Sudan University of Sciences and Technology

College of Graduate studies

A study of the Responses of Hearingfor Normal Hearing of Iraqi and Sudanese UsingDistortion product Otoacoustic Emissions.

دراسة الاستجابات السمعية للعراقيين والسودانيين ذوي السمع الطبيعي باستخدام ناتج تشوه الانبعاثات الصوتية الانية

Athesis Submitted for Fulfillment of PhD Degree in Medical Physics.

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2017

Dedication

This thesis is dedicated

To My Father &Mother

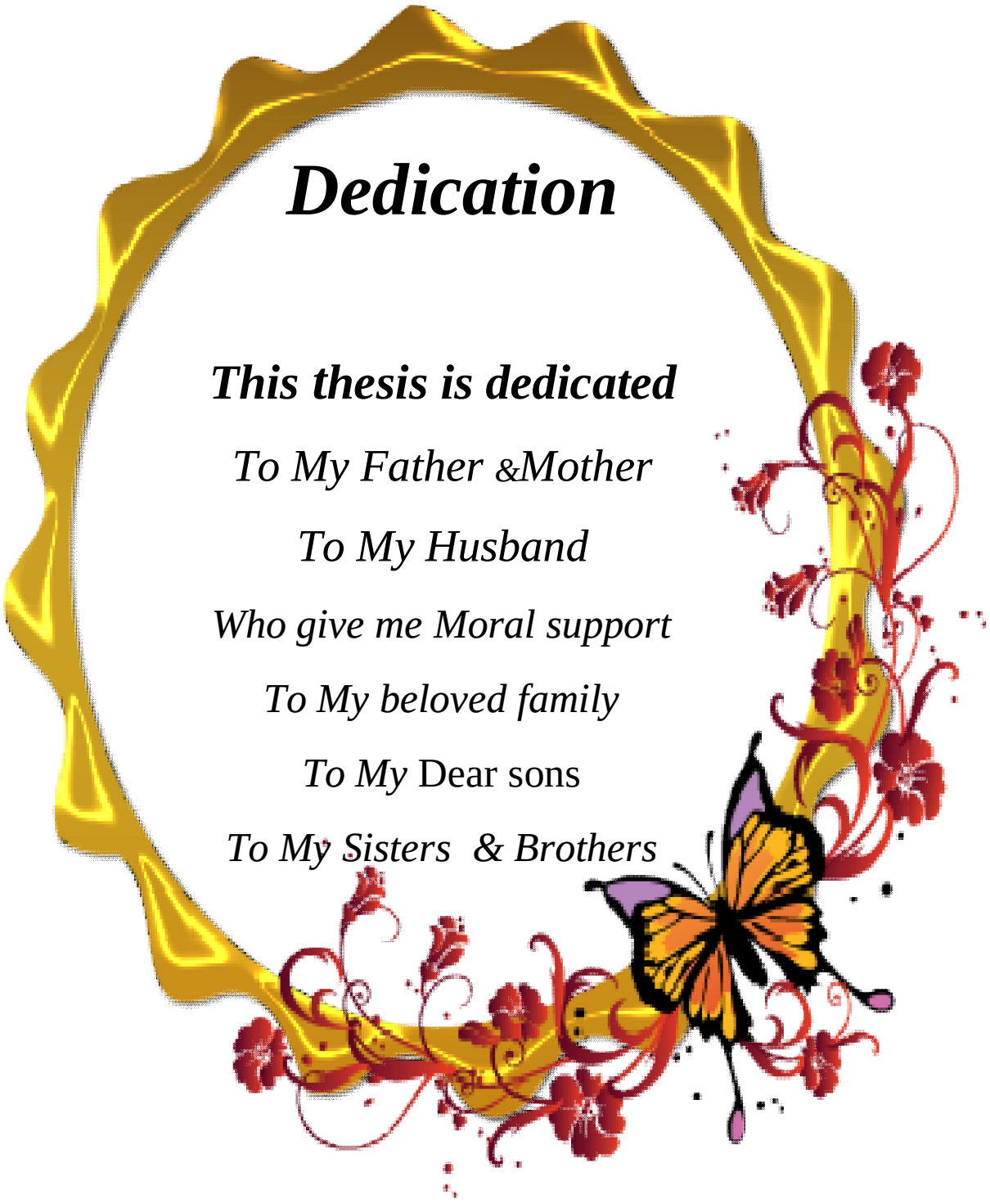
To My Husband

Who give me Moral support

To My beloved family

To My Dear sons

To My Sisters & Brothers



InThe Name of ALLAH the most Gracious...most Merciful

Acknowledgement

This thesis would not appear in its present from without the help of my almighty God and kind assistance and support of the following individuals.

Iam heartily thankful to my supervisors, Dr. Mohammad Al- fadil, and Dr. Aeda Al-Kaisy, for their encouragement, educational support, endurance and guidance from the initial to the end of the research.

My sincere thanks are extended to Dr. Salah Al- Hayani for his helpful comments and guidance through my research.

Iam heartily thankful to my dear husband whosupported me both professionally and personally and who continued to encourage me throughout the study period,(God bless and keep him).

I would like to express my greatfulness toprof. sabah Aziz and prof. wesal Abdul-Razzak and Dr. Zahraa Sabahfor their encouragement and support.

I extremely greateful to all members in specialized surgery hospital, Hearing and speech center of Baghdad who have supported me in any respect during the completion of the thesis.

My sincere thanksto members in specialized Royal care hospital especially altaib Ali Dawelbeat for his helpful comments through my work.

Avery special thanks and gratitude to my dear parents for their encourage and continuous prayers throughout my life.

My sincere thanks to my beloved kids for their support and patience throughout the years of study, (God bless and keep them).My gratitude to my dear brother and my sisters for their help and support.

At the end, I offer my regards and blessings to all of those who supported me in any respect during the completion of the thesis.

Abstract

The purpose of this research was designed to study theresponsesof hearing or distortion product otooacoustic emissions amplitude(DPI) for normal hearing of Iraqi and Sudanese using Distortion product Otoacoustic Emissions and to study the influence of the age, ear side, gender and racial on theresponsesof hearing for normal hearing of Iraqi and Sudanese subjects and comparison between them.

An additional purpose of this study was proposal model Linear and nonlinear Equations to evaluate the average of DPI with Respect of Frequency For all groups Iraqi and Sudanese .Final goal of the present study was the Comparison of The Average of DPI Level with respect to frequency between The Experimental data and Theoretical model data for Iraqi and Sudanese Groups.

Routine procedures were used such as pure tone Audiometer was performed to assess hearing ability in all subjects and tympanometry was performed to assess middle ear system.

The total number of Iraqi subjects which completed all tests was 106 male and female with age from (2-40) y were divided into four groups based on age : Group-I (2-10) year , with total number of subjects is 26 consisted of 13 females and 13 males , Group-II (11-20) year, with total number of subjects is 26 consisted of 13 females and 13 males, Group-III (21-30) year ,with total number of subjects is 28 consisted of 13 females and 15 males, Group-IV(31-40) year, with the total number of subjects is 26 consisted of 13 females and 13 males.For Sudanese subjects the total number of subjects which completed all tests was 78 Subjects with age from (2-30) year contained (39) females and (39) males. Subjects were placed into three groups based on age Group-I (2-10) year, with total number of subjects is 26 consisted of 13 females and 13 males, Group-II (11-20) year, with total number of subjects is 26 consisted of 13 females and 13 males, Group-III (21-30) year, with total number of subjects is 26 consisted of 13 females and 13 males.

The experimental data was revealed that: The decision about whether a Distortion Product Otoacoustic Emission is present often depends on a visual assessment of the response along with certain objective criteria, such as distortion product otoacoustic emissions level (DP1) and signal to Noise Ratio dB. DPOAEs were considered present when the signal level exceeded the noise floor by 3 dB SPL for narrow frequency bands and 6

dB SPL for wide frequency bands and DPOAEs is thought to have an amplitude(DPI level) that may vary from -10dB SPL to +30dB SPL in healthy ears.

The results show an age, ear asymmetry, gender and racial were effect on the (DP1 level and SNRs) for all Iraqi and Sudanese subjects.Statistically Results show significant difference among age groups on (DPI and SNRs) but according to ear side, gender and racial No significant difference on the (DP1 and SNRs).

The Comparison of The Average of DPI Level with respect to frequency between The Experimental tested data and Theoretical model data was approximately similar for Iraqi and Sudanese Subjects respectively. The result show the nonlinear proposal model was better than that from linear model to evaluate the average of DPI compared with experimental tested

الخلاصة

ان الغرض من هذا البحث هو دراسة الاستجابات السمعية للعراقيين والسودانييينذوي السمع الطبيعيالناتجةعنتحفيزاو تشوه القوقعة بالانبعاثات الصوتية الانية. ودراسة تأثير عوامل العمر وجانب الاذن الايمن والايسر والجنس والعرق على الاستجابات السمعية للعراقيين والسودانييينومقارنة نتائج تلك العوامل, فضلا عن اقتراح انموذج لمعادلات خطية ومعادلات لاخطية لتقيم معدل الاستجابات السمعية(DP1) نسبة الى التردد لجميع المجاميع العراقيين والسودانيين ومقارنة النتائج النظرية التي يتم الحصول عليها من الانموذج المقترح مع تلك النتائج التي تم الحصول عليها باستخدام الاجهزة المختبرية .

تضمنت الاختبارات فحوصات طبية مثل تخطيط السمع لتقييم السمع الطبيعي وتخطيط طبلة الاذن لتقييم الاذن الوسطى .حيث بلغ العدد الكلي للاشخاص العراقيين الذين تم فحص سمعهم الطبيعي 106 شخص من الاناث والذكور تتراوح اعمارهم ما بين 2 سنة و 40 سنة موزعين 52 اناث و 54 ذكور على اربعة مجاميع المجموعة الاولى تتراوح اعمارهم ما بين (2-10) سنة 13 اناث و 13 ذكور والمجموعة الثانية تتراوح اعمارهم ما بين (11-20) سنة 13 اناث و 13 ذكور والمجموعة الثالثة تتراوح اعمارهم ما بين (21-30) سنة 13 اناث و 15 ذكور والمجموعة الرابعة تتاوح اعمارهم ما بين (31-40)سنة 13 اناث و 13 ذكور.وبلغ عدد الاشخاص السودانيين الذين تم فحص سمعهم الطبيعي شخص 78من الاناث والذكور تتراوح اعمارهم مابين (2-30) سنة موزعين 39 اناث و 39 ذكور على ثلاثة مجاميع المجموعة الاولى تتراوح اعمارهم ما بين (2-10) سنة 13 اناث و 13 ذكور و المجموعة الثانية تتراوح اعمارهم ما بين (11-20) سنة والمجموعة الثالثة تتراوح اعمارهم ما بين (21-30) سنة .

ان المعايير التي يمكن الاعتماد عليها كمؤشر لوجود الاشارة (DPI) هي ان تكون قيمة نسبة الاشارة الى الضوضاء (SNR) يجب ان تكون اكبر من 3 ديسبل للترددات الواطئة و6 ديسبل للترددات العالية وقيمة مستوى الاشاره (DP1) ما بين -10 ديسبل الى 30 ديسبل وكانت جميع النتائج العملية تقع ضمن هذه المعايير .

اظهرت النتائج وجود تأثير عوامل العمر وجانب الاذن والجنس والعرق على مستوى الاشارة (DP1)و (SNR) لكل من الاشخاص العراقيين والسودانيين وان التحليل المعنوي اظهر تأثير العمر على كل من (DP1)و (SNR) بشكل واضح بينما التحليل المعنوي لم يظهر بشكل واضح لعوامل جانب الاذن والجنس والعرق .

اظهرت النتائج التي النظرية تم الحصول عليها من معادلات الانموذجين المقترحين الخطية واللاخطية تقريبا مساوية للنتائج التي الحصول عليها من الاختبارات العملية للعراقيين والسودانيين على التوالي كما ان النتائج اظهرت ان معادلات الانموج اللاخطي كانت افضل من تلك النتائج التي تم الحصول عليها من معادلات الانموذج الخطي مقارنة مع تلك النتائج العملية.

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Abbreviations

E	External ear
M	Middle ear and
I	Inner ear
IHCs	Inner hair cells
OHCs	Outer hair cells
BM	Basilar membrane
CA	Cochlear amplifier
TW	travelling wave
XBM	Displacements of the basilar membrane
HB	Hair-bundle
fOHC	Force of outer hair cell
DVOHC	OHC membrane potential
V TM/RL	Velocity between tectorial membrane and Reticular lamina
ATP	Adenoid Tri Phosphate
PM	Plasma membrane
SSC	Sub surface cistern
AX c	axial core
CP	Cuticlular plate
ECIS	extra cistern space
PM	plasma membrane
DPI	Distortion product otoacoustic emissions level(Responses of hearing)
DPOAEs	Distortion product Otoacoustic emissions
OAEs	Otoacoustic emissions

SOAEs	spontaneous Otoacoustic emissions
EOAEs	Evoked Otoacoustic emissions
TEOAEs	Transient evoked Otoacoustic emissions
SFOAEs	Stimulus frequency OAEs
SPL	Sound pressure level
dB	Decibel
Signal to Noise Ratio	SNR
daPa	deca Pascal
HL	Hearing level
FR	Female Right
FL	Female Left
MR	Male Right
ML	Male Left

Chapter One
Introduction

1-1 The mechanics of hearing:

Hearing has become the main means of social interaction and communication.Hearing is the result of the collaboration between the ear and the auditory brain. An ear without a brain is like an unplugged microphone, but without ears we wouldn't even be able to imagine what a sound was like(Pujol, 2016).As sound waves enter the ear, they travel through the outer ear, the external auditory canal, and strike the eardrum.The eardrum responds to the acoustic sound wave collected by the earcanal, and its vibration is transmitted down the series of ossicles to the inner ear. This action is passed onto the cochlea in the inner ear, which is a fluid-filled snail-like structure that contains the receptor organ for hearing is called organ Corti that translate the vibration of sounds from its surrounding ducts into electrical impulses that are carriedbysensory nerves to the brain. (David and Dugdale, 2012).

1-2 Anatomy of the ear:

The ear can be divided into three distinct regions based on their function and locationin the peripheral auditory system.The acoustic signals manifested as pressure fluctuations in the air are collected by the external ear and transmitted through themiddle ear towards the inner ear for transduction into electrical neural impulses to thebrainas shown in Figure (1-1).

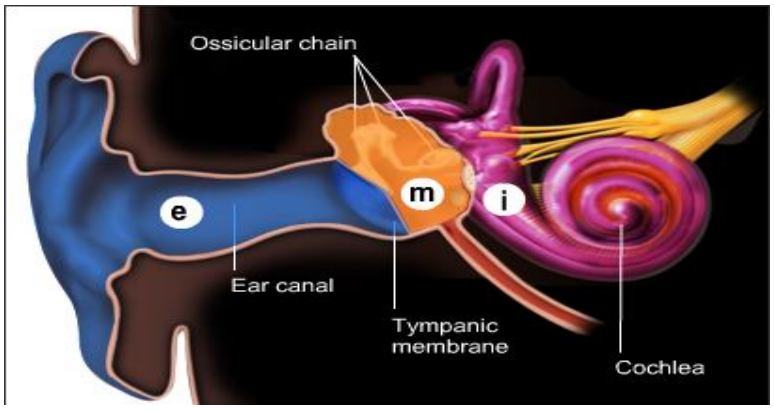


Figure (1-1): Cross-section of the human ear divided into three regions: [E] External ear, [M] Middle ear and [I] Inner ear (Pujolfrom promenade round cochlea, 2016).

The outer or external ear (e blue) is composed of the pinna (the visible part) and the ear canal. The latter is closed off by the eardrum. In the middle ear (m orange), the eardrum is mechanically linked by a chain of three tiny bones (the ossicles) to another membrane (the oval window) which closes the inner ear (i red).The hearing part of the inner ear is rolled up into a spiral called the cochlea, as it looks like a snail shell .
The middle ear is an air-filled cavity in the temporal bone. Its purpose is to provideimpedance matching between the acoustic waves in air and the fluid vibration in theinner ear. The middle ear consists of the threeossicles, namely the malleus, incus and stapes. The malleus is attached to the eardrum and the stapes to the oval window inthe cochlea.
The eardrum responds to the acoustic sound wave collected by the ear
Canal and its vibration are transmitted down the series of ossicles to the inner ear provides anamplification of pressure transmitted to the (LimKian, 2015).

The Inner ear consists of semicircular canal which acts as balance organ and the cochlea which serves as hearing organ (Drake et al, 2005).The cochleahas a spiral shape resembling the shell of a snailas shown inFigure (1-2a)(Mireilleand Rabillard, 2013).The cochlea divided into three chambers: scalavestibuli, scala media and the scala tympani. The scalavestibuli forms the upper chamber and at the base of this chamber is the oval window. The lower chamber is the scala tympani. It too has a basal aperture, the round window, which is closed by an elastic membrane. The scala media separates the other two chambers along most of their length. The start of the cochlea, where the oval and round windows are located is known as the basal end, while the other end, the inner tip is known as the apex. The scalavestibuli and the scala tympani communicate with one another via the helicontrema, an opening in the cochlear duct at theapexas shown in Figure (1-2b)(Mireille andRabillardfromPromenade around the cochlea, 2013).

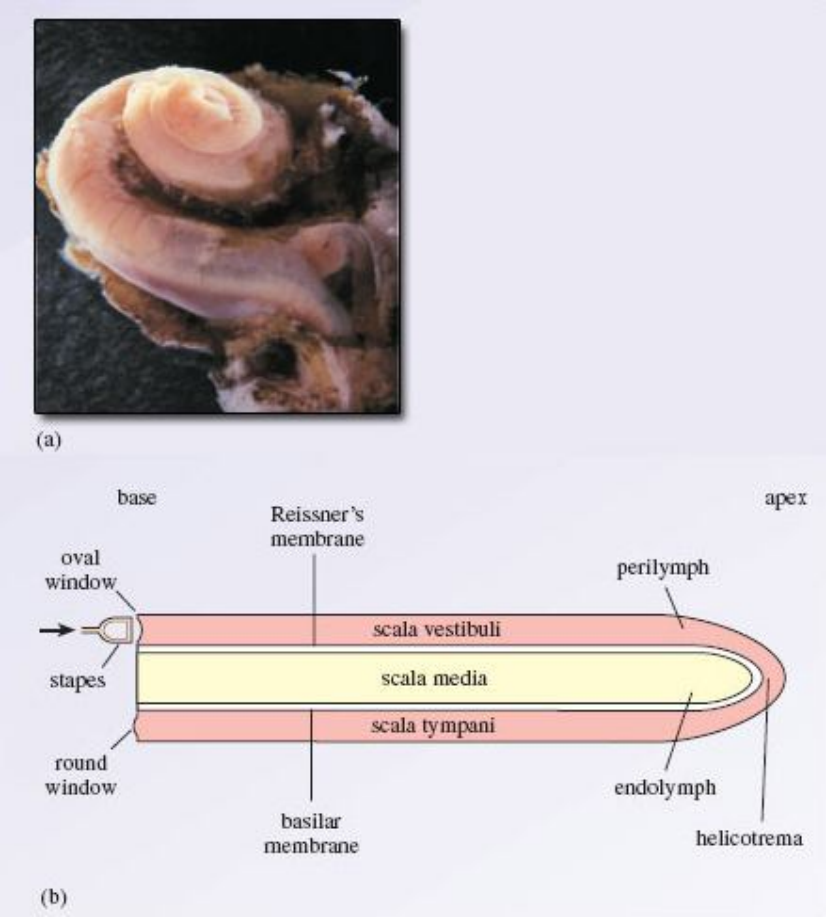
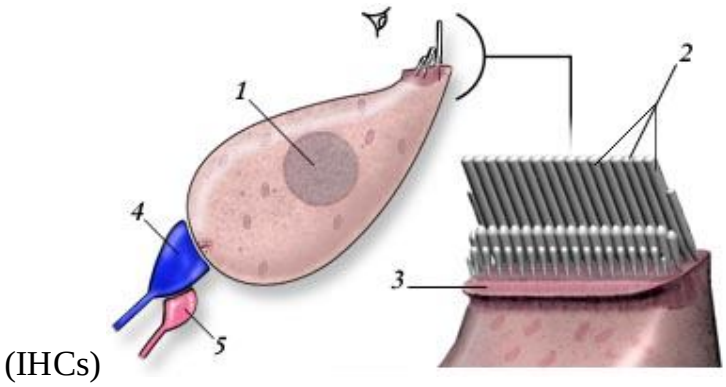
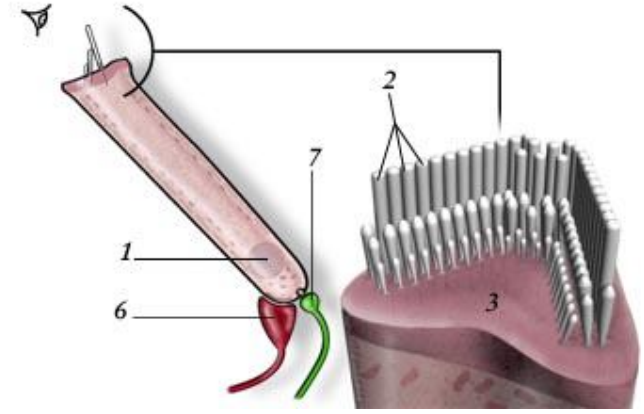


Figure (1-2) Diagram (a) Coiled cochlea of a human (b) diagram representation of the three scala of theuncoiled cochlea. (MireillefromPromenade, 2013)

Cochlear, as well as vestibular, sensory cells are called hair cells because they are characterized by having a cuticular plate with a tuft of stereocilia bathing in the surrounding endolymph. The cell body itself is localized in the perilymph compartment. Schematically, both types of cells, inner hair cells (IHCs) and outer hair cells (OHCs), differ by their shape and the pattern of their stereociliaas shown in Figure (1-3).(Pujol , 2013).



(IHCs)



OHCs)

1. Nucleus
2.Stereocilia
3.Cuticularplate
4.Radial afferent ending (dendrite of type I neuron)
5.Lateralefferentending
6.Medialefferentending
7. Spiral afferent ending (dendrite of type II neuron)

Figure (1-3) Hair cells of cochlea (OHCs and IHCs)
(Pujol, from Promenade round the cochlea, 2013).

In the human cochlea, there are 3,500inner hair cells which are arranged in single row and about12, 000 outer hair cells are arranged in three parallel rows. The hair cells have from 20 to 300 stereo cilia arranged in three rows projecting from their apices.

The function of the inner hair cells serve as sensory receptor, it will send the information by releasing neurotransmitters at its base to initiate activity in the primary auditory nerve (Sewell, 1996).

The function of the outer hair cell is to amplify the vibration at specific regions of the cochlea by expanding and contracting in response to sound

(Brownell et al,1985).The outer hair cells play specific role in amplification of sounds based on their motility (Dallos, 2008).

The specialized organ in cochlea is organ of Corti. It situated between the basilar membrane (BM) and the tectorial membrane (TM) which is a matrix of sensory and supporting cells as shown in Figure (1-4)(Pujol and Irving ,2013) proposed that The function of the organ of Corti is to transducer auditory signals and maximize the hair cells' extraction of sound energy. The organ of Corti vibrates up and down entirely in response to sound pressure waves a transverse movement develops between the reticular lamina and the tectorial membrane this leads to deflect outer hair cell stereocilia. (OghalaiJohn, 2004).

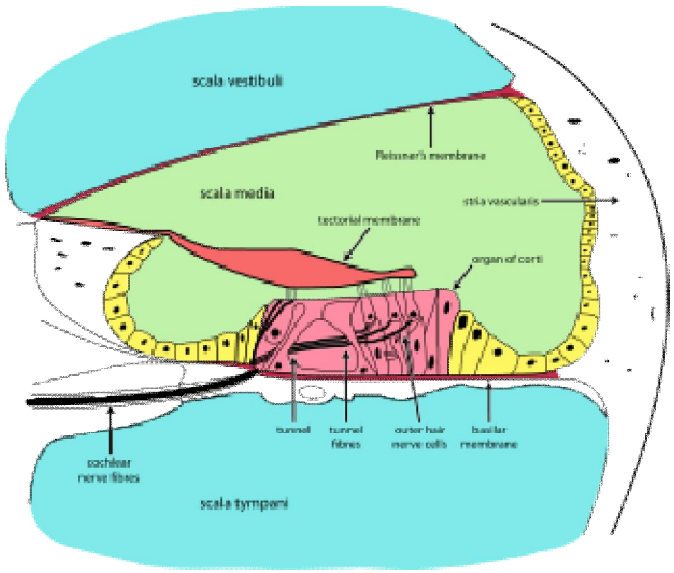


Figure (1-4): TheOrgan Of Corti(Pujol and Irving, 2013).

1-3 Mechanical properties of the Cochlea:

The cochlea has two mechanical properties passive and active. Figure (1-5)show the suggested role of the outer hair cell active processes in cochlear mechanics. Traveling sound pressure wave produces passive motion of cochlear structures such as the basilar membrane andthe reticular lamina. Mechanical interaction with outer hair cells elicits alterations in cell length or cell stiffness. Resultant changes feedback on the passive cochlear mechanics and increase the mechanical response of the hearing organ, which isdetected by the inner hair cells, in synaptic contact with afferent nerve fibers.(Matsand Flock, 1998).

Mechanical activity of the outer hair cells can alsoevoke emissions of sound into the auditory canal. In absence of the cochlear amplifier, mainly passive mechanical componentsare reflected in the neural response (right), which is broadly tuned (dashed curve). In the “active” cochlea, the response (solid curve) exhibits both great sensitivity andfrequency selectivity.

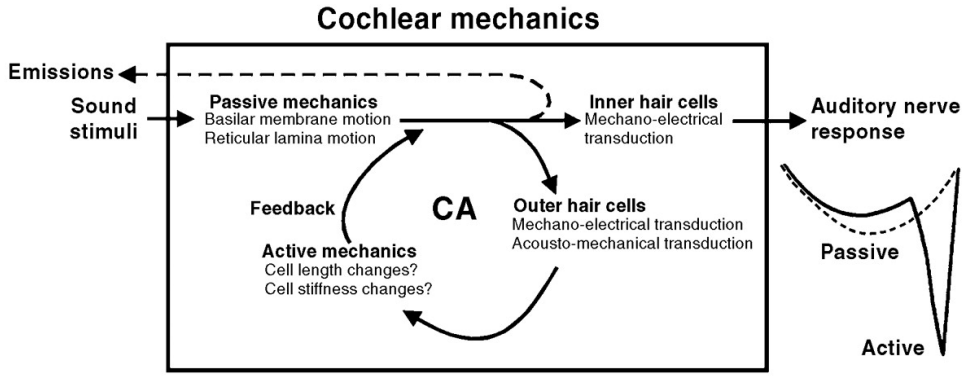


Figure (1-5) Cochlear mechanics. (Mats and Flock, 1998)

ThePassive cochlear mechanisms are related to systemic differences in the physical characteristicsof the vibrating structures along the cochlear and this process cannot explain the sensitivity and frequency selectivity of the mammalian hearing. (Emilyanet al, 2008).

Active cochlear mechanisms are associated with outer hair cell motility in the living cochlea. These mechanisms amplify movement along the basilar membrane and transmit mechanicalinformation to the inner hair cells, thus improving audio perception capabilities in mammals.(Brownell, 2002.,Brownell and Oghalai, 2000.,Gummer et al, 2002 .,Iwasa and Adachi, 1997).

1-4 Structure and Properties of the Basilar Membrane

The mechanical properties of the basilar membrane are the key to the cochlea's operation.The basilar membrane is widest and low stiffness at the apex of the cochlea, and narrowest and high stiffness at the base of cochlea (Richard et al, 2004). This means that the amplitude of a sound wave travelling through the basilar membrane varies as it travels through the cochlea.(Plewes, 2006).

Themechanical properties of the basilar membrane is not uniform vary continuously along its length in two ways. First, the membrane is wider at its apex compared to the base by a factor of about 5, and second, it decreases in stiffness from base to apex, the base being 100 times stiffer. The parameters of the membrane at a given point along its length determine its characteristic frequency (CF) the frequency at which it is maximum sensitive to sound vibrations. When the CF is high thevibration of basilar membrane is located towards the base of the cochlea (Nobili et al, 1998).Every part of the basilar membrane can be considered as a mass spring system with different resonant characteristics high resonant frequencies at the base of cochlea and low resonant frequencies at the apical end of cochlea (Schnuppetal, 2011).This causes sound input of a certain frequency to vibrate some locations of the membrane more than other locations. When the human ear is presented to a sound, the time taken for the wave to travel through the cochlea is only 5 milliseconds (Plewes, 2006). The displacement of vibration on the cochlea depends upon the frequency of the presented stimuli; lower frequencies stimulate the apex, in comparison to higher frequencies, which stimulate the base of the cochlea as shown in Figure (1-6) (Promenade, 2003).

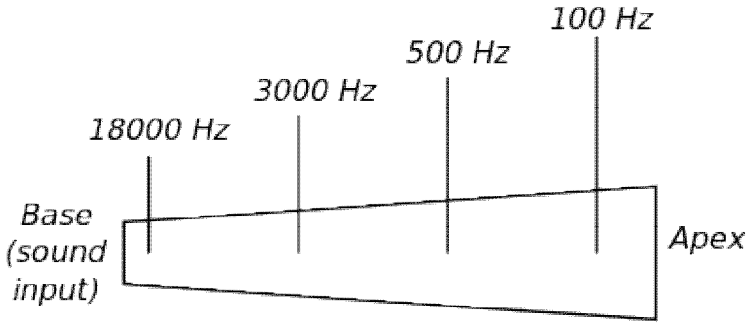


Figure (1-6) Simplified schematic of the basilar membrane showing the change in characteristic frequency from base to apex (promenade, 2003).

1-5 Traveling Wavealong the cochlea:

(Dancer, 1992), defined the term traveling wave which is that the wave of displacement that propagation t he basilar membrane from base to apex in response to acoustic stimulation. The motion of the basilar membrane is generally described as a traveling wave (Richardet al, 2004). The Figure (1-7) shows the amplitude of the traveling wave along the basilar membrane for different frequencies and show that the position where the

traveling wave reaches its maximum amplitude varies directly with the frequency of stimulation(Dallos, 1992).

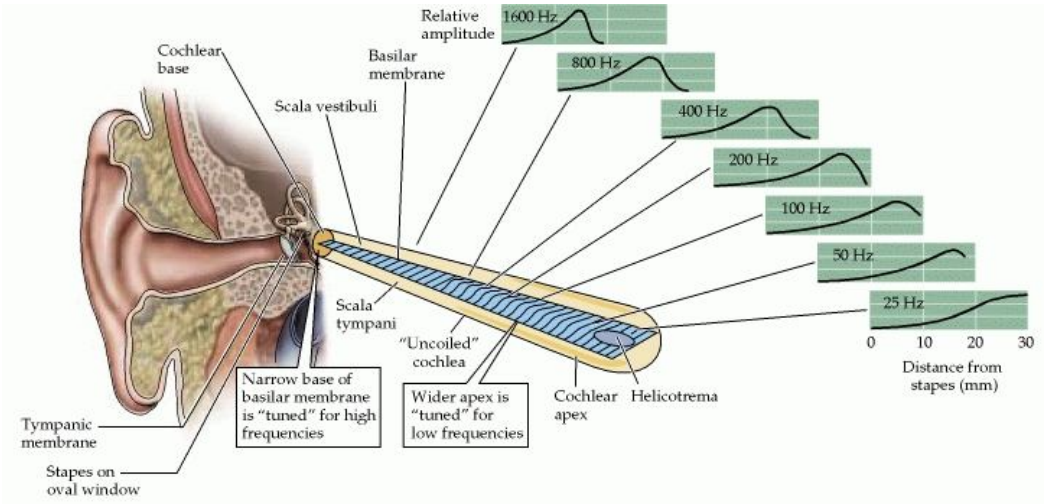


Figure (1-7) Traveling waves along the cochlea (Dallos, 1992).

1-6 The Cochlear amplifier (CA)

The cochlear amplifier is a nonlinear active process providing the mammalian ear with its extraordinary sensitivity, large dynamic range and sharp frequency tuning. The active process in the cochlea was first proposed By ThomasGold, (Gold, 1948).Outer hair cell electromotility has been suggested to underlie the cochlear amplifier.(Maoiléidigh and Jülicher,2010).

The amplification of cochlear was described by two theories called Stereo cillirly motility and Somatic motility. Thestereocillirlytheoryproposes thatamplification is produced by intricate vibrations of the bundles of ciliaemerge from the apical surface of hair cells. These cilia increase in length along a consistent axis.(Ricci, 2003).

According to The somatic motility holds that the sound signal is amplified by an amplifier protein, called prestin embedded in plasma membrane of the outer hair cell. (Ashmore, 2008).

The active mechanism amplifies the vibrations of the basilar membrane by around 50 dB (this increases cochlear sensitivity) over a narrow portion of the organ of Corti.There are two similar frequencies able toactivate two distinct cochlear regions, allowing them to be distinguished from each other this is known as frequency selectivity.

Frequency tuning depends closely on the electromotile properties of the OHCs. As shown in Figure (1-8). (Guyet al, 2016)

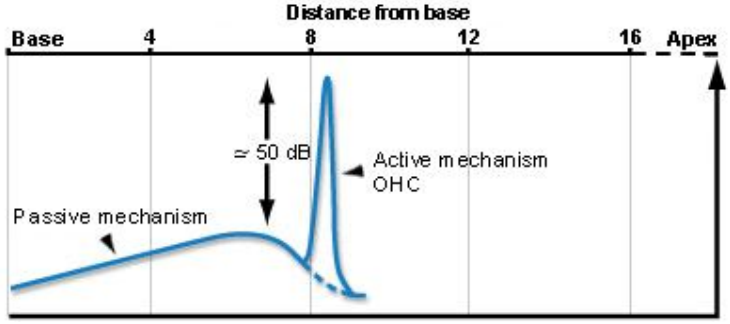


Figure (1-8) OHC active mechanism and tuning

(Guy et al, 2016)

Process involved in the cochlear amplifieras shown in Figure (1-9). (Ashmore et al, 2010), Sound causes displacements of the basilar membrane, XBM, and organ of Corti leading to deflection of the OHC hair-bundleHB. Activation and adaptation of the mechanotransducer channels generate a tuned transducer current culminating in a change in OHC membrane potential DVOHC, thatDrives the somatic motor. The force, fOHC, produced by OHC electromotility augments basilar membrane motion and may also deform the organ of Corti.(Mammanoand Ashmore, 1993). Gating of the mechanical transducer channels may generate sufficient force, fHB, to move the hair-bundles (the hair-bundle motor) and the organ Corti. Theinner hair cell bundles are stimulated by the relative velocity, vTM/RL, between Tectorial Membrane and Reticular Lamina

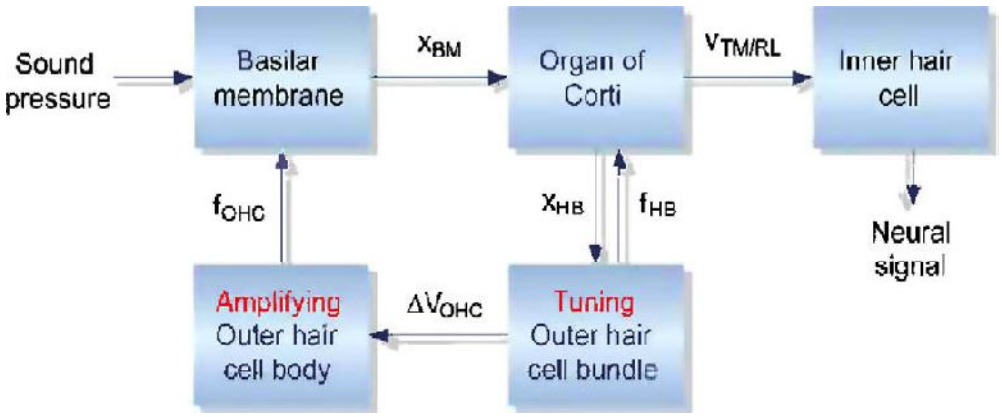


Figure (1-9) TheCochlear amplifier.(Ashmore et al, 2010)

1-7the Outer Hair Cells Electro Motility:

The electro motility of outer hair cells is a shape change that results from the direct conversion of electrical potential into a mechanical force (Brownell et al., 1985). It does not depend on intracellular voltages and does not require ATP (Adeno Tri Phosphate). (Brownelland Kashar, 1986).Thus, OHCs elongate and contract at acoustic frequencies with each cycle of sound as their intracellular voltage change. This amplifies the vibration of the basilar membrane permitting hearing sensitivity and frequency selectivity (Brownell et al, 1985., Kachar et al, 1986.,Ashmore, 1987) as shown in Figure (1-10).

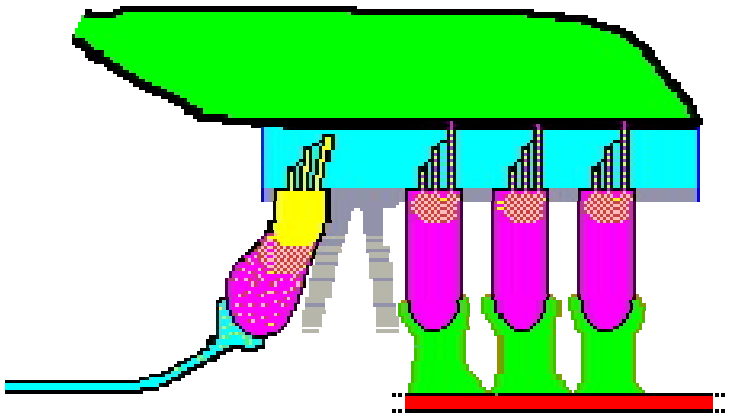


Figure (1-10)theelectro motility of outer hair cells.

The outer hair cells are cylindrically shaped with lengths ranging from 20 to 90 mm along the cochlea and with a radius of 4–5 mm .The hair bundle, composed of stereocilia, are located at the apex of the cell. The lateral wall is the source of electro motility (Robert et al, 2000).

Each part of the OHCs has a specific function, at the apex of the outer hair are stereo cilia which responsible for converting the mechanical energy of the basilar membrane into electrical energy. At the base of the OHCs are synaptic structures which responsible for converting electrical energy into chemical energy (Oghalai, 2004). The lateral wall of outer hair cells contains: the plasma membrane (PM), subsurface cistern (SSC) and a specialized cytoskeleton is found inside the plasma membrane which containsactins, spectrin, and pillar molecules, it works to permit electro motile cell length changesas shown in Figure(1-11).(Brownel and Popel,1998).

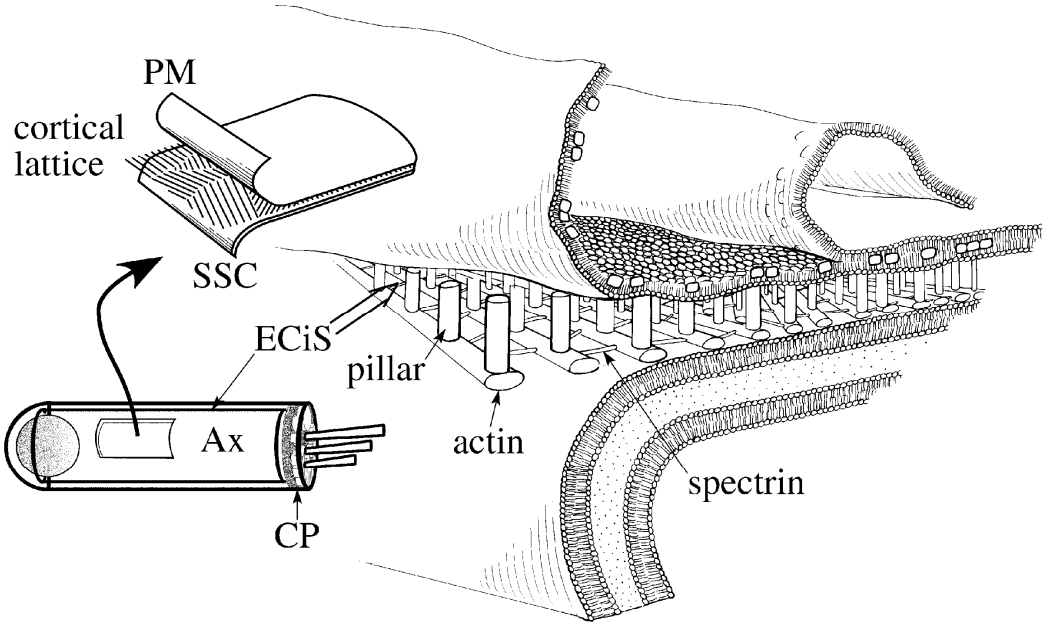


Figure (1-11)Thelateral wall components Ax,c Axial core; CP, cuticular plate; ECiS, extra cisternal space; PMplasma membrane.
(Brownell and Popel ,1998)

The lateral wall of the OHC and some of the particlesin the plasma membrane called the prestin protein which is not expressed in other hair cells, and likely works in concert with associated protein and lipids of the lateral wall to form (motor complexes). Each motor complex senses the intracellular voltage andgenerates force by changing its Surfacearea.(Kakehata et al, 1999).The motility of outer hair cells is an important for generating DPOAEs.(Brownell et al, 1985).

Recent studies used Distortion product otoacoustic emissions (sound emitted when the ear is stimulated acoustically by two sinusoidal signals primaries with appropriately chosen frequencies f1, f 2 and stimulus levels L1, L2.(Pickles, 1988),supporting that prestin-based electromotility is required for cochlear amplification and generating DPOAEsfor normal hearing cochlear. (Lieberman et al, 2002 andDallasetal, 2008)

1-8 Problem of the study:

The human ear is an exceedingly complex organ; the information from two ears is combined in a perplexing neural network, then human brain. There are many subtle effects and poorly understood phenomena related to human hearing. In fact, noise is probably the most common occupational hazard facing people today. Therefore any abnormality affected any part of the ear will lead to degradation of cochlea function and hence the otocoustic emission, the test of cochlea function usually assessed according to standard normative data that is different between nation. This fact dictates that indigenous normative data should be generated.

Research question:

- Does gender, age, ear side and racialaffect on DPOAEs?
- Does the internal noise and environment noise affect on the response of DPOAEs.
- Does the external ear canal affect on DPOAEs response

1-9Objectives:

The general objective of this study was designed to determine the DPOAEs response for normal hearing subject in order to establish normative data.

Specific objective

- To assess the cochlea function (especially outer hair cell motility) with normal hearing subject using DPOAEs.
- To find the effect of age, gender and ear side on DPOAEs response
- To assess middle ear function.
- To find the effect of racialon DPOAEs response for normal hearing ofIraqi and Sudanese Subjects.
- To propos model of linear equation and Nonlinear to evaluatethe Rate of change in DPI Level with respect of Frequency for all Group Subjects Iraqi and Sudanese.

1-10 Significanceof the study:

The study is an important to evaluate Distortion product otoacoustic emissions Level DPI with respect of frequency for all Groups Subjects Iraqi and Sudanese and to assess middle ear system.

Distortion product Otoacoustic emission (DPOAEs) assessment provides detailed frequency specific information or cochlear function and can be used to record at higher frequencies.

1-11 Overview of the study:

This study contains five chapters; chapter one includes introduction, chapter two literature review while chapter three includes methodology and chapter four result and data presentation, the last chapter, discussion and conclusion. ANOVA test and T- test 2 tailed will be used for the analysis of data by using a suitable version with the assistance of statistician also the result would be discussed thoroughly andcorrelated to the previous studies and the conclusion would be presented accordingly.

Chapter Two

THEORETICAL BACKGROUND

2-1Historical Reviewof Distortion productOtoacoustic Emissions (DPOAES):

Distortion product otoacousticemissions were first demonstrated experimentally by David Kemp reported that thesound is introduced within a healthy normal hearing and functioning cochlea called distortion product Otoacoustic emission. (Kemp, 1978), and it can be used to identify frequency ranges of normal hearing in the pathological ears. (Kemp et al, 1990).

DPOAEs are generated by presenting two tones of slightly different Frequencies at the same time. Because of the nonlinear characteristics of the cochlea, the two tones intermediate and create combination tones (distortion products) not present in the original stimulus. (Martin et al ,1990 andPickles,1988).

Nonlinearity in OHC functionproduces intermediation distortion at theregion of greatest overlap between traveling wavesevoked by the primary tones. Linear reflection is also produced around the peak of the apicalward travelingwave at the distortion product characteristicFrequency. Both emissions reverse propagate basally, Combining in the ear canal to produce a mixed type of OAE that includes contributions from morethan one cochlear site.(Christopher et al,2004).

As implementation of DPOAEs in the audiology, The most robust andreliably present DPOAEs in mammals are the cubic distortionone at $2f1-f2$.

They have been shown to arise through a number of different cellular and mechanical causes within the inner ear. (Kujawa et al, 1996 and Chang et al, 1997). The most extensively studied and clinically used is the DPOAEs at the frequency $2f_1-f_2$ (Dorn et al., 1999).The level of DPOAEs as a function of frequency is used Commonly as an indicator of cochlear health Compared to normal hearing. DPOAEsmay provide the most convenient tool in evaluating the efferent auditory pathway (Deeter et al, 2009).

Many western countries now have national programmers for the universal hearing screening of newborn babies. Periodic early childhood hearing screenings program are also utilizing DPOAEs technology (Eiserman and Shisler, 2010).The distortion product otoacoustic emissions offer a noninvasive, objective measure of cochlear function known to be sensitive to minor changes in cochlear physiology (Rao and Long, 2011).And theyReflect a combination of inner ear and external/middle ear function,

subjects with small ear canals such as infants are different than adults due to the difference in external and middle ear size (Grenner, 2012).

The DPOAEs are highly sensitive and highly dependent on outer hair cell function, they do not require behavioral responses, and they offer immediate, ear-specific results. Further are relatively inexpensive and do not require a sound-treated booth.(Jessica et al , 2013).

The measurements of DPOAEsare effective for screening middle-ear abnormalities and moderate or severe degrees of hearing loss, because normal DPOAEs responses are not obtained if hearing thresholds are approximately 30 to 40 dB hearing levels or higher (united health care, Oxford, 2015)

2-2 Typesand proportiesof the Otoacoustic emissions (OAEs):

The Otoacoustic emissions (OAEs) are divided into two categories. One category, spontaneous otoacoustic emissions (SOAEs), is recorded without external acoustic stimulation and are present inApproximately fifty percent of normal hearing ears (Lonsbury and Martin, 1990).The second, evoked otoacoustic emissions (EOAEs) are divided into three types based on thestimuli eliciting the response.

Transiently evoked (TEOAEs); are sounds mitted in response to acoustic stimuli of very short duration; usually clicks but can be tone-bursts (Kemp, 1978 and Cheng, 1993).

Stimulus frequency otoacoustic emissions (SFOAEs): are generated during Continuous stimulation with a single, low level tone and represent a Steady state evoked response.

Distortionproductotoacoustic emissions (DPOAEs): Is Sound emitted in response to two –simultaneous tones of different frequencies (Brown and Kemp, 1984 and Jaramillo et al, 1993).

The proporties ofOtoacoustic emissions (OAEs):

- Otoacoustic emissions (OAEs) are an active process of sound in thecochlea within inner ear. The source of the acoustic energy is physiological nature. The motility of outer hair cells is an important for generating OAEs (Brownell et al, 1985 and Zenner, 1986).
- Otoacoustic emissions are clinically important because they are the basis of a simple, non-invasive, test for hearing defects in newborn babies and in children who are uncooprative in conventional hearing tests. (Kemp, 2002).
- The recording ofOAEs requires normal middle ear function (Wada et al, 1995).Cochlear responses must be able to travel efficiently through

the middle ear and tympanic membrane to the ear canal.

- In the cochlea, OAEs are by-product of the non-linear sound amplification process.(Davis, 1983 and Dallos, 1992). The generation of OAEs is highly non-linear leading to use of non-linear protocol for generation of OAEs.
- Otoacoustic emissions are considered preneural responses indicating healthy cochlear status and cannot be used to detect sensory neural hearing losses because they occur before the signal is transmitted to the auditory nerve and are related to the physiological process underlying the sensitivity and the fine tuning of the normal cochlea (Probst etal, 1991 and Norton, 1990).
- Otoacoustic Emissions (OAEs) are present in nearly all ears with normal hearing sensitivity and are considered a general characteristic of the human peripheral auditory system (Probst et al, 1991).
- The measuring ofOAEs is highly reproducible. The temporal and spectral characteristicsofOAEs are unique for each subject; fingerprint of the inner ear (Hunter et al, 1994., Kei et al and Lutman et al, 1997).

2-3Distortion product otoacoustic emissions (DPOAEs):

Distortion Product Otoacoustic emissions DPOAEs arise when the ear is stimulated acoustically by two tones or sinusoidal signals primaries with appropriately chosen frequencies *(f_1 , f_2)* and stimulus levels *(L_1, L_2)*(Pickles, 1988).

These tones produce a family of DPOAEs in the cochlea, the strongest emission has a frequency of $2f_1 - f_2$,the two primary tones are usually chosen with a frequency ratio of f_2 / f_1= 1.22, because this combination produces a relatively high amplitude(Stover et al, 1996).The outer hair cells (OHCs) stimulated by f1 and f2 frequencies stimulate a third set of OHCs located between f1 and f2. The excitation of this third set of OHCs creates a separate tone, known as the Distortion Product as shown in Figure (2-1)

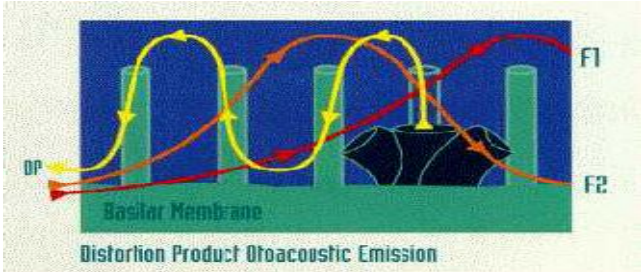


Figure (2-1) Distortion Product otoacoustic emissions
(Adnan AL Maamury, 2005).

In humans DPOAEs are supposed to primarily reflect OHC activity at the $f_2$place, there is evidence that DPOAEs are generated by two distinct cochlear sources(Whitehead et al, 1992., Shera and Guinan, 1999). Source is believed to arise from the nonlinear interactions between the f1 and f2 primary tones, near the peak of the f2 traveling wave (TW)(Kalluri and Shera, 2001) referred to this constituent as the generator or distortion component, while (Fahey et al, 2000), described it as a wave-fixed component. This component is thought to travel both apically and basally within the cochlea, when the apically traveling segment arrives at the 2f1−f2 DPOAE frequency place (fdp) on the basilar membrane (BM), A second component, which is produced by a coherent-reflection mechanism, travels basally to generate another DPOAE source referred to as the reflection component or a place-fixed component.the prevailing view is that lower-sideband DPOAEs (2f1−f2) conform to a two-source model with the emissions arising from two discrete locations associated with distinct mechanisms of generation.

The most prominent and mostly used in clinical practice is the cubic difference distortion product denoted as 2f1-f2.(Glen and Martin, 2002).

The vast majority of physiological and psychophysical studies involving DPOAEs concentrate on the *(2 f 1- f2)*distortion product. (Lonsbury et al, 1991b). the responsesare usually most robust and recorded at the emitted frequency of ($2f1 - f_2$) therefore they generally are charted according to f_2 because that region approximates the cochlear frequency region generating the response.(Kathleen,2016).The $2f_1 - f_2$ DP-grams were generated as part of a larger research protocol conducted during various experiments in the Infant Auditory Research (Medical Center) over 5 years.

2-4 DPOAEs- Recording

DPOAEs are non-invasive and technically simple to record, No behavioral response is required for participating in the testing (Kemp et al, 1990 and Probst et al, 1991). DPOAEs are measured by presenting two an acoustic stimulus to the ear canal through a probe that is inserted in the outer third of the ear canal as shown in Figure (2-2) .The probe contains two loudspeaker that generate stimulus and a miniature microphone that measures the resulting DPOAES that are produced in the cochlea and are then transmitted back through the Middle ear into the outer ear canal. The resulting sound that is picked up by the microphone is digitized and processed by specially designed Hardware and software. The very low- level DPOAEs are

differentiated by the software from both the background noise and from the contamination of the evoking stimuli.

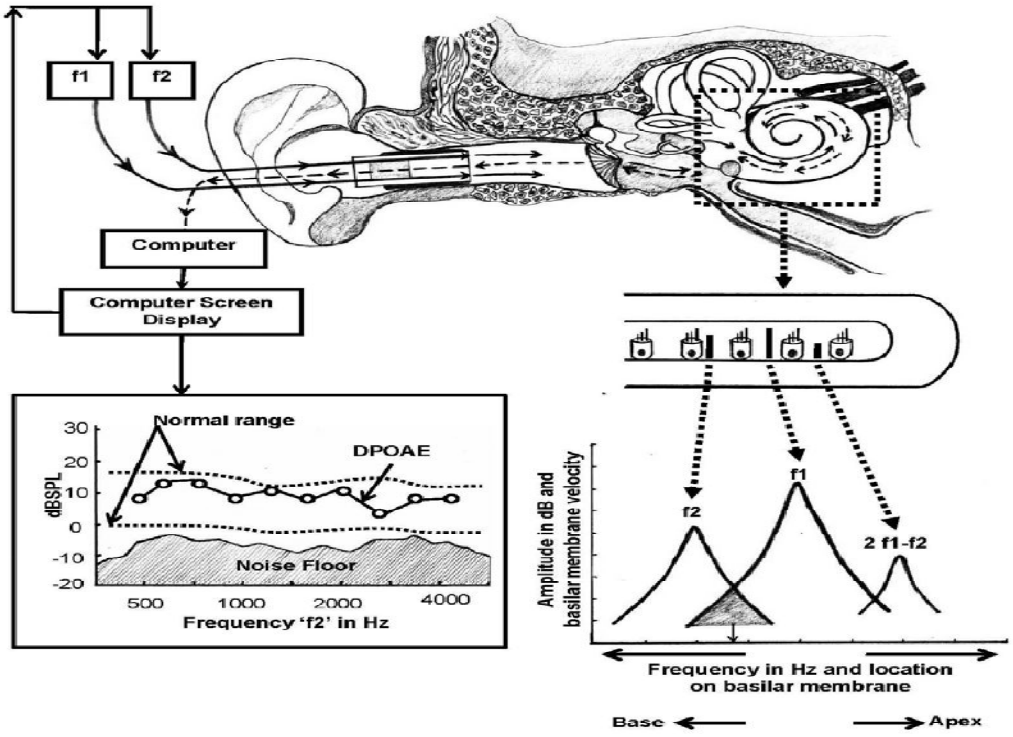


Figure (2-2) The measurement of distortion product otoacoustiemissions illustration appears with permission of artist Anuradha Bantwal..

2-5 Protocol of Distortion product Otoacoustic Emissions.

A protocol used to the acquisition of DPOAE response was nonlinear mode. This protocol has many advantages such as, decreases time test and reduces the amount of low frequency noise contaminations.The Distortion product OAEs protocols employed in clinical practice are included two categories (Martin et al, 1990., Stover et al, 1996 and Kummer et al,1998). Protocols using primaries with equal intensities are called symmetric(L_1=L_2).When this protocols are used the distortion product otoacoustic emissions information is referenced to the geometric mean. AnotherProtocols using unequal primary intensities (L1higher than L_2) are called asymmetrical, when asymmetrical DPOAEsprotocols are used the intermediation components are generated close the f_2 primary tone. Therefore the DPOAEs information is referenced to f2. (Glen and Martin, 2002).

A Protocol was used a fixed ratio f2/f1 was kept at 1.22 since this ratio produces the largest 2f1-f2 amplitude. (Stover et al, 1996).

Previous studies revealedthat moderate level primary tones presented in the range of 55–65 dB SPL represent a good compromise between sensitivity and specificity. (Whitehead et al, 1992) and provide the best accuracy in separating normal hearing subjects from subjects with hearing loss. (Stover and colleagues, 1996).

2-6 Distortion Product Otoacoustic Emissions Criteria:

DPOAEs equipment will provide measures of DPOAEs Amplitude, Background Noise, and Signal-to-Noise Ratio (SNR), DPOAEs were considered present when the signal level exceeded the noise floor by 3 dB SPL for narrow frequency bands (Brasset al, 1999., Harrison and Norton, 1999) and 6 dB SPL for wide frequency bands (Prieve et al, 1993). DPOAEs is thought to have an amplitude (DPI level) that may vary from -10dB SPL to +30dB SPL in healthy ears.(Robinette and Glattke, 2007).Detection thresholdsof the DPOAEs depend almostentirely on the noise floor and the sensitivity of the measurement equipment. The measurement of DPOAEs are influenced by several noise sources have been identified (popelka et al, 1998). There are two types of noises sources: external noises such as ambient noise, electromagnetic interference and internal noises that are generated by subjects such as heavy breathing or coughing. Noises sources can obscure the recording of emissions, particularly in the low to mid frequencies range (Norton, et al, 2002).For DPOAEs measurement the manufacturers of the instrumentation have attempted to reduce noise level by using high-pass filtering (Vohr et al, 1993 and Weleh et al, 1996). And to improve the signal-to-noise ratio (SNR), typically several hundred individual responses to acoustic stimuli are averaged. A signal average processing has become the basic method to improve (SNR) in current DPOAEs recording. (DeToro and Miguel Anglel, 2011).

2-7 DPOAEs and Age:

Previous studies have shown that DPOAEs responses change with age. Children aged less than one year have higher DPOAEs levels than older children and adults (Spektor et al, 1991). The progressive decrease in DPOAEs appeared in children between birth and 2-4 years of age (Norton and Widen, 1990.,Prieve, 1992).Previous studies found that the age effect on DPOAEs in adults with normal hearing thresholds at low and midfrequencies (Bertoli and Probst, 1997., Prieve and Falter, 1995). The occurrence of DPOAEs decreases with increases age, independent of pure tone hearing threshold levels. (Le Page and Murray, 1998). Recent studies have shown

that DPOAEs responses change with age at frequencies as low as 1000 Hz for subjects as young as 20 years old (Poling et al, 2014).

2-8DPOAEs and Gender:

Gender differences are found for all measures of auditory function, includingDPOAEs. Previous studies have revealed that females have stronger DPOAEs than males across many age groups from infancy to adulthood. Gender differences are displayed for DPOAEs measures obtained from adults (Gaskill and Brown, 1990., Cacace et al, 1996). Another studies based on the data from 79 female ears and 70 male ears revealed that DPOAE amplitudes were greater for females than males (Lonsbury et al, 1990) and another studiesincluded 1003children (528 boys and 475 girls with a mean age of 6.2 years) weretested at their schools in Australiafound that the gender effect on distortionproduct otoacoustic emissions (DPOAEs) and revealed that DPOAEs Response were greater for females than males (Keogh et al, 2001). In contrast other studies in neonates and infants using DPOAEs which have not yielded any significant gender effect (Moller , 1999 and Sheppard et al, 1996).

2-9 DPOAEs and an ear asymmetry:

Studies of auditory function in the general population revealed an ear asymmetry effect. Right ears consistently higher responses than left ears (Chung et al, 1983) and anotherstudies revealed an ear asymmetry effect in DPOAEs and the results were found that Right ears exhibited stronger DPOAEs at 1.9, 3.0, 3.8, and. 6.0 kHz than left ears, but the difference in SNR was small,(Keogh et al., 2001). In contrast manyPrevious studies did not report an ear asymmetry effect in DPOAEs which may be due to small differences in ear asymmetry and small sample size of studies (Lonsbury et al, 1997 and pavlovcinova et al, 2010).

2-10 DPOAEs andRacial effects:

(Lura et al, 2007) examined racial effects on distortion-product otoacoustic emissions (DPOAEs), were measured in 60 young normal-hearing adult subjects (20 Caucasian, 20 Asian, 20 African-American, with ten females and ten males in each group. The findings for DPOAEs frequency sweeps can be expected amongst different racial groups given that no significant differences were identified between the groups. To further define the effects of race and gender on auditory measures, future studies should include larger numbers of subjects, measurement of body size and middle ear reflectance, and examine emission generators.

Chapter Three

MATERIAL AND METHODS

3.1 Material

Audiometer (Atoms screen 20 K-Denmark) was used to test threshold hearing level of each ear. The results were recorded on a graph called audiogram. Distotion product otoacoustic emissions (DPOAEs) and tympanometric measurements were performed by (Madsen Capella's-OAE/middle ear analyzer-GN Otometrics, Denmark) as shown in Figure (3-1).The probe system includes: speaker introduces 226 Hz probe tone, microphone measures loudness in ear canal and manometer (pump) varies air pressure against tympanic membrane (controls mobility). At a probe frequency of 226 Hz, a hand-walled cavity of 1 cm^3 offers an acoustic admittance of approximately 1 acoustic mmho. The computer-based instruments provide for correction of calibration errors through software commands.

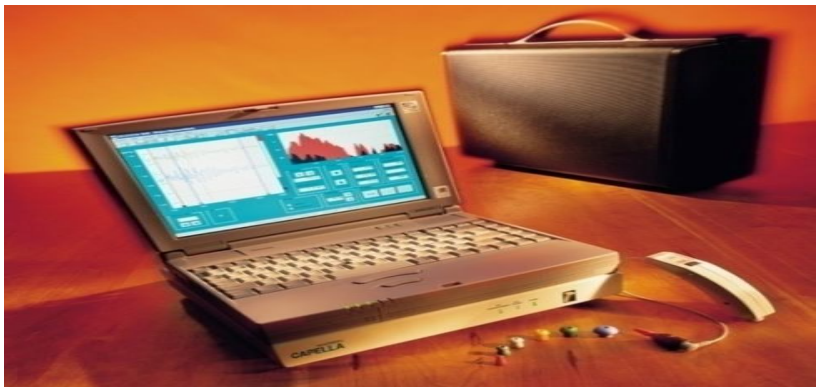


Figure (3-1) Madsen Capella's-OAE/middle ear analyzer-GN Oto metric, Denmark.

3-2 Subjects (population and sampling):

The data were obtained from samples of 106 Iraqi subjects male and female aged 2–40 years and 78 Sudanese subjects male and female aged 2-30 years without any hearing abnormalities or any risk factors for familiar hearing loss and with good general health. All subjects had normal otoscopic results, normal audiometric and tympanometry. There was no history of ontological diseases or ototoxic drug use among the studied subjects. None of the subjects reported that they were frequently exposed to intense leisure noise.

3-2-1 Iraqi Subjects:

The Iraqi subjects were divided into four groups Included the mean values for each group as shown in Table (3-1). Each group was consisted of a number of the ears in both females and males. The total number of the ears was 212, included 104 Ears in females and 108 Ears in males.Data from subjects were placed into four groups based on age : Group-I (2-10) year , with total number of subjects is 26 consisted of 13 females and 13 males , Group-II (11-20) year, with total number of subjects is 26 consisted of 13 females and 13 males, Group-III (21-30) year ,with total number of subjects is 28 consisted of 13 females and 15 males, Group-IV(31-40) year, with the total number of subjects is 26 consisted of 13 females and 13 males as shown in Table (3-1) including the mean values of general variables measured. The total number of subjects which completed all tests was 106 male and female with age from (2-40) year. 106 subjects contained (52) females and (54) males. In group I (2-10)year, the mean value of age for males was(5.54year) & for females was(6.07 year), In group II (11-20)year, the mean value of age for males was (14.07 year)& for females was (13.9 year), In group III(21-30) year, the mean value of age for males was(23.86 year)& for females was(25 year). In group IV (31-40) year, the mean value of age for males was (35.38 year) & for females was (35.15 year).

Table (3-1) Groups of Iraqi subjects.

Groups No.	Age year	Total No. of subject	No. of Males	No. of Females	Mean value of age± SD for males (year)	Mean value of age± SD for females (year)
I	2-10	26	13	13	5.54±1.89	6.07±1.94
II	11-20	26	13	13	14.07±3.65	13.92±3.15
III	21-30	28	15	13	23.86±3.89	25.0±3.91
IV	31-40	26	13	13	35.38±4.56	35.15±4.13

3-2-2 Sudanese Subjects:

The Sudanese subjects were divided into three groups Included the mean values for each group as shown in Table (3-2). Each group was consisted of a number of the ears in both females and males. The total number of the ears was 156, included 78 Ears in females and 78 Ears in males. Data from subjects were placed into three groups based on age : Group-I (2-10) year , with total number of subjects is 26 consisted of 13 females and 13 males , Group-II (11-20) year, with total number of subjects is 26 consisted of 13 females and 13 males, Group-III (21-30) year ,with total number of subjects is 26 consisted of 13 females and 13 males, as shown in Table (3-2) including the mean values of general variables measured. The total number of subjects which completed all tests was 78 male and female with age from (2-30) year. 78 subjects contained (39) females and (39) males. In group I (2-10)year, the mean value of age for males was(5.0year) & for femaleswas(6.0 year), In group II (11-20)year the mean value of age for males was (14.0 year)& for females was (13.0 year), In group III(21-30) year, the mean value of age for males was(24.5 year)& for females was(25.6 year).

Table (3-2) Groups of Sudanese subjects.

Groups No.	Age year	Total No. of subject	No. of Males	No. of Female	Mean value of ages ±SD for males (year)	Mean value of ages±SD for females (year)
I	2-10	26	13	13	5.0±1.86	6.0±1.89
II	11-20	26	13	13	14.0±2.6	13.0±2.2
III	21-30	26	13	13	24.5±3.87	25.6±3.96

3-3Procedure: (Method of data collection)

It is important to study the propertiesof Distortion productotoacoustic emissions (DPOAEs) and the function of middle earstatus.DPOAEs are influenced by the fact that the stimulus must be transmitted to the cochlea via the middle ear and the emissions must be detected in the ear canal.

Audiometer over a frequency range of 250 Hz-to-8000Hz was performed to assess hearing ability in all subjects and tympanometry was performed to assess middle ear system. All investigations were performed in low soundnoise, and both ears of all subjects tested consecutively in a random order.

Audiometer (Atoms screen 20 K-Denmark) was used to test threshold hearing level of each ear. The results were recorded on a graph called audiogram as shown in Figure (3-2).An audiogram represents an individual's hearing ability by frequency andintensity.

The softest sounds that a person can hear at a particular frequency are called hearing threshold. This is represented by markings on the graph; redrepresents the right earand blue represents the left. In a normal ear, most thresholds were approximately zero dB HL. Points below zero dB HL on the scale represented louder threshold levels.

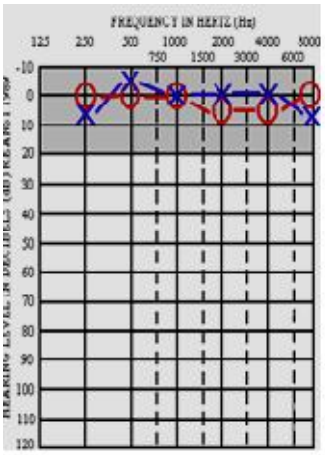


Figure (3-2) Audiogram for a subject with normal hearing

.

Tympanometry is performed by presenting a probe tone to the ear canaland measuring the acoustic admittance (an expression of the ease of energy flow that has a reciprocal relationship with impedance as measured in acoustic ohms) of this tone, as the air pressure presented to the sealed ear canal varies from positive to negative .In the normal middle ear system, energy transfer of the middle ear, as measured at the plane of the tympanic membrane is maximal at atmospheric pressure and is minimal at air pressures that produce a stiffening of the middle ear system(Robert and Dobie,2004).The standard probe tone frequency is 226 Hz; The resultingtympanogram is a pressure-admittance function that depicts the admittance characteristics of the tympanic membrane and middle ear system of the ear. (American Speech-Language-Hearing Association, 1990).The most widely utilized Tympanogram classification a system was originated by (Jerger, 1970).As

Shown in Fig (3-3) .Normal Tympanogram Type A- indicative of normal middle ear system.

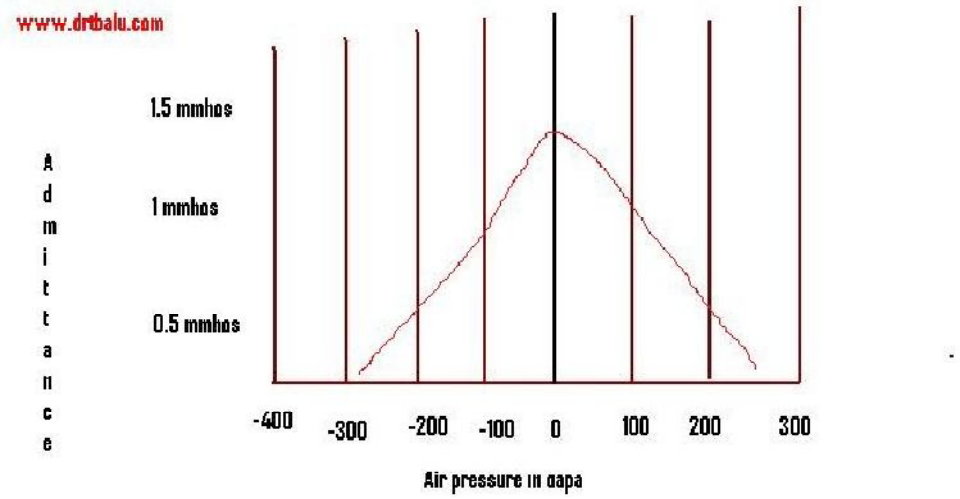


Figure (3-3) Type-A (Normal Tympanogram) . (Jerger, 1970).

3-4Distortion Product Otoacoustic Emissions gram (DPOAEs gram):

Distortion product otoacoustic emissions (DPOAEs) are evoked using a pair of primary tones *f1and f2* with particular intensity (65 - 55 dB SPL) and at fixed ratio*(f1, f2)* equal 1.22. The evoked responses from these stimuli occur at frequencies *(fdp)* mathematically related to the primary frequencies, with the two most prominent being *fdp=2f1-f2*(the cubic distortion tone, most commonly used for hearing screening) and *fdp=f2-f1*(the quadratic distortion tone). Each of the two tones is delivered by a separate transducer in the probe. The DPOAEs module provides for stimulation by each of 9 different frequencypairs (0.5, 0.75, 1.0, 1.5,2.0,3.0,4.0, 6.0, 8.0) kHz. Each of these pairs has as its geometric mean one of the standard audio logical frequencies. A protocol used to the acquisition of DPOAE response was nonlinear mode. (Christopher et al, 2012). This protocol has many advantages such as, decreases time test and reduces the amount of low frequency noise contaminations.

Distortion Productand tympanometric measurements were performed by (Madsen Capella's-OAE/middle ear analyzer-GN Otometrics, Denmark), in a quiet room to minimize the effect of the external noise. Acoustic probe tip was inserted intoeach ear canal and monitor the consistency of the probe fit during (DPOAEs) recording. Before each test the probe was calibratedby measuring the acoustic immittance of standard test cavity of known and specified volume (conformed by the manufacturer). The admittance offered by the cavity is directly related to the enclosed volume of air in a test-cavity.

The acoustic impedance value indicated by the monitor of the instrument must be equal to the known value for fixed test-cavity volume over the range of interest. The calibration was standardized according to the manufacturer recommendations (ANSI S3.39.1996) (American National Standard Institute).The probe contains two speaker's sound generator, filter and recording microphone. The speaker delivers the stimulus to the ear canal while the microphone samples the emission following stimulus presentation as shown in Figure (3-4).The microphone output was subjected to fast Fourier Transform (FFT) for signal processing. The identification of the DPOAES against the background noise was based upon recordings obtained after spectral averaging at frequency range from 0.5 kHz to 8 kHz. Filtering occurs to reduce the internal body noise and external environment noises.

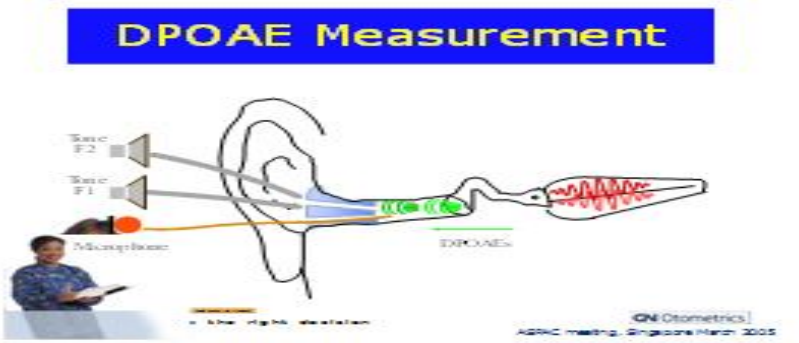


Figure (3-4).DPOAEs Measurement.

The criteria employed to consider the presence of the responses in Distortion product Otoacoustic emissions were: Response amplitude (DP1 level) that may vary from -10dB SPL to +30dB SPL in healthy ears (Robinetteand Glattke, 2007)and the signal level exceeded the noise floor by 3 dB SPL for narrow frequency bands (Harrison and Norton ,1999., Brass *et al*, 1999and Dirckx et al, 1996) and 6 dB SPL for wide frequency bands (Prieve et al, 1993) These statistics area are shown in Figure (3-5).

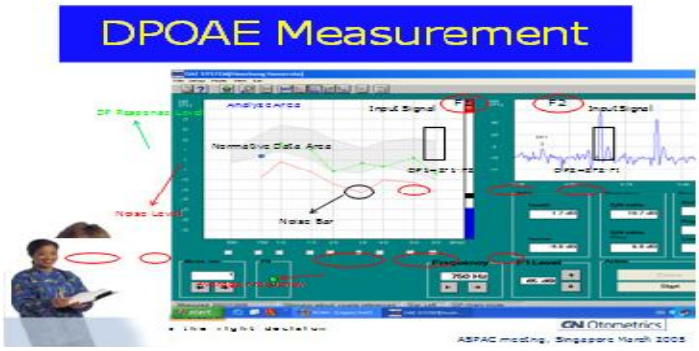


Figure (3-5) The statistics area of (DPOAEs) measurement.

3-5 Clinical Use of Normative Data of DPOAEs.

The normative data is used for Analysis of DPOAEs is represented by displaying the normative range on the DP-Gram. As shown in Figure (3-6).

The following steps are taken for analysis of DPOAE resultsanddetermine which category the recorded DPOAEs fall into.(Dhār and Hall, 2012).

1) Ensures the noise floor is sufficiently low for the correct analysis of the presence or absence of DPOAEs.

a) If the recorded DPOAE meets the SNR criteria for detection and falls within the normal range, it would be categorized as present and normal.

b) If the recorded DPOAE meets the SNR criteria for detection, but is below the normal range, it would be categorized as present, but abnormal.

c) If the recorded DPOAE does not meet the SNR criteria, it would be categorized as absent.

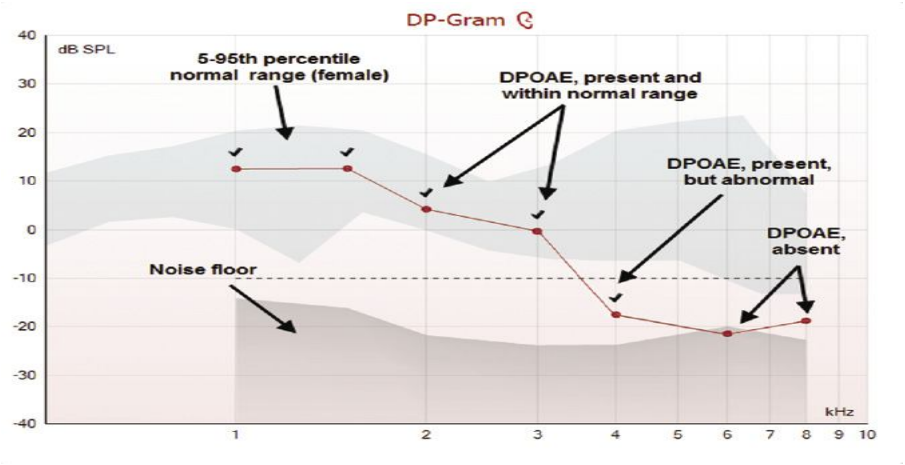


Figure (3-6). A DP-Gram from module displaying the normal range, noise floor, and recorded DPOAEs. (Ramose et al, 2013).

Chapter-Four
Results

4-1Results forIraqi Subjects:

A total of 212 ears were chosen for distortion productotoacoustic emissions (DPOAEs) testing. Study investigations were performed on all ears including pure tone audiometer. It was used to determine the hearing thresholds of each ear. Only normal hearing for Iraqi subjects was enrolled in this study. The hearing loss excluded from the study. The average audiograms for all groups were similar and parallel over frequency range (250-8000 Hz). The normal hearing sensitivity with pure-tone threshold was between 0-15 dB HL. To assess the middle ear function, probe-tone frequency of 226 Hz was used for tympanometry. Since all subjects in this study were controlled as a normal middle ear status.Tympanometricmeasurements were confirmed as a type(A) indicative of normal middle ear system for all tested ear. (Jerger , 1970).The decision about Whether a Distortion Product Otoacoustic Emission is present often depends on a visual assessment of the response along with certain objective criteria, such as distortion product Otoacoustic emissions level (DP1) and signal to Noise Ratio(SNR) dB SPL.DPOAEs were considered present when the signal level exceeded the noise floor by 3 dB SPL for narrow frequency bands (Harrison et al, 1999., Brass et al,1999andDirckx et al, 1996) and 6 dB SPL for wide frequency bands (Prieve et al, 1993) and the DPOAEs is thought to have an amplitude(DPI level) that may vary from -10dB SPL to +30dB SPL in healthy ears(Robinette and Glattke, 2007) . In the present study, the overall SNR for each tested ear was more than 3 dB SPL at the overall frequency bands (0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 kHz) and our results showed that theminimum and the maximum of the mean value of the DistortionProduct (DP1 Level) recorded for all tested ears was (-2.3dB) for female Right ear side in group-III age (21-30) year at 0.5kHz and (20.39dB) for female right ear side in group-I age (2-10) year at6kHz respectively over frequency bands (0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 kHz).Data taken for Iraqi subjects are recorded in appendixes (A), (B), (C), (D) and (E) in Tables (1 to 40). The data in Appendix (A) included Tables (1 to 9) for Group (I) age (2-10) year , the data in appendix(B) included Tables(10-18) for Group (II)age (11-20) year , the data in appendix(C) included Tables (19-27) for Group (III) age(21-30)year and the data in appendix (D) included Tables (28-36) for Group (IV) age(31-

40) year.

All appendixes were contained Distortion product Otoacoustic emission level (DP1 level) dB for Right and Left ear male, Signal Noise Ratio (SNRs) dB for Right and Left ear male, (DPI Level) dB for Right and Left ear female, (SNRs) for Right and Left ear female at each frequency respectively and comparison between average of DP1 level and SNR for females and males. Appendix (E) included Tables (37-40)comparison between average of DP1and SNRs of Right and Left ear side for females and males at each frequency for all groups (2-10) year,(11-20) year, (21-30) year and (31-40) year Respectively.

Table (9) in appendix-A indicate that in group-I (2-10)year; the mean value of DP1 Level for Right ears females was (14.27dB) higher than that in left ears females(12.06dB)and The mean value of DP1 level in the Right ears females was (14.27dB)higher than that in the Right ears males (12.12dB)and the mean value of DPI Level in the left ears females was(12.06dB)higher than that in the left ears males (11.09dB) while in male; the mean value of DP1 level in the Right ears males was (12.12dB) higher than that in the left ears males(11.09dB) as shown Figure (4-1).

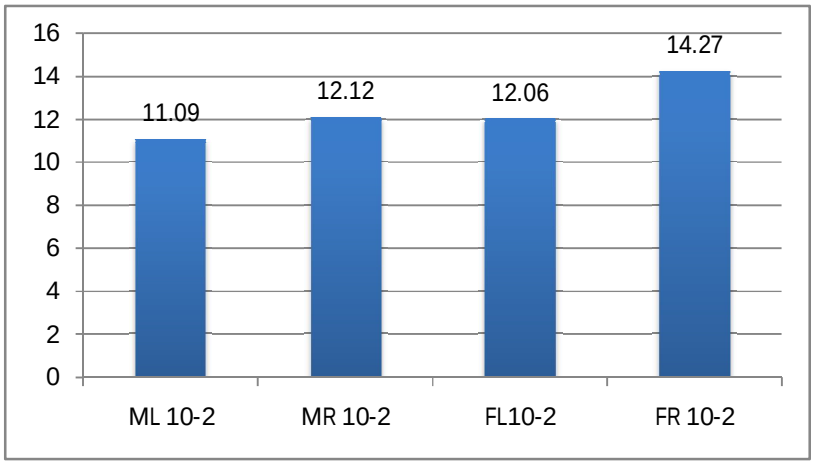


Figure (4-1) Comparison between average of DP1 level for females and males forIraqi Subjects group-I

Table (9) in appendix-A indicate that in group-I (2-10)year; the mean value of signal noise ratio(SNR dB) for Right ears females was (13.94dB) higher than that in left ears females(11.10dB)and The mean value of SNR in the Right ears females was (13.94dB)higher than that in the Right ears males (11.3dB)and the mean value of SNR in the left ears

femaleswas(11.10dB)higher than that in the left ears males (10.19dB)while in malethe mean value of SNR in the Right ears males was (11.3dB) higher than that in the left ears males(10.19dB) as shown Figure (4-2).

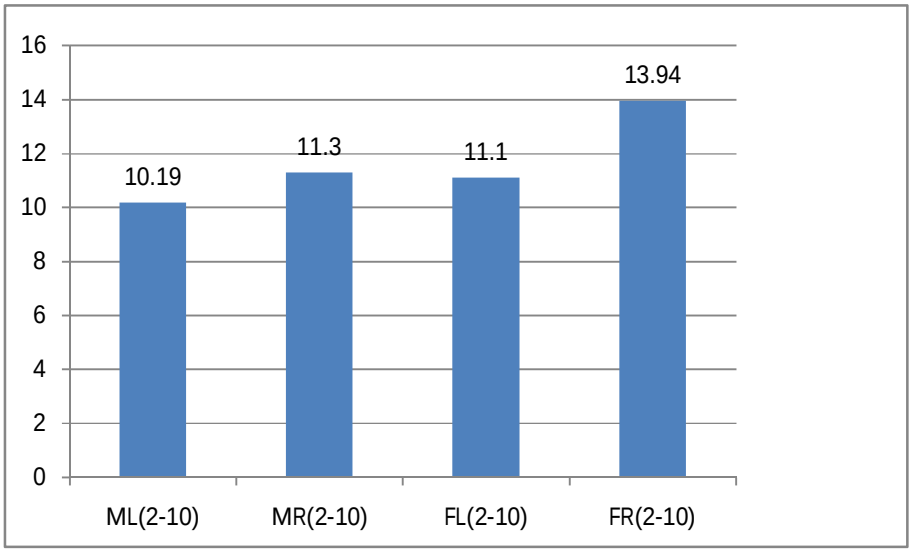


Figure (4-2) Comparison between average of SNR for females and males forIraqi Subjects group-I (2-10) years.

Table (18) in appendix-B indicate that ingroup II (11-20) years; the mean value of DP1 Level for Right ears females was (11.57dB) higher than that in left ears females(9.67dB) and The mean value of DP1 level in the Right earsfemales was (11.57dB) higher than that in the Right ears males(7.13dB), the mean value of DPI level in the left ears females was(9.06dB) higher than that in the left ears males (5.81)while in male; the mean value of DP1 level in the Right ears males was (7.15dB) higher than that in the left ears males (5.81dB) as shown in Figure (4-3).

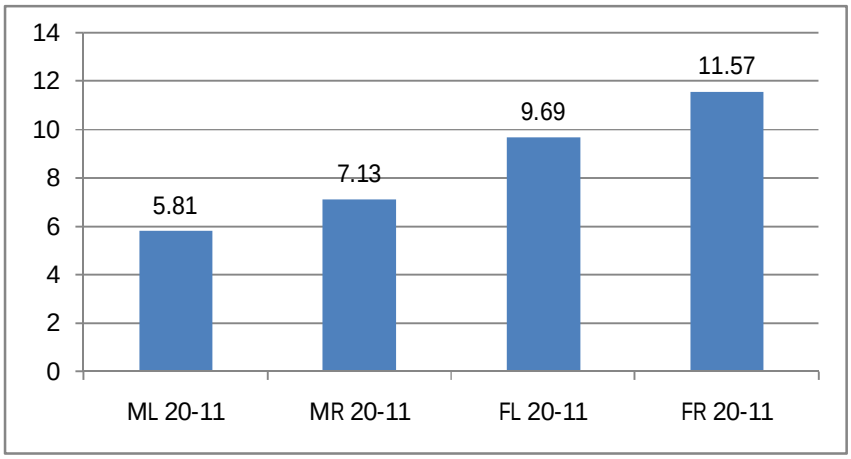


Figure (4-3) Comparison between average of DP1 level for Right and left ear

side of females and males for Iraqi Subjects group-II.

Table (18) in appendix-B indicate that ingroup II (11-20) years; the mean value of SNR in Right ears females was (10.97dB) higher than that in left ears females(9.55dB) and The mean value of SNR in the Right ears females was (10.97dB) higher than that in the Right ears males(10.71dB), the mean value of SNR in the left ears females (9.55dB) higher than that in the left ears males (9.5)while in male; the mean value of SNR in the Right ears males was (10.71dB) higher than that in the left ears males (9.5dB) as shown in Figure (4-4).

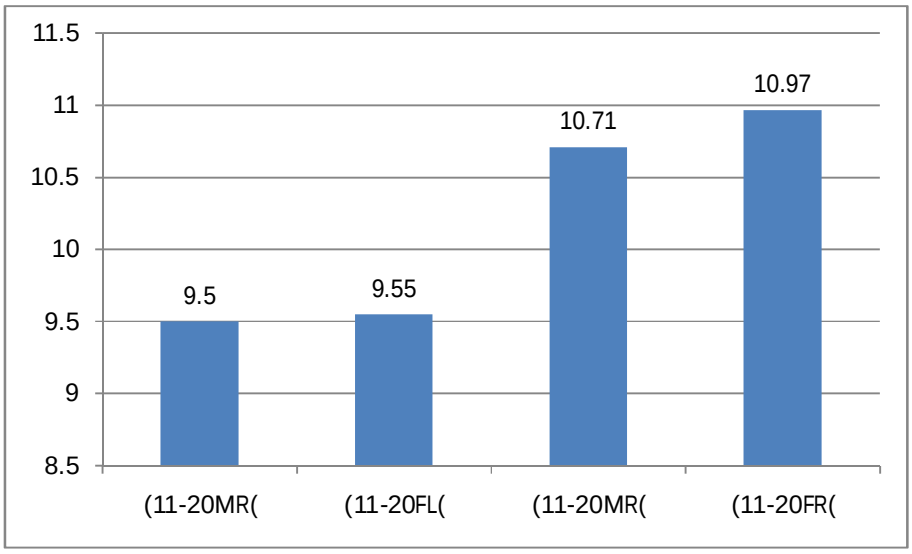


Figure (4-4) Comparison between average of SNR for Right and left ear sideof females and males for Iraqi Subjects group-II (11-20) years.

Table (27) in appendix-C indicate that in group III (21-30)years ; the mean value of DP1 Level for Right ears femaleswas (8.22dB) higher than that in left ears females(7.39dB) and the mean value of DP1 level in the Right ears females was (8.22dB) higher than that in the Right ears males (5.69dB), The mean value of DPI Level in the left ears females was(7.39dB)higher than that in the left ears males (4.98dB), while in male; the mean value of DP1 level in the Right ears males was(5.69dB) higher than that in the left ears males as shown in Fig (4-5).

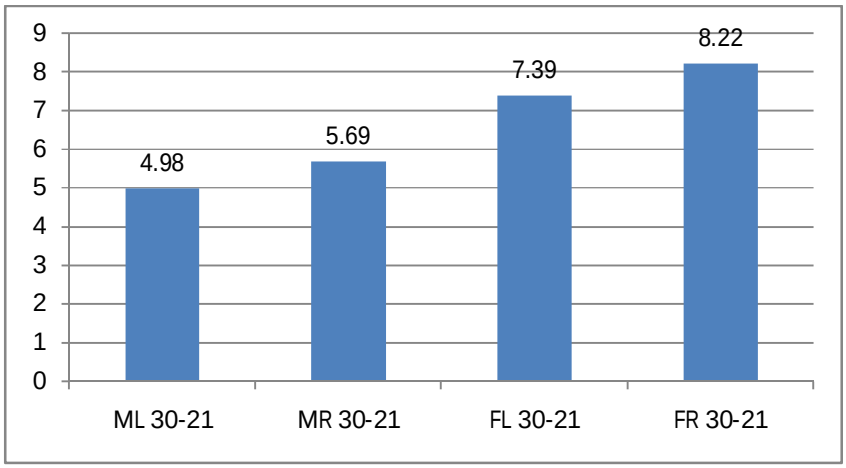


Figure (4-5)Comparison between average of DP1 level for Right and left ear side of females and males for Iraqi Subjects group-III

Table (27) in appendix-C indicate that in group III (21-30)years ; the mean value of SNR for Right ears females was (10.8dB) higher than that in left ears females(9.62dB) and The mean value of SNR in the Right ears females was (10.8) higher than that in the Right ears males (9.83dB), the mean value of SNR in the left ears females was(9.62dB)higher than that in the left ears males (9.48dB), while in male; the mean value of SNR in the Right ears males was(9.83) higher than that in the left ears males(9.48) as shown in Figure (4-6).

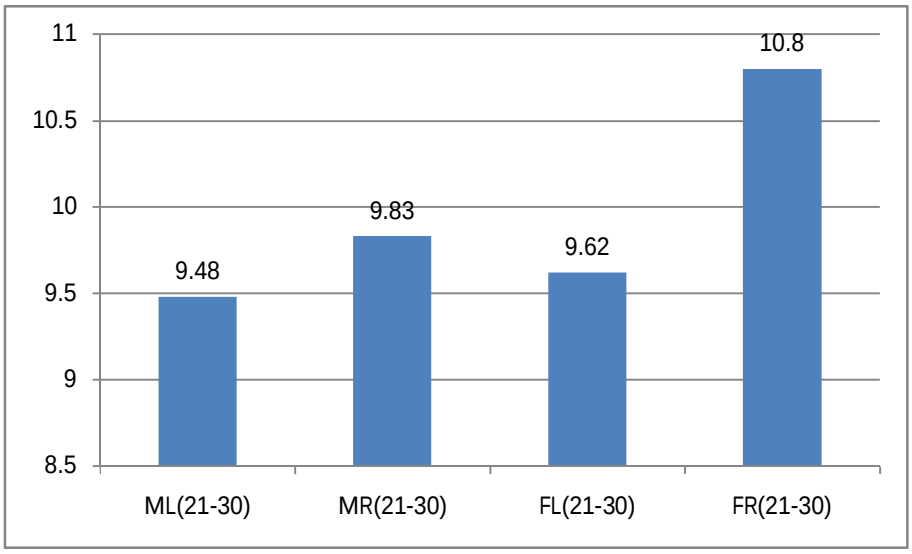


Figure (4-6) Comparison between average of SNR for Right and left ear side of females and males for Iraqi Subjects group-III (21-30) years.

Table(36) in appendix-D indicate that in group-IV(31-40)year; the mean value of DP1 Level for Right ears females was (3.66dB) higher than that in left earsfemales(2.55dB) and it's also higher than that in the Right earsmales (2.54dB), the mean value of DPI Level in the left earsfemales was(2.55dB) higher than that left ears males (1.08dB),while in male; the mean value of DP1 level in the right earsmales was (2.54dB) higher than that in the left ears males(1.08dB) as shown in Figure (4-7)

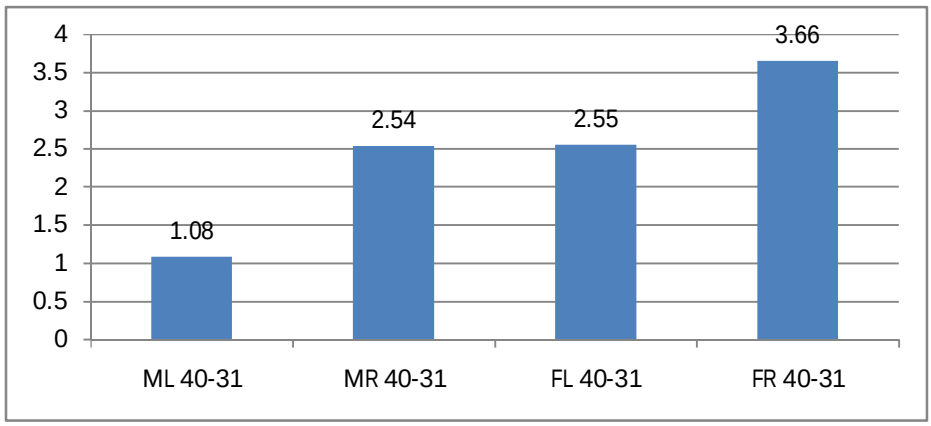


Figure (4-7) Comparison between average of DP1 level for Right and left ear side of females and males for Iraqi Subjects group-IV (31-40) years.

Table(36) in appendix-D indicate that in group-IV(31-40)year; the mean value of SNR for Right ears females was (5.02dB) higher than that in left ears females(4.22dB) and also higher than that in the Right ears males (4.59dB), the mean value of SNR in the left ears females was(4.22dB) higher than that left ears males (3.96dB),while in male; the mean value of SNR in the Right ears males was (4.59dB) higher than that in the left ears males(3.96dB) as shown in Figure (4-8).

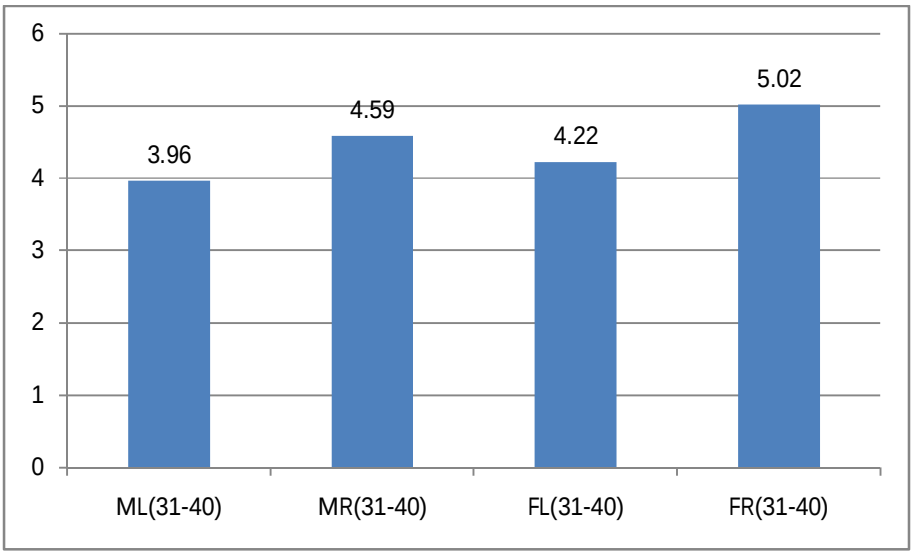


Figure (4-8) Comparison between average of SNR for Right and left ear side of females and males for Iraqi Subjects group-IV (31-40) years.

The results as shown in Tables (37 and 38) in appendix-E indicate thatthe mean value of SNR in young subjects (2-10) year was higherthan other groups and also the mean value of SNR in group-II (11-20) year was higher than that in groups (III and IV) and the mean value of SNR in group III (21-30) year was higher than that in group IV (31-40) year as shown in Figures (4-9 and 4-10) for Right and Left ear side of female and male respectively

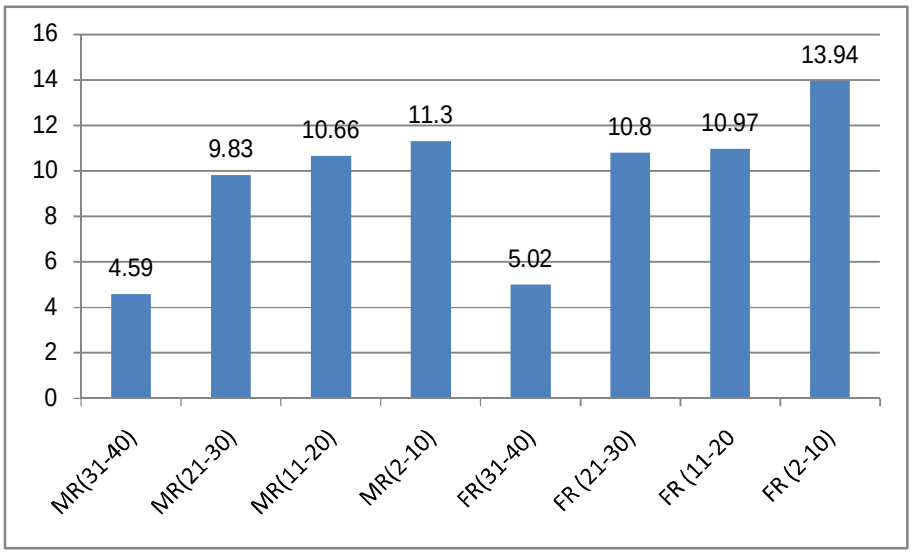


Figure (4-9) Comparison between average of SNR for Right ear side of females and males for all groups of Iraqi Subjects.

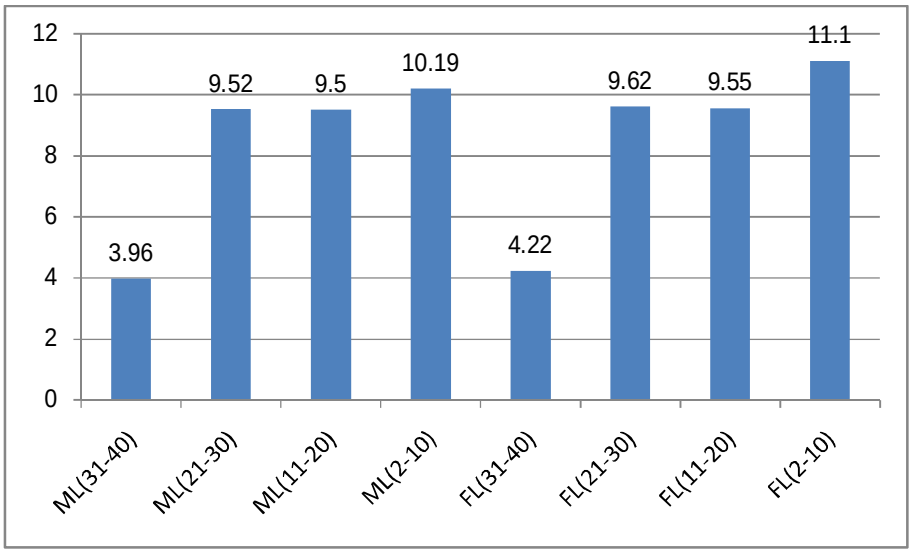


Figure (4-10) Comparison between average of SNR for Left ear side of females and males for all groups of Iraqi Subjects.

The results as shown in Tables (39 and 40) in appendix-E indicate that the mean value of DPI in young subjects (2-10) year was higherthan other groups and also the mean value of DPI level in group-II (11-20) year was higher than that in groups (III and IV) andthe mean value of DPI level in group III (21-30) year was higherthan that in group IV (31-40) year as shown in Figures (4-11 and 4-12) for Right and Left ear side of female and male respectively.

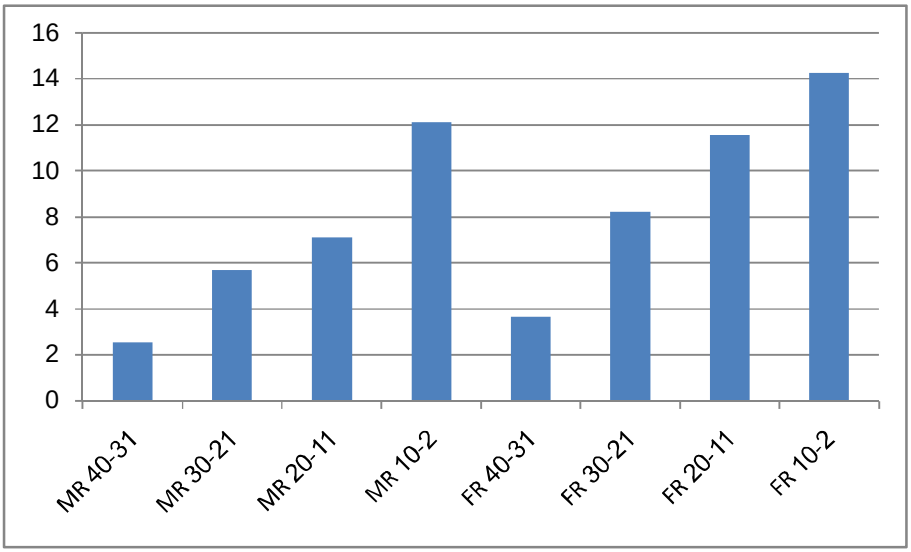


Figure (4-11)Comparison between average of DP1 level for Right ear side of Females and males for all groups of Iraqi Subjects

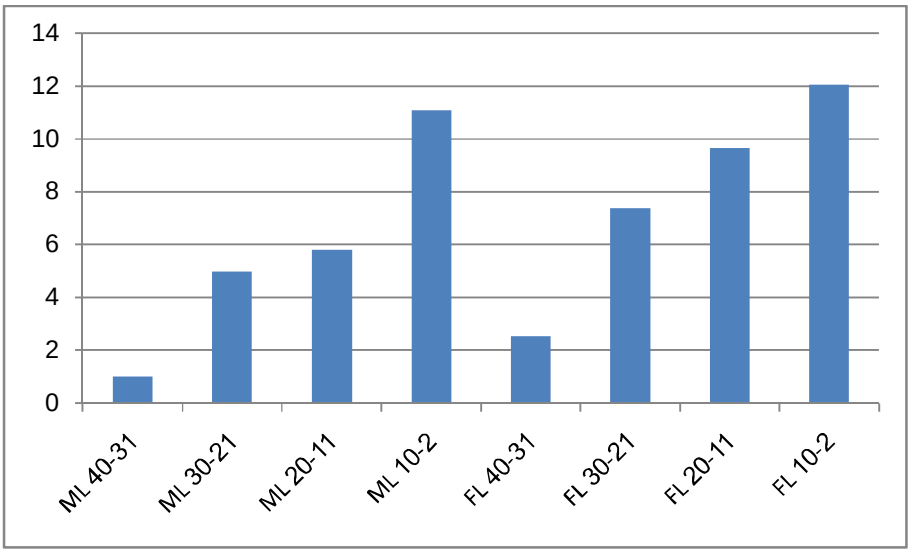


Figure (4-12)Comparison between average of DP1 level for Left ear side of females and males for all groups of Iraqi Subjects

The findings from the present study revealed an ear asymmetry, gender and age effect on DPOAEs level DPI and SNRs dB in all Iraqi subjects groups, Right ears were found to produce higher DPOAEs level DPI and SNRs dB than left ears butstatistically used T-Test (2-Tailed) no significant difference of DPOAEs level and SNR were observed between the right and left ears and also females have higher DPI level and SNRs than that males but no significant difference were observed between females and male. according to age groups the mean value of (DPI) and SNR in group I (2-10) year was higher than that other groups statistically used ANOVA-Test significant difference among age groups $p<0.05$.

4-2 Results for Sudanese Subjects:

Only normal hearing for Sudanese subjects was enrolled in this study. Data taken for Sudanese subjects are recorded in appendixes (F), (G), (H) and (I) in Tables (41 to 71). The data in Appendix (F) included Tables (41 to 49) for Group (I) age (2-10) year , the data in appendix(G) included Tables(50-58) for Group (II)age (11-20) year and the data in appendix(H) included Tables (59-67) for Group (III) age(21-30)year .All appendixes were contained Distortion product otoacoustic emission level (DP1 level) dB for Right ear and Left ear male, Signal Noise Ratio (SNRs) dB for Right ear and Left ear male, (DPI Level) dB for Right ear female and Left ear female, (SNRs) for Right andLeft ear female at each frequency respectively andcomparison between average of DP1 level and SNR for females and males.

Appendix (I)included Tables (68-71) comparison between average of DP1and SNRs of Right ear side and Left ear side for females and males at each frequency for all groups (2-10) year,(11-20) year and (21-30) year Respectively. In the present study, the overall SNR for each tested ear was more than 3 dB SPL at the overall frequency bands (0.5, 0.75, 1.0, 1.5, 2.0, 3.0,4.0, 6.0 and 8.0 kHz).The results showed that the minimum and the maximum of the mean value of the Distortion Product (DP1 Level) recorded for all tested ears was (-1.22dB) for female Left ear side in group-III age (21-30) year at 0.5kHz and (21.47dB) for female Right ear side in group-I age (2-10) year at 6.0kHz respectively over frequency bands 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 kHz.

Table (49) in appendix-F indicate that in group I (2-10)year; the mean value of DP1 Level for Right ears females was (15.23dB) higher than that in left ears females(13.42dB)and the mean value of DP1 level in the Right ears females was (15.23dB)higher than that in the Right ears males (12.65dB)andthe mean value of DPI Level in the left ears females was(13.42dB)higher than that in the left ears males (11.33dB)while in male; the mean value of DP1 level in the Right ears males was (13.65dB) higher than that in the left ears males(11.33dB) as shown in Figure (4-13).

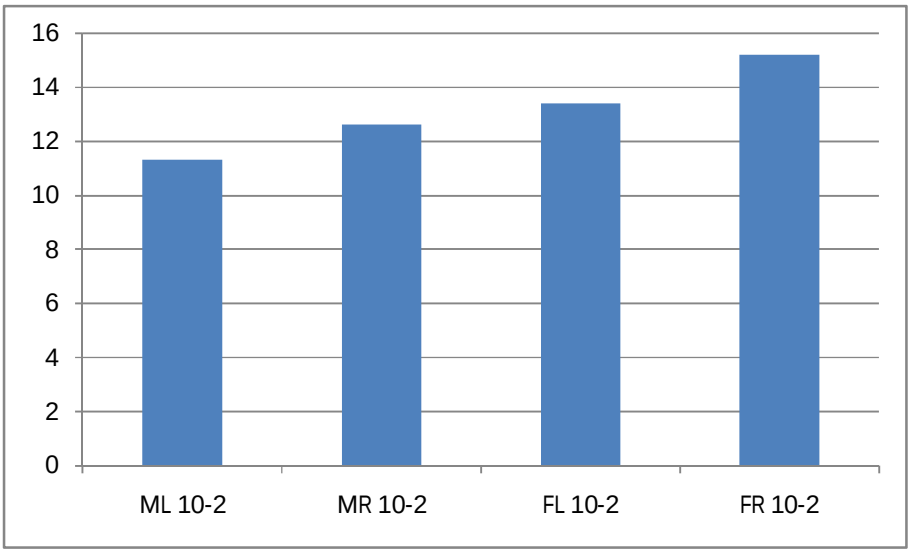


Figure (4-13) Comparison between averages of DP1 level for Right and left ear side of females and malesSudanese Subjects group-I (2-10) years.

Table (49) in appendix-F indicate that in group I (2-10)year; the mean value of SNR dB for Right ears females was (15.29dB) higher than that in left ears females(12.65dB)and the mean value of SNR dB in the Right ears females was (15.29dB)higher than that in the Right ears males (11.57dB)and the mean value of SNR dB in the left ears females was(12.65dB)higher than that in the left ears males (10.62dB)while in male; the mean value of SNR dB in the Right ears males was (11.57dB) higher than that in the left ears males(10.62dB) as shown in Figure (4-14).

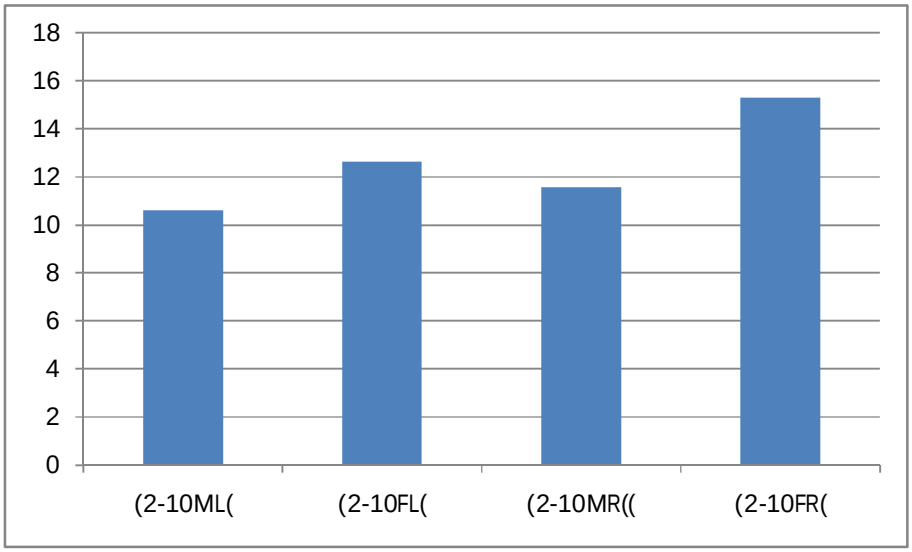


Figure (4-14) Comparison between averages of SNR dB for Right and left ear side of females and malesSudanese Subjects in group-I (2-10) years.

Table (58) in appendix-G indicate that ingroup-II (11-20) years; the mean value of DP1 Level for Right ears females was (11.95dB) higher than that in left ears females(10.37dB) and The mean value of DP1 level in the Right earsfemales was (11.95dB) higher than that in the Right ears males(8.55dB), the mean value of DPI level in the left ears females was(10.37dB) higher than that in the left ears males (6.46)whilein male; the mean value of DP1 level in the Right ears males was (8.55dB) higher than that in the left ears males (6.46dB) as shown in Figure (4-15).

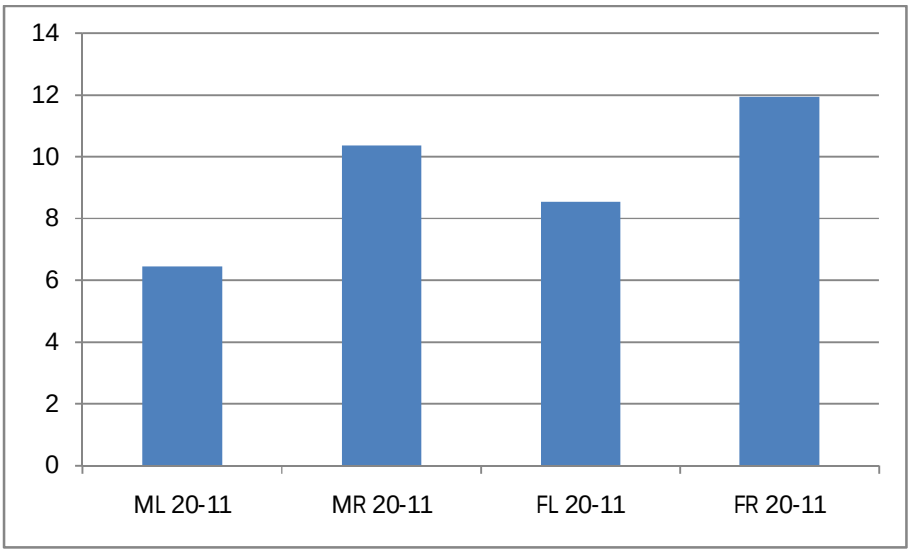


Figure (4-15) Comparison between average of DP1 level for Right and left ear Side of females and males Sudanese Subjects group-II (11-20) years.

Table (58) in appendix-G indicate that in group-II (11-20) years; the mean value of for Right ears females was (11.37dB) higher than that in left ears females(10.29dB) and The mean value of SNR dB in the Right ears females was (11.37dB) higher than that in the Right ears males(11.13dB), the mean value of SNR dB in the left ears females was(10.29dB) higher than that in the left ears males (10.01)whilein male; the mean value of SNR dB in the Right ears males was (11.13dB) higher than that in the left ears males (10.01dB) as shown in Figure (4-16).

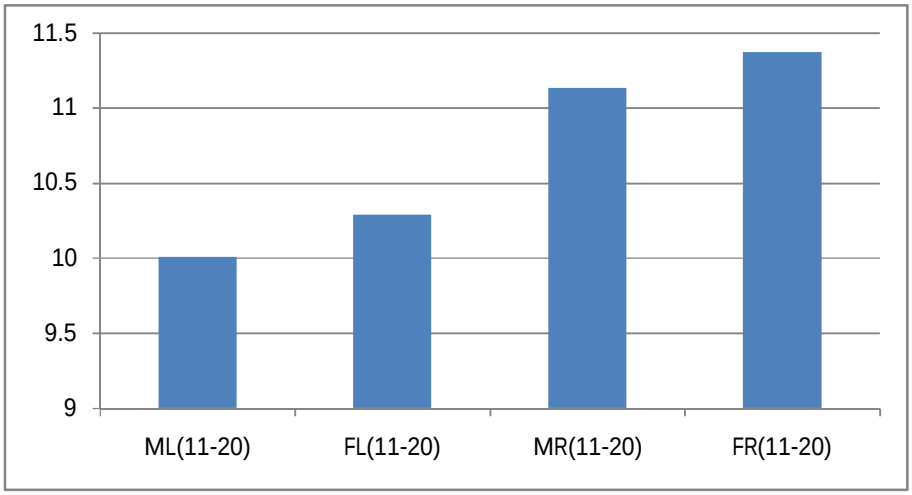


Figure (4-16) Comparison between averages of SNR dB for Right and left ear side of females and malesSudanese Subjects in group-II (11-20) years.

Table (67) in appendix-H indicate that in group III (21-30)years ; the mean value of DP1 Level for Right ears femaleswas (8.69dB) higher than that in left ears females(8.31dB) and The mean value of DP1 level in the Right ears females was (8.69dB) higher than that in the Right ears males (6.92dB), themean value of DPI Level in the left ears females was(8.31dB)higher than that in the left ears males (6.09dB), while in male; the mean value of DP1 level in the Right ears males was(6.92dB) higher than that in the left ears males (6.09dB) as shown in Figure (4-17).

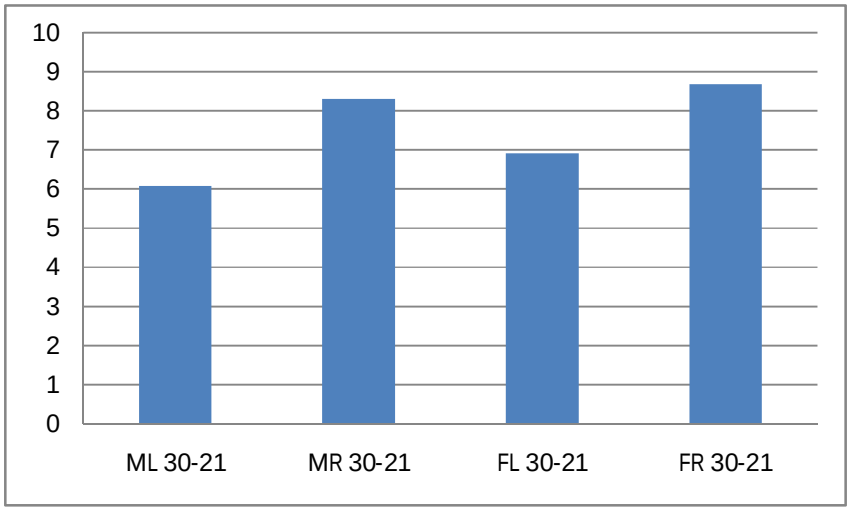


Figure (4-17) Comparison between average of DP1 level for females and males Sudanese Subjects group-III

Table (67) in appendix-H indicate that in group III (21-30)years ; the mean value of SNR dB for Right ears females was (11.30) higher than that in left ears females(10.15dB) and The mean value of SNR in the Right ears females was (11.30dB) higher than that in the Right ears males (10.59dB), the mean value of SNR in the left ears females was(10.15dB)higher than that in the left ears males (10dB), while in male; the mean value of SNR in the Right ears males was(10.59dB) higher than that in the left ears males (10dB) as shown in Figure (4-18).

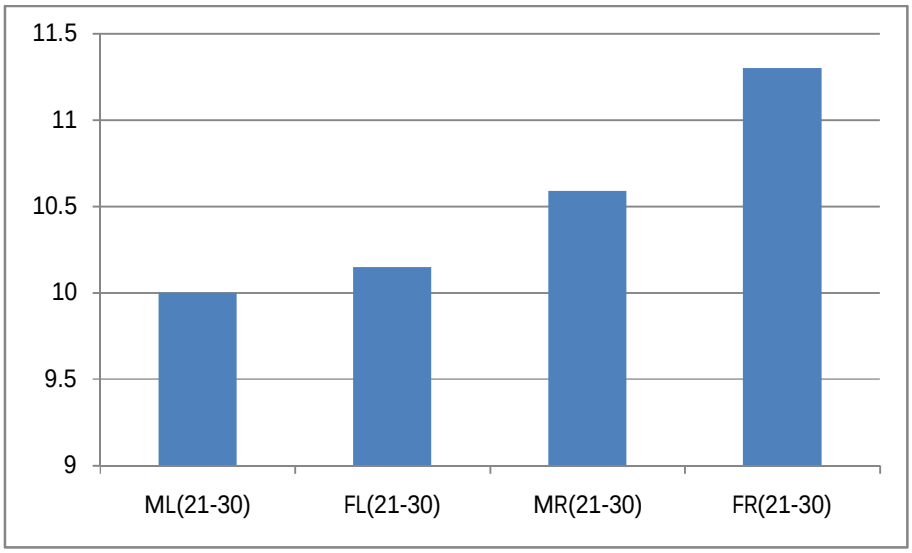


Figure (4-18) Comparison between averages of SNR dB for Right and left ear side of females and malesSudanese Subjects in group-III (21-30) years.

The results as shown in Tables (70 and 71) in appendix-I indicate that the mean value of DPI in young subjects (2-10) year was higherthan other groups and also the mean value of DPI level in group (11-20) year was higher than that in group III (21-30) as shown in Figures (4-19 and 4-20) for Right and Left ear side of female and male respectively.

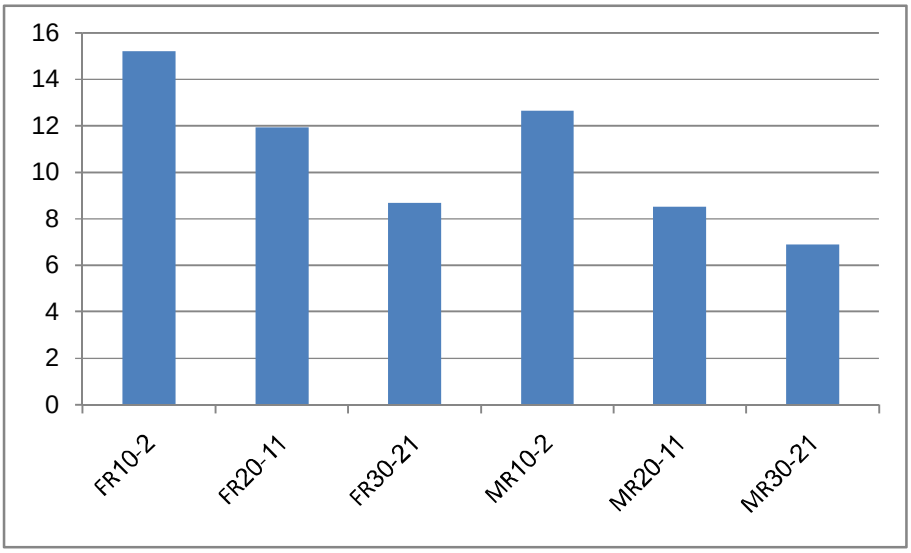


Figure (4-19) Comparison between average of DP1 level for Right ear side of females and males for all groups of Sudanese Subjects.

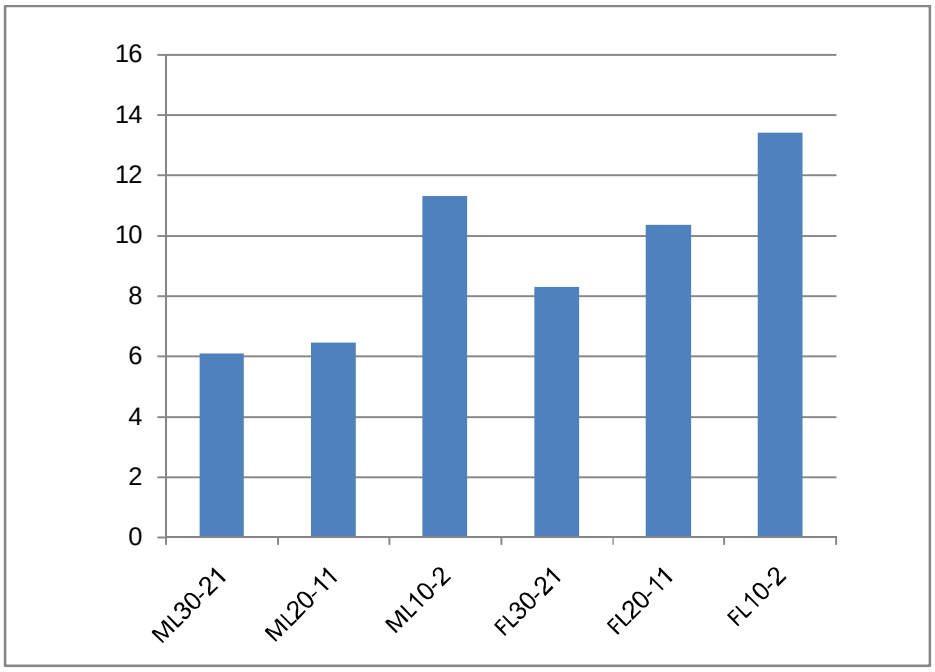


Figure (4-20) Comparison between average of DP1 level for Left ear side of females and males for all groups of Sudanese Subjects.

The results as shown in Tables (70 and 71) in appendix-I indicate that the mean value of SNR in young subjects (2-10) year was higher than other groups and also the mean value of SNR in group II (11-20) year was higher than that in group III (21-30) as shown in Figures (4-21 and 4-22) for Right and Left ear side of female and male respectively.

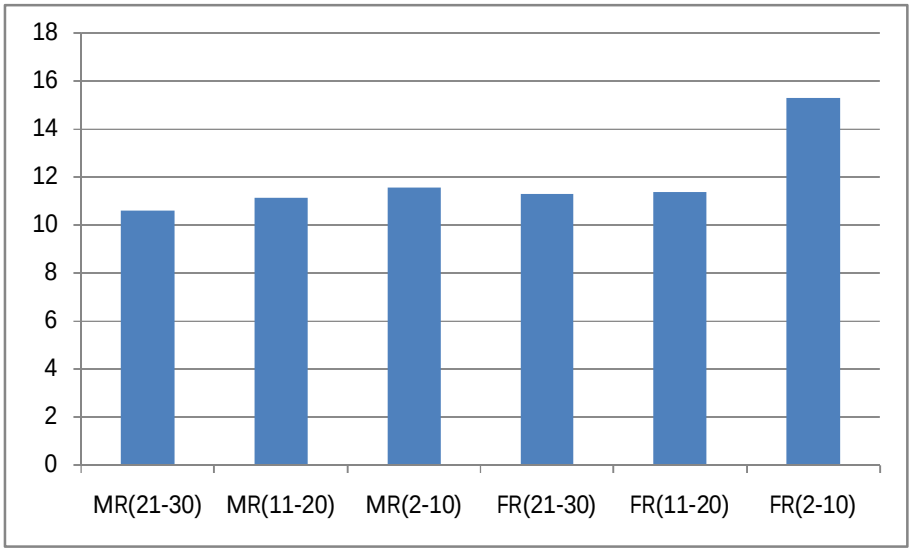


Figure (4-21) Comparison between average of SNR for Right ear side of females and males for all groups of Sudanese Subjects.

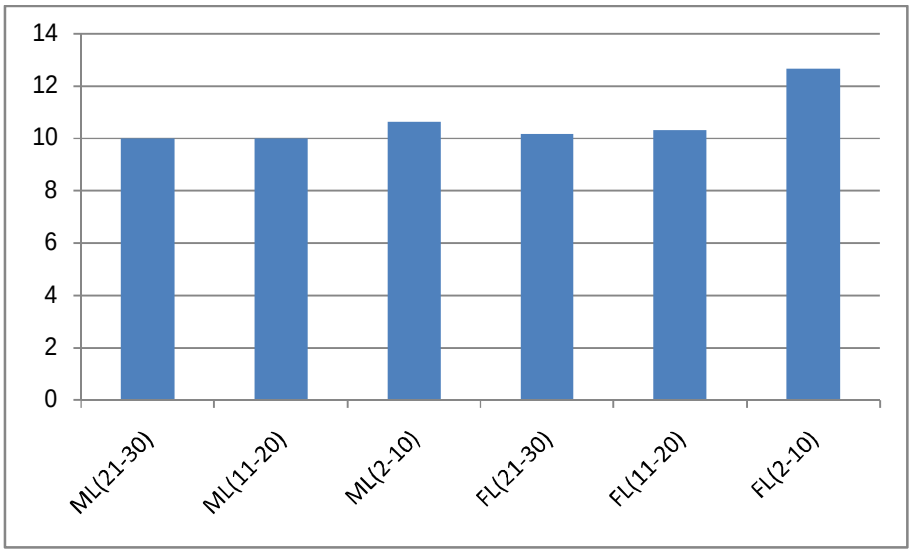


Figure (4-22) Comparison between average of SNR for Left ear side of females and males for all groups of Sudanese Subjects.

The findings from the present study revealed an ear asymmetry, gender and age effect on DPOAEs level (DPI) and SNR dB in all Sudanese subjects groups, Right ears were found to produce higher DPOAEs level (DPI) and SNR than left ears, female ears were found to produce higher DPOAEs level (DPI) than that males ears and also the mean value of DPOAEs level (DPI) and SNR in group I (2-10) year was higher than that in other groups ,the mean value of(DPI) level and SNR in group II(11-20) years was higher than that in groups III (21-30) years, these results are similar for Iraqi subjects results.

4-3 Comparison of Results between Iraqi and Sudanese Subjects:

Tables (72, 73) in appendix-K indicate that in group-I (2-10)year; the mean value of DP1 Level for Right ears females for Sudanese subjects was (15.23dB) higher than that in Right ears females for Iraqi subjects (14.27dB)and The mean value of DP1 level in the Right ears males for Sudanese subjects was (12.65dB)higher than that in the Right ears males for Iraqi subjects (12.12dB)andthe mean value of DPI Level in the left ears females was(13.42dB) for Sudanese subjects higher than that in the left ears females (12.06dB) for Iraqi subjects and the mean value of DP1 level in the Left ears males for Sudanese subjects was (11.33dB) higher than that in the left ears males(11.09dB) as shown in Figures (4-23,24) respectively.

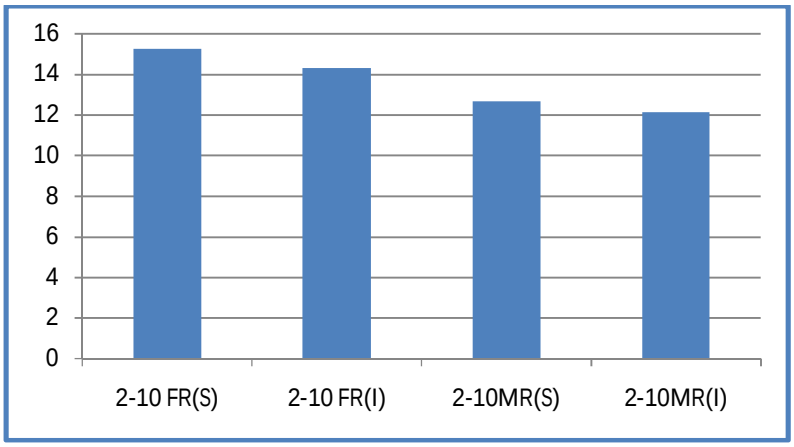


Figure (4-23)Comparison between average of DP1 level for Right ear side of females and males of Iraqi and Sudanese Subjects Group-I.

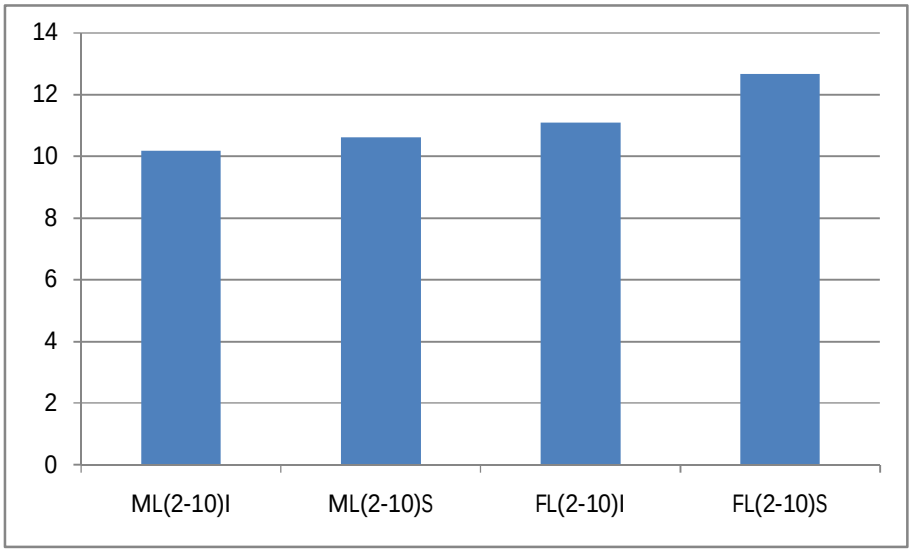


Figure (4-24)Comparison between average of DP1 level for Left ear side of females and males for of Iraqi and Sudanese Subjects Group-I.

Tables (72, 73) in appendix-K indicate that in group-II (11-20)year; the mean value of DP1 Level for Right ears females for Sudanese subjects was (11.95dB) higher than that in Right ears females for Iraqi subjects (11.57dB) and The mean value of DP1 level in the Right ears males for Sudanese subjects was (8.55dB) higher than that in the Right ears males for Iraqi subjects (7.13dB) and the mean value of DPI Level in the left ears females was(10.37dB) for Sudanese subjects higher than that in the left ears females (9.67dB) for Iraqi subjects and the mean value of DP1 level in the Left ears males for Sudanese subjects was (6.46dB) higher than that in the left ears males (5.81dB) as shown in Figures (4-25,26) respectively.

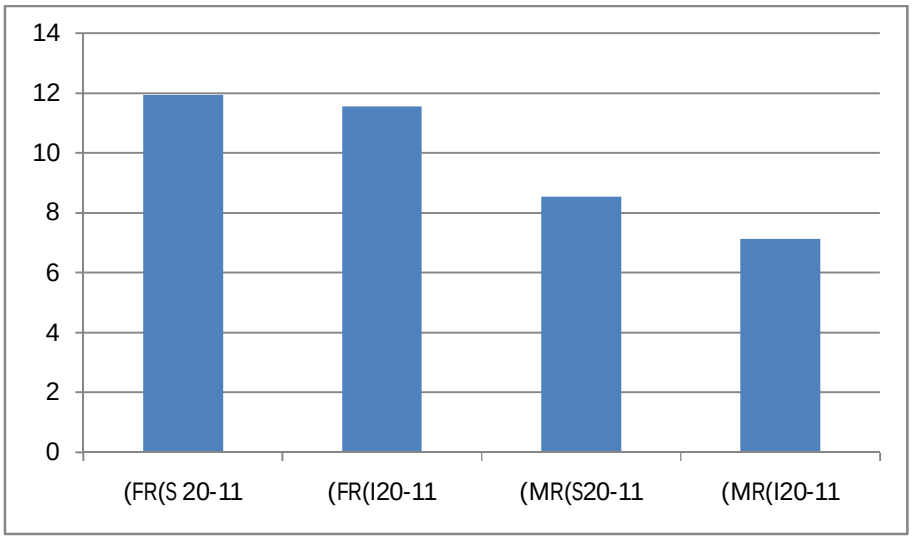


Figure (4-25) Comparison between average of DP1 level for Right ear side of females and males of Iraqi and Sudanese Subjects Group-II.

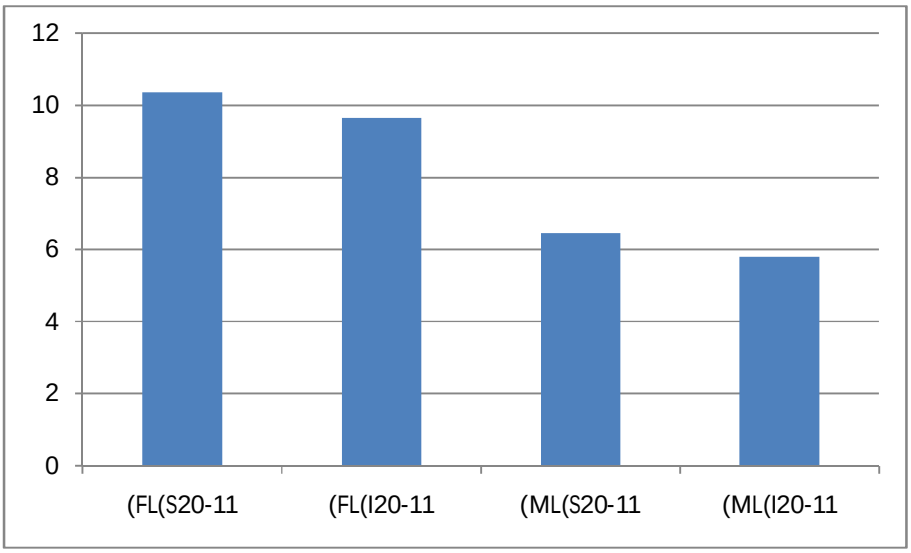


Figure (4-26) Comparison between average of DP1 level for Left ear side of females and males of Iraqi and Sudanese Subjects Group-II.

Tables (72, 73) in appendix-K indicate that in group-III (21-30)year; the mean value of DP1 Level for Right ears females for Sudanese subjects was (8.69dB) higher than that in Right ears females for Iraqi subjects (8.22dB) and The mean value of DP1 level in the Right ears males for Sudanese subjects was (6.92dB) higher than that in the Right ears males for Iraqi subjects (5.69dB) and the mean value of DPI Level in the left ears females was(8.31dB) for Sudanese subjects higher than that in the left ears females (7.39dB) for Iraqi subjects and the mean value of DP1 level in the Left ears males for Sudanese subjects was (6.09dB) higher than that in the left ears males (4.98dB) as shown in Figures (4-27,28) respectively.

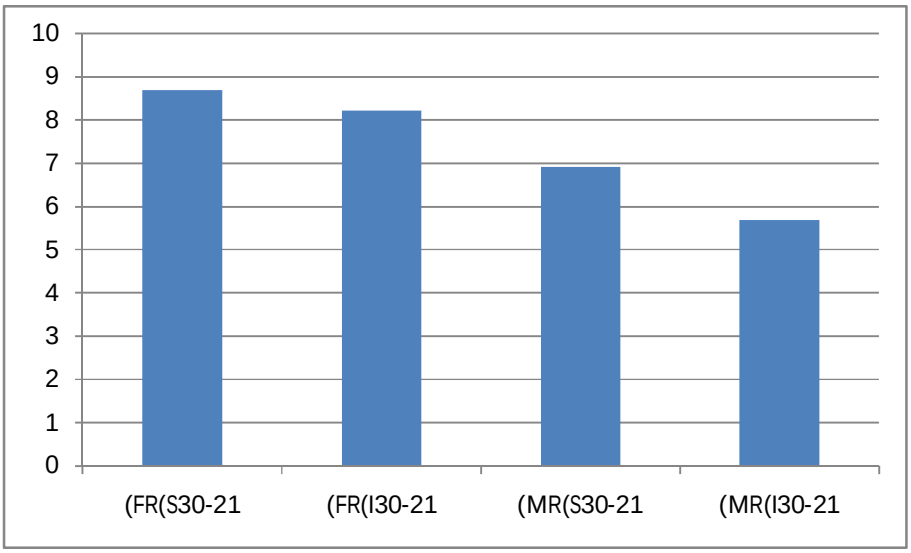


Figure (4-27)Comparison between average of DP1 level for Right ear side of females and males of Iraqi and Sudanese Subjects Group-III

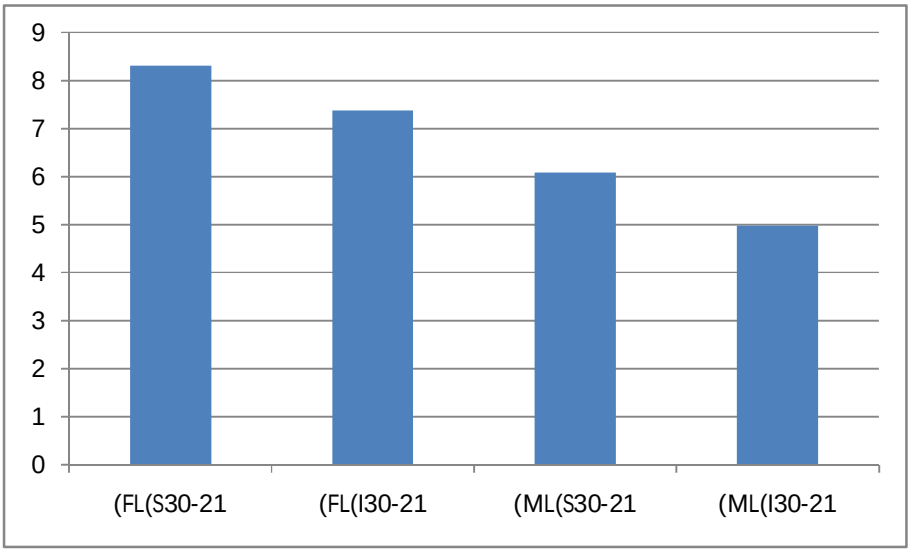


Figure (4-28)Comparison between average of DP1 level for Left ear side of females and males of Iraqi and Sudanese Subjects Group-III

The results as shown in Tables (72 and 73) in appendix-K indicate that the mean value of DPI in Sudanese subjects was higherthan that in Iraqi subjects for all groups as shown in Figures (4-29 and 4-30) for Right and Left ear side of female and male respectively.

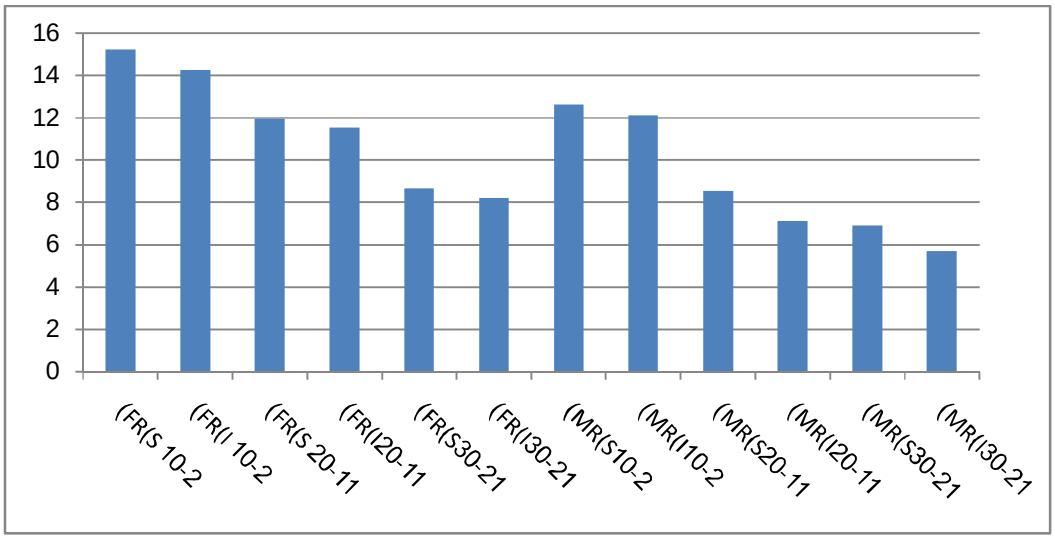


Figure (4-29) Comparison between average of DP1 level for Right ear side of females and males for all groups of Iraqi and Sudanese Subjects.

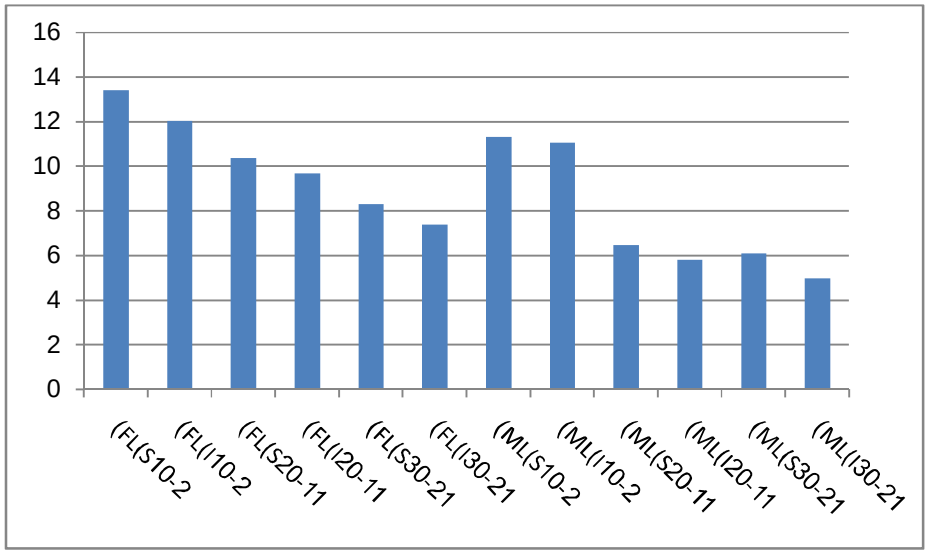


Figure (4-30) Comparison between average of DP1 level for Left ear side of females and males for all groups of Iraqi and Sudanese Subjects.

Tables (74, 75) in appendix-K indicate that in group-I (2-10)year; the mean value of SNR for Right ears females for Sudanese subjects was (15.29) higher than that in Right ears females for Iraqi subjects (13.94dB)and The mean value of SNR in the Right ears males for Sudanese subjects was (11.57dB)higher than that in the Right ears males for Iraqi subjects (11.3dB)and the mean value of SNR in the left ears females was(12.65dB) for Sudanese subjects higher than that in the left ears females (11.10dB) for Iraqi subjects and the mean value of SNR in the Left ears males for Sudanese subjects was (10.62dB) higher than that in the left ears males(10.19dB) for Iraqi subjects as shown in Figures (4-31,32) respectively.

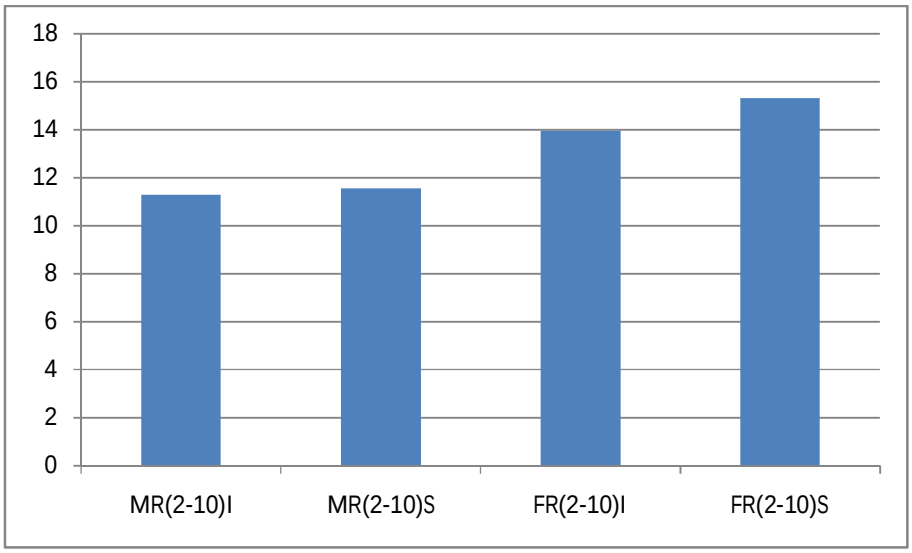


Figure (4-31)Comparison between average of SNR dB for Right ear side of females and males for Iraqi and Sudanese Subjects Group-I

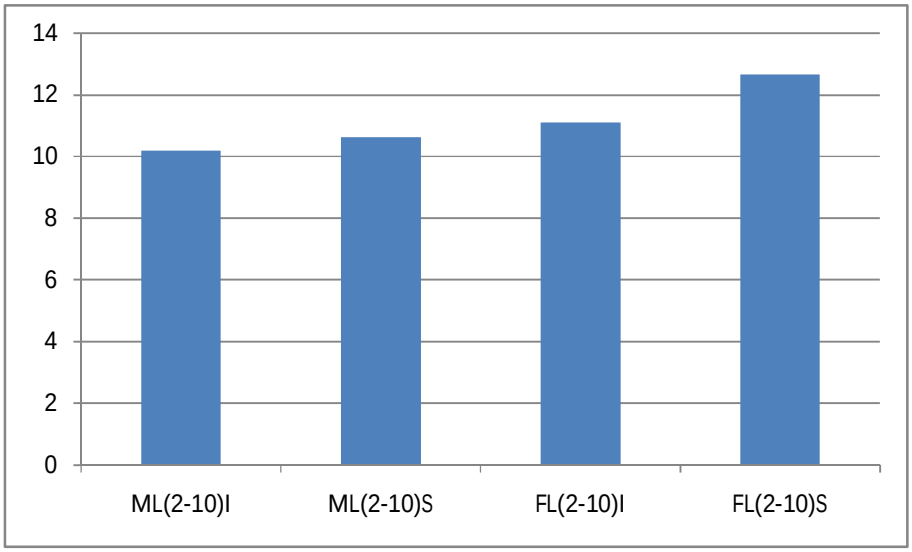


Figure (4-32) Comparison between average of SNR dB for leftear side of females and males for Iraqi and Sudanese Subjects Group-I.

Tables (74, 75) in appendix-K indicate that in group-II (11-20)year; the mean value of SNR dB for Right ears females for Sudanese subjects was (11.37dB) higher than that in Right ears females for Iraqi subjects (10.97dB) and The mean value of SNR dB in the Right ears males for Sudanese subjects was (11.13dB) higher than that in the Right ears males for Iraqi subjects (10.71dB) and the mean value of SNR dB in the left ears females was(10.29dB) for Sudanese subjects higher than that in the left ears females (9.55dB) for Iraqi subjects and the mean value of SNR in the Left ears males for Sudanese subjects was (10.01dB) higher than that in the left ears males (9.5dB) for Iraqi subjects as shown in Figures (4-33,34) respectively.

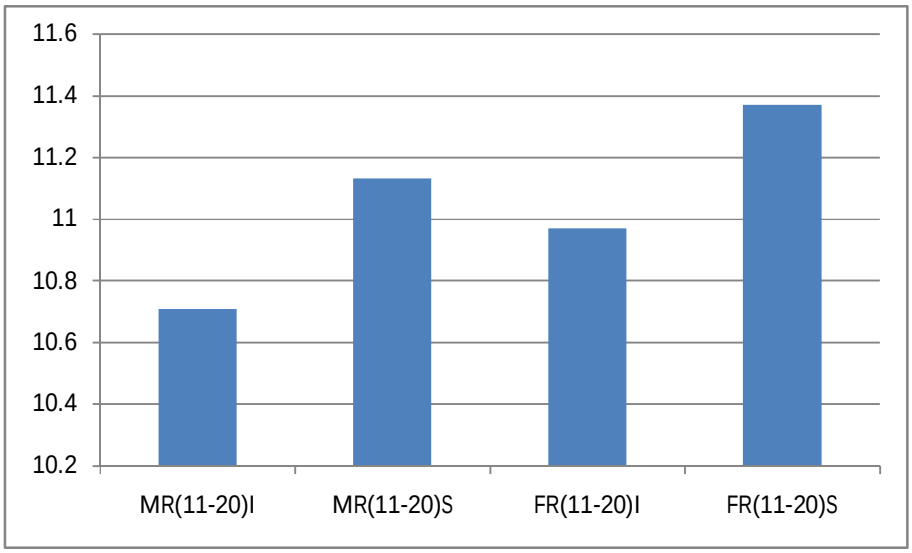


Figure (4-33) Comparison between average of SNR dB for Right ear side of females and males for Iraqi and Sudanese Subjects Group-II.

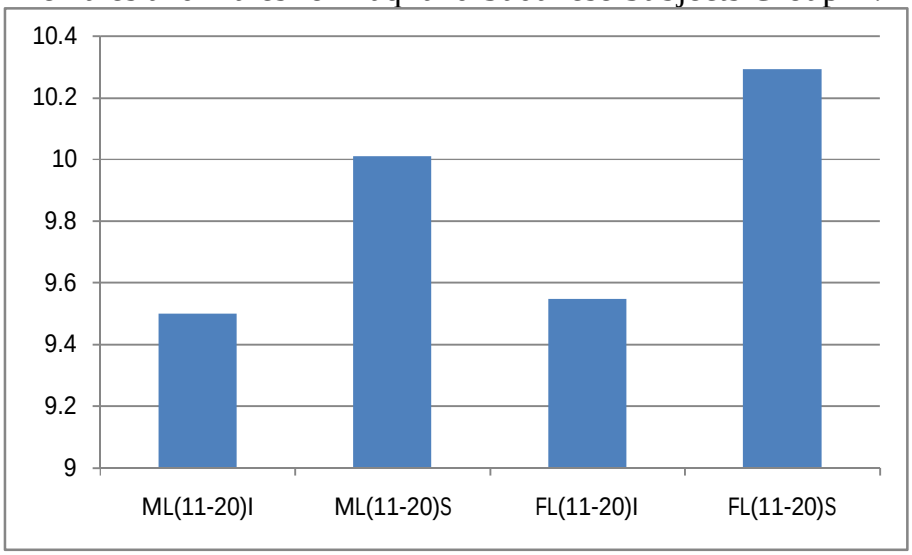


Figure (4-34) Comparison between averages of SNR dB for leftear side of females and males for Iraqi and Sudanese Subjects Group-II.

Tables (74, 75) in appendix-K indicate that in group-III (21-30)year; the mean value of SNR for Right ears females for Sudanese subjects was (11.30) higher than that in Right ears females for Iraqi subjects (10.8dB)and The mean value of SNR in the Right ears males for Sudanese subjects was (10.59dB)higher than that in the Right ears males for Iraqi subjects (9.83dB)and the mean value of SNR in the left ears females was(10.15dB) for Sudanese subjects higher than that in the left ears females (9.62dB) for Iraqi subjects and the mean value of SNR in the Left ears males for Sudanese subjects was (10 dB) higher than that in the left ears males(9.48dB) forIraqi subjects as shown in Figures (4-35, 36) respectively.

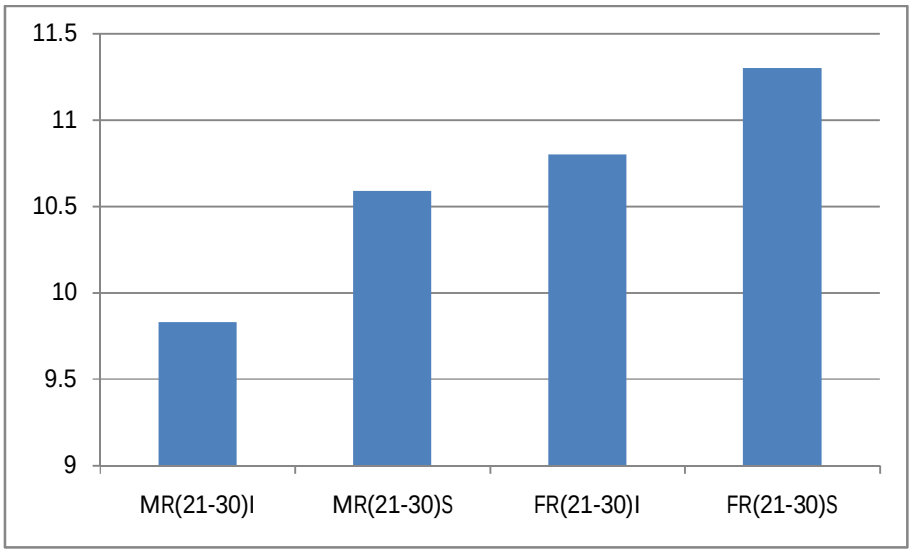


Figure (4-35) Comparison between average of SNR dB for Right ear side offemales and males for Iraqi and Sudanese Subjects Group-III.

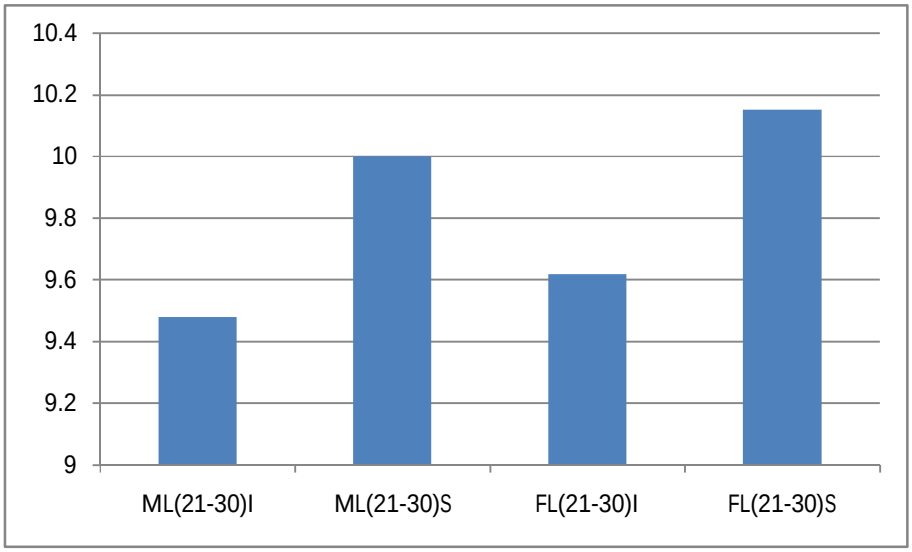


Figure (4-36) Comparison between averages of SNR dB for left ear side of females and males between Iraqi and Sudanese Subjects Group-III.

The results as shown in Tables (74 and 75) in appendix-K indicate that the mean value of SNR in Sudanese subjects was higherthan that in Iraqi subjects for each group as shown in Figures (4-37 and 4-38) for Right and Left ear side of female and male respectively.

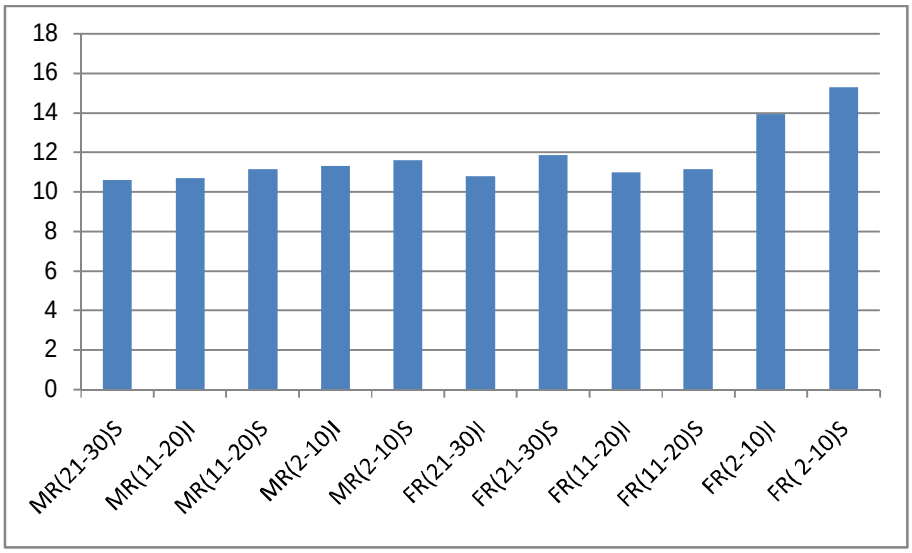


Figure (4-37) Comparison between average of SNR for Right ear side of females and males for all groupsbetween Iraqi and Sudanese Subjects.

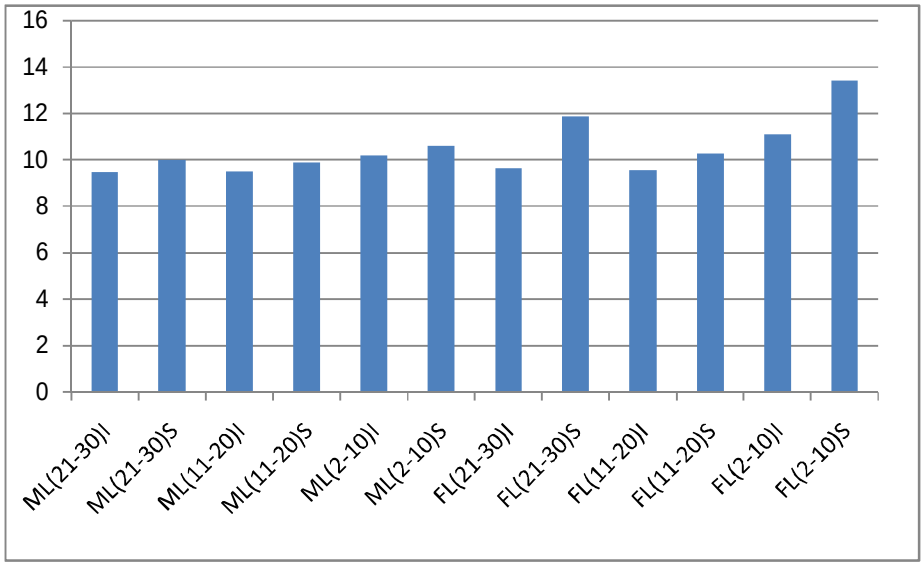


Figure (4-38) Comparison between average of SNR for left ear side of females and males for all groups of Iraqi and Sudanese Subjects.

The findings from the present study revealed racial effects on the DPOAEs level (DPI) and SNR between Iraqi and Sudanese subjects and are agreementwith the results of (Lura et al., 2007).

4-4 Model of Equation to evaluate the Rate of change in DPI with Respect of Frequency:

The researcherproposedModel include linear and nonlinear Equations as in Figures (1-24) in appendix-J depending on the results in the Table (72 and 73) in appendix-k to evaluate the rate of change in DPI Levelwith respect of frequency for group-I, II and III Iraqiand Sudanese Subjects with normal hearing and without depended on device

4-4-1 Nonlinear model Equation:

Table (4-1) Show Nonlinear Equation of The Rate of change in DPI Level Represent (Y) with respect with Frequencies Represent (x) for all Group-I, II and III for Iraqi and Sudanese subjects, R^2 equal the power of the value (x) represent frequency to Explain DPI represent(Y).

Table(4-1) Nonlinear Equation

Description/Gend. &side	**Iraqi Subjects Y**	**Sudanese Subjects Y**
FR(2-10) Years	$-0.506x^2+5.362x+5.81$ $R^2=0.72$	$-0.469x^2+5.333x+8.63$ $R^2=0.78$
FR(11-20)Years	$-0.11x^2+1.717x+8.10$ $R^2=0.64$	$-0.112x^2+1.652x+5.81$ $R^2=0.55$
FR(21-30)Years	$-0.18x^2+3.723x-4.67$ $R^2=0.88$	$-0.451x^2+5.545x-1.1149$ $R^2=0.86$
MR(2-10)Years	$-0.2707x^2+3.707x+5.18$ $R^2=0.64$	$-0.184x^2+3.215x+5.82$ $R^2=0.76$
MR (11-20)Years	$-0.014x^2+1.365x+3.288$ $R^2=0.77$	$-0.097x^2+2.081x+3.79$ $R^2=0.77$
MR(21-30)Years	$-0.008x^2+1.122x+0.36$ $R^2=0.65$	$-0.084x^2+1.710x+3.087$ $R^2=0.87$
FL(2-10)Years	$-0.399x^2+4.721x+3.937$ $R^2=0.72$	$-0.383x^2+4.672x+5.2$ $R^2=0.76$
FL (11-20)Years	$-0.097x^2+2.081x+3.79$ $R^2=0.78$	$-0.124x^2+1.868x+6.66$ $R^2=0.80$
FL(21-30)Years	$-0.008x^2+1.122x+0.36$ $R^2=0.76$	$-0.457x^2+5.447+1.108$ $R^2=0.87$
ML(2-10) Years	$-0.256x^2+3.445x+4.637$ $R^2=0.65$	$-0.235x^2+3.259x+5.128$ $R^2=0.61$
ML(11-20)Years	$-0.149x^2+2.380x+1.69$ $R^2=0.55$	$-0.121x^2+1.704x+3.185$ $R^2=0.5$
ML(21-30)Years	$-0.259x^2+2.855x+0.335$ $R^2=0.5$	$-0.288x^2+2.989x+1.479$ $R^2=0.70$

4-4-2Linear model Equation

Table (4-2) Showthe linear equation of The Rate of change in DPI Level Represent (Y) with respect to frequency(x) for all Group-I, II and III for Iraqi and Sudanese subjects, andR^2equal the power of the value (x) represent frequency to Explain DPI represent(Y).

Table(4-2) linear equation

Description\gend. & side	**Iraqi Subjects Y**	**Sudanese Subjects Y**
FR(2-10) Years	1.468x+7.704 R^2=0.55	1.547x+8.824 R^2=0.60
FR(11-20)Years	0.812x+9.142 R^2 =0.6	1.235x+10.59 R^2= 0.42
FR(21-30)Years	1.912x+1.371 R^2= 0.84	1.867x+3.142 R^2= 0.69
MR(2-10)Years	1.035x+0.520 R^2=0.65	1.021x+3.886 R^2= 0.65
MR (11-20)Years	1.247x+3.425 R^2=0.77	1.291x+4.713 R^2= 0.76
MR(21-30)Years	1.035x+0.520 R^2= 0.653	1.021x+3.886 R^2= 0.87
FL(2-10)Years	1.468x+7.704 R^2= 0.55	1.547x+8.824 R^2= 0.60
FL (11-20)Years	0.907x+6.974 R^2= 0.61	0.853x+7.838 R^2= 0.74
FL(21-30)Years	1.306x+3.514 R^2= 0.76	1.718x+3.209 R^2=0.67
ML(2-10) Years	Y=1.358x+7.053 R^2 = 0.56	Y=1.342x+7.348 R^2= 0.54
ML(11-20)Years	0.751x+3.581 R^2=0.426	0.717x+4.327 R^2= 0.42
ML(21-30)Years	Y=;0.740x+2.788 R^2= 0.329	Y=0.637x+4.204 R^2= 0.70

4-4-3 Comparison of R^2

Table (4-3) show Comparison of $R^2$the power of the value (x) represent frequency to Explain DPI represent (Y)) between Linear and Nonlinear Equation for all Group-I, II and III for Iraqi and Sudanese Subjects.

Table (4-3)Comparison of R^2 between Linear and Nonlinear Equation for all Group-I, II and III for Iraqi and Sudanese Subjects**.**

Description Gender , side and Age	Linear Iraqi Subjects	Nonlinear Iraqi Subjects	Linear Sudanese Subjects	NonlinearSudanese Subjects
FR(2-10)Years	0.55	0.72	0.60	0.78
FR(11-20)Years	0.60	0.64	0.42	0.55
FR(21-30)Years	0.64	0.85	0.69	0.86
MR(2-10)Years	0.65	0.64	0.65	0.76
MR(11-20)Years	0.77	0.77	0.75	0.77
MR(21-30)Years	0.58	0.63	0.87	0.87
FL(2-10)Years	0.55	0.72	0.60	0.76
FL(11-20)Years	0.61	0.78	0.74	0.80
FL(21-30)Years	0.76	0.76	0.67	0.87
ML(2-10)Years	0.56	0.65	0.54	0.61
ML(11-20)Years	0.42	0.55	0.42	0.50
ML(21-30)Years	0.32	0.50	0.70	0.70

The interesting finding from the results As Shown in Table (4-3) that Non linear Equation can be used better than linear Equation to evaluate DPI with respect frequency because (R^2) equal the power of the value (x) represent frequency to Explain DPI represent (Y) was higher in Nonlinearthan linear Equation.

4-4-4Comparison of the average of DPI Level

Table (4-4)showtheComparison of the average of DPI Levelwith respect to frequency between The Experimental data and Theoretical model data which represent A and B Respectively for Iraqi Subjects Age (2-10) Years of FR, FL, MR and ML Respectively.

Table (4-4) Comparison of the average of DPI Level with respect to frequency between The Experimental data and Theoretical model datafor Iraqi Subjects group-I (2-10) Years**.**

Freq. KHZ	**DPI FR A**	**DPI FR B**	**DPI FL A**	**DPI FL B**	**DPI MR A**	**DPI MR B**	**DPI ML A**	**DPI ML B**
0.5	4.57	8.36	3.0	6.1	3.38	6.9	3.15	6.2
0.75	9.13	9.5	6.0	7.2	6.4	7.8	6.0	7.0
1	11.9	10.6	11.0	8.25	11.29	8.6	10.4	7.8
1.5	17.3	12.0	14.3	10.0	15.1	10.1	14.2	9.2
2	15.4	14.5	12.5	11.7	12.9	11.4	10.2	10.4
3	17.5	16.4	11.3	14.5	9.7	13.8	9.1	12.6
4	15.5	19.1	14.3	16.3	14.1	15.5	13.2	14.1
6	20.3	19.6	20.2	17.8	19.3	17.4	18.0	15.7
8	16.6	16.6	15.5	15.9	16.8	18.4	15.2	15.4
Ave.	14.2	14.0	12.0	11.9	12.1	12.2	11.0	10.9

Table (4-5) show the Comparison of The average of DPI Level with respect to frequency between The Experimental data and Theoretical model data which represent A and B Respectively for Iraqi Subjects of Age (11-20) Years of FR, FL, MR and ML Respectively.

Table (4-5) Comparison of The average of DPI Level with respect to frequency between The Experimental data and Theoretical model datafor Iraqi Subjects of group-II (11-20) years**.**

	DPI FR A	**DPI FR B**	**DPI FL A**	**DPI FL B**	**DPI MR A**	**DPI MR B**	**DPI ML A**	**DPI ML B**
0.5	8.41	8.93	5.13	6.1	3.44	3.96	2.37	2.7
0.75	8.77	9.32	7.0	6.7	2.4	4.3	2.36	3.2
1	12.0	9.7	6.9	7.3	7.1	6.1	6.9	4.2
1.5	11.0	10.4	10.9	8.46	7.5	5.6	6.3	4.7
2	10.3	11.0	8.65	9.28	4.5	6.5	4.79	5.5
3	9.46	12.2	8.76	11.0	4.9	7.1	4.68	5.6
4	13.5	13.2	12.9	12.2	9.9	8.58	9.37	7.6
6	16.7	14.4	14.2	13.2	11.2	10.9	10.3	8.7
8	13.8	14.7	11.9	12.3	13.1	13.5	7.13	7.9
Ave.	11.5	11.8	9.6	9.6	7.13	7.38	5.81	5.56

Table (4-6) show theComparison of the average of DPI Level with respect to frequency between The Experimental data and Theoretical model data which represent A and B Respectively for Iraqi Subjects Age (21-30) Yearsof FR, FL, MR and ML Respectively.

Table (4-6) Comparison of the average of DPI Level with respect to frequency between The Experimental data and Theoretical model data for Iraqi Subjects group-III (21-30)years

Freq. KHZ	**DPI FR A**	**DPI FR B**	**DPI FL A**	**DPI FL B**	**DPI MR A**	**DPI MR B**	**DPI ML A**	**DPI ML B**
0.5	-2.3	1.12	-2.1	1.47	0.82	2.2	-0.7	1.7
0.75	3.11	2.4	1.87	2.62	2.03	2.8	2.57	2.33
1	5.32	3.7	6.86	3.72	4.95	3.31	6.87	2.93
1.5	9.86	6.2	8.85	2.62	7.33	4.89	5.97	1.89
2	6.96	7.8	8.51	7.51	5.12	5.12	1.75	5.01
3	8.7	11.1	7.28	10.3	2.45	6.61	4.35	6.57
4	13.1	13.5	11.8	12.3	8.52	7.82	8.65	7.61
6	16.3	15.3	13.3	13.0	10.9	9.37	9.56	8.14
8	13	13.2	10.1	10.0	9.09	9.75	5.9	6.63
Ave.	8.22	8.25	7.39	7.0	5.69	5.76	4.98	4.75

Table (4-7) show the Comparison ofThe Average of DPI Level with respect to frequency between The Experimental data and Theoretical model data which represent A and B Respectively for Sudanese Subjects Age (2-10) Years of FR, FL, MR and MLRespectively.

Table (4-7)Comparison of The Average of DPI Level with respect to frequency between The Experimental data and Theoretical model data for Sudanese Subjects group-I (2-10) Years

Freq. KHZ	**DPI FR A**	**DPI FR B**	**DPI FL A**	**DPI FL B**	**DPI MR A**	**DPI MR B**	**DPI ML A**	**DPI ML B**
0.5	4.76	8.5	4.1	7.4	3.77	7.3	3.33	6.64
0.75	9.84	10.0	7.45	8.4	6.33	8.0	6.28	7.38
1	12.6	11.1	12.3	9.4	11.63	8.8	11.0	8.0
1.5	17.2	13.2	15.4	7.7	15.4	10.1	14.7	9.3
2	16.5	15.0	13.3	12.8	13.29	11.4	10.3	10.5
3	18.3	18.0	13.5	15.5	9.72	13.7	9.1	12.5
4	16.8	20.1	15.5	17.5	14.23	15.6	13.3	14.1
6	21.4	21.3	21.3	19.1	19.93	18.3	18.2	15.8
8	19.1	18.6	17.6	17.6	19.55	19.6	15.6	15.6
Ave.	15.2	15.0	13.4	12.0	12.6	11.7	11.3	11.0

Table (4-8) Show theComparison ofThe Average of DPI Level with respect to frequency between The Experimental data and Theoretical model data which represent A&B Respectively for Sudanese Subjects Age (11-20) Years of FR, FL, MR and ML Respectively**.**

Table (4-8)Comparison of The Average of DPI Level with respect to frequency between The Experimental data and Theoretical model datafor Sudanese Subjects GROUP-II (11-20) Years

Freq. KHZ	**DPI FR A**	**DPI FR B**	**DPI FL A**	**DPI FL B**	**DPI MR A**	**DPI MR B**	**DPI ML A**	**DPI ML B**
0.5	8.76	9.48	7.26	7.5	3.9	4.8	3.26	4.0
0.75	8.97	9.8	8.0	7.9	4.9	5.2	4.25	4.3
1	13.6	10.2	8.3	8.4	7.9	5.6	7.3	4.7
1.5	11.0	10.9	11.1	9.1	8.2	6.6	7.28	5.3
2	10.5	11.5	9.0	9.8	6.7	7.5	2.79	6.0
3	10.2	12.6	9.1	8.2	6.0	9.1	4.73	7.1
4	13.8	13.4	13.0	12.1	10.6	10.5	9.51	8.0
6	16.7	14.5	14.1	13.4	15.5	12.6	10.8	9.0
8	13.8	14.7	13.2	13.6	13.1	14.2	8.13	8.9
Ave.	11.5	11.8	10.3	10.0	11.5	8.4	6.4	6.3

Table (4-9) show theComparison of The Average of DPI Level with respect to frequency between The Experimental data and Theoretical model data which represent A and B Respectively for Sudanese Subjects Age (21-30) Years of FR, FL, MR and ML Respectively.

Table (4-9)Comparison of The Average of DPI Level with respect to frequency between The Experimental data and Theoretical model data for Sudanese Subjects group-III (21-30) Years

Freq. KHZ	**DPI FR A**	**DPI FR B**	**DPI FL A**	**DPI FL B**	**DPI MR A**	**DPI MR B**	**DPI ML A**	**DPI ML B**
0.5	-1.2	1.5	-1.2	1.5	2.91	3.6	1.5	2.9
0.75	3.2	2.7	2.0	2.6	3.69	4.2	3.3	3.5
1	5.0	3.9	5.9	3.8	6.15	4.6	6.33	4.1
1.5	10.2	6.1	9.2	6.0	7.44	5.3	7.19	5.3
2	7.6	8.1	8.5	7.9	6.67	6.0	4.45	6.3
3	8.6	11.3	8.6	11.1	3.33	7.3	6.21	7.9
4	13.1	13.8	12.9	13.3	9.63	8.4	9.62	8.9
6	17.5	15.9	15.6	15.1	11.77	10.1	9.64	9.3
8	13.8	14.4	13.1	13.2	10.76	11.2	6.6	7.4
Ave.	8.6	8.6	8.3	8.2	6.8	6.7	6.09	6.17

The results showed that the Comparison of theAverage of DPI Level with respect to frequency between The Experimental data and Theoretical model data are approximately similar for Iraqi and Sudanese Subjectsfor Group-I, II and III then we can evaluate TheAverage of DPI Level.

4-5 Statistical Analysis:

For statistical analysis of themeasured data, paired 2-tailed t-test was used.Averaged data are presented in the form of mean ±Standard deviation [SD]. In all statistical analysis, onlyp-value < 0.05 were considered significant. All the mean value of the DP1 level has been analyzed in all groups of population according to gender and ear asymmetry by T-Test and to age by ANOVA-Test

Table (4-10) Statistical of mean value of DP1for female according to ear asymmetry.

Description	group	N	Mean	Std. Deviation
A DP1Level FR dB	I- for Iraqi subjects age 2-10 year	9	14.2700	4.89911
DP1Level FL dB		9	12.0689	5.12173
B DP1Level FR dB	II- for Iraqi subjects age 11-20 year	9	11.5789	2.73391
DP1Level FL dB		9	9.6711	2.99337
C DP1Level FR dB	III- for Iraqi subjects age 21-30 year	9	8.2289	5.71999
DP1Level FL dB		9	7.3978	4.84046
D DP1Level FR dB	IV- for Iraqi subjects age 31-40 year	9	3.6567	1.84365
DP1Level FL dB		9	2.8856	2.19184
F DP1Level FR dB	I- for Sudanese subjects age 2-10 year	9	15.2300	5.24607
DP1Level FL dB		9	13.4222	5.15046
G DP1Level FR dB	II- for Sudanese subjects age 11-20 year	9	11.9511	2.68107
DP1Level FL dB		9	10.3756	2.56263
H DP1Level FR dB	III- for Sudanese subjects age 21-30 year	9	8.6956	5.80889
DP1Level FL dB		9	8.3167	5.42579

Table (4-11) Statistical significance difference between the mean values of DP1for female according to ear asymmetry for each group.

	t-test for Equality of Means			
	t	df	Sig. (2-tailed)	Mean Difference
AEqual variances assumed	.932	16	.365	2.20111
Equal variances not assumed	.932	15.969	.365	2.20111
BEqual variances assumed	1.412	16	.177	1.90778
Equal variances not assumed	1.412	15.870	.177	1.90778
CEqual variances assumed	.333	16	.744	.83111
Equal variances not assumed	.333	15.574	.744	.83111
DEqual variances assumed	.808	16	.431	.77111
Equal variances not assumed	.808	15.544	.431	.77111
F Equal variances assumed	.738	16	.471	1.80778
Equal variances not assumed	.738	15.995	.471	1.80778
GEqual variances assumed	1.274	16	.221	1.57556
Equal variances not assumed	1.274	15.967	.221	1.57556
HEqual variances assumed	.143	16	.888	.37889
Equal variances not assumed	.143	15.926	.888	.37889

The T-Test (2-tailled) showed no significant difference of ear asymmetry of female for each group ($p>0.05$).

Table (4-12) Statistical of mean value of DP1for male according to ear asymmetry.

	Description	group	N	Mean	Std. Deviation
A	DP1Level MR dB	I- for Iraqi subjects age 2-10 year	9	12.1278	5.04215
	DP1Level ML dB		9	11.0911	4.67027
B	DP1Level MR d	II- for Iraqi subjects age 11-20 year	9	7.1333	3.67261
	DP1Level ML dB		9	5.8156	2.97751
C	DP1Level MR dB	III- for Iraqi subjects age 21-30 year	9	5.6956	3.50729
	DP1Level ML dB		9	4.9889	3.33487
D	DP1Level MR dB	IV- for Iraqi subjects age 31-40 year	9	2.5433	1.91105
	DP1Level ML dB		9	1.0767	2.19246
F	DP1Level MR dB	I- for Sudanese subjects age 2-10 year	9	12.6500	5.47151
	DP1Level ML dB		9	11.3378	4.70505
G	DP1Level MR dB	II- for Sudanese subjects age 11-20 year	9	8.5511	3.85167
	DP1Level ML dB		9	6.4600	2.84342
H	DP1Level MR dB	III- for Sudanese subjects age 21-30 year	9	6.9211	3.27266
	DP1Level ML dB		9	6.0978	2.69459

Table (4-13) Statistical significance difference between the mean values of DP1for male according to ear asymmetry for each group.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
A	Equal variances assumed	.453	16	.657	1.03667
	Equal variances not assumed	.453	15.907	.657	1.03667
B	Equal variances assumed	.836	16	.415	1.31778
	Equal variances not assumed	.836	15.344	.416	1.31778
C	Equal variances assumed	.438	16	.667	.70667
	Equal variances not assumed	.438	15.960	.667	.70667
D	Equal variances assumed	1.513	16	.150	1.46667
	Equal variances not assumed	1.513	15.707	.150	1.46667
F	Equal variances assumed	.546	16	.593	1.31222
	Equal variances not assumed	.546	15.649	.593	1.31222
G	Equal variances assumed	1.310	16	.209	2.09111
	Equal variances not assumed	1.310	14.723	.210	2.09111
H	Equal variances assumed	.583	16	.568	.82333
	Equal variances not assumed	.583	15.431	.569	.82333

The T-Test (2-tailled) showed no significant difference of ear asymmetry of male for each group ($p>0.05$).

Table (4-14) Statistical of mean value of DP1 according to gender for Right ear side.

	Description	N	Mean	Std. Devition
A	DP1Level FR dB	9	14.2700	4.89911
	DP1Level MR dB	9	12.1278	5.04215
B	DP1Level FR dB	9	11.5789	2.73391
	DP1Level MR dB	9	7.1333	3.67261
C	DP1Level FR dB	9	8.2289	5.71999
	DP1Level MR dB	9	5.6956	3.50729
D	DP1Level FR dB	9	3.6567	1.84365
	DP1Level MR dB	9	2.5433	1.91105
F	DP1Level FR dB	9	15.2300	5.24607
	DP1Level MR dB	9	12.6500	5.47151
G	DP1Level FR dB	9	11.9511	2.68107
	DP1Level MR dB	9	8.5511	3.85167
H	DP1Level FR dB	9	8.6956	5.80889
	DP1Level MR dB	9	6.9211	3.27266

Table (4-15) Statistical significance difference between the mean values of DP1for Right ear side according to gender for each group.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
A	Equal variances assumed	.914	16	.374	2.14222
	Equal variances not assumed	.914	15.987	.374	2.14222
B	Equal variances assumed	2.913	16	.010	4.44556
	Equal variances not assumed	2.913	14.783	.011	4.44556
C	Equal variances assumed	1.133	16	.274	2.53333
	Equal variances not assumed	1.133	13.271	.277	2.53333
D	Equal variances assumed	1.258	16	.227	1.11333
	Equal variances not assumed	1.258	15.979	.227	1.11333
F	Equal variances assumed	1.021	16	.322	2.58000
	Equal variances not assumed	1.021	15.972	.322	2.58000
G	Equal variances assumed	2.173	16	.045	3.40000
	Equal variances not assumed	2.173	14.278	.047	3.40000
H	Equal variances assumed	.798	16	.436	1.77444
	Equal variances not assumed	.798	12.614	.439	1.77444

The T-Test (2-tailled) showed no significant difference between gender of Right ear side for each group ($p>0.05$).

Table (4-16) Statistical of mean value of DP1 according to gender for Left ear side.

	Freq.	N	Mean	Std. Deviation
A	DP1Level FL dB	9	12.0689	5.12173
	DP1Level ML dB	9	11.0911	4.67027
B	DP1Level FL dB	9	9.6711	2.99337
	DP1Level ML dB	9	5.8156	2.97751
C	DP1Level FL dB	9	7.3978	4.84046
	DP1Level ML dB	9	4.9889	3.33487
D	DP1Level FL dB	9	2.8856	2.19184
	DP1Level ML dB	9	1.0767	2.19246
F	DP1Level FL dB	9	13.4222	5.15046
	DP1Level ML dB	9	11.3378	4.70505
G	DP1Level FL dB	9	10.3756	2.56263
	DP1Level ML dB	9	6.4600	2.84342
H	DP1Level FL dB	9	8.3167	5.42579
	DP1Level ML dB	9	6.0978	2.69459

Table (4-17) Statistical significance difference between the mean values of DP1for Right ear side according to gender for each group.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
A	Equal variances assumed	.423	16	.678	.97778
	Equal variances not assumed	.423	15.866	.678	.97778
B	Equal variances assumed	2.740	16	.015	3.85556
	Equal variances not assumed	2.740	16.000	.015	3.85556
C	Equal variances assumed	1.229	16	.237	2.40889
	Equal variances not assumed	1.229	14.198	.239	2.40889
D	Equal variances assumed	1.750	16	.099	1.80889
	Equal variances not assumed	1.750	16.000	.099	1.80889
F	Equal variances assumed	.896	16	.383	2.08444
	Equal variances not assumed	.896	15.871	.383	2.08444
G	Equal variances assumed	3.069	16	.007	3.91556
	Equal variances not assumed	3.069	15.830	.007	3.91556
H	Equal variances assumed	1.099	16	.288	2.21889
	Equal variances not assumed	1.099	11.720	.294	2.21889

The T-Test (2-tailled) showed no significant difference between gender of Left ear side for each group ($p>0.05$).

Table(4-18)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of female Right ear side for group-I (2-10)year.

	Freq.	N	Mean	Std. Deviation
K	DP1Level FR dB 2-10(S)	9	15.2300	5.24607
	DP1Level FR dB 2-10(I)	9	1 .2700	4.89911

Table(4-19)Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of female Right ear side for group-I (2-10)year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	.401	16	.694	.96000
	Equal variances not assumed	.401	15.926	.694	.96000

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects of female Right ear side for group-I (2-10) year (p>0.05).

Table(4-20)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of female Right ear side for group-II (11-20)year.

	freq	N	Mean	Std. Deviation	Std. Error Mean
K	DP1Level FR dB 11-20(S)	9	11.9511	2.68107	.89369
	DP1Level FR dB 11-20(I)	9	11.5789	2.73391	.91130

Table (4-21) Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of female Right ear side for group-II (11-20) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	.292	16	.774	.37222
	Equal variances not assumed	.292	15.994	.774	.37222

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects of female Right ear side for group-II (11-20) year (p>0.05).

Table(4-22)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of female Right ear side for group-III (21-30)year.

	freq	N	Mean	Std. Deviation	Std. Error Mean
K	DP1Level FR dB 21-30(S)	9	8.8289	5.56188	1 85396
	DP1Level FR dB 21-30(I)	9	8.4844	5.22034	1.74011

Table (4-23) Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of female Right ear side for group-III (21-30) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	.135	16	.894	.34444
	Equal variances not assumed	.135	15.936	.894	.34444

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects of female Right ear side for group-III (21-30)year (p>0.05).

Table(4-24)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of male Right ear side for group-I (2-10)year.

	Freq.	N	Mean	Std. Deviation	Std. Error Mean
K	DP1Level MR dB 2-10(S)	9	12 6500	5.47151	1.82384
	DP1Level MR dB 2-10(I)	9	12.1278	5.04215	1.68072

Table(4-25)Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of male Right ear side for group-I (2-10)year

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	.211	16	.836	.52222
	Equal variances not assumed	.211	15.894	.836	.52222

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects of male Right ear side for group-I (2-10)year ($p>0.05$).

Table(4-26)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of male Right ear side for group-II (11-20)year.

	Freq.	N	Mean	Std. Deviation	Std. Error Mean
K	DP1Level MR dB 11-2 (S)	9	8.5511	3.85167	1.28389
	DP1Level MR dB 11-20(I)	9	7.1333	3.67261	1.22420

Table (4-27) Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of female Right ear side for group-II (11-20) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	.799	16	.436	1.41778
	Equal variances not assumed	.799	15.964	.436	1.41778

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects of male Right ear side for group-II (11-20)year ($p>0.05$).

Table(4-28)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of male Right ear side for group-III (21-30)year.

	freq	N	Mean	Std. Deviation	Std. Error Mean
K	DP1Level MR dB 21-30(S)	9	6.9211	3.27266	1.09089
	DP1Level MR dB 21-30(I)	9	5.6956	3.50729	1.16910

Table (4-29) Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of male Right ear side for group-III (21-30) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	.766	16	.455	1.22556
	Equal variances not assumed	.766	15.924	.455	1.22556

The T-Test (2-tailled) showed no significant difference between Sudanese and Iraqi subjects of male Right ear side for group-III (21-30) year ($p>0.05$).

Table (4-30) Statistical of mean value of DP1 level between female Sudanese and male Iraqi subjects of Right ear side for group-I (2-10) year.

	freq	N	Mean	Std. Deviation	Std. Error Mean
K	DP1Level FR dB 2-10(S)	9	15.2300	5.24607	1.74869
	DP1Level MR dB 2-10(I)	9	12.6500	5.47151	1.82384

Table (4-31) Statistical significance difference of the mean values of DP1 level between female Sudanese and male Iraqi subjects of Right ear side for group-I (2-10) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	1.021	16	.322	2.58000
	Equal variances not assumed	1.021	15.972	.322	2.58000

Table (4-32) Statistical of mean value of DP1 level between male Sudanese and female Iraqi subjects of Right ear side for group-I (2-10) year.

	freq	N	Mean	Std. Deviation	Std. Error Mean
K	DP1Level FR dB 2-10(I)	9	14.2700	4.89911	1.63304
	DP1Level MR dB 2-10(S)	9	12.6500	5.47151	1.82384

Table (4-33) Statistical significance difference of the mean values of DP1 level between male Sudanese and female Iraqi subjects of Right ear side for group-I (2-10) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	.662	16	.518	1.62000
	Equal variances not assumed	.662	15.809	.518	1.62000

The T-Test (2-tailled) showed no significant difference between Sudanese and Iraqi subjects according to gender of Right ear side for group-I (2-10) year ($p>0.05$).

Table (4-34) Statistical of mean value of DP1 level between female Sudanese and male Iraqi subjects of Right ear side for group-II (11-20) year.

	Freq.	N	Mean	Std. Deviation	Std. Error Mean
K	DP1Level FR dB 11-20(S)	9	11.9511	2.68107	.89369
	DP1Level MR dB 11-20(I)	9	7.1333	3.67261	1.22420

Table (4-35) Statistical significance difference of the mean values of DP1 level between female Sudanese and male Iraqi subjects of Right ear side for group-II (11-20) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	3.179	16	.006	4.81778
	Equal variances not assumed	3.179	14.641	.006	4.81778

Table (4-36) Statistical of mean value of DP1 level between female Iraqi and male Sudanese subjects of Right ear side for group-II (11-20) year.

	Freq.	N	Mean	Std. Deviation	Std. Error Mean
K	DP1Level FR dB 11-20(I)	9	11.5789	2.73391	.91130
	DP1Level MR dB 11-20(S)	9	8.5511	3.85167	1.28389

Table (4-37) Statistical significance difference of the mean values of DP1 level between male Sudanese and female Iraqi subjects of Right ear side for group-II (11-20) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	1.923	16	.072	3.02778
	Equal variances not assumed	1.923	14.429	.074	3.02778

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects according to gender of Right ear side for group-II (11-20)year ($p>0.05$).

Table(4-38)Statistical of mean value of DP1 level between female Sudanese and male Iraqi subjects of Right ear side for group-III (21-30)year.

	Freq.	N	Mean	Std. Deviation	Std. Error Mean
K	DP1Level FR dB 21-30(S)	9	8.8289	5.56188	1.85396
	DP1Level MR dB 21-30(I)	9	5.6956	3.50729	1.16910

Table(4-39)Statistical significance difference of the mean values of DP1 level between female Sudanese and male Iraqi subjects of Right ear side for group-III (21-30)year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	1.430	16	.172	3.13333
	Equal variances not assumed	1.430	13.494	.176	3.13333

Table(4-40)Statistical of mean value of DP1 level between female Iraqi and male Sudanese subjects of Right ear side for group-III (21-30)year.

	Freq.	N	Mean	Std. Deviation	Std. Error Mean
K	DP1Level FR dB 21-30(I)	9	8.4844	5.22034	1.74011
	DP1Level MR dB 21-30(S)	9	6.9211	3.27266	1.09089

Table(4-41)Statistical significance difference of the mean values of DP1 level between male Sudanese and female Iraqi subjects of Right ear side for group-III (21-30)year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K	Equal variances assumed	.761	16	.458	1.56333
	Equal variances not assumed	.761	13.447	.460	1.56333

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects according to gender of Right ear side for group-III (21-30) year ($p>0.05$).

Table(4-42)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of female Left ear side for group-I (2-10)year

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level FL dB 2-10(S)	9	13.4222	5.15046	1.71682
	DP1Level FL dB 2-10(I)	9	12.0689	5.12173	1.70724

Table(4-43)Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of female Left ear side for group-I (2-10)year

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	.559	16	.584	1.35333
	Equal variances not assumed	.559	15.999	.584	1.35333

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects of female Left ear side for group-I (2-10)year ($p>0.05$).

Table(4-44)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of female Left ear side for group-II (11-20)year

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level FL dB 11-20(S)	9	10.3756	2.56263	.85421
	DP1Level FL dB 11-20(I)	9	9.6711	2.99337	.99779

Table(4-45)Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of female Left ear side for group-II (11-20)year

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	.536	16	.599	.70444
	Equal variances not assumed	.536	15.629	.599	.70444

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects of female Left ear side for group-II (11-20)year ($p>0.05$).

Table(4-46)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of female Left ear side for group-III (21-30)year

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level FL dB 21-30(S)	9	8.4522	5.16681	1.72227
	DP1Level FL dB 21-30(I)	9	7.6333	4.34569	1.44856

Table(4-47)Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of female Left ear side for group-III (21-30)year

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	.364	16	.721	.81889
	Equal variances not assumed	.364	15.544	.721	.81889

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects of female Left ear side for group-III (21-30)year ($p>0.05$).

Table(4-48)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of male Left ear side for group-I (2-10)year

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level ML dB 2-10(S)	9	11.3378	4.70505	1.56835
	DP1Level ML dB 2-10(I)	9	11.0911	4.67027	1.55676

Table(4-49)Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of male Left ear side for group-I (2-10)year

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	.112	16	.913	.24667
	Equal variances not assumed	.112	15.999	.913	.24667

Table(4-50)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of male Left ear side for group-II (11-20)year

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level ML dB 11-20(S)	9	6.4600	2.84342	.94781
	DP1Level ML dB 11-20(I)	9	5.8156	2.97751	.99250

Table(4-51)Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of male Left ear side for group-II (11-20)year

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	.470	16	.645	.64444
	Equal variances not assumed	.470	15.966	.645	.64444

Table(4-52)Statistical of mean value of DP1 level between Sudanese and Iraqi subjects of male Left ear side for group-III (21-30)year

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level ML dB 21-30(S)	9	6.0978	2.69459	.89820
	DP1Level ML dB 21-30(I)	9	5.0689	3.18612	1.06204

Table(4-53)Statistical significance difference of the mean values of DP1 level between Sudanese and Iraqi subjects of male Left ear side for group-III (21-30)year

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	.740	16	.470	1.02889
	Equal variances not assumed	.740	15.571	.470	1.02889

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects of male Left ear side for groups-I (2-10),II (11-20) and III (21-30)year ($p>0.05$).

Table(4-54)Statistical of mean value of DP1 level between female Sudanese and male Iraqi subjects of Left ear side for group-I (2-10)year.

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level FL dB 2-10(S)	9	13.4222	5.15046	1.71682
	DP1Level ML dB 2-10(I)	9	11.0911	4.67027	1.55676

Table (4-55) Statistical significance difference of the mean values of DP1 level between female Sudanese and male Iraqi subjects of Left ear side for group-I (2-10) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	1.006	16	.329	2.33111
	Equal variances not assumed	1.006	15.849	.330	2.33111

Table(4-56)Statistical of mean value of DP1 level between female Iraqi and male Sudanese subjects of Left ear side for group-I (2-10)year.

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level FL dB 2-10(I)	9	12.0689	5.12173	1.70724
	DP1Level ML dB 2-10(S)	9	11.3378	4.70505	1.56835

Table (4-57) Statistical significance difference of the mean values of DP1 level between male Sudanese and female Iraqi subjects of Left ear side for group-I (2-10) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	.315	16	.757	.73111
	Equal variances not assumed	.315	15.886	.757	.73111

Table(4-58)Statistical of mean value of DP1 level between female Sudanese and male Iraqi subjects of Left ear side for group-II (11-20)year.

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level FL dB 11-20(S)	9	10.3756	2.56263	.85421
	DP1Level ML dB 11-20(I)	9	5.8156	2.97751	.99250

Table (4-59) Statistical significance difference of the mean values of DP1 level between female Sudanese and male Iraqi subjects of Left ear side for group-II (11-20) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	3.482	16	.003	4.56000
	Equal variances not assumed	3.482	15.653	.003	4.56000

Table (4-60) Statistical of mean value of DP1 level between female Iraqi and male Sudanese subjects of Left ear side for group-II (11-20) year.

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level FL dB 11-20(I)	9	9.6711	2.99337	.99779
	DP1Level ML dB 11-20(S)	9	6.4600	2.84342	.94781

Table (4-61) Statistical significance difference of the mean values of DP1 level between male Sudanese and female Iraqi subjects of Left ear side for group-II (11-20) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	2.333	16	.033	3.21111
	Equal variances not assumed	2.333	15.958	.033	3.21111

Table (4-62) Statistical of mean value of DP1 level between female Sudanese and male Iraqi subjects of Left ear side for group-III (21-30) year.

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level FL dB 21-30(S)	9	8.4522	5.16681	1.72227
	DP1Level ML dB 21-30(I)	9	5.0689	3.18612	1.06204

Table(4-63)Statistical significance difference of the mean values of DP1 level between female Sudanese and male Iraqi subjects of Left ear side for group-III (21-30)year

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	1.672	16	.114	3.38333
	Equal variances not assumed	1.672	13.316	.118	3.38333

Table (4-64) Statistical of mean value of DP1 level between female Iraqi and male Sudanese subjects of Left ear side for group-III (21-30) year.

	freq_K2	N	Mean	Std. Deviation	Std. Error Mean
K2	DP1Level FL dB 21-30(I)	9	7.6333	4.34569	1.44856
	DP1Level ML dB 21-30(S)	9	6.0978	2.69459	.89820

Table (4-65) Statistical significance difference of the mean values of DP1 level between male Sudanese and female Iraqi subjects of Left ear side for group-III (21-30) year.

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
K2	Equal variances assumed	.901	16	.381	1.53556
	Equal variances not assumed	.901	13.359	.384	1.53556

The T-Test (2-tailled) showed no significant difference betweenSudanese and Iraqi subjects according to gender of Left ear side for groups-I (2-10),II (11-20) and III (21-30)year ($p>0.05$).

Table(4-66)Statistical of mean value of DP1 level between female Right ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40) year

	N	Mean	Std. Deviation	Std. Error
DP1 FR dB 2-10	9	14.2700	4.89911	1.63304
DP1 FR dB 11-20	9	11.5789	2.73391	.91130
DP1 FR dB 21-30	9	8.4844	5.22034	1.74011
DP1 FR dB 31-40	9	3.7367	1.63366	.54455
Total	36	9.5175	5.45909	.90985

Table(4-67)Statistical significance difference of the mean values of DP1 level between female Right ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40) year

ANOVA[a]

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	551.887	3	183.962	11.985	.000
Within Groups	491.171	32	15.349		
Total	1043.058	35			

Table(4-68)Statistical of mean value of DP1 level between male Right ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40) year

	N	Mean	Std. Deviation	Std. Error
DP1 MR dB 2-10	9	12.1278	5.04215	1.68072
DP1 MR dB 11-20	9	7.1333	3.67261	1.22420
DP1 MR dB 21-30	9	5.6956	3.50729	1.16910
DP1 MR dB 31-40	9	2.6944	1.59076	.53025
Total	36	6.9128	4.92408	.82068

Table(4-69)Statistical significance difference of the mean values of DP1 level between male Right ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and g (31-40) year

ANOVA[a]

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	418.688	3	139.563	10.387	.000
Within Groups	429.943	32	13.436		
Total	848.631	35			

Table(4-70)Statistical of mean value of DP1 level between male Left ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40) year

	N	Mean	Std. Deviation	Std. Error
DP1 ML dB 2-10	9	11.0911	4.67027	1.55676
DP1 ML dB 11-20	9	5.8156	2.97751	.99250
DP1 ML dB 21-30	9	5.0689	3.18612	1.06204
DP1 ML dB 31-40	9	1.5967	1.20210	.40070
Total	36	5.8931	4.64039	.77340

Table(4-71)Statistical significance difference of the mean values of DP1 level between male Left ear side Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group 40) year

ANOVA[a]

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	415.476	3	138.492	13.104	.000
Within Groups	338.187	32	10.568		
Total	753.663	35			

Table(4-72)Statistical of mean value of DP1 level between female Left ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40) year

	N	Mean	Std. Deviation	Std. Error
DP1 FL dB 2-10	9	12.0689	5.12173	1.70724
DP1 FL dB 11-20	9	9.6711	2.99337	.99779
DP1 FL dB 21-30	9	7.6333	4.34569	1.44856
DP1 FL dB 31-40	9	3.1189	1.63608	.54536
Total	36	8.1231	4.90848	.81808

Table(4-73)Statistical significance difference of the mean values of DP1 level between female Left ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-3 group-IV (31-40) year

ANOVA[a]

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	389.228	3	129.743	9.144	.000
Within Groups	454.034	32	14.189		
Total	843.262	35			

ANOVA Test showed significant difference between groups-I (2-10),II (11-20), III (21-30) and IV(31-40) yearfor Iraqi subjects according to age of FR, MR, ML and FL respectively ($p<0.05$).

Table(4-74)Statistical of mean value of DP1 level between male Right ear side of Sudanese subjects for group-I (2-10),group-II (11-20) and group-III (21-30) year.

	N	Mean	Std. Deviation	Std. Error
DP1 MR dB 2-10	9	12.6500	5.47151	1.82384
DP1 MR dB 11-20	9	8.5511	3.85167	1.28389
DP1 MR dB 21-30	9	6.9211	3.27266	1.09089
Total	27	9.3741	4.80664	.92504

Table(4-75)Statistical significance difference of the mean values of DP1 level between male Right ear side of Sudanese subjects for group-I (2-10),group-II (11-20) and group-III Year.

ANOVA[a]

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	156.834	2	78.417	4.240	.026
Within Groups	443.864	24	18.494		
Total	600.698	26			

Table(4-76)Statistical of mean value of DP1 level between female Right ear side of Sudanese subjects for group-I (2-10),group-II (11-20) and group-III (21-30) year

	N	Mean	Std. Deviation	Std. Error
DP1 FR dB 2-10	9	15.2300	5.24607	1.74869
DP1 FR dB 11-20	9	11.9511	2.68107	.89369
DP1 FR dB 21-30	9	8.8289	5.56188	1.85396
Total	27	12.0033	5.22410	1.00538

Table(4-77)Statistical significance difference of the mean values of DP1 level between female Right ear side of Iraqi subjects for group-I (2-10),group-II (11-20) and group-III (21-30year

ANOVA[a]

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	184.421	2	92.210	4.214	.027
Within Groups	525.152	24	21.881		
Total	709.573	26			

Table(4-78)Statistical of mean value of DP1 level between female Left ear side of Sudanese subjects for group-I (2-10),group-II (11-20) and group-III (21-30) year

	N	Mean	Std. Deviation	Std. Error
DP1 FL dB 2-10	9	13.4222	5.15046	1.71682
DP1 FL dB 11-20	9	10.3756	2.56263	.85421
DP1 FL dB 21-30	9	8.4522	5.16681	1.72227
Total	27	10.7500	4.76917	.91783

Table (4-79) Statistical significance difference of the mean values of DP1 level between female Left ear side of Sudanese subjects for group-I (2-10),group-II (11-20) and group-III (21-30) year

ANOVA

	Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	*113.047*	*2*	*56.523*	*2.836*	*.0078*
Within Groups	*478.322*	*24*	*19.930*		
Total	*591.369*	*26*			

Table(4-80)Statistical of mean value of DP1 level between male Left ear side of Sudanese subjects for group-I (2-10),group-II (11-20) andgroup-III (21-30) year

	N	Mean	Std. Deviation	Std. Error
DP1 ML dB 2-10	9	11.3378	4.70505	1.56835
DP1 ML dB 11-20	9	6.4600	2.84342	.94781
DP1 ML dB 21-30	9	6.0978	2.69459	.89820
Total	27	7.9652	4.17875	.80420

Table (4-81) Statistical significance difference of the mean values of DP1 level between male Left ear side Iraqi subjects for group-I (2-10), group-II (11-20) and group-III (21-30) year

ANOVA[a]

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	154.145	2	77.072	6.169	.007
Within Groups	299.867	24	12.494		
Total	454.011	26			

ANOVA Test showed significant difference between groups-I (2-10),II (11-20), and III (21-30)year for Sudanese subjects according to age of MR, FR, FL and ML respectively ($p<0.05$).

4-6 Statistical Analysis for SNR dB:

All the mean value of the SNR has been analyzed in all groups of population according to gender and ear asymmetry by variances T-Test and to age by ANOVA-Test

Table (4-82) Statistical of mean value of SNR for female according to ear asymmetry

	freq	N	Mean	Std. Deviation	Std. Error Mean
A	SNR FR dB	9	13.9411	4.57745	1.52582
	SNR FL dB	9	11.1022	4.18656	1.39552
B	SNR FR dB	9	10.4456	1.99216	.66405
	SNR FL dB	9	9.3944	2.78196	.92732
C	SNR FR dB	9	11.3889	3.65956	1.21985
	SNR FL dB	9	11.1622	3.44229	1.14743
D	SNR FR dB	9	5.0222	.51185	.17062
	SNR FL dB	9	4.2189	.28396	.09465
F	SNR FR dB	9	15.2922	4.37133	1.45711
	SNR FL dB	9	12.9667	4.39755	1.46585
G	SNR FR dB	9	11.1211	2.65591	.88530
	SNR FL dB	9	10.2944	2.77652	.92551
H	SNR FR dB	9	11.8556	3.77898	1.25966
	SNR FL dB	9	11.8911	3.47369	1.15790

Table (4-83) Statistical significance difference between the mean values of SNR for female according to ear asymmetry for each group

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
A	Equal variances assumed	1.373	16	.189	2.83889
	Equal variances not assumed	1.373	15.874	.189	2.83889
B	Equal variances assumed	.922	16	.370	1.05111
	Equal variances not assumed	.922	14.496	.372	1.05111
C	Equal variances assumed	.135	16	.894	.22667
	Equal variances not assumed	.135	15.940	.894	.22667
D	Equal variances assumed	4.117	16	.001	.80333
	Equal variances not assumed	4.117	12.498	.001	.80333
F	Equal variances assumed	1.125	16	.277	2.32556
	Equal variances not assumed	1.125	15.999	.277	2.32556
G	Equal variances assumed	.645	16	.528	.82667
	Equal variances not assumed	.645	15.969	.528	.82667
H	Equal variances assumed	-.021-	16	.984	-.03556-
	Equal variances not assumed	-.021-	15.888	.984	-.03556-

The T-Test (2-tailled) showed no significant difference of ear asymmetry of female for each group ($p>0.05$).

Table (4-84) Statistical of mean value of SNR for male according to ear asymmetry

A	SNR MR dB	9	11.3000	4.60597	1.53532
	SNR ML dB	9	10.1978	4.34250	1.44750
B	SNR MR dB	9	11.7967	3.85956	1.28652
	SNR ML dB	9	9.7478	2.44805	.81602
C	SNR MR dB	9	10.0878	1.97739	.65913
	SNR ML dB	9	9.5289	2.06166	.68722
D	SNR MR dB	9	4.5856	.40997	.13666
	SNR ML dB	9	3.9567	.33753	.11251
F	SNR MR dB	9	11.5733	4.63952	1.54651
	SNR ML dB	9	10.6289	4.45415	1.48472
G	SNR MR dB	9	11.1356	2.93058	.97686
	SNR ML dB	9	9.8989	2.77580	.92527
H	SNR MR dB	9	10.5922	2.51787	.83929
	SNR ML dB	9	10.0056	2.01522	.67174

Table (4-85) Statistical significance difference between the mean values of SNR for male according to ear asymmetry for each group

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
A	Equal variances assumed	.522	16	.609	1.10222
	Equal variances not assumed	.522	15.945	.609	1.10222
B	Equal variances assumed	1.345	16	.197	2.04889
	Equal variances not assumed	1.345	13.540	.201	2.04889
C	Equal variances assumed	.587	16	.565	.55889
	Equal variances not assumed	.587	15.972	.565	.55889
D	Equal variances assumed	3.553	16	.003	.62889
	Equal variances not assumed	3.553	15.431	.003	.62889
F	Equal variances assumed	.441	16	.665	.94444
	Equal variances not assumed	.441	15.973	.665	.94444
G	Equal variances assumed	.919	16	.372	1.23667
	Equal variances not assumed	.919	15.953	.372	1.23667
H	Equal variances assumed	.546	16	.593	.58667
	Equal variances not assumed	.546	15.267	.593	.58667

The T-Test (2-tailled) showed no significant difference of ear asymmetry of male for each group ($p>0.05$).

Table (4-86) Statistical of mean value of SNR according to gender for Right ear side

	freq	N	Mean	Std. Deviation	Std. Error Mean
A	SNR FR dB	9	13.9411	4.57745	1.52582
	SNR MR dB	9	11.3000	4.60597	1.53532
B	SNR FR dB	9	10.4456	1.99216	.66405
	SNR MR dB	9	11.7967	3.85956	1.28652
C	SNR FR dB	9	11.3889	3.65956	1.21985
	SNR MR dB	9	10.0878	1.97739	.65913
D	SNR FR dB	9	5.0222	.51185	.17062
	SNR MR dB	9	4.5856	.40997	.13666
F	SNR FR dB	9	15.2922	4.37133	1.45711
	SNR MR dB	9	11.5733	4.63952	1.54651
G	SNR FR dB	9	11.1211	2.65591	.88530
	SNR MR dB	9	11.1356	2.93058	.97686
H	SNR FR dB	9	11.8556	3.77898	1.25966
	SNR MR dB	9	10.5922	2.51787	.83929

Table (4-87) Statistical significance difference between the mean values of SNR for Right ear side according to gender for each group

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
A	Equal variances assumed	1.220	16	.240	2.64111
	Equal variances not assumed	1.220	15.999	.240	2.64111
B	Equal variances assumed	-.933-	16	.365	-1.35111-
	Equal variances not assumed	-.933-	11.980	.369	-1.35111-
C	Equal variances assumed	.938	16	.362	1.30111
	Equal variances not assumed	.938	12.304	.366	1.30111
D	Equal variances assumed	1.998	16	.063	.43667
	Equal variances not assumed	1.998	15.272	.064	.43667
F	Equal variances assumed	1.750	16	.099	3.71889
	Equal variances not assumed	1.750	15.944	.099	3.71889
G	Equal variances assumed	-.011-	16	.991	-.01444-
	Equal variances not assumed	-.011-	15.848	.991	-.01444-
H	Equal variances assumed	.835	16	.416	1.26333
	Equal variances not assumed	.835	13.934	.418	1.26333

The T-Test (2-tailled) showed no significant difference between gender of Right ear side for each group ($p>0.05$).

Table (4-88) Statistical of the mean value of SNR according to gender for Left ear side

	freq	N	Mean	Std. Deviation	Std. Error Mean
A	SNR FL dB	9	11.1022	4.18656	1.39552
	SNR ML dB	9	10.1978	4.34250	1.44750
B	SNR FL dB	9	9.3944	2.78196	.92732
	SNR ML dB	9	9.7478	2.44805	.81602
C	SNR FL dB	9	11.1622	3.44229	1.14743
	SNR ML dB	9	9.5289	2.06166	.68722
D	SNR FL dB	9	4.2189	.28396	.09465
	SNR ML dB	9	3.9567	.33753	.11251
F	SNR FL dB	9	12.9667	4.39755	1.46585
	SNR ML dB	9	10.6289	4.45415	1.48472
G	SNR FL dB	9	10.2944	2.77652	.92551
	SNR ML dB	9	9.8989	2.77580	.92527
H	SNR FL dB	9	11.8911	3.47369	1.15790
	SNR ML dB	9	10.0056	2.01522	.67174

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Table (4-89) Statistical significance difference between the mean values of SNR for left ear side according to gender for each group

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
A	Equal variances assumed	.450	16	.659	.90444
	Equal variances not assumed	.450	15.979	.659	.90444
B	Equal variances assumed	-.286-	16	.779	-.35333-
	Equal variances not assumed	-.286-	15.745	.779	-.35333-
C	Equal variances assumed	1.221	16	.240	1.63333
	Equal variances not assumed	1.221	13.085	.244	1.63333
D	Equal variances assumed	1.783	16	.093	.26222
	Equal variances not assumed	1.783	15.545	.094	.26222
F	Equal variances assumed	1.120	16	.279	2.33778
	Equal variances not assumed	1.120	15.997	.279	2.33778
G	Equal variances assumed	.302	16	.766	.39556
	Equal variances not assumed	.302	16.000	.766	.39556
H	Equal variances assumed	1.409	16	.178	1.88556
	Equal variances not assumed	1.409	12.837	.183	1.88556

The T-Test (2-tailled) showed no significant difference between gender of left ear side for each group ($p>0.05$).

Table(4-90)Statistical of mean value of SNR between female Right ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40) year

	N	Mean	Std. Deviation	Std. Error
SNR FR dB 2-10	9	13.9411	4.57745	1.52582
SNR FR dB 11-20	9	11.4544	1.84094	.61365
SNR FR dB 21-30	9	11.3889	3.65956	1.21985
SNR FR dB 31-40	9	5.0222	.51185	.17062
Total	36	10.4517	4.45878	.74313

Table(4-91)Statistical significance difference of the mean values of SNR between female Right ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40) years.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	391.851	3	130.617	13.750	.000
Within Groups	303.972	32	9.499		
Total	695.824	35			

Table(4-92)Statistical of mean value of SNR between male Right ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40) year

	N	Mean	Std. Deviation	Std. Error
SNR MR dB 2-10	9	11.3000	4.60597	1.53532
SNR MR dB 11-20	9	10.0467	1.88017	.62672
SNR MR dB 21-30	9	10.0878	1.97739	.65913
SNR MR dB 31-40	9	4.5856	.40997	.13666
Total	36	9.0050	3.68056	.61343

Table(4-93)Statistical significance difference of the mean values of SNR male Right ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40) year

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	243.504	3	81.168	11.262	.000
Within Groups	230.625	32	7.207		
Total	474.129	35			

Table(4-94)Statistical of mean value of SNR between male Left ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40) year.

	N	Mean	Std. Deviation	Std. Error
SNR ML dB 2-10	9	10.1978	4.34250	1.44750
SNR ML dB 11-20	9	9.5122	1.82312	.60771
SNR ML dB 21-30	9	9.5289	2.06166	.68722
SNR ML dB 31-40	9	3.9567	.33753	.11251
Total	36	8.2989	3.55116	.59186

Table(4-95)Statistical significance difference of the mean values of SNR Between male Left ear side Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40) year

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	229.012	3	76.337	11.503	.000
Within Groups	212.364	32	6.636		
Total	441.376	35			

Table(4-96)Statistical of mean value of SNR between female Left ear side of Iraqi subjects for group-I (2-10),group-II (11-20),group-III (21-30) and group-IV (31-40)

	N	Mean	Std. Deviation	Std. Error
SNR FL dB 2-10	9	11.1022	4.18656	1.39552
SNR FL dB 11-20	9	11.2133	1.82957	.60986
SNR FL dB 21-30	9	11.1622	3.44229	1.14743
SNR FL dB 31-40	9	4.2189	.28396	.09465
Total	36	9.4242	4.09750	.68292

Table(4-97)Statistical significance difference of the mean values of SNR betweenFemale Left ear side of Iraqi subjects for group-I (2-10), group-II (11-20), group-III (21-30) and group-IV (31-40) year.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	325.195	3	108.398	13.217	.000
Within Groups	262.437	32	8.201		
Total	587.632	35			

ANOVA Test showed significant difference of SNR parameter between groups-I (2-10),II (11-20), III (21-30) and IV(31-40) year for Iraqi subjects according to age of FR, MR, ML and FL respectively ($p<0.05$).

Table(4-98)Statistical of mean value of SNR between male Right ear side of Sudanese subjects for group-I (2-10),group-II (11-20) and group-III (21-30) year.

	N	Mean	Std. Deviation	Std. Error
SNR MR dB 2-10	9	11.5733	4.63952	1.54651
SNR MR dB 11-20	9	11.1356	2.93058	.97686
SNR MR dB 21-30	9	10.5922	2.51787	.83929
Total	27	11.1004	3.37396	.64932

Table (4-99) Statistical significance difference of the mean values of SNR between male Right ear side of Sudanese subjects for group-I (2-10), group-II (11-20) and group-III (21-30) Year.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.348	2	2.174	.179	.837
Within Groups	291.625	24	12.151		
Total	295.974	26			

Table (4-100) Statistical of the mean values of SNR between Female Right ear side of Sudanese subjects for group-I (2-10), group-II (11-20) and group-III (21-30) year

	N	Mean	Std. Deviation	Std. Error
SNR FR dB 2-10	9	15.2922	4.37133	1.45711
SNR FR dB 11-20	9	11.1211	2.65591	.88530
SNR FR dB 21-30	9	11.8556	3.77898	1.25966
Total	27	12.7563	3.98454	.76682

Table(4-101)Statistical significance difference of the mean values of SNR between Female Right ear side of Sudanese subjects for group-I (2-10), group-II (11-20) and group-III (21-30) year

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	89.245	2	44.622	3.310	.054
Within Groups	323.545	24	13.481		
Total	412.790	26			

Table (4-102) Statistical of the mean values of SNR between male left ear side of Sudanese subjects for group-I (2-10), group-II (11-20) and group-III (21-30) year.

	N	Mean	Std. Deviation	Std. Error
SNR ML dB 2-10	9	10.6289	4.45415	1.48472
SNR ML dB 11-20	9	9.8989	2.77580	.92527
SNR ML dB 21-30	9	10.0056	2.01522	.67174
Total	27	10.1778	3.13567	.60346

Table (4-103) Statistical significance difference of the mean values of SNR between male left ear side of Sudanese subjects for group-I (2-10), group-II (11-20) and group-III (21-30) year

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.798	2	1.399	.133	.876
Within Groups	252.845	24	10.535		
Total	255.643	26			

Table (4-104) Statistical of the mean values of SNR between Female left ear side of Sudanese subjects for group-I (2-10), group-II (11-20) and group-III (21-30) year

	N	Mean	Std. Deviation	Std. Error
SNR FL dB 2-10	9	13.4222	5.15046	1.71682
SNR FL dB 11-20	9	10.2944	2.77652	.92551
SNR FL dB 21-30	9	11.8911	3.47369	1.15790
Total	27	11.8693	3.99255	.76837

Table (4-105) Statistical significance difference of the mean values of SNR between Female left ear side of Sudanese subjects for group-I (2-10), group-II (11-20) and group-III (21-30) year.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	44.030	2	22.015	1.426	.260
Within Groups	370.422	24	15.434		
Total	414.452	26			

ANOVA Test showed no significant difference of SNR parameter between groups-I (2-10),II (11-20) and III (21-30)year for Sudanese subjects according to age of MR, FR, ML and FL respectively ($p>0.05$).

Chapter Five

5-1 Discussion

DPOAEs are thought to be initiated by nonlinear distortion in the basilar membrane's response to the two-tone stimulus (f1 and f2). For thecubic distortion product (2f1-f2) and other DPs tuned more apically than the f2 place secondary component arises as a coherent linear reflection near the place associated with theDP frequency. DPOAEs have been explained as originating from interference between these two Sources and from multiple reflections of these two components between the oval window and the DPOAEs tontopic place (Dhar et al, 2002).It is generally accepted that the mechanical response behavior of basilar membrane is characterized by high degree of frequency tuning. This response, however, is dependent on the integrity of the outer hair cells (OHC).these structures play a major role in the generation of the electromechanical activity which can be measured asDistortion Productotoacoustic emissions in the outer ear canal.

In our research for all tested earsthe hearing threshold level was between (0-25 dB) over frequency levels range of 250 Hz to 8000 Hz. and correspond to normative data obtained in recent studies.(Stover and Norton, 1993).

The Results fortympanometric measurements in all tested ears were confirmed Type- A tympanogram which indicative of normal middle ear system. The results are similar to tympanogram classification a system was originated by (Jerger, 1970).

The decision about Whether a Distortion Product Otoacoustic Emission is present often depends on a visual assessment of the response along with certain objective criteria, such as distortion product otoacoustic emissions level (DP1) and signal to Noise Ratio(SNR) dB SPL.DPOAEs were considered present when the signal level exceeded the noise floor by 3 dB SPL for narrow frequency bands (Harrison *et al*,1999., Brass*et al*, 1999and Dirckx et al, 1996) and 6 dB SPL for wide frequency bands (Prieve et al, 1993) and the DPOAEs is thought to have an amplitude(DPI level) that may vary from -10dB SPL to +30dB SPL in healthy ears(Robinette and Glattke, 2007) .

In the present study for Iraqi subjects the overall SNR for each tested ear was more than 3 dB SPL at the overall frequency bands (0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 kHz) and our results showed that the minimum and the maximum of the mean value of the Distortion Product (DP1 Level) recorded for all tested ears was (-2.3dB) for female Right ear

side in group-III age (21-30) year at 0.5kHz and (20.39dB) for female right ear side in group-I age (2-10) year at 6kHz respectively over frequency bands (0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 kHz. While for Sudanese subjects The results showed that the minimum and the maximum of the mean value of the Distortion Product (DP1 Level) recorded for all tested ears was (-1.22dB) for female Left ear side in group-III age (21-30) year at 0.5kHz and (21.47dB) for female Right ear side in group-I age (2-10) year at 6.0kHz respectively over frequency bands 0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 kHz, these results agreement with previous study as denoted above.

The findings from the present study revealed an age effect on DPOAEs level (DPI) and SNR in all subjects groups, the mean value of DPI and SNR in young subjects (2-10) year was higher than other groups, statistically usedANOVA Test showed significant difference of DPI and SNR parameters between groups-I (2-10),II (11-20), III (21-30) and IV(31-40) year for Iraqi subjects according to age of FR, MR, ML and FL respectively ($p<0.05$)but for Sudanese subjects ANOVA Test showed no significant difference of DPI and SNR parameters between groups-I (2-10),II (11-20) and III (21-30) year according to age of FR, MR, ML and FL respectively ($p>0.05$).

Results are similar to early study described adult–infant age differences in the context of a DP-Gram (Abdulla, 1996). The difference in DPOAEs amplitudes (DP1level dB) among age groups was due to factors other than differences in hearing thresholds. It is very likely that the Cochlea that accompany aging and affect basilar membrane mechanics, resulting in Reduction of the cochlear amplifier. Previous studies found Progressive age-related OHC loss in the cochlea from normal hearing population (Willott, 1991., Wright and Davis, 1987). Other studies reported the atrophy of the organ of Corti in older subjects with normal hearing (Boettcher, 1995) and physiologic change seems to occur in the aged cochlea (Wright and Davis, 1987). There are three different types of physiological Changes in the cochlea were identified as sensory cell loss at high frequency region, atrophy of the striavascularis and calcification and stiffening of the basilar membrane (BM).

DPOAEs responses change with age at frequencies as low as 1000 Hz for individuals as young as 20 years old (Poling et al, 2014).

In fact the responses are larger in babies than they are in adults. It has been demonstrated previously that OAEs decrease in the first 6-years of

the life is rapid, at later ages the decrease continues more slowly with relatively comparable results (Konet al, 2000., Prieve, 1992 and satoh, 1998).

The initial fast decrease can be explained by developmental changes in external and middle ear parameters, which rapidly decelerate around the age (6-7 years) (Konet al,2000), whereas thedecrease in the later period could be predominantly caused by spontaneous impairment of the hearing function (Bray and Kemp, 1987).

The findings from the present study revealed an ear asymmetry, gender and age effect on DPOAEs level(DPI) and SNRs dB in all Iraqi and Sudanese subjects groups, Right ears were found to produce higher DPOAEs level(DPI) and SNRs dB than left ears, but statistically used T-Test (2- Tailed), no significant difference of DPOAEs level and SNR were observed between the right and left ears and also females have higher DPOAEs level DPI and SNRs than that males butno significant difference of DPOAEs level and SNR were observed between females and males.The results were agreement withthe results of (Gaskill and Brown, 1990., Cacace et al, 1996., Lonsbury et al, 1990 andKeogh et al, 2001).

In humans DPOAEs exhibit sex differences that females have higher DPOAEs than males across many age groups from infancy to adulthood, whenever sex differences exist at birth, they cannot be attributable to current differences in the levels of sex hormones, so it is considered that these differences are after effects of earlier differences in development ((Nelson , 2005).the better gender -documented during prenatal development is the differential exposure to androgens in male and female fetuses. To be specific, reasonable explanation is one that prenatal androgen exposure leads to weak the cochlear amplifier in males and decreasing their DPOAEs (McFadden et al, 2005).

The previous studies based on small sample size did not report an ear asymmetry effect in DPOAEs (Lonsbury et al, 1997). In fact, the ear asymmetry effect in DPOAEs in the current study was not clearly significant. Other studies suggested that the ear asymmetry was a result of a prenatal asymmetry occurring in the auditory system during the first trimester of pregnancy. (Previc, 1991)

Studies of auditory function in the general population revealed an ear asymmetry effect. Right ears consistently higher responses than left ears (Chung et al, 1983)and another study (Keogh et al, 2001) revealed an ear

asymmetry effect in DPOAEs and the results were found that Right ears exhibited stronger DPOAEs at 1.9, 3.0, 3.8, and. 6.0 kHz than left ears. The essence of the right ear advantage discussion says that the left hemisphere is dominant for speech and language processing and the contra lateral auditory pathways are stronger. Therefore when sounds from the right ear sent to the left hemisphere (via contra lateral pathways) a right ear advantage is often apparent regarding speech, language, and dichotic presentation of language-based sounds, particularly in younger people.

Other findings from the present study revealed racial effect on (DPI) level and SNR parameters between Iraqi and Sudanese subjects for all groups. Sudanese subjects areexpressingmore DPI and SNR parametersthan females and males of Iraqi subjects for all groups. Previous study suggested that may be related to middle earconduction properties ((Dreisbach et al, 2007 andNavid, 2008). any difference in the physical properties of themiddle ear ossicles, tympanic membrane and externalauditory meatus can affect on the DPOAEs recorded.Butno significant differences were identified between the groups. Our results are agreement with the results of (Lura et al, 2007).

To further assess the effects of race on DPOAEs measures, future studies should include larger numbers of subjects, measurement of body size and middle ear reflectance, and examine emission generators.

An additional goal of this study was proposal model of Equations to evaluate the Rate of change in DPI with Respect of Frequency For all groups Iraqi and Sudanese Subjects with normal hearing and without depended on device. Proposal model include Linear and Nonlinear Equations and wefound from comparison between them proposal model of Nonlinear was better than Linear to evaluate the Rate of change in DPI because R^2represent the power of the value of frequency (x) to explain DPI Level(Y) was higher in Nonlinear.

Another interesting finding of the present study was the Comparison of TheAverage of DPI Level with respect to frequency between The Experimental data and Theoretical model data are approximately similar for Iraqi and Sudanese Subjectsfor all Groups and we can evaluate TheAverage of DPI Level without depended on device for each Group by presenting Theoretical model of Nonlinear Equation.

5-2 Conclusion:

Distortion product Otoacousticemissions (DPOAEs) are the result of biomechanical activity associated with healthy OHCs (Electro motility). This activity produces a signal within the cochlea that is transmitted backward through the middle ear and into the ear canal. The resulting sound that is picked up by the microphone is digitized and processed by specially designed Hardware and software. The low- level of (DPOAEs) is differentiated by the software from both the background noise and from the contamination of the evoking stimuli.

Distortion product otoacoustic emission amplitude (DPI level) index which is an important parameter to measure reflect the presence of DPOAEs response.

The DPOAEs are thought to have amplitude(DPI level) that may vary from -10dB SPL to +30dB SPL in healthy ears.

The Signal to Noise Ratio (SNR) more than 3dB for narrow frequency bands (0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0, 6.0 and 8.0 kHz) and 6 dB for wide frequency bands can be taken as an indicator of DPOAEs responses compared to the noise floor.

It appears that DPI level and SNR are an important parameters, these index are utilized to evaluate the effects of middle ear and outer ear canalon DPOAEs responses.

The DPOAEs have considerable clinical relevance because it can be obtained in almost normal subjects. DPOAEs occur in 100% of normal hearing population.

The present investigation have found an age effect on DPI and SNR obtained from Iraqi and Sudanese subjects .Results show significant effect of age on DPOAEs parameters. The age effects might be attributed to the anatomic and physiologic difference in ear canal and/or middle ear between children and adults.

Theresults show no significant effect of ear asymmetry and gender on (DPI and SNR) for Iraqi and Sudanese subjects.

The present study revealed racial effect on (DPI) level and SNR parameters between Iraqi and Sudanese subjects for all groups that may be related to middle ear conduction properties. Sudanese subjectsexpressing more DPI and SNR parameters than Iraqi subjects.

The proposal model linear and nonlinear equations can be used to evaluate the Rate of change in DPI with Respect of Frequency For all

groups Iraqi and Sudanese Subjects without depended on device. The results from nonlinear equations were better than that from Linear equations.The present study showed that the Comparison of The Average of DPI Level with respect to frequency between Experimental data and Theoretical nonlinear model data are approximately similar for Iraqi and Sudanese Subjectsforall Groups that it can be evaluate The Average of DPI Level without depended on device for each Group by presenting Theoretical model of Nonlinear Equation.

5-3 Limitations:

- DPOAEs have restrictions as measures of developmentalprocesses Such as the degree of body temperature between different subjects, high blood pressure (hypertension), aging, and menstrual cycle that weakens the cochlear amplifiers will produce both a loss of hearing sensitive and weakness DPOAEs produce.
- Interference of Electric microphone noise, physiological noise (breathing, blood flow) and external acoustic noise with the DPOAEs recording process do not allow DPOAEs measurements at very low stimulus levels. Especially below 0.5 kHz, reliable DPOAEs measurements are not possible even at high stimulus levels. Noise is still a problem in the detection of DPOAEs signals.

5-4 Recommendations:

- The fact that all healthy ears showed stable DPOAEs responses, we recommended other clinical investigators to use the DPOAEs as a valuable audiological investigation technique.
- The further study should be included larger numbers of subjects, measurement of body size and middle ear reflectance, and examine emission generators in order to obtain highaccuracy for comparison between results.
- The test of cochlea function usually assessed according to standard normative data of distortion product otoacoustic emissions that is different between nations. This fact dictates that indigenous normative data should be generated.

Reference :

- Abdala C, (1996). ; “Distortion product otoacoustic emission (2f1 −f2) amplitude as a function of f2/f1 frequency ratio and primary tone level separation in human adults and neonate”J AcoustSoc Am. 100:3726–3740
- Adnan Mohsin Ali AL Maamury, (2005).;"Analysis of transient evoked otoacoustic emissions".
- Ashmore JF. (1987). ;"A fast motile response in guinea-pig outer hair cells: The cellular basis of the cochlear amplifier".J Physiol 388:323–347.
- American Speech-Language-Hearing Association, (1990).; "Guidelines for screening for hearing impairment and middle ear disorders". ASHA31:71–77.
- Ashmore J,(2008). ;"Cochlear outer hair cell motility". Physiol Rev. 88(1):173-210
- Ashmore et al,(2010). ;" Hearing Research". 266 1–17.
- American National StandardInstitute specification for Instruments to Measure Aural Acoustic Impedance and Admittance (Aural Acoustic Admittance), ANSI S3. 39-1996. New York: ANSI.

- Brown A.M, Kemp D.T, (1984). ; "Suppressibility of the 2F1-F2 stimulated acoustic emissions in gerbil and man" Hear Res. 13: 29-37.
- Brownell WE, Bader C. R. Bertrand D. and de Ribaupierre, Y. (1985). ; "Evoked mechanical responses of isolated cochlear outer hair-cells" Science 227:194-196.
- Bray, P., & Kemp, D. T, (1987).;" An advanced cochlear technique suitable for infant screening". *British* Journal of Audiology, 21, 191–204.
- Bertoli,S.,Probst,R.,1997.Theroleoftransient-evokedotoacoustic emissiontestingintheevaluationofelderlypersons.EarHear.18,
- Brownell, W. E. and A. S. Popel, 1998. ;"Electrical and mechanical anatomy of the outer hair cell". *In* Psychophysical and Physiological Advances in Hearing. A. R. Palmer, A. Rees, A. Q. Summerfield and R. Meddis, editors. Whurr Publishers Ltd, London, 89–96.

- Brownell WE, Kachar B, (1986). ; "Outer hair cell motility: a possible electro-kinetic mechanism. In Peripheral Auditory Mechanisms",eds Allen JB, Hall JL, Hubbard AE, Neely ST, Tubis A. (Springer, Berlin), pp 369–376.
- Brownell WE, (2002); "on the origins of outer hair cell electromotility". In: Berlin CI, Hood LJ, Ricci AJ(eds), Hair Cell Micromechanisms and Otoacoustic Emissions. Clifton Park, NY:Thomson Delmar Learning; 25-46.
- Brownell WE, Oghalai JS, (2000);" Structural basis of outer hair cell motility or where's the motor?" In: Lim D , Cell and Molecular Biology of the Ear. New York: Plenum Press; 69-83.
- Boettcher, F.A., Gratton, M.A. & Schmiedt, R.A, (1995). ;"Effects of noise and age on the auditory system". Occupational Medicine, 10, 577-591.
- Brown, A.M., Harris, F.P.& Beveridge, H.A, (1994). ;"two sources of acoustic distortion products from the human cochlea". Journal of the Acoustical Society of America, 100, 3260-3267.
- Brown, A.M., McDowell, B. & Forge, A, (1989). ;"Acoustic distortion products can be used to monitor the effects of chronic gentamicin treatment". Hearing Research, 42, 143-156.
- Brass, D.J., & Krackhardt, D, (1999). ;The social capital of 21st century leaders. In J.G. Hunt &R.L. Phillips (Eds.), Out-of-the-Box Leadership(pp. 179-194). Stamford, CT: JAI Press.
- Christopher A, Shera and carolina Abadala,(2012). ; "Otoacoustic emission Mechanism and applications".
- Cheng J, (1993);"Time-frequency signal representation of transient evoked otoacoustic emissions via smoothed pseudo winger distribution" report 12g Dept of technical audiology, karolinska Institution Stockholm. PP. 1-18.
- Chang, Kay W, Norton, Susan, (1 September 1997). ;"Efferently mediated changes in the quadratic distortion product (f2−f1)". *The* Journal of the Acoustical Society of America **102** (3): 1719.
- Cacace A, McClelland W, Weiner J, McFarland D, (1996). ;"Individual differences and the reliability of 2fl-f2".
- Chung DY, Mason K, Gannon RP, Wilson GN, (1983). ;"The Ear effect as a function of age and hearing loss". JAcoust Soc Am 73:1277-1282.

- David C. Dugdale,(2012). ;"Hearing and the cochlea –Health".

Update Date: 11/10/2012.

- Davis H, (1983). ; "An active process in cochlear mechanics" Hearing Research, 9(1), 79-90.
- De Toro and Miguel Anglel,(2011). ;"Effect of noise over exposure on DPOAEs".
- Dallos P, (1992). ;"The active cochlea" Journal of Neuroscience, 12:4575–4585.
- Dreisbach LE[1], Kramer SJ, Cobos S, Cowart K,(2007). ;" Racial and gender effects on pure-tone thresholds and distortion-product otoacoustic emissions (DPOAEs) in normal-hearing young adults"**.**
- DancerA,(1992). ;"Experimental look at cochlear mechanics". Audiology;31:301–312.
- Drake, Richard L,Vogl, Wayne, Tibbitts, Adam W.M. Mitchell,(2005) ; illustrations by Richard; Richardson, Paul,;Gray's anatomy for students.
- Deeter, R., R. Abel, L. Calandruccio and S. Dhar, (2009); "Contralateral acoustic stimulation alters the magnitude and phase of distortion product otoacoustic emissions." J Acoust Soc Am 126(5): 2413-2424.
- Dallos P,(2008).;"Cochlear amplification, outer hair cells and prestin". Curr OpinNeurobiol. ;18(4):370–376.
- Dhar S., Long G. R., Talmadge C. L., and Tubis A. (2002).; "The effect of stimulus-frequency ratio on distortion product otoacoustic emission components," J. Acoust. Soc. Am. 117, 3766–3776. 10.1121/1.1903846.
- Dorn PA, Piskorski P, Gorga MP, Neely ST, Keefe DH, (1999).; predicting audiometric status from distortion product otoacoustic emissions using multivariate analyses Ear Hear. Apr; 20(2):149–163.
- Dhar S, Hall J, (2012). ;" Otoacoustic Emissions, Principles, Procedures and Protocols". San Diego: Plural Publishing;.

- Dirck X JJJ;Daemers TH;Somers F; Offecers FE; Govaerts PJ, (1996);Numerical assessmentof TEOAEs screeingresults; currently used criteria and their effect onTEOAEs prevalance fiures. Acta Otolarynogl,118;672-679.

- Eiserman, W. , & Shisler, L. (2010). Identifying Hearing Loss in Young Children: Technology Replaces the Bell. Zero to Three Journal, 30, No.5, 24-28.
- Emilyan A. Ivanov, Svetla P. Pentcheva,2008."characterstics of electromotility of outer hair cell lateral wall".

- Fahey, B. B. Stagner, B. L. Lonsbury-Martin and G. K. Martin, (2000), "Nonlinear interactions that could explain distortion product Interference response areas" J. Acoust. Soc. Am. 108, 1786-1802.
- Gold T, (1948). "Hearing II. The Physio basis of the action of the cochlear" Proc. R. Soc. Edin 135, 492-498.
- Geisler CD:From Sound to Synapse: Physiology of the Mammalian Ear. New York: Oxford University Press; 1998.
- Guy, Rebillard, Pujol,(2016);"This active amplification mechanismwhich gives the cochlea remarkable frequency selectivity".
- Gummer AW, Meyer J, Frank G, Sherer MP, Preyer S;"Mechanical transduction in outer hair cells". Audiology and Neuro-Otology. 2002; 7, 13-16.
- Gaskill, S.A.and Brown, A.M. (1990);"the behavior of the acoustic distortion products, 2f1- f2, from the human ear and its relation to auditory sensitivity". Journal of the Acoustical Society of America, 88, 821-839.
- GlenK,Martin, 2002);"DPOAEs generation Mechanisms".
- Grenner J, (2012);"Significance of a notch in the otoacoustic emission stimulus spectrum". J Laryngol OtolSep; 126(9):897-901.

- Harris, F.P., Lonsbury-Martin, B.L., Stagner, B.B. Coats, A.C. & Martin, G.K, (1989);"Acoustic distortion products in humans: Systematic changes in amplitude as function of f2/f1 ratio". Journal of Acoustical Society of America, 85, 220-229.

- Hunter M.F., Kimm L., Cafarelli Dees D., Kennedy C. R. and Thornton A.RD, (1994);"Feasibility of otoacoustic emission defection followed by ABR as a universal neonatal screening test for hearing impairment" Br. J. Audio, 28, 47.
- Harrison WA, Norton SJ. (1999). Characteristics of transient evoked otoacoustic emissions in normalhearing and hearing-impaired children. *Ear Hear* 20:75–86.

- Iwasa KH, Adachi M. Force generation in the outer hair cell of the cochlea. Biophys J.1997; 73:546-555.

- Jaramillo F., Markin V.S., Hudspetch A.J, (1993);"Auditory illusion and the single hair cells", Nature, 364, 527-529.
- Jessica Arrue Ramos, MAudSt, MAudSA (CCP); Sinnet Greve Bjerge Kristensen, MA; and Douglas L. Beck, AuDA ,(2013); review of OAE concepts, the application of screening versus diagnostic OAEs, as well as normative data to help clinicians in the interpretation of DPOAEs for the Interacoustics Titan DPOAE440 module″.
- Jerger J. (1970). Clinical experience with impedance audiometry. Arch Otolaryngol Head Neck Surg 92:311-324.

- Kujawa, SG; Fallon, M; Skellett, RA; Bobbin, RP, (August 1996); "Time-varying alterations in the f2-f1 DPOAE response to continuous primary stimulation. II. Influence of local calcium-dependent mechanisms." *Hearing research* **97**.
- Kemp D.T, (1978);" Stimulated acoustic emissions from within the human auditory system" J. Acoust Soc. Am., 64:1386–1391.
- Kemp D.T., Ryan S., Bray P, (1990);"A guide to the effective use of otoacoustic emissions" Ear Hear, 11, 93-105.
- Kemp D.T,(2002); Otoacoustic emissions,their origin in cochlear function and use.
- Kei J., McPherson B., Smyth V., Latham A. and Loscher J, (1997);"Trasient evoked otocaoustic emissions in infants: Effects of gender, ear asymmetry and activity status" Audiology, 36, 61-71.

- Kemp D.T., Chum R.A, (1986);"Observation on the generator mechanism of stimulus frequency acoustic emissions- Two tone suppression" In psychophysical physiological and behavioral studies in hearing, edited by G. Vanden Brink and F.A. Bilsen (delft University, delft, the Netherlands), pp. 34-42.
- Kalluri, C. A. Shera, (2001); “Distortion-product source unmixing" A test of the two-mechanism model for DPOAE generation” J. Acoust. Soc. Am. 109, 622-637.
- Kathleen C M, Campbell ,(2016); "Otoacoustic emissions".
- Kakehata S, Santos-Sacchi J,(1999); Membrane tension directly shifts voltage dependence of outer hair cell motility and associated gating charge. Biophys J. ; 68:2190–2197.
- Kachar B, Brownell WE, Altschuler R, Fex J,(1986);"Electrokinetic shape changes of cochlear outer hair cells". Nature 322:365–368.
- Kon , K ; Inagaki ,M ; kaga , M,(2000) ;Developmental changes Distortion product otoacoustic emissions in different age groups.Brain Dev.22(1);41-46.
- Keogh,Joseph Kei, CarlieDriscoll, Veronica Smyth, (2001) ; Distortion-Product Otoacoustic Emissions in School children Effects of Ear Asymmetry and Gender.
- Kummer, P., Janssen, T. & Arnold, W, (1998); the level and growth behavior of the 2f1-f2 distortion product otoacoustic emission and its relationship to auditory sensitivity in normal hearing and cochlear hearing loss. Journal of the Acoustical Society of America, 103, 3431-3444.
- Kei J, McPherson B, Smyth V, Latham S, Loscher J, (1997); "Transient evoked otoacoustic emissions in infants: Effects of gender, ear asymmetry and activity status ". Audiology 36:61-71.
- Liberman MC., Gao J., He DZ., et al., (2002),"Prestin is required to electromotility of the outer hair cell and for cochlear amplifier" Nature 419, 300-304.
- Lutman M.E., Davis AC., Fortnum H.M., Wood S., (1997),"Field sensitivity of targeted neonatal hearing screening by transient-evoked otoacoustic emissions" Ear Hear 18, 265-276.

- Lonsbury-Martin, F. P. Harris, B. B. Stagner, M. D.Hawkins, and G. K. Martin, (1990b) “Distortion-product emissions 158 in humans, I. Basic properties in normally hearing subjects” Ann.Otol. Rhinol.Laryngol, 99, Suppl. 147, 3-14.
- LePage,E.L.,Murray,N.M,(1998);"Latentcochleardamageinpersona l stereousers":astudybasedMed.J.Aust.169,588–592.
- Laura E. Dreisbach, Steven J. Kramer, Sandra Cobos, Kristin Cowart ,(Jan 2007); "Racial and gender effects on pure-tone thresholds and distortion-product otoacoustic emissions (DPOAEs) in normal-hearing young adults"International Journal of Audiology , Vol. 46, No. 8, Pages 419-426: 419-426.
- Lonsbury-Martin, B.L. & Martin, G.K. (1990). The clinical utility of distortion product otoacoustic emissions. Ear & Hearing, 11, 144-154.55
- Lonsbury-Martin BL, Martin GK, Whitehead ML, (1997); "Distortion product otoacoustic emissions".In:RobinetteM,
- Glattke T, eds . Otoacoustic Emissions: Clinical Applications.

New York: Thieme, 83-109.

- Lim Kian Meng,(2015);" Mechanics of Hearing".
- Martin G.K., Probest R., Lonsbury-Martin BL., (1990), "Otoacoustic emissions in human ears" normative finding ear hears, 11, 106-120.
- McFadden, D.; Westhafer, J.G.; Pasanen, E.G.; Carlson, C.L. and Tucker, D.M. (2005); “Physiological evidence of hyper masculinization in boys with the inattentive type of attention –

Deficit / hyperactivity disorder (ADHD)” Clinical Neuro Science Research. 5: 233-245.

- Mammano, F., Ashmore, J.F., 1993;"Reverse transduction measured in the isolated cochlea by laser Michelson interferometer". Nature 365, 838–841.
- Mireille Lavigne-Rabillard, "from promenade around the cochlea, 2013".

- Maoiléidigh, D. & Jülicher, F, (2010);"the interplay betweenactive hair bundle motility and electro motility in the cochlea". J. Acoust. Soc. Am. 128, 1175–1190.
- Moller AR, (1999) ;"Pathophysiology of severe tinnitusand chronic pain". In: Hazell J, ed. Proceedings of the SixthInternational Tinnitus Seminar. London: Tinnitus andHyperacusis Centre, 26-31.
- Mats Ulfendahl, Åke Flock,(1998) ;" Outer Hair Cells Provide Active Tuning in the Organ of Corti Physiology".

- Nobili, R., F. Mammano, and J. F. Ashmore. 1998. How well do we understand the cochlea? Trends Neurosci. 21:159 –167.
- Norton, S. J., Gorga, M. P., Widen, J. E., Folsom, R. C.,Sininger, Y., Cone-Wesson, B., . . . Fletcher, K, (2002) ;"Identification of neonatal hearing impairment: Evaluation of transient-evoked otoacoustic emission, distortion- product otoacoustic emission, and auditory brain stem response test performance". Ear and Hearing, 21, 508–528.
- Nelson R.J, (2005); “An introduction to behavioral Endocrinology” (3rd Ed.) Sunderland, MA: Sinauer.
- Norton, S. J., & Widen, J. E. (1990);" Evoked otoacoustic emissions in normal-hearing infants and children": Emerging Data and issues. *Ear and Hearing, 11*, 121–127.
- Navid, Feeney, M. Patrick; Schairer, Kim S, (2008);" Ear and Hearing".
- Oghalai John S, (2004);"The cochlear amplifier: Augmentation of the traveling wave within the inner ear" Curr. Opin. Otolaryngology Head Neck Surg. 12(5)431-438.
- Pickles, J. O,(1988);“An introduction to the physiology of hearing” 2nd edition, San Diego: Academy Press Inc.
- Promenade round cochlea , 2013; IHC.
- Previc FH, (1991);"A general theory concerning the prenatal Origins of cerebral lateralization in humans". Psychol Reu 98:299-334.

- Prieve,B.A,(1992);"Otoacousticemissionsininfantsandchildren";basic characteristicsandclinicalappl.
- Plewes, K, (2006); "Anatomy and physiology of the ear".

- Prieve BA, Gorga MP, Schmidt A, Neely ST, PetersJ, Schulte L, Jesteadt W, (1993);"Analysis of transient- evoked otoacoustic emissions in normal-hearing and hearing-impaired ears". J. Acoust Soc Am. 93:3308–3319.
- Prieve,B.A.,Falter,S.R.,1995.COAEsandSSOAEsinadultswith increasedage.EarHear.16,521–52.
- Popelka, M. M., Cruickshanks, K. J., Wiley, T. L., Tweed, T. S., Klein, B. E. K., Klein, R., 1998;. Low prevalence of hearing aid use among older adults with hearing loss: The epidemiology of hearing loss study. Journal of the American Geriatrics Society, 46:1075-*1078*.
- Pujol, R from Promenade round the cochlea,(2016).
- Pujol, R from Promenade round the cochlea, (2013); Hair cells.
- Pujol and Irving S, (2013);" Organ of Corti".
- Promenade,(2003);"Simplified schematic of the basilar membrane. Illustrating the change in characteristic frequency from base to apex".
- Probst, R., Lonsbury-Martin, B.L. & Martin, G.K. (1991). A review of otoacoustic emissions. Journal of Acoustical Society of America, 89, 2027-2067.
- Poling, G. L., Siegel, J. H., Lee, J., Lee, J., & Dhar, S, (2014);"Characteristics of the 2f (1)-f(2) distortion product otoacoustic emission in a normal hearing population". *J Acoust Soc Am*, *135*(1), 287-299. doi: 10.1121/1.4845415
- Ricci,A, (2003). ;"Active hair bundle movements ana the cochlear amplifier". J,Am.Acd. Audio.14(6):325-38.
- Pavlovcinovo, Janka, Tomas,Kinga,sona,(2010);" Pediatric Otto rhino laryngdogy' 74(173-177).

- Richard R. Fay, Arthur N. Popper, and Sid P. Bacon, (2004).;Compression: From Cochlea to Cochlear Implants. Springer, ISBN 0-387-00496-3.
- Rao A, Long GR,(2011);"Effects of aspirin on distortion product fine structure: interpreted by the two-source model for distortion product otoacoustic emissions generation". J Acoust Soc Am. Feb; 129(2):792–800.

- Robert M. Raphael, Aleksander S. Popel, and William E. Brownell, (2000).;"A Membrane Bending Model of Outer Hair Cell Electromotility".
- Robert A. Dobie, Susan Van Hemel,(2004). ;"Committee on Disability Determination for Individuals with Hearing Impairments " - Social Science.
- Ramos JA, Kristensen SGB, Beck DL, (2013). ;" An overview of OAEs and normative data for DPOAEs". Hearing Review20(11):30-33.
- Robinette, M.S., & Glattke, T. J,(2007);"Otoacoustic emissions: Clinical applications". New York: Thieme. Ross, B., Picton, T. W., Herdman, A. T., Hillyard.
- Sewell, (1996). ;"Neurotransmitters and synaptic transmission". In:The cochlea.(Dallos P, Popper AN, Fay RR, eds), pp 503–533. New York: Springer.
- Schnupp J., Nelken I., King A, (2011);" Auditory Neuroscience. Cambridge MA": MIT Press. ISBN 0-262-11318-X.
- Sheppard, S., Brown, A., & Russell, P, (1996); British Journal of Audiology, 30: 261-274.
- Stover LJ, Norton SJ, (1993) ;"the effects of aging on otoacoustic emissions". J Acoust Soc Am 94:2670–2681.
- Stover, L. & colleagues, (1996);" the effects of aging on otoacoustic emissions".
- Spektor,A.,Leonard,G.,Kim,D.O.,Jung,M.D.,Smurzynski,J,(1991); "Otoacousticemissionsinnormalandhearing-impairedchildrenand normaladults".Laryngoscope101,965–97.
- Stover LJ, Neely ST, Gorga MP, (1996);" Latency and multiple sources of distortion otoacoustic emissions". Journal of Acoustical Society of America 99: 1016
- Shera, C. A., Guinan, J.J, (1999)"; Evoked otoacoustic emissions Arise by two fundamentally different mechanisms": taxonomy for mammalian OAEs. Journal of the Acoustical Society of America, 105, 782–798.
- Christopher A. Shera and carolina Abdala,(2004). ;"Otoacoustic emissions- Mechanizms and applications".

- Satoh, Y,Kanzaki,J;O-Uchi,T, Yoshihara, S, (1998). ; "Age related changes in transient emissions and distortion product otoacoustic emissions in Normal- hearing ears". Auris. Nasus, larynxx,25;121-130.

- United health care, oxford, (October1, 2015);"Otoacoustic emission testing".
- Vohr, B. R., White, K. R., Maxon, A. B., & Johnson, M. J, (1993);"Factors affecting the interpretation of transient evoked otoacoustic emission results in neonatal hearing screening". *Seminars in Hearing, 14*, 57-72.

- Willott, J.F. (1991); "Aging and the auditory system Anatomy, physiology, and Psychophysics" San Diego: Singular Publishing Group, Inc
- Wright, A., Davis, A., Bredberg, G., Ulehlova, L., & Spencer, H. (1987); "Cell distributions in the normal human cochlea" ActaOto-Laryngologica supplement, 444.
- Wada H., Ohyama K., Kobayashi T. and Noguchi S, (1995);"Effects of middle ear on otoacoustic emissions" Audiology 34, 161-176.
- Whitehead, M.L., Lonsbury-Martin, B.L. & Martin, G.K, (1992);"Relevance of animal models to the clinical application of otoacoustic emissions". Seminar in hearing, 13, 81-101
- Weleh,D; Grevile,KAThorne,PR;Purdy,SC(1996); "Influence of acquation parameters on the measurment of the click evoked otoacoustic emissions in neonates in a hosptial enviroment". Audiology,35:143-57.
  .
- Zenner, H.P., Zimmerman, U. and Schmitt, U, (1986). ;"Reversible Contractions of isolated mammalian cochlear hair cells". Hear. Res. 18, 127-133.

Appendix-A

Group (I) age (2-10) years for Iraqi subjects

Table (1) DP1 Level (dB) for Right ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	10.6	9.9	21.1	22.7	18.8	16.2	22.8	22.0	24.9
2	0.0	1.6	7.8	8.4	12.3	7.8	13.6	10.3	10.9
3	2.9	2.3	6.5	14.6	12.6	9.9	12.5	19.7	23.3
4	3.0	7.9	12.0	18.3	14.6	15.7	15.0	20.2	14.0
5	0.2	5.8	19.2	11.1	11.2	5.9	10.3	22.6	19.8
6	4.3	14.0	12.6	13.0	14.9	7.8	13.4	18.4	16.9
7	3.6	2.2	12.5	18.8	12.8	7.0	9.0	19.5	13.4
8	1.6	8.9	13.1	15.7	14.2	5.3	14.5	20.7	21.8
9	3.9	5.27	7.8	15.4	12.1	5.8	17.1	15.2	20.7
10	2.0	4.0	2.5	14.4	15.1	12.0	16.3	21.3	20.0
11	4.0	1.6	4.8	13.7	7.7	10.9	9.3	20.1	17.4
12	3.5	14.5	14.6	15.1	9.6	7.9	13.7	21.1	25.0
13	4.4	5.2	12.3	16.3	12.2	14.2	15.9	20.0	22.3
average	3.38	6.40	11.29	15.19	12.93	9.72	14.10	19.3	16.84

Table (2) DP1 Level (dB) for left ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	2.9	15.6	17.9	20.0	19.0	23.0	15.0	24.9	13.7
2	1.0	6.8	7.5	11.0	2.8	6.5	13.9	16.3	4.8
3	0.7	5.3	5.5	13.0	13.5	9.8	13.0	25.0	14.3
4	3.6	1.6	4.2	12.6	4.5	11.7	19.2	19.0	13.0
5	3.2	11.4	12.4	16.9	9.5	6.9	12.4	18.9	20.2
6	3.1	2.8	-1.5	8.0	7.5	3.7	15.7	14.5	20.0
7	4.4	9.6	18.6	17.2	15.9	13.5	11.3	15.0	21.0
8	3.0	0.7	13.4	17.2	11.4	3.1	10.1	20.0	14.5
9	3.9	3.5	12.4	12.4	1.6	10.4	14.8	12.6	12.1
10	3.6	8.0	8.3	12.0	15.6	3.8	15.6	11.8	12.9
11	2.9	6.3	11.5	14.6	12.4	9.0	4.2	13.7	14.5
12	3.7	5.3	15.2	12.3	7.2	6.8	12.0	18.1	17.8
13	4.9	1.4	10.0	17.8	12.9	10.9	15.4	24.9	20.0
average	3.15	6.02	10.42	14.23	10.29	9.1	13.27	18.05	15.29

Table (3) Signal Noise Ratio SNRs (dB) for Right ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.2	5.4	9.4	17.3	24.6	18.9	25.2	30.5	17.9
2	3.9	6.9	6.2	10.4	13.3	16.2	19.2	16.3	14.6
3	3.8	6.5	8.5	11.0	13.3	13.9	14.9	13.8	15.8
4	3.0	5.0	6.3	19.7	14.6	19.1	18.2	17.1	10.0
5	3.5	4.9	9.3	14.0	10.9	10.7	12.7	14.0	9.8
6	3.3	6.5	10.2	5.9	6.5	16.5	16.1	13.2	16.9
7	3.9	4.5	14.9	13.3	12.5	12.6	17.7	13.4	7.4
8	3.4	6.6	6.7	22.1	6.8	6.5	23.3	11.9	8.7
9	3.5	5.7	5.7	12.5	8.8	9.5	12.6	19.4	6.9
10	4.5	6.1	10.3	12.5	14.6	17.6	17.7	18.9	7.4
11	3.0	4.5	7.6	18.4	11.8	16.7	15.7	16.2	7.9
12	3.5	7.6	9.6	18.4	12.6	8.9	9.0	10.3	10.7
13	3.9	3.2	7.0	10.9	7.4	16.3	13.0	14.9	7.9
average	3.39	5.65	8.59	14.34	12.13	14.11	16.52	16.06	10.91

Table (4) Signal Noise Ratio SNRs (dB) for left ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.0	8.7	17.9	11.5	28.8	20.3	24.1	10.8	19.7
2	3.1	6.1	6.1	6.9	10.5	14.4	13.6	7.4	6.2
3	3.0	5.0	6.4	10.0	8.3	15.1	14.6	23.5	16.1
4	3.0	3.3	6.5	11.8	9.5	19.3	25.4	12.8	6.1
5	3.1	5.1	6.5	13.7	6.1	9.4	10.6	14.8	7.8
6	3.0	5.9	7.1	8.2	9.8	17.2	13.3	23.7	9.1
7	3.2	6.1	10.4	13.8	17.3	10.8	18.6	22.4	6.3
8	3.3	4.1	6.5	12.1	10.6	7.1	12.6	18.5	10.5
9	3.0	4.5	12.7	10.0	6.9	14.7	20.9	15.1	8.0
10	3.2	4.4	5.2	6.5	6.4	13.8	8.1	7.8	6.2
11	3.1	3.3	6.3	8.9	9.7	15.1	10.7	17.2	8.2
12	3.2	5.1	10.3	12.1	7.2	7.7	7.5	8.4	6.8
13	3.3	3.2	7.8	16.4	8.3	10.1	22.2	20.1	6.4
average	3.11	4.98	8.44	10.92	10.72	13.46	15.55	15.57	9.03

Table (5) DP1 Level (dB) for Right ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.2	6.6	16.2	11.7	17.3	20.7	5.4	19.2	16.9
2	3.7	10.7	10.3	14.6	12.5	15.2	12.8	20.0	19.1
3	3.9	9.0	8.3	16.2	20.6	16.5	20.2	20.2	4.9
4	4.2	12.1	15.8	17.1	20.3	20.1	20.5	20.0	20.2
5	3.6	10.7	13.7	14.3	15.0	15.5	10.7	21.2	21.3
6	3.9	4.6	10.9	17.9	12.5	19.1	16.7	25.5	4.5
7	3.3	11.4	13.9	16.9	14.1	20.7	13.3	14.5	7.9
8	4.8	9.9	11.3	14.3	15.2	23.7	19.1	25.0	20.8
9	7.1	8.6	15.8	12.5	12.6	14.6	16.9	24.9	19.8
10	3.5	5.3	14.7	14.2	15.1	13.5	17.8	14.7	12.8
11	5.2	6.0	7.7	12.6	16.1	16.9	10.3	15.6	3.5
12	4.9	10.0	8.8	16.6	11.0	12.7	17.6	20.5	20.1
13	8.2	13.9	7.5	19.2	18.4	19.3	20.4	24.3	24.1
average	4.57	9.13	11.91	17.3	15.43	17.57	15.51	20.39	16.62

Table (6) DP1 Level (dB) for left ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	9.8	3.5	6.7	10.8	9.6	6.4	12.8	18.3	23.2
2	10.9	9.6	7.6	16.3	9.4	2.3	13.0	17.3	16.5
3	10.1	8.0	12.5	17.4	20.1	18.7	18.3	16.1	9.7
4	7.0	8.4	15.3	15.4	15.3	12.9	18.5	14.9	20.0
5	0.6	10.8	10.8	10.6	4.2	4.0	10.1	19.9	18.8
6	-3.9	4.1	13.6	13.5	10.2	2.4	12.6	24.7	20.1
7	4.5	13.6	18.5	15.8	20.3	20.6	11.2	13.3	1.6
8	6.6	0.7	9.2	12.4	12.6	22.9	17.4	25.5	23.9
9	-8.6	3.2	5.9	11.5	13.7	12.3	17.7	22.8	7.4
10	-10.0	8.9	14.6	10.8	14.6	10.5	15.6	24.8	23.5
11	3.1	-8.3	7.2	17.8	12.9	1.6	7.2	21.3	12.7
12	-1.3	4.8	12.2	18.3	10.0	14.0	21.0	21.1	17.9
13	10.8	10.8	9.9	16.4	13.2	19.2	11.6	23.1	7.3
average	3.04	6.00	11.07	14.38	12.56	11.37	14.38	20.24	15.58

Table (7) Signal Noise Ratio SNRs (dB) for Right ear female.

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.0	9.4	8.5	11.6	10.8	16.9	15.7	18.2	8.9
2	9.4	8.7	10.5	16.7	15.1	18.0	17.0	15.6	18.7
3	3.5	9.3	9.0	15.0	24.0	19.6	24.4	15.2	13.8
4	4.0	6.7	6.1	20.3	17.9	13.3	20.6	24.0	20.2
5	7.0	8.3	6.6	16.9	9.1	18.5	13.3	21.5	10.3
6	4.9	9.7	13.2	19.1	11.7	16.9	15.5	14.9	16.6
7	15.8	3.2	15.2	17.7	13.1	16.8	6.2	16.4	15.3
8	3.2	9.6	16.5	12.0	12.3	31.2	24.8	29.9	10.6
9	14.7	6.6	12.0	17.1	11.7	24.1	23.7	32.1	12.0
10	6.5	10.1	6.6	16.7	9.3	14.0	17.3	10.0	10.0
11	3.2	13.1	13.7	17.6	7.9	19.0	11.0	8.4	16.7
12	3.5	14.3	10.3	18.0	17.2	18.2	19.4	10.0	18.7
13	3.1	7.6	8.8	10.2	10.2	26.1	25.6	25.4	15.4
average	6.37	8.96	10.53	16.06	13.1	19.43	18.04	18.58	14.4

Table (8) Signal Noise Ratio SNRs (dB) for left ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	7.0	3.9	7.7	13.0	11.9	14.5	17.7	20.8	14.5
2	6.4	13.7	7.5	19.8	9.6	10.7	17.9	17.4	7.0
3	3.0	6.7	10.6	18.5	23.4	22.2	6.7	13.5	5.1
4	3.0	6.1	11.1	10.2	16.4	19.5	23.5	20.8	20.9
5	4.0	4.4	10.7	9.9	8.3	13.1	18.4	18.7	13.5
6	3.8	7.4	10.5	10.5	11.2	8.4	11.3	21.0	13.8
7	6.2	10.1	10.1	18.0	13.6	24.5	15.3	7.3	7.6
8	3.4	9.4	4.4	6.6	8.1	27.3	9.2	7.5	8.3
9	3.5	5.2	7.9	10.9	11.7	11.0	17.2	15.6	4.9
10	6.0	6.5	6.1	8.5	9.7	10.9	12.5	27.9	16.2
11	3.0	3.2	3.5	7.8	6.3	13.2	14.4	11.3	7.2
12	4.4	6.7	8.2	6.6	6.6	16.7	15.5	12.5	9.5
13	3.2	6.2	6.2	6.9	14.7	8.8	17.8	23.1	5.6
Average	4.38	6.88	8.04	11.32	11.65	15.45	15.18	16.7	10.32

Table (9) comparison between average of DP1 level and SNR for females and males at each frequency

No.	Frequency KHz	DP1Level FR dB	DP1Level FL dB	SNR FR dB	SNR FL dB	DP1Level MR dB	DP1Level ML dB	SNR MR dB	SNR ML dB
1	0.5	4.57	3.04	6.37	4.38	3.38	3.15	3.39	3.11
2	0.75	9.13	6.0	8.96	6.88	6.40	6.02	5.65	4.98
3	1.0	11.91	11.07	10.53	8.04	11.29	10.42	8.59	8.44
4	1.5	17.3	14.38	16.06	11.32	15.19	14.23	14.34	10.92
5	2.0	15.43	12.56	13.1	11.65	12.93	10.29	12.13	10.72
6	3.0	17.57	11.37	19.43	15.45	9.72	9.1	14.11	13.46
7	4.0	15.51	14.38	18.04	15.18	14.10	13.27	16.52	15.55
8	6.0	20.39	20.24	18.58	16.7	19.3	18.05	16.06	15.57
9	8.0	16.62	15.58	14.4	10.32	16.84	15.29	10.91	9.03
	average	14.27	12.06	13.94	11.10	12.12	11.09	11.3	10.19

Appendix- B

Group (II) age (11-20) years for Iraqi Subjects

Table (10) DP1 Level (dB) for Right ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.8	4.1	11.6	8.3	2.7	-3.0	6.6	11.6	16.1
2	2.3	2.2	2.5	10.8	12.4	4.1	12.5	15.7	13.7
3	5.4	3.5	10.6	12.6	9.7	15.0	14.1	15.2	10.8
4	6.5	-5.0	10.5	-4.4	-0.7	12.0	1.6	16.1	4.3
5	1.1	3.5	13.1	5.9	1.1	5.0	13.0	17.3	14.1
6	4.2	6.5	3.8	4.1	-4.7	-0.8	6.2	14.6	17.5
7	-1.4	8.8	7.9	12.7	11.3	6.6	14.2	13.9	7.0
8	0.0	1.5	3.1	3.4	10.3	10.9	17.5	15.1	18.1
9	1.4	5.7	5.3	7.3	-2.6	-3.1	0.7	12.6	9.1
10	7.3	-9.4	0.3	3.0	6.3	-1.3	10.7	20.5	19.2
11	7.1	-3.4	-1.4	4.8	0.3	8.8	10.9	16.3	11.7
12	6.0	7.0	13.4	17.2	16.1	4.7	17.0	21.3	15.5
13	1.1	6.6	11.6	12.5	-3.2	4.8	3.8	13.5	13.2
average	3.44	2.43	7.1	7.55	4.53	4.9	9.90	11.25	13.1

Table (11) DP1 Level (dB) for left ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
1	9.1	1.2	5.6	7.0	-5.8	-2.3	0.6	-3.6	-4.7
2	-2.3	4.2	9.1	11.3	6.7	5.3	13.8	-1.2	7.3
3	-4.3	6.2	6.9	8.9	8.9	4.3	15.3	13.9	-10.0
4	5.4	2.4	4.2	13.1	12.9	6.7	-2.5	2.8	-5.3
5	7.5	5.1	8.2	2.2	-8.8	5.6	9.6	13.7	17.6
6	-0.5	4.4	5.5	0.3	-11.7	4.8	9.6	12.4	6.6
7	-3.8	5.5	5.8	12.9	10.2	8.9	11.7	10.6	5.3
8	-6.2	4.4	5.6	8.5	8.2	5.0	10.3	23.6	21.0
9	4.4	-3.1	9.6	-9.3	-10.3	8.0	12.7	11.5	17.6
10	9.7	-3.0	4.9	7.2	3.5	-4.2	10.6	16.3	16.3
11	4.4	-5.4	10.6	-5.2	-6.4	6.4	8.9	8.0	-2.8
12	0.4	2.7	5.6	16.7	18.9	10.5	15.2	18.2	13.5
13	7.1	6.2	8.1	9.2	3.9	1.9	6.1	8.8	10.4
average	2.37	2.36	6.9	6.36	2.79	4.68	9.37	10.38	7.13

Table (12) Signal Noise Ratio SNRs (dB) for Right ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	7.0	9.1	17.8	8.3	9.5	11.9	16.4	6.6	6.3
2	6.6	10.8	10.9	9.8	13.3	9.4	11.3	5.9	9.1
3	4.6	6.4	14.1	19.2	16.4	21.2	20.4	7.8	10.6
4	5.9	14.2	3.5	11.3	6.9	4.3	6.6	0.7	8.9
5	8.6	6.1	6.2	10.8	9.7	10.0	8.4	8.5	10.9
6	6.7	5.3	8.6	9.6	10.6	6.9	13.0	17.9	12.1
7	6.5	6.3	6.5	8.8	17.6	16.0	20.4	14.4	10.2
8	8.5	6.9	6.3	13.2	12.3	12.4	13.3	13.4	10.1
9	9.4	8.9	16.0	15.8	12.7	15.9	7.4	14.0	11.1
10	9.9	13.2	6.3	9.2	10.0	6.3	8.7	21.3	6.8
11	7.9	6.5	6.7	10.1	6.6	17.3	14.8	6.6	9.7
12	4.8	7.1	6.1	11.2	11.6	15.5	18.6	19.9	6.2
13	6.5	6.3	15.1	9.6	9.0	9.8	17.0	15.3	7.0
average	7.14	8.23	9.54	11.3	11.24	12.06	16.13	11.7	9.15

Table (13) Signal Noise Ratio SNRs (dB) for left ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.1	3.3	7.0	10.9	6.9	8.6	9.7	5.3	2.1
2	3.9	8.3	9.3	11.3	11.6	13.2	14.0	1.7	4.5
3	6.3	6.9	9.0	10.9	8.0	15.5	20.3	9.3	7.3
4	3.5	6.6	6.2	12.0	9.7	2.5	7.5	3.4	4.6
5	4.8	6.4	8.5	8.1	6.9	13.0	17.1	11.0	9.7
6	3.6	6.4	7.9	12.7	7.1	8.8	10.3	15.1	10.3
7	4.9	6.2	7.2	11.3	14.2	14.4	21.8	13.3	11.2
8	5.4	7.0	9.8	11.6	13.9	14.7	20.7	19.9	17.7
9	3.7	5.1	9.4	6.6	6.1	3	6.1	3	3.4
10	3.6	6.9	6.5	12.6	7.7	6.7	14.5	9.4	11.6
11	4.5	8.2	6.3	6.4	8.0	17.9	17.2	9.7	4.7
12	3.9	9.6	16.3	16.7	23.5	15.8	16.2	18.5	5.2
13	3.8	11.6	15.5	13.8	16.0	10.7	10.0	12.6	5.6
average	4.30	7.11	9.14	11.14	10.73	11.13	14.26	10.16	7.53

Table (14) DP1 Level (dB) for Right ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	7.5	4.8	14.0	11.6	8.8	8.3	16.3	16.8	16.4
2	5.5	7.4	16.6	8.0	10.1	20.0	17.7	15.9	11.7
3	7.4	20.5	12.6	10.7	11.9	5.5	15.9	10.6	10.6
4	5.6	7.4	13.7	10.6	7.0	3.4	12.6	10.6	10.2
5	2.5	12.3	4.2	13.3	11.2	9.8	12.3	20.2	15.7
6	11.8	7.1	12.6	10.9	8.4	12.0	7.5	17.8	10.9
7	11.2	11.8	9.9	10.1	14.8	9.3	12.4	19.9	15.7
8	11.2	5.3	10.0	9.9	11.1	5.9	13.9	15.9	15.1
9	6.7	7.4	16.3	15.1	9.9	12.2	12.2	12.9	14.5
10	11.4	9.6	8.9	9.3	7.4	8.9	9.0	21.8	15.8
11	8.4	5.8	12.5	12.0	10.5	9.1	14.6	13.6	14.6
12	8.0	6.3	10.2	7.8	13.8	8.7	16.4	23.5	17.4
13	12.2	8.4	14.8	14.5	10.1	10.0	15.8	17.8	11.6
average	8.41	8.77	12.02	11.06	10.38	9.46	13.58	16.73	13.8

Table (15) DP1 Level (dB) for left ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.5	6.9	5.1	11.7	7.0	3.6	13.9	12.0	12.6
2	3.8	8.6	12.0	10.4	10.0	11.4	14.6	15.4	10.1
3	8.7	17.9	3.8	12.0	11.0	10.7	15.7	10.2	5.0
4	2.6	8.2	3.2	10.4	9.1	9.5	8.6	20.1	16.1
5	7.9	3.8	-0.6	7.2	8.9	9.0	9.7	6.4	15.5
6	3.6	5.2	4.2	6.4	10.0	3.5	8.7	12.1	16.6
7	5.0	10.5	13.6	10.8	9.0	11.9	8.4	17.9	13.6
8	3.8	3.6	2.4	11.5	9.4	10.1	15.6	10.5	15.3
9	9.1	4.8	5.3	15.4	7.5	6.4	16.2	11.3	7.7
10	8.9	3.4	9.0	12.2	6.0	8.1	15.2	19.0	3.6
11	7.2	7.7	10.9	13.8	8.3	12.2	16.9	19.7	19.1
12	13.8	8.2	7.9	8.3	7.2	6.7	13.1	20.9	17.7
13	5.9	10.6	13.4	11.8	9.1	10.8	11.3	9.2	2.0
average	5.13	7.64	6.93	10.91	8.65	8.76	12.91	14.20	11.91

Table (16) Signal Noise Ratio SNRs (dB) for Right ear female.

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	6.5	9.1	8.5	8.3	10.1	8.5	9.8	6.5	8.2
2	6.6	6.4	18.8	8.6	8.3	27.9	24.0	26.7	6.9
3	3.4	14.0	6.3	12.7	15.6	17.4	13.2	12.6	7.6
4	7.5	6.5	9.7	15.8	11.1	7.1	15.2	9.9	4.0
5	7.7	12.4	6.7	6.1	17.3	12.8	18.9	24.4	11.4
6	13.8	11.6	12.0	9.4	6.8	10.7	6.7	7.5	10.7
7	6.6	6.5	11.7	11.1	8.1	7.8	13.3	10.3	11.2
8	12.3	8.1	7.2	10.6	12.8	8.1	11.3	4.3	15.3
9	3.3	10.1	6.1	6.2	7.2	15.4	11.2	5.2	4.6
10	3.8	7.9	13.4	12.2	11.4	8.1	16.2	18.2	6.3
11	3.4	9.2	13.3	12.8	14.7	11.2	15.7	12.6	6.3
12	5.9	11.0	3.0	10.7	14.5	11.1	8.6	16.6	8.4
13	3.7	7.9	4.7	9.2	9.1	10.1	8.4	11.5	12.1
average	7.99	9.28	9.33	10.28	11.30	12.01	13.2	12.79	12.55

Table (17) Signal Noise Ratio SNRs (dB) for left ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.9	8.2	6.7	3.0	12.9	12.7	6.7	10.5	6.4
2	6.5	11.1	18.7	11.2	24.1	26.4	21.1	24.3	24.0
3	5.9	3.9	6.6	17.8	19.7	6.3	9.2	2.3	4.0
4	7.8	10.1	9.8	11.2	15.2	11.3	8.1	8.3	3.3
5	4.8	7.6	7.4	7.2	12.9	19.1	15.6	8.2	9.2
6	6.9	11.6	6.7	12.3	9.6	7.9	7.2	6.8	0.6
7	4.9	6.1	8.8	16.4	16.3	10.3	11.0	15.1	10.3
8	8.4	6.2	11.3	7.9	11.0	6.2	16.0	6.9	3.2
9	4.0	3.6	4.4	7.0	6.1	6.6	9.7	3.6	3.9
10	8.3	6.6	12.1	14.6	14.6	9.6	11.9	17.6	6.4
11	6.4	7.6	7.1	6.3	13.4	17.6	19.9	14.8	10.2
12	9.3	4.6	0.4	7.6	10.5	7.9	13.2	22.4	7.2
13	8.1	3.4	0.1	0.4	3.9	9.3	13.6	0.3	6.3
Average	6.55	6.96	7.7	9.45	13.09	11.6	12.5	10.85	7.30

Table (18) comparison between average of DP1 level and SNR for females and males at each frequency

No.	Frequency KHz	DP1Level FR dB	DP1Level FL dB	SNR FR dB	SNR FL dB	DP1Level MR dB	DP1Level ML dB	SNR MR dB	SNR ML dB
1	0.5	8.41	5.13	7.99	6.55	3.44	2.37	7.14	4.30
2	0.75	8.77	7.64	9.28	6.96	2.43	2.36	8.23	7.11
3	1.0	12.02	6.93	9.33	7.7	7.1	6.9	9.54	9.14
4	1.5	11.06	10.91	10.28	9.45	7.55	6.36	11.3	11.14
5	2.0	10.38	8.65	11.30	13.09	4.53	2.79	11.24	10.73
6	3.0	9.46	8.76	12.01	11.6	4.9	4.68	12.0	11.13
7	4.0	13.58	12.91	13.2	12.5	9.90	9.37	16.13	14.26
8	6.0	16.73	14.20	12.79	10.85	11.25	10.38	11.7	10.16
9	8.0	13.8	11.91	12.55	7.30	13.1	7.13	9.15	7.53
	average	11.57	9.67	10.97	9.55	7.13	5.81	10.71	9.5

Appendix-C- Group (III) age (21-30) years for Iraqi Subjects

Table (19) DP1 Level (dB) for Right ear male

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.2	13.1	10.9	9.8	9.2	9.1	13.2	13.2	13.1
2	1.2	6.4	12	13.8	10.7	3.6	12.8	23.1	17.0
3	4.5	7.1	14.5	15.3	9.6	4.9	12.3	20.3	8.5
4	-1.2	0.1	1.5	7.7	7.5	11	13.8	12.9	17.1
5	-5.9	3.1	7.3	8.6	5.7	-11.1	4.9	-3.2	2.1
6	-6.6	-6.1	-5.3	2.9	5.0	2.5	4.8	16.3	13.8
7	-4.1	9.2	11.4	15.3	11.7	6.5	7.6	9.8	3.0
8	14.7	-0.8	-3.1	-3.6	2.0	5.1	6.7	2.8	7.8
9	-10	-5.0	-8.9	-4.1	4.7	0.6	6.4	9.5	4.4
10	0.3	9.4	15.1	15.6	11.2	7.4	11.4	5.3	11.8
11	-1.6	3.3	4.8	8.1	2.7	8.4	15.5	25.3	25.6
12	17.8	-2.0	9.7	17.7	11.5	5.9	15.7	18.2	16.0
13	-1.6	-10.1	-9.6	-9.2	-10.4	-10	-2.9	3.0	-1.3
14	3.9	0.6	6.4	6.7	-3.0	-6.6	-2.5	-6.5	-7.4
15	-3.4	2.2	7.5	5.4	-1.3	-0.9	8.1	13.3	4.9
average	0.81	2.03	4.95	7.33	5.12	2.45	8.52	10.95	9.09

Table (20) DP1 Level (dB) for Left ear male

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
1	9.3	13.5	12.8	2.0	-0.3	10.6	15	11.7	10.0
2	0.8	6.8	14.3	13.5	11.5	11.1	15.3	24.1	12.0
3	-2.6	-2.5	8.7	11.8	0.4	1.3	8.1	10.4	3.1
4	6.7	4.2	6.9	8.1	7.4	4.9	12.7	17.3	18.8
5	-2.9	2.0	9.8	8.7	-4.2	2.0	1.1	-8.9	-8.8
6	-7.1	-5.0	6.5	6.2	-0.1	1.3	9.5	13.4	8.7
7	7.3	1.5	5.2	9.5	8.0	13.4	11.3	4.8	-2.7
8	2.1	7.9	8.9	8.1	1.6	6.4	14.4	9.5	2.7
9	-8.4	-0.2	-4.7	-0.5	4.1	6.8	4.0	3.9	-6.1
10	-3.3	7.9	15	16.5	9.9	11.7	12.6	17.6	21.4
11	6.6	-0.6	2.2	2.1	2.6	5.5	11.6	18.1	7.4
12	-1.0	5.7	9.8	13.2	10.3	13.9	14.0	5.7	5.3
13	-10.0	-9.0	-4.4	-4.9	-9.5	-10.9	-1.7	1.5	0.7
14	1.7	5.4	7.3	6.2	-5.7	-4.0	-2.0	4.3	17.3
15	-10.0	1.0	4.8	-0.9	-9.9	-8.7	3.8	10.0	-1.2
average	-0.72	2.57	6.87	5.97	1.75	4.35	8.65	9.56	5.90

Table (21) Signal Noise Ratio SNRs (dB) for Right ear male

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.4.	14.5	9.1	10.2	10.5	6.2	11.3	8.0	3.0
2	4.0	11.0	7.0	20.4	16.8	13.1	20.6	27.3	13.6
3	3.7	12.5	10.9	6.5	11.0	11.1	12.3	6.6	3.3
4	3.5	7.0	14.2	13.6	15.6	17.7	20.0	12.2	17.1
5	3.0	6.6	7.4	15.8	6.3	7.7	11.8	9.9	9.7
6	5.0	6.7	8.7	6.9	10.1	9.9	7.9	16.3	7.1
7	6.1	6.5	15.4	19.0	15.8	16.2	15.5	9.6	6.3
8	6.3	4.0	6.9	9.2	8.0	10.8	13.5	4.0	5.6
9	4.9	6.2	7.3	6.0	7.8	7.1	12.1	9.8	8.0
10	3.8	12.6	11.3	17.1	18.2	14.4	15.9	7.4	7.6
11	4.4	9.0	9.4	12.7	14.8	17.8	20.9	28	20.3
12	3.3	4.7	5.7	6.7	6.9	7.4	11.0	6.1	10.5
13	4.4	4.1	3.4	6.5	4.7	5.0	10.2	8.2	4.0
14	4.8	6.5	10.2	8.3	9.2	8.3	4.5	4.0	6.3
15	6.2	6.9	15.9	7.1	8.6	14.2	8.6	14.6	12.6
average	4.45	7.92	9.52	11.06	10.95	11.12	13.07	11.46	9.0

Table (22) Signal Noise Ratio SNRs (dB) for Left ear male

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	12.2	19.8	12.9	11.9	8.5	11.0	12.0	8.0	10.0
2	6.5	9.9	11.7	14.0	7.9	9.3	8.4	4.6	3.3
3	4.0	7.3	11.7	9.4	8.0	7.5	13.6	9.0	3.0
4	8.7	7.3	11.7	13.2	17	16.5	15.2	20	11.5
5	3.8	6.2	9.1	16	9.3	14.1	14.6	5.2	6.1
6	3.0	6.6	13.1	11.0	6.5	11.5	15.4	15	8.5
7	6.8	8.9	7.2	10.7	6.4	11.9	10.3	6.9	6.8
8	7.8	7.3	8.6	7.4	6.5	10.3	13	6.8	4.6
9	5.8	8.7	5.7	4.0	11.6	11.8	9.7	9.8	3.0
10	8.1	7.5	18.8	23.4	19.2	12.8	8.9	20.6	12.5
11	8.3	10.6	8.9	8.8	10.4	13.9	17.3	8.8	6.0
12	8.1	4.3	16.5	9.0	6.6	9.1	10.2	11.0	3.1
13	3.0	4.3	6.1	6.2	6.1	8.5	13.7	5.0	3.0
14	6.5	11.8	15.2	8.9	6.3	6.1	11.9	8.4	8.7
15	6.6	8.3	9.4	6.2	7.8	8.1	14.6	7.6	6.2
average	6.61	8.58	11.10	10.67	9.20	10.82	12.58	9.78	6.42

Table (23) DP1 Level (dB) for Right ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	1.7	2.6	8.9	2.4	4.5	12.5	18.5	23.9	20.1
2	-9.1	0.8	0.6	5.4	0.4	-1.0	-0.1	11.2	14.3
3	2.3	5.8	8.8	14.5	11.1	16.2	16.4	9.5	7.4
4	-4.4	3.8	8.1	15.2	8.2	5.1	18.9	25.6	25.6
5	-9.0	0.5	-4.9	12.8	14.1	12.7	14.2	5.1	-3.6
6	-5.3	-4.2	-0.1	10.9	5.6	9.3	9.5	11.7	19.8
7	-3.6	5.3	11.3	12.8	13.9	12.9	18.8	23.6	7.6
8	-0.8	9.9	12.7	16.2	6.6	12.4	11.7	18.0	15.1
9	6.5	0.0	4.5	4.5	3.0	-6.6	0.5	3.1	-4.3
10	-10.4	-1.4	3.6	7.5	4.4	9.6	8.9	22.6	24.0
11	-0.4	6.3	5.5	7.3	-0.5	6.5	18.7	21.9	15.0
12	-8.8	5.0	5.1	10.6	9.0	11.1	16.8	16.0	9.1
13	10.9	6.1	5.1	8.1	10.3	12.8	17.7	18.8	13.3
average	-2.3	3.11	5.32	9.86	6.96	8.70	13.11	16.30	13.0

Table (24) DP1 Level (dB) for Left ear female

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	-4.0	7.3	2.9	6.7	15.0	6.3	14.8	18.6	11.4
2	3.6	11.1	15.8	17.1	11.2	10.0	15.7	19.3	23.1
3	-1.6	7.7	13.8	13.4	14.5	9.8	4.2	6.1	3.9
4	13.1	3.0	12.0	13.8	8.4	-0.6	16.8	21.6	16.8
5	-9.7	-6.6	-5.3	9.5	8.1	8.2	11.2	6.8	-3.3
6	0.3	-3.5	9.0	13.0	10.4	11.0	14.7	13.4	5.5
7	-2.9	11.6	10.4	7.2	5.3	9.0	15.9	24.3	20.6
8	-10.7	-8.7	-3.2	-6.3	-0.3	5.4	1.7	-3.2	-0.2
9	-8.1	-9.8	10.9	5.1	-0.4	-4.2	8.3	-2.2	6.6
10	-10.7	0.0	4.1	10.6	12.6	11.1	4.7	20.1	22.1
11	-6.5	4.2	6.9	3.5	3.0	7.4	13.3	18.5	4.6
12	-10.2	0.1	5.1	11.4	11.6	10.8	19.1	24.5	23.4
13	2.6	8.0	7.0	10.1	11.3	10.5	13.4	1.0	-2.7
average	-2.12	1.87	6.87	8.85	8.51	7.28	11.83	13.36	10.13

Table (25) Signal Noise Ratio SNRs (dB) for Right ear female.

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.5	9.1	8.9	10.1	7.7	20.3	17.3	20.5	4.5
2	9.0	6.1	6.5	8.1	11.8	11.9	7.4	14.6	6.7
3	6.5	12.5	8.6	16.0	18.1	10.6	21.6	10.2	13.4
4	6.7	11.4	10.9	20.6	7.9	14.6	17.6	8.8	10.5
5	4.2	6.3	6.2	16.5	23.6	21.0	21.1	8.2	4.0
6	5.0	6.5	6.6	16.1	13.9	18.7	12.4	6.3	6.7
7	4.0	14.2	14.3	12.4	12.7	18.5	24.5	10.3	6.5
8	7.0	15.3	14.4	21.2	13.4	20.0	17.6	13.6	7.0
9	6.2	6.4	12.8	7.1	10.3	8.5	8.9	7.1	3.0
10	3.8	7.0	7.7	9.3	10.8	16.4	16.3	18.1	6.3
11	7.3	8.7	11.9	13.3	6.8	19.0	13.5	6.5	6.1
12	4.2	6.3	7.0	7.1	11.7	17.9	19.1	8.8	6.7
13	9.8	11.0	9.8	6.1	6.1	17.3	18.4	15.6	8.8
average	5.93	9.29	9.66	12.60	11.90	16.5	16.59	9.03	6.73

Table (26) Signal Noise Ratio SNRs (dB) for Left ear female

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.5	8.6	4.0	11.4	13.9	16.5	3.3	6.1	3.0
2	8.1	8.0	10.9	19.8	18.6	13.0	9.2	4.0	12.4
3	6.8	11.5	16.1	19.4	23.8	18.2	7.2	5.5	10.1
4	9.0	6.5	9.9	13.9	8.4	10.3	8.1	3.1	7.1
5	3.0	3.0	3.4	12.7	12.8	21.3	7.1	9.5	3.3
6	4.2	6.6	17.3	10.7	12.9	17.8	8.9	7.5	6.8
7	5.6	14.4	11.0	10.3	13.8	18.2	9.3	6.3	16.1
8	3.0	6.4	7.6	7.9	9.3	7.2	8.1	3.0	3.3
9	6.1	6.3	17.8	11.6	15.0	9.9	10.0	6.1	6.2
10	3.0	7.5	8.4	15.1	20.3	18.2	11.0	3.1	7.7
11	3.6	6.6	16.1	10.3	8.6	11.9	10.8	10.6	6.7
12	3.2	6.7	9.6	9.4	7.8	11.6	9.5	3.2	11.0
13	8.0	15.4	15.5	17.6	11.1	12.7	8.2	5.0	3.0
Average	5.23	8.26	11.35	12.29	13.56	14.36	8.51	5.61	7.43

Table (27) comparison between average of DP1 level and SNR for females and males at each frequency

No.	Frequency KHz	DP1Level FR dB	DP1Level FL dB	SNR FR dB	SNR FL dB	DP1Level MR dB	DP1Level ML dB	SNR MR dB	SNR ML dB
1	0.5	-2.3	-2.12	5.93	5.23	0.82	-0.72	4.45	6.61
2	0.75	3.11	1.87	9.29	8.26	2.03	2.57	7.92	8.58
3	1.0	5.32	6.87	9.6	11.35	4.95	6.87	9.52	11.10
4	1.5	9.86	8.85	12.60	12.29	7.33	5.97	11.06	10.67
5	2.0	6.96	8.51	11.9	13.56	5.12	1.75	10.95	9.20
6	3.0	8.70	7.28	16.51	14.36	2.45	4.35	11.12	10.82
7	4.0	13.11	11.83	16.5	8.51	8.52	8.65	13.07	12.58
8	6.0	16.30	13.36	9.03	5.61	10.95	9.56	11.46	9.78
9	8.0	13.0	10.13	6.75	7.43	9.09	5.90	9.0	6.42
	average	8.22	7.39	10.8	9.62	5.69	4.98	9.83	9.48

Appendix-D

Group (IV) age (31-40) years for Iraqi Subjects

Table (28) DP1 Level (dB) for Right ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	-4.5	2.2	6.2	-1.3	-1.2	-3.9	6.0	2.7	4.5
2	-6.0	-4.5	0.1	5.0	3.4	5.3	7.2	3.9	4.6
3	-1.8	0.4	6.2	5.5	7.1	7.0	6.5	4.4	3.8
4	-1.4	-2.0	-3.3	-3.6	2.7	2.0	3.6	8.6	13.4
5	-2.2	3.4	6.7	8.0	5.2	4.0	5.5	6.7	4.8
6	-5.2	1.6	4.1	4.4	4.3	3.6	6.8	2.3	4.8
7	-5.2	-5.7	2.5	4.0	-3.8	2.1	3.2	3.9	0.0
8	3.1	3.4	5.1	2.6	6.0	4.3	5.7	6.9	-4.9
9	3.5	2.9	2.0	-0.1	4.0	2.3	-5.7	-0.2	-5.6
10	3.6	-1.5	3.0	3.6	4.6	5.5	2.5	7.2	4.4
11	3.1	2.7	0.6	2.3	1.3	2.8	6.4	4.7	4.9
12	-4.7	0.0	3.8	3.2	4.2	2.4	3.0	2.5	4.3
13	0.0	-0.9	2.8	4.6	3.4	4.9	3.2	6.2	4.0
average	-1.36	0.15	3.06	2.94	3.17	3.25	4.14	4.6	2.94

Table (29) DP1 Level (dB) for left ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
1	-4.7	1.6	4.2	-2.6	-1.9	-4.3	3.9	1.6	3.2
2	-6.5	-6.0	-1.9	3.4	2.9	3.3	4.5	3.2	3.8
3	-2.0	-2.6	-3.7	-4.1	1.8	1.4	2.6	5.1	9.1
4	-1.9	-3.3	-4.6	-4.2	1.6	1.2	2.9	4.6	9.3
5	-2.3	2.5	4.2	3.5	2.2	3.9	4.8	5.2	3.6
6	-5.4	0.9	3.9	4.1	3.3	2.6	4.8	1.2	3.7
7	-5.5	-6.3	1.4	3.3	-4.1	1.9	2.2	2.9	-1.9
8	2.2	2.4	3.5	1.9	4.8	2.1	3.9	4.9	-6.3
9	-3.7	1.7	1.6	-2.3	-1.3	1.2	-6.7	-1.1	-6.1
10	-3.8	-2.2	2.4	3.2	3.9	4.4	1.5	4.8	3.7
11	-6.6	1.1	-1.2	1.9	1.1	2.0	4.3	3.7	3.9
12	-4.9	-1.1	1.7	3.8	2.2	1.6	2.6	5.1	3.4
13	-1.1	-2.2	1.8	3.7	2.6	4.1	2.3	5.1	3.1
average	-3.65	-1.03	1.02	1.2	1.46	1.95	2.58	3.56	2.6

Table (30) Signal Noise Ratio SNRs (dB) for Right ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.5	3.7	3.2	5.3	4.5	3.7	4.2	3.2	3.9
2	4.6	5.9	5.4	3.6	6.7	5.6	3.4	4.8	4.2
3	3.7	3.9	5.1	6.0	4.0	5.1	6.2	6.3	5.6
4	6.1	4.2	6.3	6.1	5.5	5.2	6.2	6.1	4.1
5	6.4	6.3	4.9	4.6	5.8	5.5	4.8	3.1	4.9
6	4.3	5.2	5.6	8.2	5.2	6.3	6.7	5.1	3.9
7	3.4	3.8	3.5	3.9	4.6	3.9	3.4	3.9	4.9
8	5.6	3.2	3.7	5.6	5.2	5.9	3.1	3.7	3.9
9	3.5	4.0	4.2	3.9	5.1	5.6	5.2	6.1	3.8
10	4.1	5.2	3.4	3.2	3.4	5.3	4.5	4.8	4.9
11	3.6	3.3	4.2	4.6	3.9	4.1	3.3	3.5	3.8
12	3.7	3.9	4.3	5.2	6.1	5.2	5.1	3.6	4.1
13	3.6	3.8	5.4	6.6	3.1	5.0	3.2	4.4	6.3
average	4.39	4.34	4.55	5.14	4.85	5.11	4.56	4.51	3.82

Table (31)Signal Noise Ratio SNRs (dB) for left ear male

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.0	3.0	3.1	4.2	3.5	3.0	3.9	3.1	3.4
2	3.9	3.3	4.2	3.2	4.7	3.6	3.0	3.6	4.0
3	3.1	3.2	4.9	5.2	3.9	4.7	5.2	4.9	3.9
4	3.0	3.7	5.2	4.9	5.2	3.9	4.5	5.3	3.9
5	3.9	6.2	3.6	3.0	5.6	3.6	3.7	3.0	3.6
6	3.3	3.5	4.3	6.7	4.2	5.3	5.9	4.8	3.0
7	3.3	3.5	3.2	3.0	3.9	3.2	3.1	3.0	4.0
8	4.5	3.0	3.1	4.2	4.9	5.1	3.0	3.3	3.8
9	3.0	3.8	3.9	3.4	4.9	4.2	5.0	5.6	3.3
10	3.9	4.1	3.1	3.0	3.2	3.9	3.5	4.1	3.8
11	3.3	3.1	3.9	4.2	3.8	3.9	3.0	3.2	3.6
12	3.0	3.3	3.9	4.2	5.4	4.2	4.8	3.3	3.4
13	3.2	3.4	4.3	6.1	3.0	4.9	3.1	3.4	5.2
average	3.42	3.62	3.9	4.25	4.55	4.12	3.98	4.01	3.76

Table (32) DP1 Level (dB) for Right ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	-1.5	3.3	6.5	-1.1	1.1	2.9	6.4	3.7	4.7
2	-2.2	4.5	1.1	5.4	4.9	5.4	7.8	4.1	4.6
3	1.2	2.2	6.9	5.8	7.3	7.2	6.8	4.9	4.1
4	1.9	1.3	-1.9	-2.2	3.3	3.5	4.2	8.9	13.9
5	-1.4	3.5	6.9	8.7	5.5	5.2	5.7	6.9	5.3
6	1.2	1.9	5.3	4.7	4.6	3.9	6.9	2.8	4.9
7	-3.2	2.2	3.3	4.9	3.3	2.4	3.3	4.1	1.9
8	3.2	3.5	5.3	2.8	6.1	4.7	5.9	7.2	3.9
9	-1.3	3.1	2.4	1.3	5.2	3.4	1.9	1.2	2.6
10	-2.6	1.3	3.3	3.8	5.1	5.8	3.0	7.6	5.4
11	-2.2	2.9	1.3	2.5	1.9	2.9	6.8	4.8	5.2
12	-3.6	1.3	3.9	3.5	5.2	3.4	3.3	3.5	4.4
13	1.2	1.9	3.3	4.8	3.6	5.1	3.5	6.5	4.4
average	-0.72	2.53	3.66	3.61	4.39	4.29	5.04	5.09	5.02

Table (33) DP1 Level (dB) for left ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	-2.3	3.1	6.3	-1.2	-1.1	-2.8	6.3	2.8	4.6
2	-3.3	-2.2	0.4	5.2	3.9	5.3	7.7	4.0	4.6
3	-1.5	1.2	6.4	5.6	7.2	7.1	6.7	4.5	3.9
4	1.1	-1.9	-2.1	-3.2	3.0	2.2	3.8	8.7	13.6
5	-1.5	3.5	6.8	8.5	5.3	4.9	5.6	6.8	5.1
6	-5.1	1.7	4.9	4.6	4.4	3.8	6.8	2.4	4.8
7	-4.1	-5.4	2.9	4.5	-3.3	2.3	3.2	4.0	1.8
8	3.1	3.4	5.2	2.7	6.0	4.5	5.8	7.1	3.3
9	-5.5	3.0	2.2	1.0	5.0	3.3	-4.2	-0.1	-4.2
10	-2.9	-1.3	3.2	3.7	4.9	5.7	2.9	7.5	4.9
11	-5.4	2.8	1.2	2.4	1.8	2.8	6.7	4.7	5.0
12	-4.5	1.0	3.8	3.3	4.9	2.5	3.1	2.9	4.3
13	0.9	1.5	3.0	4.7	3.5	5.0	3.4	6.3	4.2
average	-2.10	0.80	3.40	3.22	3.58	3.58	4.45	4.74	4.30

Table (34)Signal Noise Ratio SNRs (dB) for Right ear female.

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.7	3.7	3.4	5.4	4.9	3.9	5.1	3.8	3.9
2	4.9	5.9	6.1	3.9	6.8	5.8	3.9	5.5	4.0
3	4.1	3.9	5.2	6.3	5.2	6.1	6.4	6.4	5.9
4	6.8	4.2	6.8	5.4	5.7	5.5	6.5	6.2	4.3
5	6.9	6.3	5.9	4.6	5.9	5.9	4.9	3.3	5.1
6	5.2	5.2	7.6	8.7	5.3	6.5	6.9	5.3	4.0
7	3.8	3.8	3.4	4.1	4.8	4.9	5.4	4.1	4.9
8	6.6	3.2	3.9	6.2	5.4	6.1	4.1	3.8	4.1
9	4.5	4.0	4.4	4.9	6.1	6.7	6.2	6.2	4.8
10	5.1	5.2	3.4	3.8	4.4	6.3	4.8	4.9	5.6
11	3.9	3.3	4.9	4.8	4.5	7.1	3.5	3.6	4.3
12	4.1	3.9	5.3	5.9	6.9	5.7	5.7	3.9	4.2
13	3.7	3.3	7.4	6.8	3.2	5.3	3.4	5.1	6.5
average	4.94	4.3	5.20	5.44	5.31	5.83	5.13	4.77	4.28

Table (35) Signal Noise Ratio SNRs (dB) for left ear female

Freq. / No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.3	3.2	3.2	4.4	3.9	3.3	4.0	3.2	3.6
2	4.4	3.9	5.2	3.3	4.8	3.8	3.3	3.9	4.0
3	3.5	3.3	4.9	5.6	4.1	4.9	5.3	5.2	3.9
4	3.9	3.9	5.6	5.1	5.4	4.1	4.8	5.5	4.2
5	4.3	6.2	4.6	3.3	5.8	3.8	3.8	3.3	3.7
6	4.3	4.5	5.3	6.9	4.4	5.5	5.9	4.9	3.5
7	3.5	3.6	3.3	3.4	4.7	3.6	3.3	3.2	4.1
8	4.9	3.1	3.2	4.4	5.3	5.2	3.6	3.7	3.9
9	3.7	3.9	4.1	3.6	5.1	4.4	5.1	5.8	3.4
10	3.9	4.9	3.3	3.2	3.5	4.4	3.7	4.3	3.9
11	3.4	3.2	4.3	4.5	3.9	4.1	3.2	3.4	3.8
12	3.5	3.6	5.8	4.4	5.7	4.3	4.9	3.6	3.6
13	3.5	3.3	6.3	6.3	3.2	5.0	3.4	3.5	5.7
Average	3.85	3.89	4.54	4.49	4.6	4.33	4.17	4.11	3.94

Table (36) comparison between average of DP1 level and SNR for females and males at each frequency

No.	Frequency KHz	DP1Level FR dB	DP1Level FL dB	SNR FR dB	SNR FL dB	DP1Level MR dB	DP1Level ML dB	SNR MR dB	SNR ML dB
1	0.5	-0.72	-2.10	4.94	3.85	-1.36	-3.65	4.39	3.42
2	0.75	2.53	0.8	4.3	3.89	0.15	-1.03	4.34	3.62
3	1.0	3.66	3.4	5.20	4.54	3.06	1.02	4.55	3.9
4	1.5	3.61	3.22	5.44	4.49	2.94	1.2	5.14	4.25
5	2.0	4.39	3.58	5.31	4.6	3.17	1.46	4.85	4.55
6	3.0	4.29	3.58	5.83	4.33	3.25	1.95	5.11	4.12
7	4.0	5.04	4.45	5.13	4.17	4.14	2.58	4.56	3.98
8	6.0	5.09	4.74	4.77	4.11	4.6	3.56	4.51	4.01
9	8.0	5.02	4.30	4.28	3.99	2.94	2.6	3.82	3.76
	average	3.66	2.55	5.02	4.22	2.54	1.08	4.59	3.96

Appendix- E

For Iraqi Subjects

Table (37) comparison between average of SNRs of Right ear side for females and males at each frequency for all groups (2-10),(11-20), (21-30) and (31-40) years.

No.	Frequency KHz	SNR FR dB 2-10	SNR FR dB 11-20	SNR FR dB 21-30	SNR FR dB 31-40	SNR MR dB 2-10	SNR MR dB 11-20	SNR MR dB 21-30	SNR MR dB 31-40
1	0.5	6.37	7.99	5.93	4.94	3.39	7.14	6.69	4.39
2	0.75	8.96	9.28	9.29	4.3	5.65	8.23	7.92	4.34
3	1.0	10.53	9.33	9.6	5.20	8.59	9.54	9.52	4.55
4	1.5	16.06	10.28	12.60	5.44	14.34	11.3	11.06	5.14
5	2.0	13.1	11.30	11.90	5.31	12.13	11.24	10.95	4.85
6	3.0	19.43	12.01	16.51	5.83	14.11	12.06	11.12	5.11
7	4.0	18.04	13.2	16.5	5.13	16.52	16.13	13.07	4.56
8	6.0	18.58	12.79	9.03	4.77	16.06	11.7	11.46	4.51
9	8.0	14.4	12.55	6.75	4.28	10.91	9.15	9.0	3.82
	average	13.94	10.97	10.8	5.02	11.3	10.71	9.83	4.59

Table (38) comparison between average of SNR of left ear side for females and males at each frequency for all groups(2-10), (11-20),(21-30) and (31-40) years.

No.	Frequency KHz	SNR FL dB 2-10	SNR FL dB 11-20	SNR FL dB 21-30	SNR FL dB 31-40	SNR ML dB 2-10	SNR ML dB 11-20	SNR ML dB 21-30	SNR ML dB 31-40
1	0.5	4.38	6.55	5.23	3.85	3.11	4.30	6.61	3.42
2	0.75	6.88	6.96	8.26	3.89	4.98	7.11	8.58	3.62
3	1.0	8.04	7.7	11.35	4.54	8.44	9.14	11.10	3.9
4	1.5	11.32	9.45	12.29	4.49	10.92	11.14	10.67	4.25
5	2.0	11.65	13.09	13.56	4.6	10.72	10.73	9.20	4.55
6	3.0	15.45	11.6	14.36	4.33	13.46	11.13	10.82	4.12
7	4.0	15.18	12.5	8.5	4.17	15.55	14.26	12.58	3.98
8	6.0	16.7	10.85	5.61	4.11	15.57	10.16	9.7	4.01
9	8.0	10.32	7.30	7.43	3.99	9.03	7.53	6.42	3.76
	average	11.10	9.55	9.62	4.22	10.19	9.5	9.48	3.96

Table (39) comparison between the average of DP1 level of Right ear side for females and males at each frequency for all groups

No.		DP1Level FR dB 2-10	DP1Level FR dB 11-20	DP1Level FR dB 21-30	DP1Level FR dB 31-40	DP1Level MR dB 2-10	DP1Level MR dB 11-20	DP1Level MR dB 21-30	DP1Level MR dB 31-40
1	0.5	4.57	8.41	-2.3	-0.72	3.38	3.44	0.82	-1.36
2	0.75	9.13	8.77	3.11	2.53	6.40	2.43	2.03	0.15
3	1.0	11.91	12.02	5.32	3.66	11.29	7.1	4.95	3.06
4	1.5	17.3	11.06	9.86	3.61	15.19	7.55	7.33	2.94
5	2.0	15.43	10.38	6.96	4.39	12.93	4.53	5.12	3.17
6	3.0	17.57	9.46	8.70	4.29	9.72	4.9	2.45	3.25
7	4.0	15.51	13.58	13.11	5.04	14.10	9.90	8.52	4.14
8	6.0	20.39	16.73	16.30	5.09	19.3	11.25	10.95	4.6
9	8.0	16.62	13.8	13.0	5.02	16.84	13.1	9.09	2.94
	average	14.27	11.57	8.22	3.66	12.12	7.13	5.69	2.54

Table (40) comparison between average of DP1 level of left ear side for females and males at each frequency for all groups

No.	Frequency KHz	DP1Level FL dB 2-10	DP1Level FL dB 11-20	DP1Level FL dB 21-30	DP1Level FL dB 31-40	DP1Level ML dB 2-10	DP1Level ML dB 11-20	DP1Level ML dB 21-30	DP1Level ML dB 31-40
1	0.5	3.04	5.13	-2.12	-2.10	3.15	2.37	-0.72	-3.65
2	0.75	6.0	7.64	1.87	0.8	6.02	2.36	2.57	-1.03
3	1.0	11.07	6.93	6.87	3.4	10.42	6.9	6.87	1.02
4	1.5	14.38	10.91	8.85	3.22	14.23	6.36	5.97	1.2
5	2.0	12.56	8.65	8.51	3.58	10.29	2.79	1.75	1.46
6	3.0	11.37	8.76	7.28	3.58	9.1	4.68	4.35	1.95
7	4.0	14.38	12.91	11.83	4.45	13.27	9.37	8.65	2.58
8	6.0	20.24	14.20	13.36	4.74	18.05	10.38	9.56	3.56
9	8.0	15.58	11.91	10.13	4.30	15.29	7.13	5.90	2.6
	average	12.06	9.67	7.39	2.55	11.09	5.81	4.98	1.08

Appendix-F

Group (I) age (2-10) year for Sudanese subjects

Table (41) DP1 Level (dB) for Right ear male

Freq No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	10.6	10.1	19.1	21.0	18.8	16.2	20.8	22.0	23.3
2	1.5	1.8	8.8	8.8	13.3	7.8	13.9	10.5	11.9
3	3.0	2.8	7.5	14.8	12.8	9.9	13.5	19.9	23.6
4	3.2	7.9	12.0	18.9	14.6	15.7	16.0	20.3	14.8
5	2.1	5.8	20.0	11.5	13.2	5.9	11.3	23.6	18.8
6	4.5	15.0	14.6	13.2	14.9	7.8	12.4	18.5	17.9
7	3.6	2.4	13.5	18.9	13.8	7.0	9.9	19.7	14.4
8	1.6	8.7	11.5	15.5	14.2	5.3	16.5	20.9	20.8
9	3.9	5.5	8.8	15.8	12.1	5.8	17.4	16.2	22.7
10	2.4	4.3	2.8	14.8	15.1	12.0	15.3	22.3	21.0
11	4.2	1.9	4.8	13.5	7.9	10.9	11.3	23.1	18.4
12	3.8	10.5	14.9	15.3	9.8	7.9	13.8	20.1	24.0
13	4.7	5.6	13.0	18.3	12.3	14.2	12.9	22.0	22.6
average	3.77	6.33	11.63	15.40	13.29	9.72	14.23	19.93	19.55

Table (42) DP1 Level (dB) for left ear male

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.1	15.0	15.9	20.2	19.2	20.0	15.2	22.9	13.9
2	1.2	8.8	7.9	10.0	3.7	8.5	14.1	18.3	5.8
3	1.7	5.4	8.5	13.4	13.5	9.9	13.3	25.0	14.6
4	3.3	2.6	6.2	12.5	4.4	10.7	19.5	19.9	13.2
5	3.4	9.4	10.4	18.9	9.9	7.9	12.7	20.0	21.0
6	2.9	2.9	2.5	8.3	8.2	3.9	16.0	14.7	20.3
7	4.6	8.6	16.9	15.2	16.1	6.7	11.2	15.2	20.9
8	3.6	2.7	13.3	17.9	13.1	8.9	10.2	21.0	14.7
9	3.9	3.7	15.4	12.7	1.9	10.8	13.0	11.6	13.1
10	4.1	8.3	9.3	18.0	13.6	4.1	16.2	12.1	13.2
11	3.2	6.7	10.5	15.1	11.4	9.2	4.9	13.8	14.3
12	3.6	6.3	15.4	11.9	8.2	6.9	12.6	18.4	17.9
13	4.8	1.3	10.9	18.2	11.9	11.0	14.1	23.9	20.4
average	3.33	6.28	11.00	14.79	10.39	9.11	13.30	18.21	15.63

Table (43) Signal Noise Ratio SNRs (dB) for Right ear male

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.3	5.4	9.8	15.3	20.6	19.1	25.0	23.8	18.1
2	3.8	7.9	7.1	10.9	16.3	15.9	19.8	19.9	16.0
3	3.9	6.6	7.9	13.0	13.6	14.8	15.0	15.8	15.5
4	3.4	5.3	6.9	20.0	15.0	16.1	18.4	19.1	10.2
5	3.4	4.7	9.7	14.2	10.2	10.9	13.7	16.0	8.8
6	3.2	6.9	11.0	5.9	6.7	16.7	16.4	13.9	15.9
7	3.9	5.5	15.1	11.3	12.8	11.6	19.1	14.4	7.9
8	3.8	6.8	6.6	20.1	7.2	6.9	20.3	12.1	9.7
9	3.6	5.9	5.5	13.5	8.9	9.8	12.9	19.5	8.9
10	4.8	6.0	10.4	12.7	15.1	19.0	19.7	19.2	7.7
11	3.3	4.3	7.8	19.1	11.9	16.9	16.7	16.4	8.0
12	3.7	7.9	9.8	17.9	12.6	10.1	9.3	10.7	10.4
13	3.6	3.3	8.1	13.9	8.4	15.9	15.0	14.8	9.9
average	3.66	5.88	8.9	14.44	12.25	14.13	17.02	16.58	11.30

Table (44) Signal Noise Ratio SNRs (dB) for left ear male

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.2	9.7	18.1	10.9	25.0	20.8	25.0	11.8	20.1
2	3.5	6.6	6.3	8.9	15.5	13.9	12.8	7.8	6.3
3	3.1	5.3	5.9	11.0	9.3	15.6	14.9	20.5	15.8
4	3.9	3.6	5.5	10.9	9.8	20.3	25.0	13.1	8.1
5	4.0	6.1	7.5	13.9	6.3	9.6	10.9	15.4	9.8
6	3.3	6.9	7.3	8.5	9.8	18.1	15.3	20.7	9.1
7	3.1	6.3	10.1	13.9	16.9	10.8	16.9	22.6	5.3
8	3.2	4.6	6.9	12.7	10.9	7.3	12.8	18.9	11.2
9	3.9	4.3	13.1	10.2	7.9	16.0	21.0	15.9	8.1
10	3.2	5.1	6.2	7.5	6.3	13.9	8.8	9.9	6.4
11	3.7	3.9	7.0	9.9	8.9	14.6	10.9	19.0	8.7
12	3.0	5.8	9.3	13.2	8.5	7.9	7.7	18.6	7.8
13	3.6	3.7	6.8	15.9	9.0	11.8	20.9	25.0	6.6
average	3.43	5.53	8.46	11.33	11.08	13.89	15.60	16.86	9.48

Table (45) DP1 Level (dB) for Right ear female

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.9	6.8	18.2	15.7	18.4	21.3	8.4	19.9	19.1
2	3.9	9.7	11.2	16.5	13.0	15.4	11.8	21.8	18.9
3	5.1	9.6	10.3	16.6	20.0	18.5	22.7	20.8	14.9
4	3.7	12.3	16.0	17.6	22.3	20.7	20.2	19.9	20.7
5	4.2	10.9	13.9	15.9	17.0	15.9	10.9	23.2	23.3
6	3.9	3.6	11.9	19.8	13.9	20.1	18.7	23.9	25.0
7	3.8	13.4	14.0	16.8	16.1	20.9	15.3	19.9	17.9
8	4.6	10.9	11.6	14.9	15.6	23.0	19.0	24.0	20.9
9	7.9	8.8	15.9	18.9	12.8	14.9	18.9	24.9	18.9
10	3.4	8.3	13.9	19.7	15.3	15.5	16.9	14.9	16.8
11	4.2	7.0	9.3	16.8	18.1	19.2	15.3	18.6	13.5
12	3.9	10.8	10.4	15.6	13.0	13.9	19.6	24.5	20.4
13	8.5	15.9	7.9	18.9	19.0	19.4	20.7	22.9	23.1
average	4.76	9.84	12.65	17.20	16.5	18.36	16.8	21.47	19.49

Table (46) DP1 Level (dB) for left ear female

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	9.9	3.9	7.3	11.8	10.3	8.4	14.8	18.6	22.9
2	10.9	10.1	9.6	16.8	9.8	5.3	11.0	19.3	19.9
3	9.1	7.9	13.0	19.4	22.0	16.7	18.9	18.9	9.8
4	8.8	8.8	15.0	14.9	15.8	15.9	19.5	19.8	20.7
5	9.8	11.0	10.9	10.9	6.2	4.9	13.1	20.6	19.9
6	-3.9	3.1	16.9	15.5	11.4	12.3	12.8	22.9	22.1
7	6.5	15.6	18.8	13.9	20.7	20.3	12.9	19.9	11.6
8	8.6	10.7	9.7	15.4	12.3	23.7	18.8	21.9	21.9
9	-7.6	3.4	9.9	13.5	11.7	12.9	18.7	22.9	17.4
10	-10.0	9.9	18.6	10.9	14.8	12.5	15.8	22.8	22.5
11	8.1	3.9	7.9	19.8	16.9	11.6	9.2	20.8	12.3
12	-7.3	4.8	12.5	19.1	10.2	13.0	23.0	23.9	18.9
13	10.8	3.8	10.9	18.5	11.9	18.9	13.8	24.6	9.8
average	4.10	7.45	12.38	15.41	13.38	13.56	15.56	21.3	17.66

Table (47) Signal Noise Ratio SNRs (dB) for Right ear female

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.3	10.1	18.5	13.3	12.8	20.9	18.7	14.9	9.9
2	9.8	9.7	10.5	17.4	14.7	19.9	16.9	19.6	19.7
3	4.5	10.3	19.0	15.3	22.0	16.6	26.2	15.8	15.8
4	4.7	6.9	16.3	21.7	18.9	15.3	20.9	24.2	21.2
5	7.8	8.8	11.6	18.9	11.9	19.2	16.3	23.5	12.3
6	3.9	10.7	17.2	13.3	13.7	17.9	18.5	24.9	16.7
7	10.8	3.2	18.2	19.0	16.1	16.9	16.2	26.4	16.3
8	13.2	9.9	11.5	18.0	18.8	29.2	22.9	25.9	13.6
9	16.2	6.8	12.8	20.1	11.9	21.1	23.9	22.9	12.1
10	6.9	12.0	16.0	18.7	19.8	17.0	19.8	10.9	10.7
11	5.2	15.1	10.7	15.6	9.9	18.0	16.0	8.7	15.7
12	3.7	16.3	15.0	17.9	18.4	18.8	17.4	10.8	20.7
13	3.4	6.6	10.5	10.4	10.8	28.3	23.8	25.7	16.2
average	7.26	9.72	14.44	16.89	15.36	19.93	19.80	18.78	15.45

Table (48) Signal Noise Ratio SNRs (dB) for left ear female

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	7.8	6.9	7.9	15.7	11.7	11.9	15.9	22.9	16.5
2	8.4	16.1	8.5	19.4	19.6	12.7	20.9	16.8	17.0
3	3.7	6.6	11.6	19.9	10.7	24.2	16.8	13.1	15.1
4	4.0	5.1	10.9	13.2	16.6	19.9	22.5	20.2	20.4
5	4.8	4.0	12.7	9.6	18.3	13.7	19.4	19.1	13.9
6	3.9	9.2	16.0	10.3	11.8	18.4	13.7	21.3	13.9
7	5.2	10.0	10.4	18.8	15.6	26.5	16.0	9.9	17.6
8	4.4	9.3	14.4	16.6	18.1	25.3	19.2	8.9	18.1
9	3.5	7.2	17.6	12.9	14.7	17.0	18.1	15.8	14.0
10	6.2	8.5	6.8	10.5	10.7	16.9	12.3	24.8	15.2
11	3.4	3.3	5.5	8.8	14.3	12.2	14.0	11.9	10.2
12	4.9	6.9	6.2	7.8	9.6	15.7	12.5	18.5	11.5
13	3.7	7.2	9.4	8.9	18.3	8.9	18.6	22.1	15.1
Average	4.91	7.71	10.60	13.26	14.61	17.17	16.91	17.33	14.2

Table (49) comparison between average of DP1 level and SNR for females and males at each frequency for Sudanese age (2-10) years.

No.	Frequency KHz	DP1Level FR dB	DP1Level FL dB	SNR FR dB	SNR FL dB	DP1Level MR dB	DP1Level ML dB	SNR MR dB	SNR ML dB
1	0.5	4.76	4.10	7.26	4.91	3.77	3.33	3.66	3.43
2	0.75	9.84	7.45	9.72	7.71	6.33	6.28	5.88	5.53
3	1.0	12.65	12.38	14.44	10.60	11.63	11.00	8.9	8.46
4	1.5	17.20	15.41	16.89	13.26	15.40	14.79	14.44	11.33
5	2.0	16.5	13.38	15.36	14.61	13.29	10.39	12.25	11.08
6	3.0	18.36	13.56	19.93	17.17	9.72	9.11	14.13	13.89
7	4.0	16.8	15.56	19.80	16.91	14.23	13.30	17.02	15.60
8	6.0	21.47	21.3	18.78	17.33	19.93	18.21	16.58	16.86
9	8.0	19.49	17.66	15.45	14.2	19.55	15.63	11.30	9.48
	average	15.23	13.42	15.29	12.96	12.65	11.33	11.57	10.62

Appendix-G

Group (II) for Sudanese subjects age (11-20) years

Table (50) DP1 Level (dB) for Right ear male for Sudanese

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.1	3.1	10.9	8.8	3.1	2.0	11.1	12.9	18.0
2	2.9	2.2	4.5	11.1	16.3	4.4	10.5	15.8	12.2
3	4.4	3.3	10.8	12.8	7.7	11.0	16.2	18.7	11.8
4	6.8	1.9	11.5	1.9	2.1	16.0	1.9	17.8	4.9
5	2.4	3.8	12.0	5.4	2.9	5.4	12.8	13.8	11.1
6	4.8	5.5	3.3	4.9	1.8	1.1	6.6	16.9	16.9
7	2.1	9.2	8.1	11.3	11.6	5.6	11.2	16.6	8.5
8	-1.7	3.5	3.9	3.2	13.1	11.1	15.5	14.9	16.7
9	2.4	5.4	7.3	9.3	3.3	2.1	6.7	13.9	9.9
10	8.0	7.4	3.3	3.3	6.5	2.3	11.8	19.8.	20.0.
11	7.2	1.9	2.4	3.9	0.8	9.1	13.9	19.3	11.8
12	5.1	7.8	11.4	19.0	17.0	2.7	15.9	23.9	16.1
13	2.2	8.6	14.2	12.7	1.2	6.6	3.9	16.5	12.9
average	3.9	4.91	7.96	8.27	6.72	6.01	10.61	15.5	13.13

Table (51) DP1 Level (dB) for left ear male for Sudanese

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
1	9.8	3.2	6.1	7.3	-4.2	-2.3	0.8	1.2	1.7
2	1.1	5.1	8.9	10.9	5.9	5.3	11.9	2.3	2.3
3	2.3	4.8	7.1	9.9	8.4	4.3	16.0	13.5	0.0
4	4.8	2.2	4.7	14.3	11.8	6.7	0.5	3.9	1.3
5	1.5	6.0	10.2	2.7	2.1	5.6	8.6	14.2	11.6
6	0.5	3.7	5.7	2.3	1.7	4.8	9.8	10.4	5.6
7	1.8	5.7	7.0	11.9	9.2	8.9	11.9	11.6	5.7
8	1.2	3.8	5.3	8.9	8.9	5.0	11.1	20.8	11.0
9	3.9	3.4	8.6	1.3	1.3	8.0	10.9	12.1	15.6
10	2.7	2.7	5.5	4.2	1.5	-4.2	10.1	16.7	16.8
11	1.4	4.4	11.1	1.8	-4.8	6.4	6.9	8.8	9.9
12	2.2	3.7	6.2	10.7	15.5	10.5	15.3	16.9	14.1
13	9.3	6.6	8.6	8.5	4.3	1.9	9.1	9.2	10.1
average	3.26	4.25	7.3	7.28	2.79	4.73	9.51	10.89	8.13

Table (52) Signal Noise Ratio SNRs (dB) for Right ear male for Sudanese

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	6.8	9.9	18.1	9.2	10.2	13.2	11.4	8.6	7.3
2	5.9	10.1	11.4	10.6	13.8	8.4	15.2	6.2	10.4
3	6.1	7.3	15.9	15.9	12.8	20.3	19.8	7.3	11.0
4	5.7	11.2	9.5	15.3	9.9	8.3	20.6	9.9	9.9
5	6.6	8.6	8.1	11.4	10.0	11.5	19.7	8.8	11.9
6	8.3	5.4	8.3	8.9	9.6	6.4	21.0	11.6	10.1
7	5.9	8.0	6.2	9.2	19.2	18.0	18.4	18.4	9.1
8	6.8	7.7	8.3	15.1	13.1	13.2	16.2	16.0	13.5
9	8.9	8.4	14.0	16.2	10.7	10.9	10.7	11.8	11.1
10	10.4	11.2	8.1	10.1	10.9	8.3	18.1	20.1	8.8
11	6.1	6.6	7.7	12.3	8.5	16.8	14.8	15.9	9.2
12	5.3	8.4.	8.3	9.9	10.3	17.5	19.3	13.9	4.2
13	4.9	5.7	11.9	13.2	9.4	10.3	16.9	16.7	9.6
average	6.74	8.34	10.44	12.3	11.41	12.54	17.08	11.67	9.7

Table (53) Signal Noise Ratio SNRs (dB) for left ear male for Sudanese

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.0	3.7	7.7	9.8	8.6	6.6	9.3	8.3	3.9
2	3.8	9.3	10.3	13.3	10.6	18.5	16.0	6.6	4.6
3	6.0	6.4	9.8	11.9	8.7	11.5	19.3	10.2	8.3
4	4.3	7.6	5.1	10.0	7.7	5.5	8.5	4.8	3.6
5	5.7	6.6	8.9	11.8	5.6	11.9	18.0	9.0	9.9
6	6.9	5.9	9.9	15.7	10.1	9.5	10.7	18.3	11.7
7	8 .2	8.2	7.4	11.7	16.0	11.4	20.5	11.3	10.2
8	5.9	7.7	8.8	16.5	13.9	16.9	18.7	19.0	18.9
9	6.6	6.9	9.7	10.0	6.5	13.4	9.1	3.9	6.4
10	6.3	6.0	4.5	12.2	9.4	4.7	16.5	9.8	10.6
11	4.4	9.1	6.6	4.4	8.8	15.9	11.4	10.7	7.7
12	7.3	10.2	18.2	11.7	19.7	18.1	16.8	16.7	6.6
13	5.6	9.6	16.4	13.9	18.0	10.9	9.9	14.3	5.9
average	5.76	7.47	9.48	11.76	11.04	11.13	14.20	10.99	8.33

Table (54) DP1 Level (dB) for Right ear female for Sudanese

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	6.5	5.0	11.0	10.9	8.9	9.8	18.2	13.8	18.4
2	5.9	8.2	16.9	9.9	11.1	19.7	17.4	13.9	10.7
3	9.4	18.9	14.6	11.3	10.8	7.5	16.9	10.8	12.4
4	5.5	7.6	16.7	11.6	7.7	6.4	12.3	12.6	11.2
5	3.5	11.3	6.2	15.3	10.2	8.8	10.9	20.3	15.0
6	12.3	7.7	15.2	10.4	9.6	12.6	8.5	17.8	11.5
7	10.9	13.8	7.9	11.1	15.0	10.3	11.4	18.9	13.7
8	11.8	5.5	11.3	9.4	10.1	8.9	14.9	17.9	16.1
9	6.9	6.9	13.9	12.1	8.9	11.2	12.7	13.8	14.8
10	13.0	9.8	10.4	10.3	10.4	9.9	9.6	20.9	16.0
11	8.8	6.3	13.6	9.2	9.5	9.9	14.5	17.6	12.6
12	9.2	6.7	11.2	10.8	11.8	8.0	18.4	20.6	16.6
13	10.2	9.0	14.4	11.5	13.1	10.2	13.9	18.9	10.3
average	8.76	8.97	13.63	11.06	10.54	10.24	13.81	16.75	13.8

Table (55) DP1 Level (dB) for left ear female Sudanese

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	4.5	6.6	6.2	10.4	5.0	5.6	11.9	9.9	11.9
2	5.8	9.6	11.0	11.6	12.2	9.4	16.6	18.8	13.1
3	8.7	10.9	4.4	13.0	11.7	11.3	15.0	10.2	8.0
4	3.6	8.7	3.7	9.4	10.1	5.5	8.9	18.9	17.7
5	9.9	8.8	2.4	7.8	9.7	7.9	10.7	10.8	15.3
6	3.6	6.6	11.2	8.4	8.9	8.5	7.7	12.6	13.6
7	8.5	9.5	15.6	9.8	9.4	10.6	10.4	18.9	16.8
8	3.8	8.3	3.3	10.9	7.4	11.5	16.3	10.7	18.3
9	6.1	3.8	6.3	16.3	10.5	6.8	18.2	9.3	6.9
10	8.9	6.4	11.2	12.6	8.5	8.8	11.2	15.0	8.6
11	8.2	8.8	10.0	15.8	6.3	14.2	10.9	16.7	15.0
12	16.8	5.2	7.7	8.6	7.8	6.9	16.5	19.0	19.4
13	6.1	11.0	16.1	9.8	10.6	11.6	14.8	13.2	8.0
average	7.26	8.01	8.39	11.10	9.08	9.12	13.00	14.15	13.27

Table (56) Signal Noise Ratio SNRs (dB) for Right ear female for Sudanese

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	9.9	7.1	9.5	9.3	10.8	8.0	9.4	8.5	8.6
2	6.8	9.4	11.9	6.6	9.0	20.0	20.0	20.0	8.9
3	7.8	16.0	12.3	16.3	11.9	18.9	18.2	16.6	9.6
4	6.8	6.8	9.9	18.8	10.0	17.1	16.6	10.9	4.3
5	7.7	14.4	8.7	5.1	18.3	12.9	18.5	19.4	10.4
6	9.8	10.0	14.0	9.8	6.8	15.7	10.7	17.5	9.7
7	10.8	6.9	11.9	10.4	8.8	7.9	16.3	10.3	10.8
8	11.0	10.1	10.2	9.6	18.8	10.1	10.0	4.2	5.0
9	9.9	13.1	7.9	6.7	7.7	15.0	11.7	8.2	6.6
10	7.8	7.3	16.4	12.7	10.4	8.8	13.2	17.9	3.3
11	8.8	9.7	11.8	11.4	18.5	10.8	15.9	14.6	8.3
12	10.9	14.0	13.0	13.3	13.9	9.1	8.9	13.9	10.0
13	6.9	7.2	3.9	8.8	15.0	13.0	11.4	18.7	9.9
average	8.83	10.15	10.87	10.67	12.3	12.86	13.90	14.71	8.10

Table (57) Signal Noise Ratio SNRs (dB) for left ear female for Sudanese

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.8	6.2	5.6	9.0	18.9	10.7	6.0	9.5	9.4
2	8.2	13.1	8.7	8.2	20.9	20.8	12.9	20.8	20.8
3	3.6	3.4	16.6	16.8	19.9	16.3	18.2	12.3	4.7
4	3.8	11.9	9.9	10.2	16.7	18.0	17.1	8.8	6.6
5	4.9	7.9	11.4	6.2	14.9	19.7	15.8	10.2	9.8
6	9.8	17.6	10.7	15.3	9.8	17.9	10.3	6.2	5.7
7	6.9	6.1	4.8	10.4	11.3	10.6	8.0	11.7	10.6
8	8.2	8.2	10.3	9.9	18.0	6.8	18.0	6.6	3.7
9	4.5	3.4	14.3	7.3	6.6	10.0	9.2	5.6	6.9
10	3.6	8.6	9.1	10.6	10.6	9.0	10.4	19.6	8.3
11	6.8	7.7	11.0	6.6	16.4	11.6	11.9	12.8	9.2
12	4.7	6.0	3.9	4.6	10.8	9.9	16.4	20.4	7.8
13	9.0	3.1	6.8	3.9	6.9	8.7	15.2	9.6	3.3
Average	5.98	7.93	9.46	9.15	13.97	13.07	13.03	11.85	8.21

Table (58) comparison between average of DP1 level and SNR for females and males at each frequency for Sudanese age (11-20) years.

No.	Frequency KHz	DP1Level FR dB	DP1Level FL dB	SNR FR dB	SNR FL dB	DP1Level MR dB	DP1Level ML dB	SNR MR dB	SNR ML dB
1	0.5	8.76	7.26	8.83	5.98	3.9	3.26	6.74	5.76
2	0.75	8.97	8.01	10.15	7.93	4.91	4.25	8.34	7.47
3	1.0	13.63	8.39	10.87	9.46	7.91	7.3	10.44	9.48
4	1.5	11.06	11.10	10.67	9.15	8.27	7.28	12.3	11.76
5	2.0	10.54	9.08	12.3	13.97	6.72	2.79	11.41	11.04
6	3.0	10.24	9.12	12.86	13.07	6.01	4.73	12.54	11.13
7	4.0	13.81	13.00	13.90	13.03	10.61	9.51	17.08	14.20
8	6.0	16.75	14.15	14.71	11.85	15.5	10.89	11.67	10.99
9	8.0	13.8	13.27	8.10	8.21	13.13	8.13	9.7	8.33
	average	11.95	10.37	11.37	10.29	8.55	6.46	11.13	10.01

Appendix-H

Group (III) age (21-30) years for Sudanese subjects

Table (59) DP1 Level (dB) for Right ear male

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	3.0	16.0	11.4	7.8	11.2	9.7	11.8	10.8	10.7
2	3.2	4.8	14.0	16.6	9.3	3.9	16.3	19.3	14.0
3	5.2	7.3	10.9	12.7	10.0	2.9	10.9	18.2	10.5
4	2.4	2.1	3.5	7.9	5.9	9.3	11.8	10.7	11.9
5	-1.7	3.6	5.3	6.6	6.8	-10.6	8.9	6.9	6.1
6	0.9	1.9	-5.8	4.4	5.6	3.6	6.6	16.0	16.6
7	1.1	6.2	13.0	11.7	13.7	6.8	7.2	9.9	6.0
8	11.9	-0.5	-1.0	1.9	2.7	5.6	9.7	1.9	9.8
9	0.0	1.4	1.9	-4.8	6.8	1.8	6.0	10.0	4.9
10	3.3	9.8	18.8	16.2	9.2	6.4	13.4	8.8	16.8
11	-1.9	6.3	6.8	7.8	3.7	8.7	15.9	20.0	20.5
12	9.9	-3.0	7.6	16.9	10.7	3.9	11.7	16.2	11.0
13	0.6	-8.1	-6.4	-8.9	-8.8	-8.6	-4.9	3.9	1.1
average	2.91	3.67	6.15	7.44	6.67	3.33	9.63	11.73	10.76

Table (60) DP1 Level (dB) for Left ear male

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
1	8.9	11.5	11.8	0.0	1.6	11.0	11.9	9.7	9.0
2	3.8	8.8	12.6	16.4	8.0	9.9	18.6	18.9	11.0
3	1.9	1.6	10.6	10.8	0.0	3.3	10.1	16.7	6.4
4	6.0	3.2	9.7	9.9	4.4	4.2	11.0	19.0	16.5
5	1.2	3.8	8.0	7.3	-1.2	0.0	-2.3	0.9	4.8
6	-3.1	0.0	4.5	2.8	1.8	1.9	8.8	11.8	8.9
7	3.3	1.9	8.2	11.5	8.7	11.8	13.0	8.8	1.9
8	2.7	5.8	9.3	8.8	2.3	8.4	11.8	9.0	-2.3
9	-4.4	0.1	1.9	1.9	4.8	4.8	8.0	3.6	6.0
10	1.4	6.9	-1.5	11.0	10.7	10.0	10.6	10.9	19.7
11	6.0	1.5	2.5	2.8	1.9	-8.5	9.6	16.6	-6.2
12	0.0	6.8	7.3	17.2	13.6	15.4	11.9	-3.7	6.8
13	-8.0	-9.0	-2.7	-6.9	1.3	8.6	2.1	3.2	3.7
average	1.51	3.3	6.33	7.19	4.45	6.21	9.62	9.64	6.63

Table (61) Signal Noise Ratio SNRs (dB) for Right ear male

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	6.3	11.5	8.8	11.0	9.5	6.2	11.3	8.7	3.6
2	3.0	16.0	3.6	22.2	18.0	11.0	19.3	20.0	11.3
3	8.7	10.5	10.3	4.5	10.0	16.3	16.3	10.3	6.3
4	9.9	6.0	18.0	16.6	16.8	18.5	18.0	11.8	10.0
5	8.6	6.9	3.7	11.8	8.3	3.7	16.6	9.2	9.9
6	5.9	8.2	8.2	8.9	9.0	6.8	3.9	11.4	10.7
7	8.0	5.5	9.0	14.9	11.8	18.2	15.9	10.6	8.3
8	7.8	4.8	10.8	12.0	8.3	11.6	18.5	8.0	3.6
9	3.9	3.9	8.9	9.0	5.9	5.1	16.1	8.8	6.0
10	8.5	16.6	11.8	18.6	16.7	16.6	18.9	7.9	10.6
11	4.7	8.0	10.0	10.5	16.2	18.2	19.0	19.9	19.0
12	3.6	6.7	6.9	8.7	4.9	4.4	10.0	9.1	18.5
13	6.8	3.3	8.0	10.3	6.3	6.8	10.8	10.6	3.9
average	6.59	8.69	9.07	12.23	10.6	11.03	14.96	12.86	9.3

Table (62) Signal Noise Ratio SNRs (dB) for Left ear male

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	10.0	16.8	16.0	9.9	8.8	9.0	10.0	10.0	8.0
2	5.5	11.9	10.9	18.0	9.3	11.3	9.9	3.6	10.3
3	8.0	7.8	13.0	6.4	6.0	7.0	16.3	6.0	3.9
4	10.2	9.3	9.7	16.6	16.7	10.5	11.2	18.9	9.5
5	3.0	8.2	13.1	14.3	9.0	18.6	10.0	10.2	10.7
6	6.0	5.6	11.7	11.5	8.5	10.4	18.7	16.8	8.8
7	3.8	8.3	6.2	9.9	3.4	9.9	10.2	10.6	3.8
8	4.5	9.0	6.6	7.7	6.0	8.3	11.9	8.8	8.6
9	8.8	6.8	8.7	6.0	10.0	16.8	10.7	11.8	3.7
10	3.1	9.5	16.6	19.4	18.3	13.6	8.6	18.6	11.4
11	9.0	11.3	10.9	11.8	10.8	10.9	18.5	9.8	6.6
12	8.7	6.3	18.0	13.0	4.6	6.1	9.9	16.0	5.1
13	6.6	3.9	4.0	6.9	8.7	10.7	16.6	8.0	7.4
average	6.70	8.82	11.18	11.64	9.23	11.00	12.5	11.46	7.52

Table (63) DP1 Level (dB) for Right ear female .

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	-2.6	2.8	6.7	4.6	6.8	10.5	18.0	19.3	19.8
2	1.1	1.6	3.3	3.9	3.7	6.8	3.9	16.8	18.3
3	2.4	8.7	9.2	11.8	9.0	11.0	14.6	12.3	11.7
4	-1.9	-2.6	5.8	18.0	8.7	8.6	18.2	23.7	20.0
5	-6.8	1.9	1.9	10.6	11.9	10.0	16.5	11.0	5.2
6	-3.3	-4.0	2.4	13.2	10.8	9.3	10.0	16.9	18.9
7	-6.6	5.8	-3.6	9.9	13.2	11.8	15.4	19.7	6.6
8	1.4	7.5	10.8	11.0	5.7	10.8	13.9	18.0	16.5
9	3.1	0.9	4.9	8.5	3.8	2.7	3.6	10.4	2.6
10	-9.2	2.3	6.2	9.6	3.3	6.5	6.9	20.8	19.0
11	1.7	5.3	3.8	5.8	1.9	-3.9	20.0	19.9	16.4
12	-3.9	8.6	6.3	9.3	10.0	9.7	18.6	18.0	6.8
13	8.9	3.7	8.0	16.4	11.2	18.3	11.9	21.8	18.6
average	-1.20	3.26	5.05	10.2	7.69	8.62	13.19	17.58	13.87

Table (64) DP1 Level (dB) for Left ear female.

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	-1.3	9.0	3.1	8.3	11.0	6.3	18.3	11.9	10.8
2	3.8	8.4	11.5	11.9	10.8	9.0	16.6	18.7	18.0
3	2.8	6.3	8.8	18.0	16.3	11.2	3.3	16.6	11.9
4	16.1	3.2	10.0	16.9	8.9	3.3	11.9	20.0	16.3
5	-6.6	1.9	2.3	10.2	10.3	6.5	18.6	10.7	9.9
6	3.1	-2.9	-4.6	9.0	11.3	16.3	10.9	18.8	8.9
7	0.0	-6.8	9.6	3.8	3.7	10.6	18.8	19.0	20.0
8	-9.6	1.2	1.2	6.2	5.6	3.3	3.9	10.5	8.6
9	-8.5	0.0	8.6	1.1	-1.9	2.7	10.0	6.6	6.2
10	-9.6	-3.6	4.4	11.0	6.9	9.6	6.6	16.9	19.4
11	5.3	4.2	9.3	4.6	9.2	11.0	11.0	23.2	9.7
12	-8.8	-2.7	3.1	10.8	8.6	9.6	18.9	18.5	20.2
13	-2.6	8.0	10.3	8.5	10.2	12.5	19.0	11.9	11.6
average	-1.22	2.01	5.96	9.25	8.53	8.60	12.90	15.63	13.19

Table (65) Signal Noise Ratio SNRs (dB) for Right ear female.

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	9.8	9.6	7.9	11.0	10.8	9.7	11.8	18.9	6.0
2	8.6	8.0	10.6	8.9	9.6	11.3	18.6	16.4	3.9
3	9.4	10.9	6.6	10.3	16.1	10.6	20.0	14.6	10.8
4	4.6	16.3	11.0	18.0	10.3	8.0	16.8	10.0	9.6
5	8.9	3.3	9.9	13.8	19.7	16.8	19.0	12.8	8.0
6	5.7	6.0	10.3	19.6	20.0	14.6	16.9	9.9	3.3
7	3.0	10.0	16.0	10.2	8.5	7.8	20.2	18.8	9.0
8	7.5	15.9	13.3	16.6	18.6	13.8	11.7	11.4	3.0
9	10.7	4.8	11.9	9.9	11.6	9.7	14.5	10.8	10.2
10	3.0	5.7	3.5	10.9	8.8	18.3	18.4	20.3	5.5
11	6.9	9.4	10.9	13.2	12.7	16.0	13.0	8.9	3.9
12	8.4	10.6	9.5	11.8	10.9	10.7	17.9	10.0	6.3
13	7.3	11.8	6.3	13.6	9.6	9.6	20.9	16.2	9.7
average	7.21	9.40	9.82	12.90	12.86	12.06	16.9	13.76	6.86

Table (66) Signal Noise Ratio SNRs (dB) for Left ear female

Freq. No.	0.5 kHz	0.75 kHz	1.0 kHz	1.5 kHz	2.0 kHz	3.0 kHz	4.0 kHz	6.0 kHz	8.0 kHz
1	6.5	6.8	3.0	10.5	9.9	9.9	5.8	18.3	8.6
2	9.3	10.7	9.9	18.8	11.9	6.0	8.2	11.0	7.8
3	3.9	9.6	18.0	16.4	19.8	10.7	6.7	13.5	9.3
4	8.6	10.0	11.9	9.9	16.3	10.9	9.6	16.1	11.2
5	6.0	6.0	6.6	10.7	10.7	8.8	3.8	10.5	6.6
6	8.2	8.3	19.3	13.8	18.6	10.9	9.7	8.9	5.9
7	6.6	16.4	9.0	9.6	16.8	9.0	8.9	20.4	10.2
8	5.0	8.9	11.6	6.3	10.0	8.8	9.0	3.8	8.4
9	3.9	3.0	15.8	10.6	15.6	10.6	8.6	8.6	10.2
10	6.1	9.5	10.7	18.1	18.3	9.2	3.8	19.3	6.3
11	5.4	10.2	18.8	8.8	11.7	6.8	4.2	9.4	8.5
12	3.0	5.7	10.4	16.0	9.3	8.6	7.7	18.7	3.8
13	6.9	11.8	19.2	11.9	16.1	9.8	9.5	19.5	5.3
Average	6.10	8.0	12.63	12.41	14.23	9.23	7.34	13.69	7.85

Table (67) Comparison between average of DP1 level and SNR for females and males at each frequency

No.	Frequency KHz	DP1Level FR dB	DP1Level FL dB	SNR FR dB	SNR FL dB	DP1Level MR dB	DP1Level ML dB	SNR MR dB	SNR ML dB
1	0.5	-1.20	-1.22	7.21	6.10	2.91	1.51	6.59	6.70
2	0.75	3.26	2.01	9.40	8.09	3.67	3.3	8.69	8.82
3	1.0	5.05	5.96	9.82	12.63	6.15	6.33	9.07	11.18
4	1.5	10.2	9.25	12.90	12.41	7.44	7.19	12.23	11.64
5	2.0	7.69	8.53	12.86	14.23	6.67	4.45	10.6	9.23
6	3.0	8.62	8.60	12.06	9.23	3.33	6.21	11.03	11.00
7	4.0	13.19	12.90	16.9	7.34	9.63	9.62	14.96	12.5
8	6.0	17.58	15.63	13.76	13.69	11.73	9.64	12.86	11.46
9	8.0	13.87	13.19	6.86	7.85	10.76	6.63	9.3	7.52
	average	8.69	8.31	11.30	10.15	6.92	6.09	10.59	10.00

11.00

Appendix- I

For Sudanese Subjects

Table (68) comparison between average of SNR of Right ear side for females and males at each frequency for all groups (2-10), (11-20), (21-30)

No.	Frequency KHz	SNR FR dB 2-10	SNR FR dB 11-20	SNR FR dB 21-30	SNR MR dB 2-10	SNR MR dB 11-20	SNR MR dB 21-30
1	0.5	7.26	8.83	7.21	3.66	6.74	6.59
2	0.75	9.72	10.15	9.40	5.88	8.34	8.69
3	1.0	14.44	10.87	9.82	8.9	10.44	9.07
4	1.5	16.89	10.67	12.90	14.44	12.3	12.23
5	2.0	15.36	12.3	12.86	12.25	11.41	10.6
6	3.0	19.93	12.86	12.06	14.13	12.54	11.03
7	4.0	19.80	13.90	16.9	17.02	17.08	14.96
8	6.0	18.78	14.71	13.76	16.58	11.67	12.86
9	8.0	15.45	8.10	6.86	11.30	9.7	9.3
	average	15.29	11.37	11.30	11.57	11.13	10.59

Table (69) comparison between average of SNR of left ear side for females and males at each frequency for all groups (2-10), (11-20), (21-30)

No.	Frequency KHz	SNR FL dB 2-10	SNR FL dB 11-20	SNR FL dB 21-30	SNR ML dB 2-10	SNR ML dB 11-20	SNR ML dB 21-30
1	0.5	4.91	5.98	6.10	3.43	5.76	6.70
2	0.75	7.71	7.93	8.09	5.53	7.47	8.82
3	1.0	10.60	9.46	12.63	8.46	9.48	11.18
4	1.5	13.26	9.15	12.41	11.33	11.76	11.64
5	2.0	14.61	13.97	14.23	11.08	11.04	9.23
6	3.0	17.17	13.07	9.23	13.89	11.13	11.00
7	4.0	16.91	13.03	7.34	15.60	14.20	12.5
8	6.0	17.33	11.85	13.69	16.86	10.99	11.46
9	8.0	14.2	8.21	7.85	9.48	8.33	7.52
	average	12.65	10.29	10.15	10.62	10.01	10.00

Table (70) comparison between the average of DP1 level of Right ear side for females and males at each frequency for all groups

No.	Frequency KHz	DP1Level FR dB 2-10	DP1Level FR dB 11-20	DP1Level FR dB 21-30	DP1Level MR dB 2-10	DP1Level MR dB 11-20	DP1Level MR dB 21-30
1	0.5	4.76	8.76	-1.20	3.77	3.9	2.91
2	0.75	9.84	8.97	3.26	6.33	4.91	3.67
3	1.0	12.65	13.63	5.05	11.63	7.91	6.15
4	1.5	17.20	11.06	10.2	15.40	8.27	7.44
5	2.0	16.5	10.54	7.69	13.29	6.72	6.67
6	3.0	18.36	10.24	8.62	9.72	6.01	3.33
7	4.0	16.8	13.81	13.19	14.23	10.61	9.63
8	6.0	21.47	16.75	17.58	19.93	15.5	11.73
9	8.0	19.49	13.8	13.87	19.55	13.13	10.76
	average	15.23	11.95	8.69	12.65	8.55	6.92

Table (71) comparison between average of DP1 level of left ear side for females and males at each frequency for all groups

No.	Frequency KHz	DP1Level FL dB 2-10	DP1Level FL dB 11-20	DP1Level FL dB 21-30	DP1Level ML dB 2-10	DP1Level ML dB 11-20	DP1Level ML dB 21-30
1	0.5	4.10	7.26	-1.22	3.33	3.26	1.51
2	0.75	7.45	8.01	2.01	6.28	4.25	3.3
3	1.0	12.38	8.39	5.96	11.00	7.3	6.33
4	1.5	15.41	11.10	9.25	14.79	7.28	7.19
5	2.0	13.38	9.08	8.53	10.39	2.79	4.45
6	3.0	13.56	9.12	8.60	9.11	4.73	6.21
7	4.0	15.56	13.00	12.90	13.30	9.51	9.62
8	6.0	21.3	14.15	15.63	18.21	10.89	9.64
9	8.0	17.66	13.27	13.19	15.63	8.13	6.63
	average	13.42	10.37	8.31	11.33	6.46	6.09

Appendix- J

Linear and non-Linear equations curve for Iraqi and Sudanese subjects for all groups

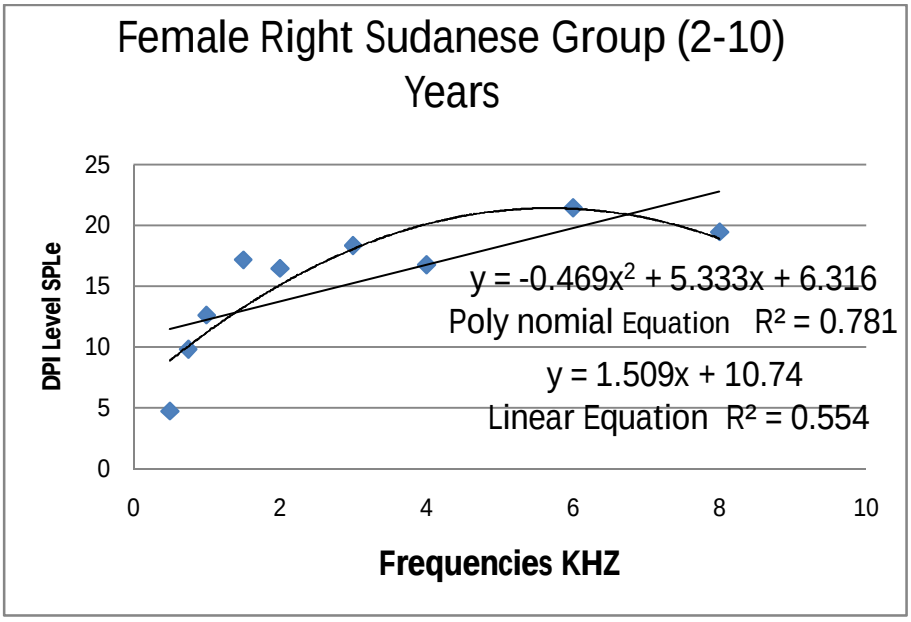

Figure (1) Linear and non-Linear equations curve for Female Right ear Sudanese subjects group (2-10) year

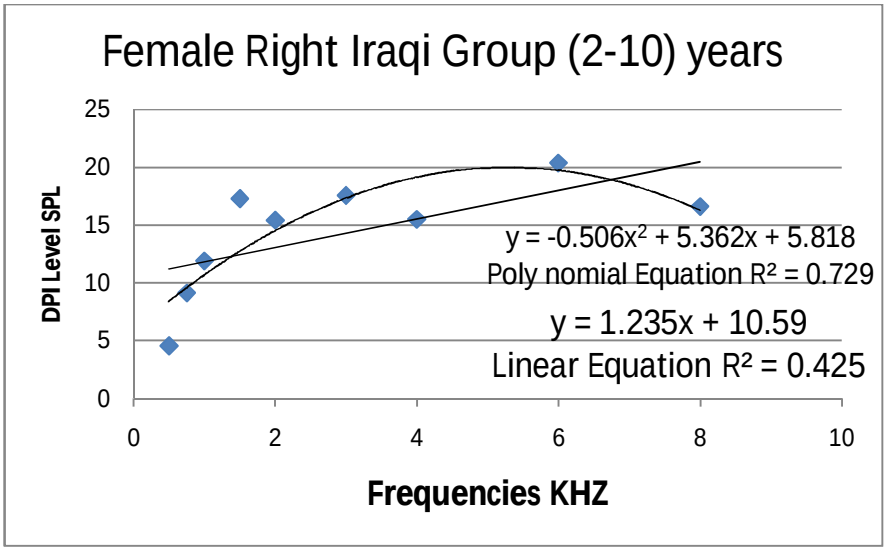

Figure (2) Linear and non-Linear equations curve for Female Right ear Iraqi subjects group (2-10) year

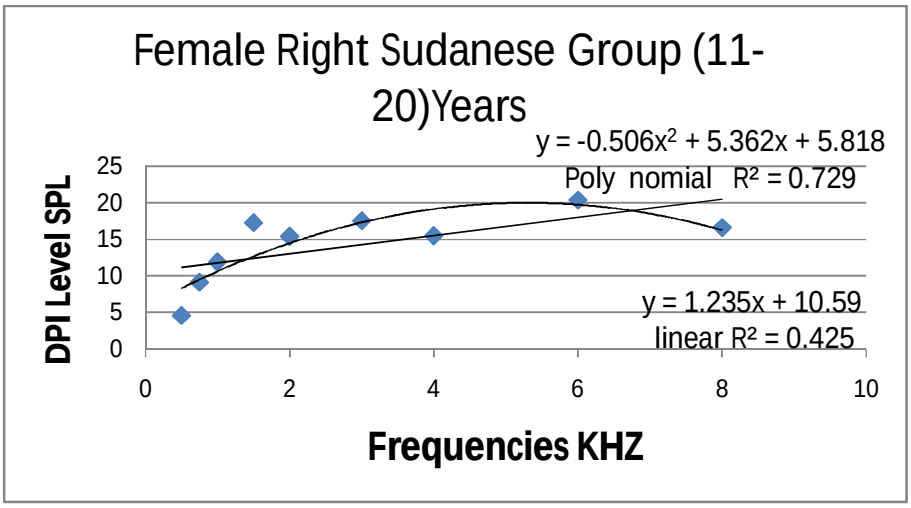

Figure (3) Linear and non-Linear equations curve for Female Right ear Sudanese subjects group (11-20) year

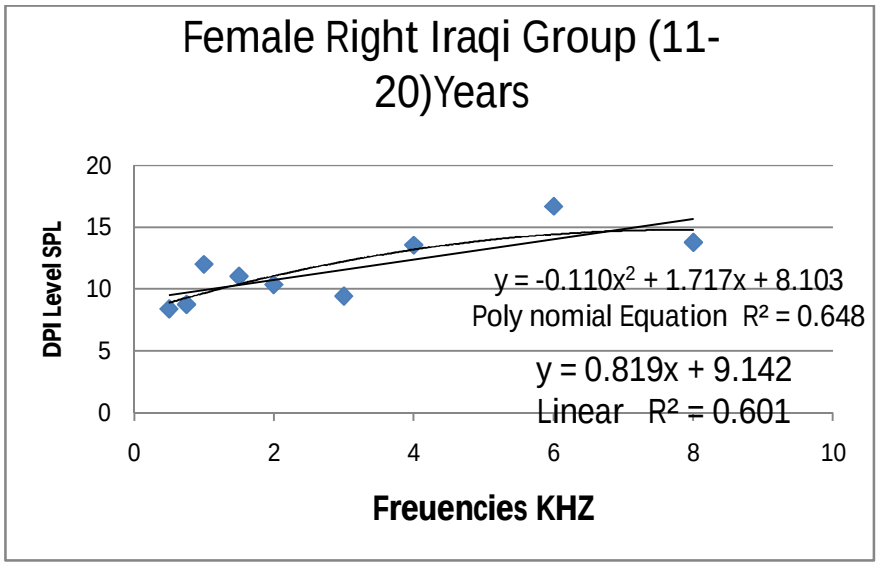

Figure (4) Linear and non-Linear equations curve for Female Right ear Iraqi subjects group (11-20) year

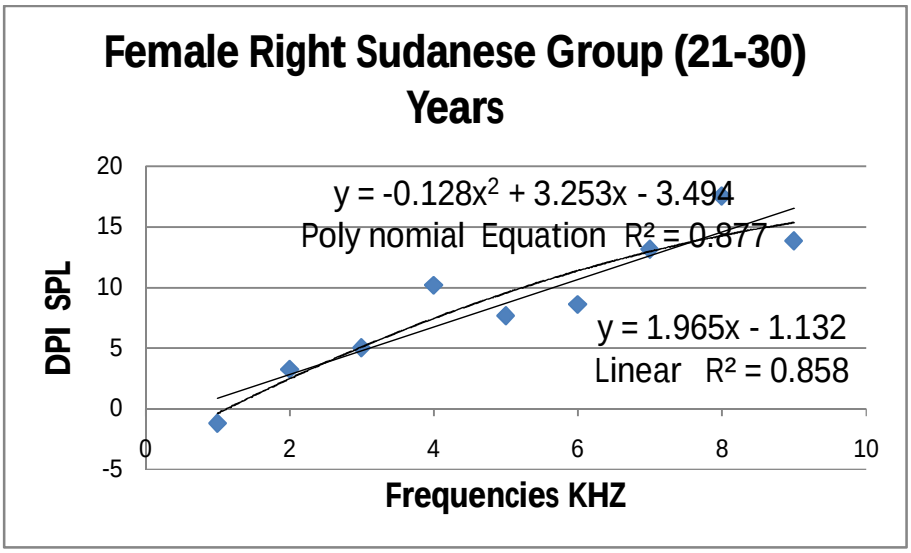

Figure (5) Linear and non-Linear equations curve for Female Right ear Sudanese subjects group (21-30) year

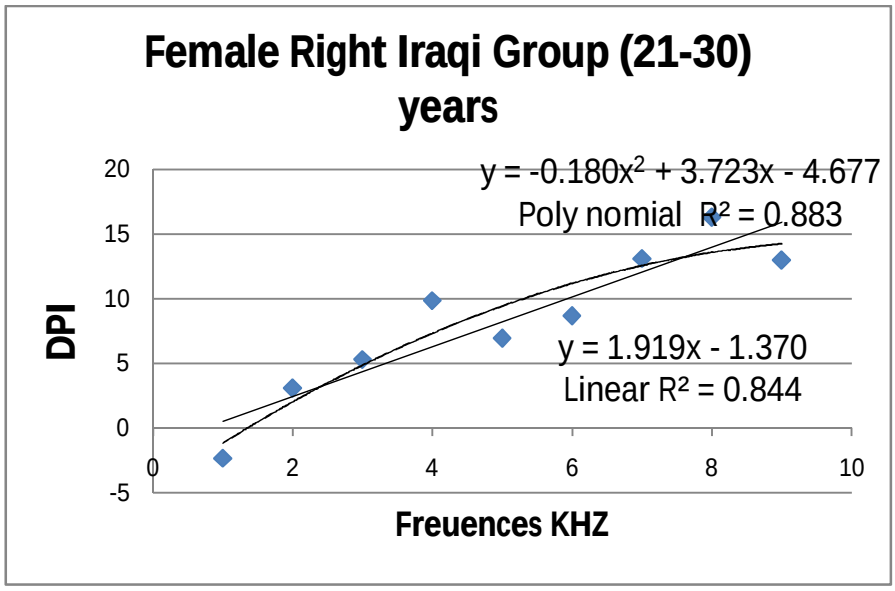

Figure (6) Linear and non-Linear equations curve for Female Right ear Iraqi subjects group (21-30) year

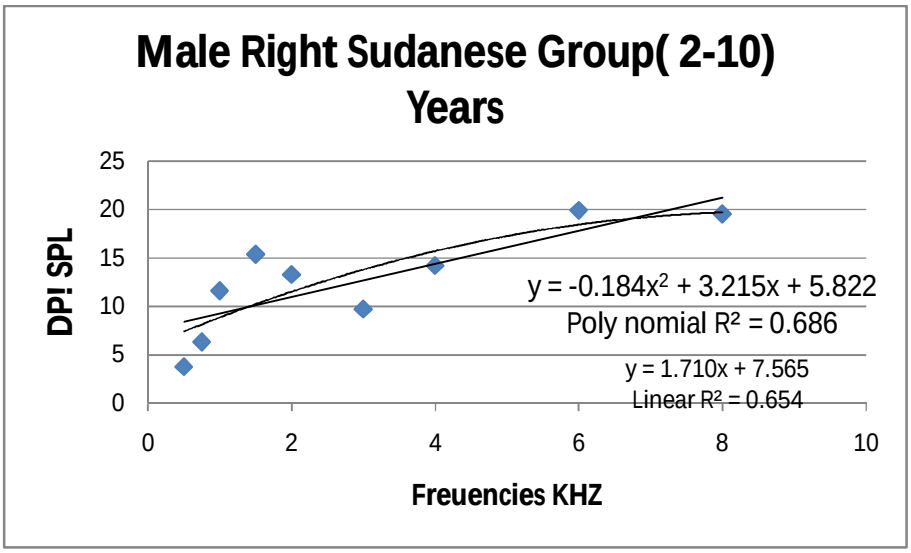

Figure (7) Linear and non-Linear equations curve for male Right ear Sudanese subjects group (2-10) year

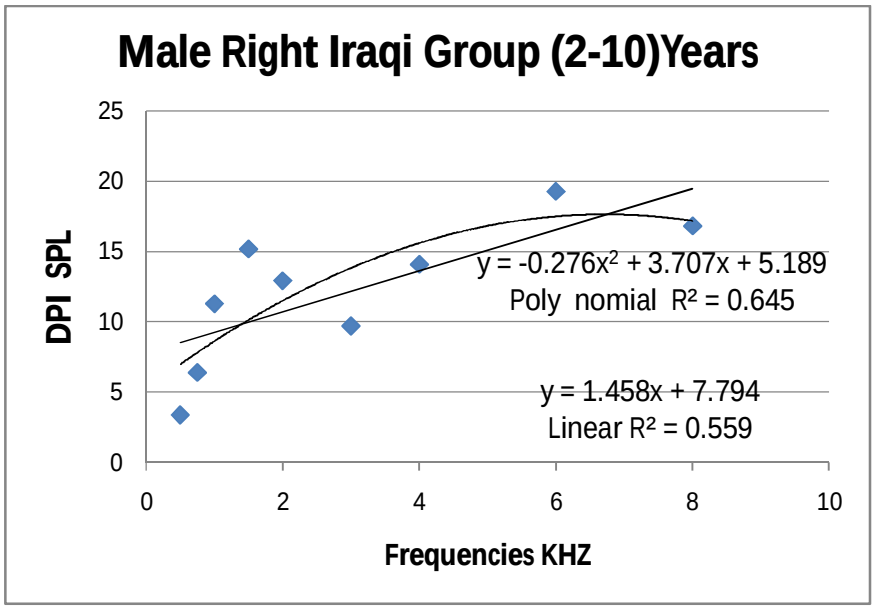

Figure (8) Linear and non-Linear equations curve for male Right ear Iraqi subjects group (2-10) year

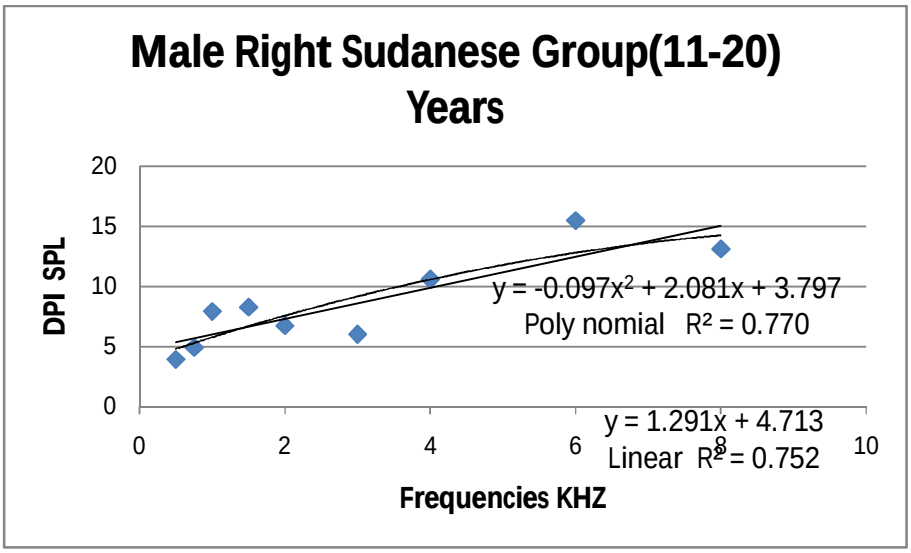

Figure (9) Linear and non-Linear equations curve for male Right ear Sudanese subjects group (11-20) year

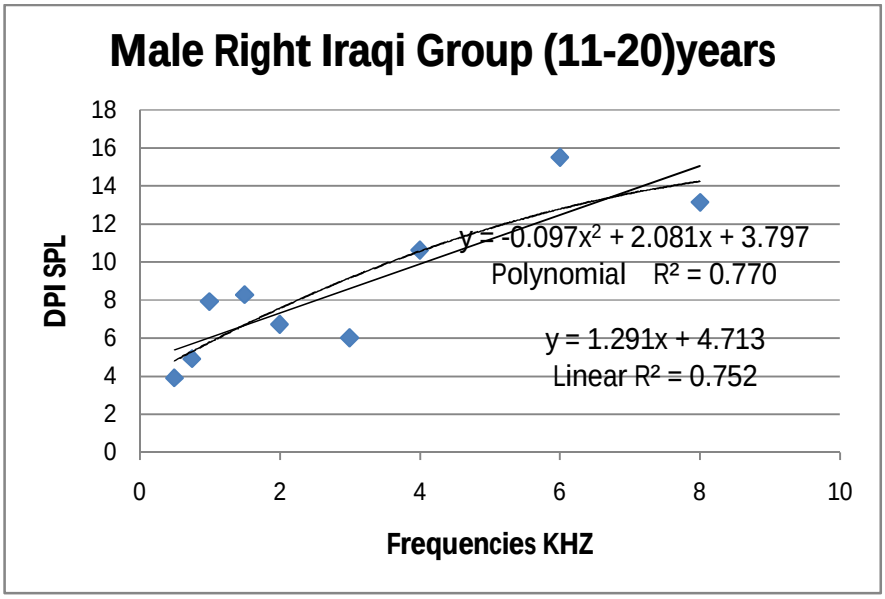

Figure (10) Linear and non-Linear equations curve for male Right ear Iraqi subjects group (11-20) year

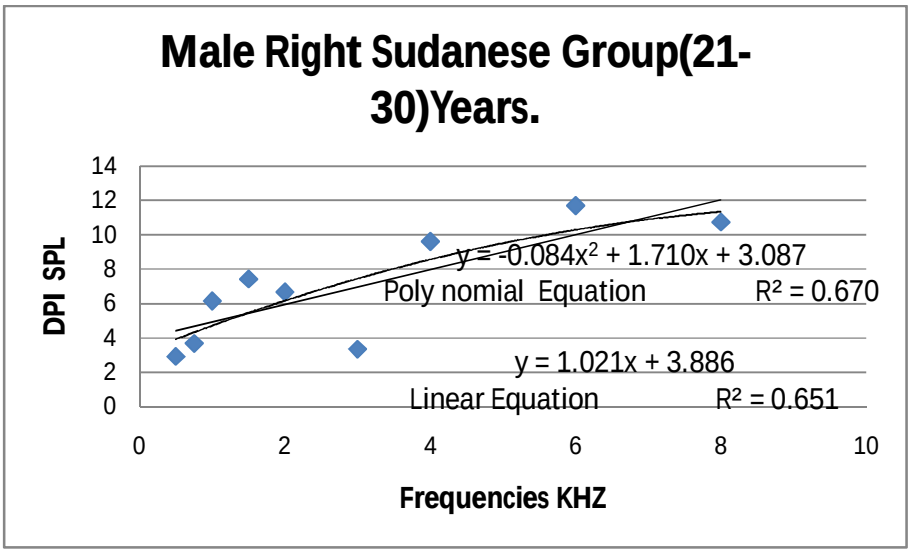

Figure (11) Linear and non-Linear equations curve for male Right ear Sudanese subjects group (21-30) year

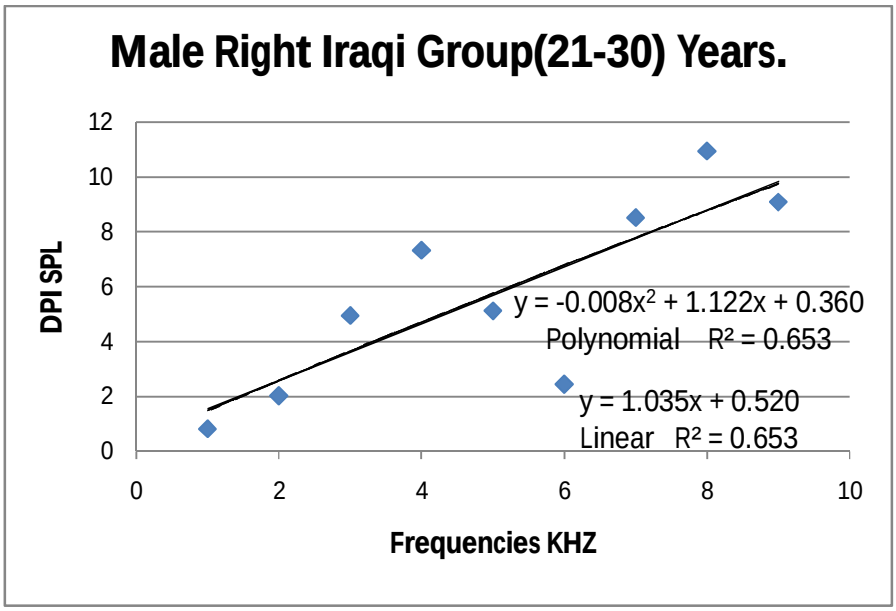

Figure (12) Linear and non-Linear equations curve for male Right ear Iraqi subjects group (21-30) year

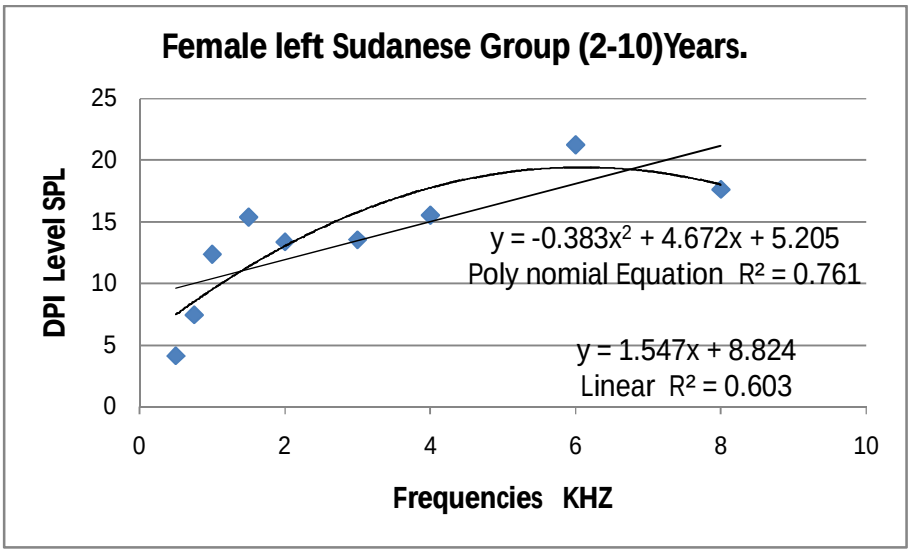

Figure (13) Linear and non-Linear equations curve for Female Left ear Sudanese subjects group (2-10) year

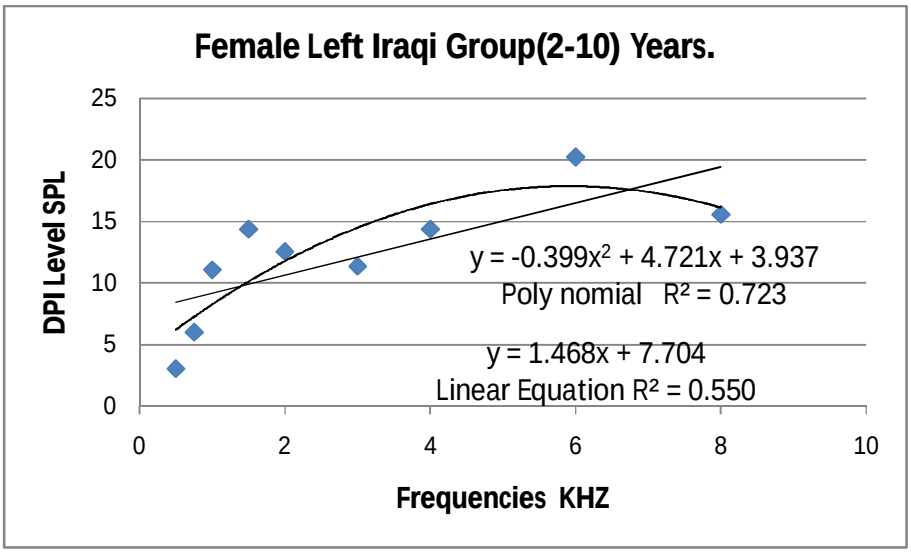

Figure (14) Linear and non-Linear equations curve for Female Left ear Iraqi subjects group (2-10) year

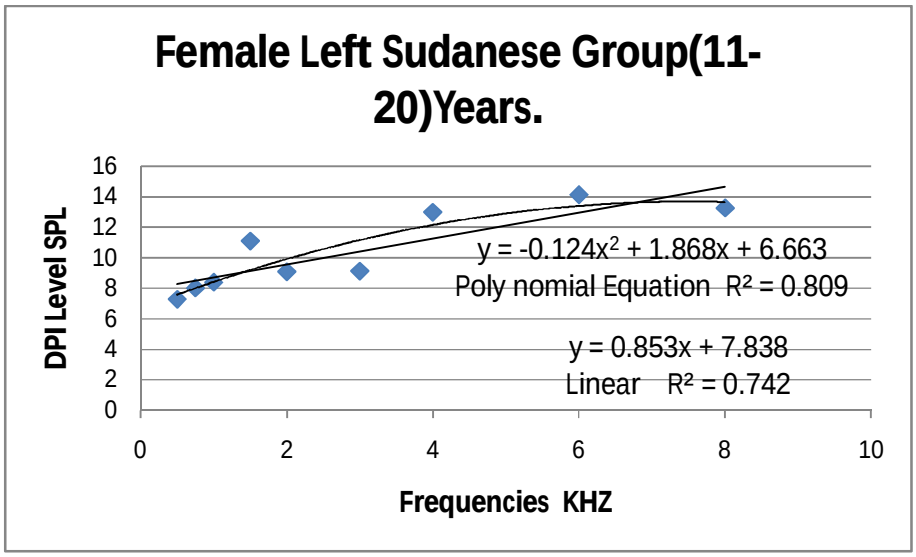

Figure (15) Linear and non-Linear equations curve for Female Left ear Sudanese subjects group (11-20) year

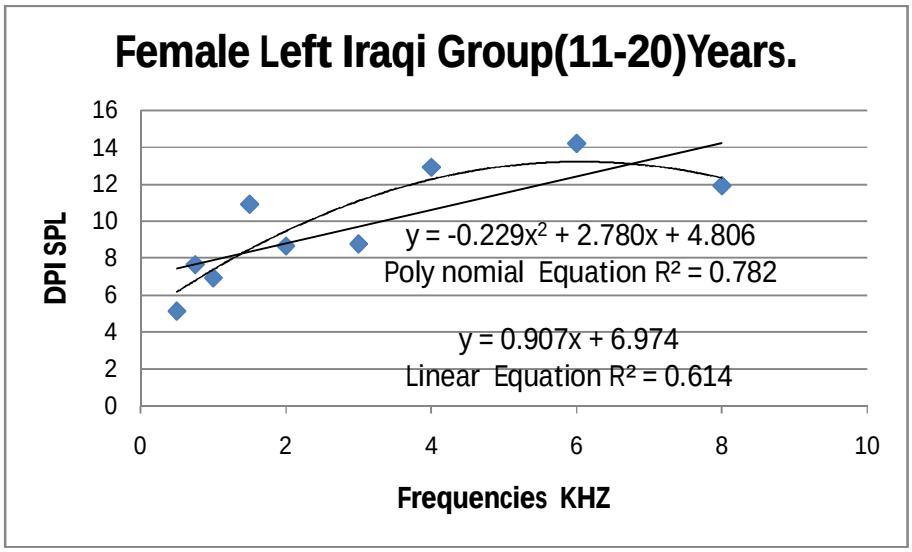

Figure (16) Linear and non-Linear equations curve for Female Left ear Iraqi subjects group (11-20) year

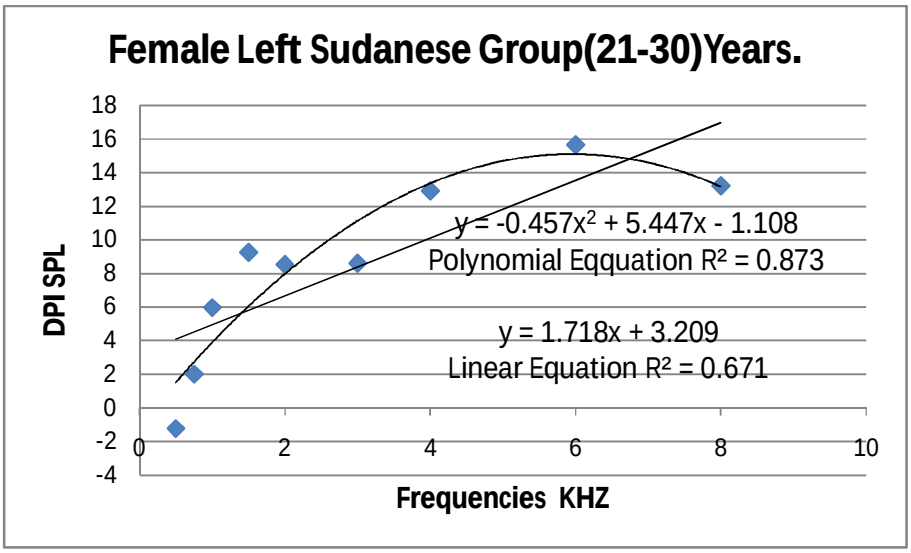

Figure (17)Linear and non-Linear equations curve for Female Left ear Sudanese subjects group (21-30) year

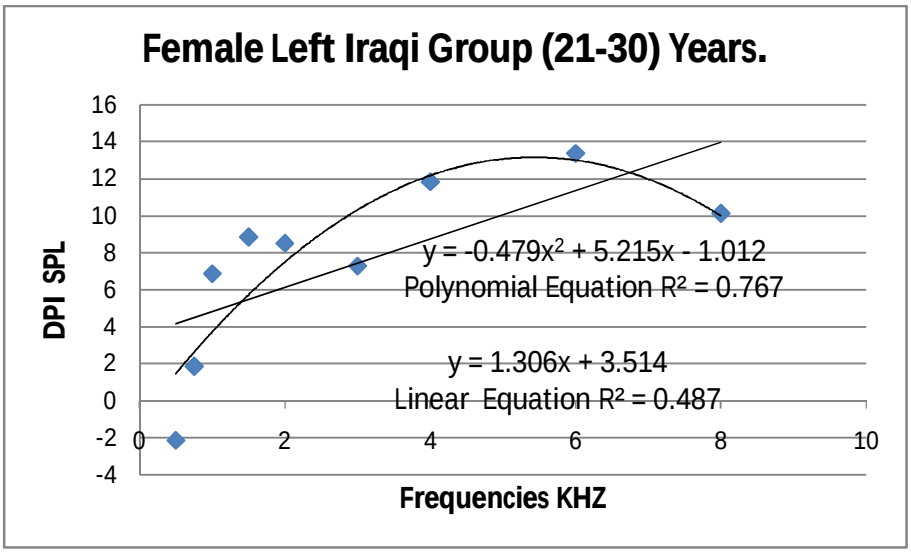

Figure (18) Linear and non-Linear equations curve for Female Left ear Iraqi subjects group (21-30) year

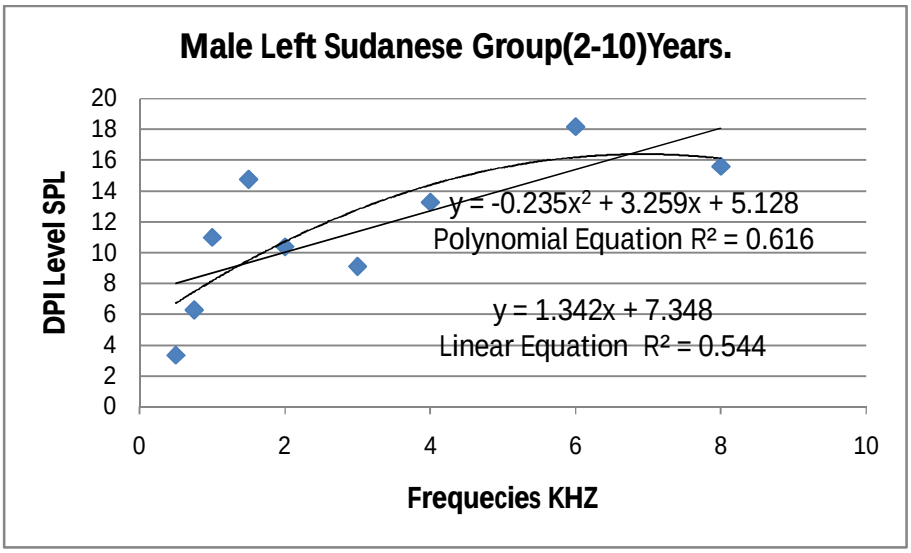

Figure (19) Linear and non-Linear equations curve for male Left ear Sudanese subjects group (2-10) year

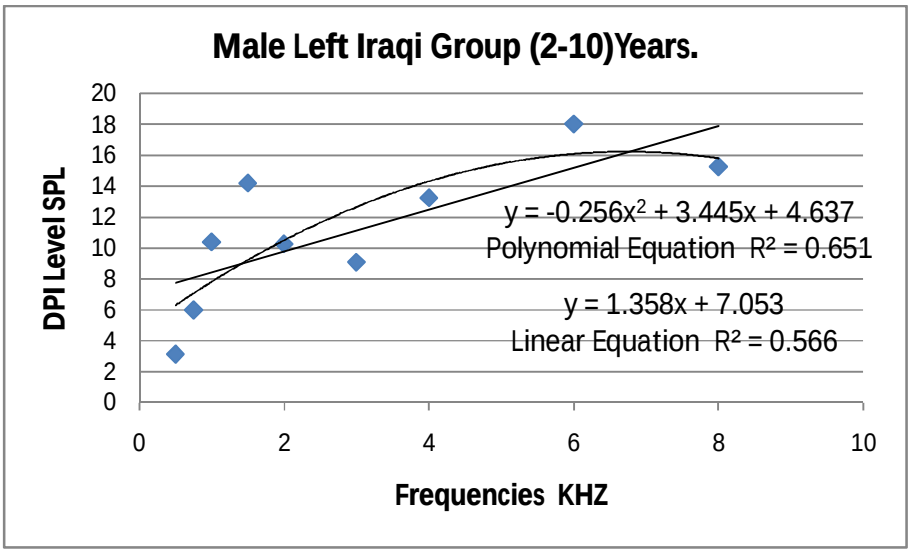

Figure (20) Linear and non-Linear equations curve for male Left ear Iraqi subjects group (2-10) year

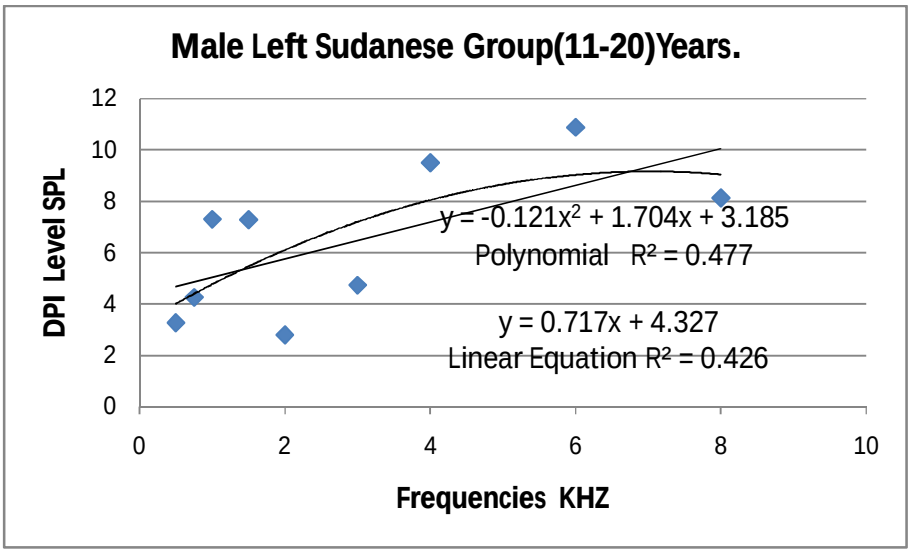

Figure (21)Linear and non-Linear equations curve for male Left ear Sudanese subjects group (11-20) year

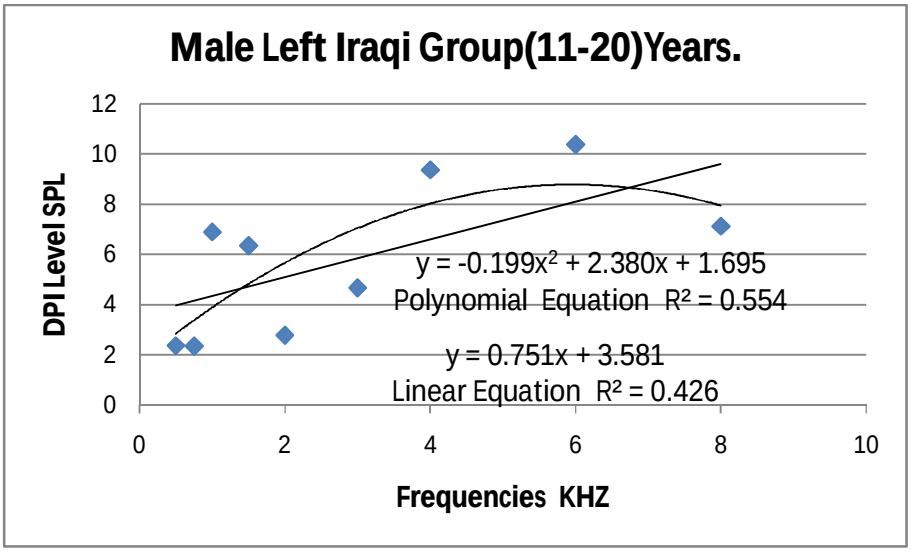

Figure (22) Linear and non-Linear equations curve for male Left ear Iraqi subjects group (21-30) year

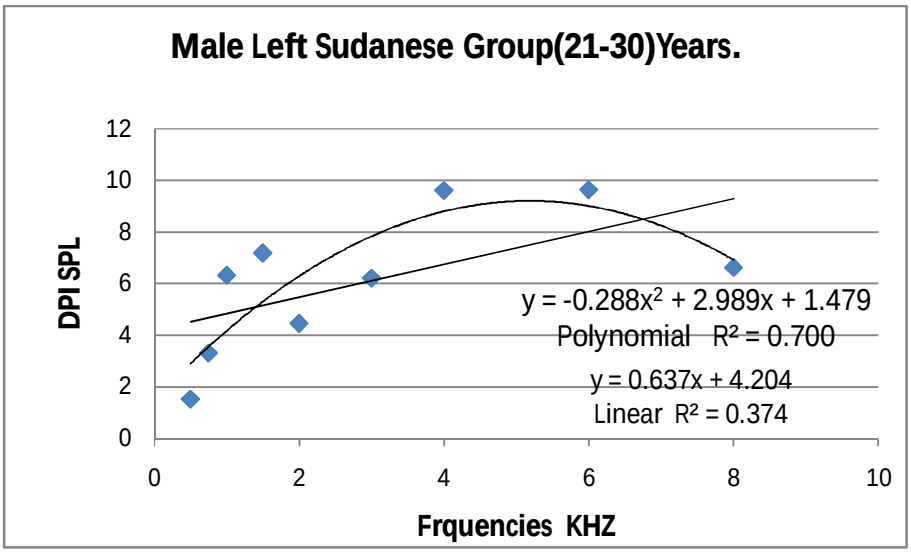

Figure (23)Linear and non-Linear equations curve for male Left ear Sudanese subjects group (21-30) year

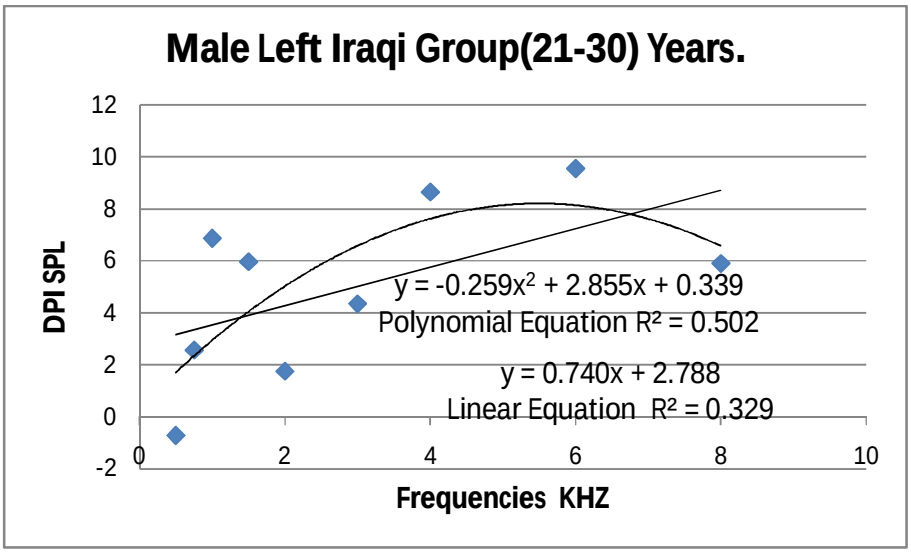

Figure (24) Linear and non-Linear equations curve for male Left ear Iraqi subjects group (21-30) year

Appendix-K

Comparison between Sudanese and Iraqi subjects

Table (72) comparison the average of DP1 level between Sudanese (S) and Iraqi (I) Subjects of Right ear side for females and males at each frequency for all groups

No.	Frequency KHz	DP1Level FR dB 2-10(S)	DP1Level FR dB 2-10(I)	DP1Level FR dB 11-20(S)	DP1Level FR dB 11-20(I)	DP1Level FR dB 21-30(S)	DP1Level FR dB 21-30(I)	DP1Level MR dB 2-10(S)	DP1Level MR dB 2-10(I)	DP1Level MR dB 11-20(S)	DP1Level MR dB 11-20(I)	DP1Level MR dB 21-30(S)	DP1Level MR dB 21-30(I)
1	0.5	4.76	4.57	8.76	8.41	-1.20	-2.3	3.77	3.38	3.9	3.44	2.91	0.82
2	0.75	9.84	9.13	8.97	8.77	3.26	3.11	6.33	6.40	4.91	2.43	3.67	2.03
3	1.0	12.65	11.91	13.63	12.02	5.05	5.32	11.63	11.29	7.91	7.1	6.15	4.95
4	1.5	17.20	17.3	11.06	11.06	10.2	9.86	15.40	15.19	8.27	7.55	7.44	7.33
5	2.0	16.5	15.43	10.54	10.38	7.69	6.96	13.29	12.93	6.72	4.53	6.67	5.12
6	3.0	18.36	17.57	10.24	9.46	8.62	8.70	9.72	9.72	6.01	4.9	3.33	2.45
7	4.0	16.8	15.51	13.81	13.58	13.19	13.11	14.23	14.10	10.61	9.90	9.63	8.52
8	6.0	21.47	20.39	16.75	16.73	17.58	16.30	19.93	19.3	15.5	11.25	11.73	10.95
9	8.0	19.49	16.62	13.8	13.8	13.87	13.0	19.55	16.84	13.13	13.1	10.76	9.09
	average	15.23	14.27	11.95	11.57	8.69	8.22	12.65	12.12	8.55	7.13	6.92	5.69

Table (73) comparison average of DP1 level between Sudanese (S) and Iraqi (I) Subjects of left ear side for females and males at each frequency for all groups

No.	Frequency KHz	DP1Level FL dB 2-10(S)	DP1Level FL dB 2-10(I)	DP1Level FL dB 11-20(S)	DP1Level FL dB 11-20(I)	DP1Level FL dB 21-30(S)	DP1Level FL dB 21-30(I)	DP1Level ML dB 2-10(S)	DP1Level ML dB 2-10(I)	DP1Level ML dB 11-20(S)	DP1Level ML dB 11-20(I)	DP1Level ML dB 21-30(S)	DP1Level ML dB 21-30(I)
1	0.5	4.10	3.04	7.26	5.13	-1.22	-2.12	3.33	3.15	3.26	2.37	1.51	-0.72
2	0.75	7.45	6.0	8.01	7.64	2.01	1.87	6.28	6.02	4.25	2.36	3.3	2.57
3	1.0	12.38	11.07	8.39	6.93	5.96	6.87	11.00	10.42	7.3	6.9	6.33	6.87
4	1.5	15.41	14.38	11.10	10.91	9.25	8.85	14.79	14.23	7.28	6.36	7.19	5.97
5	2.0	13.38	12.56	9.08	8.65	8.53	8.51	10.39	10.29	2.79	2.79	4.45	1.75
6	3.0	13.56	11.37	9.12	8.76	8.60	7.28	9.11	9.1	4.73	4.68	6.21	4.35
7	4.0	15.56	14.38	13.00	12.91	12.90	11.83	13.30	13.27	9.51	9.37	9.62	8.65
8	6.0	21.3	20.24	14.15	14.20	15.63	13.36	18.21	18.05	10.89	10.38	9.64	9.56
9	8.0	17.66	15.58	13.27	11.91	13.19	10.13	15.63	15.29	8.13	7.13	6.63	5.90
	average	13.42	12.06	10.37	9.67	8.31	7.39	11.33	11.09	6.46	5.81	6.09	4.98

Table (74) comparison the average of SNR (dB) between Sudanese (S) and Iraqi (I) Subjects of Right ear side for females and males at each frequency for all groups

No.	Frequency KHz	SNR FR dB 2-10(S)	SNR FR dB 2-10(I)	SNR FR dB 11-20(S)	SNR FR dB 11-20(I)	SNR FR dB 21-30(S)	SNR FR dB 21-30(I)	SNR MR dB 2-10(S)	SNR MR dB 2-10(I)	SNR MR dB 11-20(S)	SNR MR dB 11-20(I)	SNR MR dB 21-30(S)	SNR MR dB 21-30(I)
1	0.5	7.26	6.37	6.53	7.99	7.21	5.93	3.66	3.39	6.74	7.14	6.59	6.69
2	0.75	9.72	8.96	10.15	9.28	9.40	9.29	5.88	5.65	8.34	8.23	8.69	7.92
3	1.0	14.44	10.53	10.87	9.33	9.82	9.6	8.9	8.59	10.44	9.54	9.07	9.52
4	1.5	16.89	16.06	10.67	10.28	12.90	12.60	14.44	14.34	12.3	11.3	12.23	11.06
5	2.0	15.36	13.1	12.3	11.30	12.86	11.90	12.25	12.13	11.41	11.24	10.6	10.95
6	3.0	19.93	19.43	12.86	12.01	16.99	16.51	14.13	14.11	12.54	12.06	11.03	11.12
7	4.0	19.80	18.04	13.90	13.2	16.9	16.5	17.02	16.52	17.08	16.13	14.96	13.07
8	6.0	18.78	18.58	14.71	12.79	13.76	9.03	16.58	16.06	11.67	11.7	12.86	11.46
9	8.0	15.45	14.4	8.10	12.55	6.86	6.75	11.30	10.91	9.7	9.15	9.3	9.0
	average	15.29	13.94	11.12	10.97	11.85	10.8	11.57	11.3	11.13	10.71	10.59	9.83

Table (75) comparison average of SNR (dB) between Sudanese (S) and Iraqi (I) Subjects of left ear side for females and males at each frequency for all groups

No.	Frequency KHz	SNR FL dB 2-10(S)	SNR FL dB 2-10(I)	SNR FL dB 11-20(S)	SNR FL dB 11-20(I)	SNR FL dB 21-30(S)	SNR FL dB 21-30(I)	SNR ML dB 2-10(S)	SNR ML dB 2-10(I)	SNR ML dB 11-20(S)	SNR ML dB 11-20(I)	SNR ML dB 21-30(S)	SNR ML dB 21-30(I)
1	0.5	4.10	4.38	5.98	6.55	6.10	5.23	3.43	3.11	4.69	4.30	6.70	6.61
2	0.75	7.45	6.88	7.93	6.96	8.99	8.26	5.53	4.98	7.47	7.11	8.82	8.58
3	1.0	12.38	8.04	9.46	7.7	12.63	11.35	8.46	8.44	9.48	9.14	11.18	11.10
4	1.5	15.41	11.32	9.15	9.45	12.41	12.29	11.33	10.92	11.76	11.14	11.64	10.67
5	2.0	13.38	11.65	13.97	13.09	14.23	13.56	11.08	10.72	11.04	10.73	9.23	9.20
6	3.0	13.56	15.45	13.07	11.6	14.61	14.36	13.89	13.46	11.13	11.13	11.00	10.82
7	4.0	15.56	15.18	13.03	12.5	16.51	8.5	15.60	15.55	14.20	14.26	12.5	12.58
8	6.0	21.3	16.7	11.85	10.85	13.69	5.61	16.86	15.57	10.99	10.16	11.46	9.7
9	8.0	17.66	10.32	8.21	7.30	7.85	7.43	9.48	9.03	8.33	7.53	7.52	6.42
	average	13.42	11.10	10.29	9.55	11.89	9.62	10.62	10.19	9.89	9.5	10.00	9.48