6 to -3 at 500Hz, 17 to -1at l000 Hz, 7 to 2 at 2000Hz, 5 to -4 at 4000 Hz , and from 9 to -4 at 8000 Hz, the adopted normative data can be used to quantify the estimated hearing threshold levels for subject.

Conclusion: DPOAEs normative data developed for the otometrics Madsen Capella-2 can be adopted for estimation of behavioral hearing threshold levels taking into consideration to assess the noise floor and avoid any contamination of internal noise may be generated from the subjects.

Key words: Distortion product otoacoustiic emission, Otometric Madsen Capella -2.

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Introduction

Otoacoustic emissions (OAEs) are sounds given off by the inner ear when the cochlea is stimulated by a sound. When sound stimulates the cochlea, the outer hair cells vibrate. The vibration produces a nearly inaudible sound that echoes back into the middle ear. The sound can be measured with a small probe inserted into the ear canal.People with normal hearing produce emissions. Those with hearing loss greater than 25–30 decibels (dB) do not produce these very soft sounds. The OAE test is often part of a new born hearing screening program. This test can detect blockage in the outer ear canal, as well as the presence of middle ear fluid and damage to the outer hair cells in the cochlea. There are four types of otoacoustic emissions: spontaenous , transient evoked otoacoustic emission, distortion product otoacoustic emission and sustained frequency otoacoustic emission. **(1)** Distortion product otoacoustic emissions (DPOAEs) reflect outer hair cell integrity and cochlear function. They are an effective diagnostic tool and can detect hearing loss with accuracy. DPOAEs are easily and rapidly recorded in newborns and children,

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and provide basic hearing screening information as well as detailed diagnostic information in cases of suspected hearing loss. DPOAEs also provide hearing scientists with a frequency-specific and non-invasive probe of the cochlea and cochlear amplifier function. The distortion product produced by the cochlea is a bi-product of the two stimulation frequencies denoted F1 and F2 and their corresponding intensities or sound levels (L1 and L2). [2] Hearing screening program for detection of hearing loss in newborns and very young infants has been established at all hospitals of the Jordan Royal Medical Services (RMS) for 2 decades. New technology provides new devices for the detection of hearing loss, recently the royal medical services have new devices in service for neonate hearing screening program, and these devices are otometric Madsen Capella 2. Each device must have selected protocols for testing and normative data to interpret the results; the present study is designed to establish a normative data for otologically normal hearing for the otometric Madsen Capella 2 device and to use these normative data as a reference for interpreting the test results for normal and abnormal findings. Before commencing the study approval has been achieved from the ethical committee of the royal medical services of Jordan to carry out the present study.

Methods

The accuracy of any hearing test depends on many factors especially the patient's status, ambient noise and the proper use of the instruments. All subjects were instructed for the purpose of the present study and the instruction of each test to be performed. The test booth ambient noise was measured using sound level meter type kaajer before carrying out all tests. All subjects who participated in the present study were selected after insurances that all ears are ontologically normal, that is, no external and middle ear abnormalities, no history of ear infection or surgeries, and have no exposure to noise. Otoscopic examination revealed no abnormalities , followed by pure tone audiometry to assess the threshold of hearing for each subjects were performed using Otometric Madsen Astera -2 audiometr , hearing threshold levels for each subject were within normal limits (less than 20 dB HL) at all tested frequencies between 500 Hz and 8000 Hz . Then each subject underwent tymanometric testing to ensure no any middle ear abnormalities that might interfere with recording of otoacoustic emission , then each subject underwent distortion product otoacoustic emission recording using the new device optometric Madsen Capella- 2. DPOAEs were recorded using two different sound levels with the same primary tones labeled f1 and f2 with a ration f2/f1 equal to 1.22. For the frequency range between 500-8000 Hz , with one frequency per octave , the primary tone level used L1 for f1 75 dB SPL and L2 for f2 L 65 dB SPL .recording of the DPOAEs were repeated twice for the accuracy and repeatability of the measurements and to avoid the affect of rejected signal that may arise during the recording for example the subject couldn't keep very calm and quite during the recording because otoacoustic emission recording may be affected by the internal noise from the subject. The results for each subject were displayed and stored in a DP Gram module. Another distortion product otoacoustic emission was recorded from each subject in which the primary tone level used L1 for f1 65 dB SPL and L2 for f2 55 dB SPL without changing any of the previous parameter mentioned above. The reason for that is to assess which is the best level of stimulus intensity to be adopted for better protocol. All measurements were performed on the same day by the same audiologist and in the same test booth; all measurements were repeated twice for the accuracy and repeatability.

Results:

Data analysis using Anova one way analysis at ($P<0.01$) comparison showed significant distortion product between the two primary tone levels stimulus in favor of L1/f1 compared with L2/F2 tone levels. At the bottom tables show the normative data for adopted OAES of the same intensities for different frequencies.

Table I: The mean hearing threshold levels (HTL) of the Rt ear of 400 otologically normal hearing subjects.

Frequency(Hz)	500	1000	2000	4000	8000
Mean (HTL)	15	10	10	15	10

Table II: The normative distortion product values obtained using L1=75 dB SPL and L2=65 dB SPL and L1=65 dB SPL and L1=55 dB SPL of the Rt ear of the 400 subjects

L1/f1	**L2/f2**	**500Hz**		**1000Hz**		**2000Hz**		**4000Hz**		**8000Hz**	
(dB)	**(dB)**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**
75	65	14	- 1	23	2	21	0	16	-5	19	-1
65	55	8	2	6	3	14	-2	11	-1	10	3

*Where L1/f1 and L2/f2 stands for the primary tone level of stimulus used in the measurements of Distortion product otoacoustic emission.

Discussion:

Janssen reviewed the effectiveness of distortion product otoacoustic emission testing for getting frequency –specific information about a hearing loss problem in newborns after hearing screening and concluded that DPOAEs audiograms provide a tool for a fast automated frequency specific and quantitative evaluation of a mild or moderate hearing loss in follow up [(3)]. Carolina et al concluded that DPOAES are easily and rapidly recorded in newborns and children, and provide basic hearing screening information as well as detailed diagnostic information in cases of suspected hearing loss [(2).] Jessica et al developed DPOAE normative data for the interacoustic Titan and recommended to assess the noise floor and ensure it is sufficiently low for the correct analysis of the presence or absence of DPOAEs and to determine which category the recorded DPOAEs is used in order to make diagnostic inferences about DPOAEs results [(4)]. The results of the present study showed significantly greater DPOAEs levels ($P<0.01$) in the adult subjects between the primary tone levels L1=75 to 65 dB and L2 =65 to 55 dB. The differences being in the vales of 6 to -3 at 500Hz, 17 to -1at l000 Hz, 7 to 2 at 2000Hz, 5 to -4 at 4000 Hz , and from 9 to -4 at 8000 Hz, the adopted normative data can be used to quantify the estimated hearing threshold levels for subject. The results of the present study showed that the values for distortion product otoacoustic emissions presented in Table II, that should be adopted and to be displayed as normative data for the L1/F1 75 to 65 which give better results of distortion product vales than that present in the same table for the primary tone levels L2/F2 from 65 dB to 55 dB. It is acceptable to adopt these normative data for L1/F1 75 to 65 dB presented in Table II as a guideline for estimation of normal distortion product otoacoustic emission because when we use the higher intensities we have got better results as these high level intensities minimize the effect of floor noise and internal noise of the subjects , where as the primary tone levels of L2/F2 results in contamination of the signal of the distortion product with noise floor which might be misleading to accept the accurate results .In comparison of the adopted normative data with the mean hearing threshold levels of the Rt ear of 400 subjects participated in the present study , we have found that any subject who have normal hearing threshold levels at any test frequency should have distortion product otoacoutsic emission values within the adopted values presented in Table II . The adopted data for the primary level L1/F1 =75 dB SPL give better estimation than that L1/F1 =65 dB SPL which give clear DPOAEs results .and these normative data are in parallel to the mean hearing threshold levels of 40 normal hearing subjects. The results of the present study are in agreement with the results and recommendation of Janseen, Carolina et al and Jessica et al. From our experience diagnostic inferences about distortion product otoacoustic emission , it is recommended to test in isolated booth where noise floor less than 40 dB spl , subject to be very quiet , and to relay on the signal to noise ration .

Conclusion:

DPOAEs normative data developed for the otometrics Madsen Capella2 can be adopted for estimation of behavioral hearing threshold

levels taking into consideration to assess the noise floor and avoid any contamination of internal noise may be generated from the subjects. Before testing assess the noise floor in the isolated test room, select which criteria for acceptance the results depending on the signal to noise ratio. For children we recommend to be very quit and not to relay on the findings if testing in not isolated booth.

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