A COMPARATIVE STUDY OF IMPEDANCE RESULTS USING TWO IMMITTANCE INSTRUMENTS IN NORMALS

Register No. M 9320

An Independent Project submitted as part fulfilment for
the First Year M.Sc, (Speech and Hearing)
to the University of Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE - 570 006
MAY 1994

Dedicated to

My Parents and Satheesh

For their boundless love, understanding, tolerance, high ideals and capabilities which contributed significantly to my education and personal life

CERTIFICATE

This is to certify that the independent project entitled " **A COMPARATIVE STUDY OF IMPEDANCE RESULTS USING TWO IMMITTANCE INSTRUMENTS IN NORMALS** " is a bonafide work done in part fulfilment for the First Year Degree of Master of Science (Speech and Hearing), of the student with Register No. M 9320.

Mysore
May 1994

Director
All India Institute of Speech and Hearing
Mysore - 570 006

CERTIFICATE

This is to certify that the independent project entitled " A COMPARATIVE STUDY OF IMPEDANCE RESULTS USING TWO IMMITTANCE INSTRUMENTS IN NORMALS " has been prepared under my supervision and guidance.

Mysore
May 1994

Dr. (Miss.) S.Nikam
Guide

DECLARATION

I hereby declare that this independent project entitled " A COMPARATIVE STUDY OF IMPEDANCE RESULTS USING TWO IMMITTANCE INSTRUMENTS IN NORMALS " is the result of my own study under the guidance of Dr. (Miss.) S.Nikam, Professor and Head of the Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any other University for any other Diploma or Degree

Mysore
May 1994

Register No. M 9320

CONTENTS

LIST OF TABLES

LIST OF GRAPHS

ACKNOWLEDGMENTS

First and foremost I extend my heartfelt gratitudes to my teacher and guide **Dr. (Miss.) S. Nikam,** Professor and Head of the Department of Audiology, All India Institute of Speech and Hearing for her excellent guidance and help.

I am thankful to **Dr. (Miss.) S. Nikam,** Director, A.I.I.S.H., for permitting me to take up this work.

I also thank -

Mrs. Vanaja, C.S., Mr. Animesh Burman., Miss. Manjula, and Mrs. Revathi for their valuable help in completing this project.

Department of electronics for their timely help.

Mr. Jayaram, B.D., Statistician, C.I.I.L., and **Mr. Venkatesh, C.S.** Lecturer, A.I.I.S.H., Mysore for guiding **and** helping me in doing the statistical analysis.

Dr. Vidyasagar for his valuable suggestions and constant help.

Mithilesji, Dushi, Gaga, Mamatha, Suraj and Sreejith for their deep rooted love, concern, support and best wishes.

Ritu, Mona, Jyothi, Anu and Deepa for being there during the difficult times and offering assistance and encouragement.

Venu, Arun, Bishu and Rajeev for making my work enjoyable by their friendly touch.

All my classmates for inducing in me the competitive spirit and all other friends for coming forward and helping me wholeheartedly.

Ramesh **Babu** for extending a helping hand whenever needed.

The **library staff** for allowing me to peep into the ocean of A.I.I.S.H. literature.

Last but not the least, I thank M/s COMPUTER STROKE (A Data Processing Division of RACS) for their neat and accurate strokes.

INTRODUCTION

Immittance audiometry refers collectively to the measures of acoustic impedance and acoustic admittance. Acoustic impedance is a measure of the opposition to the flow of acoustic energy into the middle ear transmission system. Conversely acoustic admittance is a measure of the ease which which acoustic energy flows into the middle ear. Acoustic impedance at a surface is a reciprocal of the acoustic admittance at the plane of the surface. Immittance audiometry provides a rapid, atraumatic and objective . technique for evaluating the integrity of the middle ear transmission system, estimating middle ear pressure, estimating volume of ear canal or middle ear and evaluating eustachian tube function. It is used for the differential diagnosis of :

(a) Middle ear pathologies,
(b) Seventh cranial nerve lesion,
(c) Retrocochlear pathologies,
(d) Cochlear pathologies &
(e) for prediction of hearing sensitivity.

Therefore the impedance audiometry is widely used in all audiological departments and is appealing in an otolaryngology practice.

The history of clinical acoustic immittance measures is well over 100 years old. According to Feldman (1970), the first attempts at objective assessment of middle ear function using acoustic impedance measures were performed by Lucae (1867). Lucae used an instrument that was a distant fore runner of the Schuster (1934) and Zwislocki (1963) mechanical acoustic impedance bridges. There is substantial literature on the measurement of acoustic immittance characteristics of human ears dating back to the early 1900s. The clinical popularity of acoustic immittance measures, however did not grow dramatically until the electro acoustic impedance units became commercially available. Impedance audiometry started with Metz, (1946) construction of a mechanical device for detection of changes in acoustic impedance of the middle ear. The method was further developed and since the construction of the electro-acoustic bridge Terkildsen and Nielsen, 1960) it has become an important diagnostic tool for middle ear mechanics and middle ear diseases. The advantages of impedance audiometry are clear. However in practical clinical work the conventional, low-speed, tympanometry is thought to be too time consuming to be used in routine patient evaluation. One of the most obvious problems in the practical use of impedance audiometry has been to obtain an air tight seal around the probe tip in the patient's ear canal. Especially in the investigation of small children who cannot stay concentrated the performance has to be fast in order to avoid interference from movement, crying etc. During recent years efforts have been made to construct impedance bridges that could be managed by the clinician in routine work and such an instrument has been presented by Jonsson, et.a1. ,(1982). Their construction has then been further developed to make it possible to obtain and present tympanograms and middle ear reflexes in a fast and simple way on a light emitting diode (LED) matrix.

Astounding developments in computerized and digital technology have made available a diversity of precise measurement tools for analysis of the auditory system and hearing. Immittance measurements and their inclusion in the audiometric test battery has added a powerful dimension to the diagnostic testing process. Recommendations based on differential reliable test results may now be made with the highest degree of certainty and confidence.

Need for the study

During the past 20 to 30 years acoustic immittance techniques and procedures have progressed from a specialized technique used in a few clinics and laboratories to a routine procedure used in most otologic and audiologic facilities. Recent advances in computerized and digital technology made it possible for the manufacturers to come out with a wide variety of sophisticated instruments. With such wide varieties of immittance audiometers becoming commercially available it is incumbent on the part of an audiologist to check the validity of such instruments with the existing ones. It throws light on the instrumental variations and the need to obtain normative data with respect to a particular instrument.

Although there are numerous immittance findings in normal ears the comparison and clinical utility of these data are limited due to instrumentation differences, population differences, the lack of reported variance measures associated with sample means and differences in the variables and units of measurement. Collecting normative data for a particular instrument with respect to the Indian population is inevitable from the view point of diagnosis. Establishing normative data is very important for the classification of ears into normal or abnormal. This depends on which normative data was used for the comparison. Hence the present study is aimed at obtaining normative date for middle ear analyzer (GSI33) and to compare it with the immittance audiometer Z0174 in order to check its validity.

The present study was designed to determine the following:

(1) To provide normative data for Middle Ear Analyzer (GSI33) for impedance values in subjects aged between 18 years and 25 years for both males and females.

(2) To check whether there is any significant difference between Middle Ear Analyzer (GSI33) and Immittance Audiometer (Z0174) with respect to impedance values in both males and females.

REVIEW OF LITERATURE

Normative data is very important for the classification of ears into normal or abnormal. The classification of ears into normal and abnormal depends on which normative data was used for the comparison. It is wise on the part of an audiologist to construct a normative data for the clinical population and for the new model of instrument which he has procured.

There appears to be numerous studies to establish norms for impedance measurements by using both Zwislocki's bridge and electro-acoustic impedance bridge. The magnitude and direction of deviations from normal immittance values indicate the type of middle ear pathology involved. As recently as 1965, criteria for normal impedance were not well established. Both Zwislocki (1963) and Feldman (1965) has published loosely defined "typical normal" values and Hecker and Kryter (1965) had published range of normal values which was too wide to help the clinician in the diagnosis of middle ear pathology. (Burke, 1970)

Burke, et.al.,(1970) have compared three normative data published by Feldman, 1967; Bicknell and Morgan, 1968; Burke, et.al., 1970 and found variations among the three reported norms. Jerger, et.al., 1972 have compared 6 normative data, 3 studies using Zwislocki bridge and three studies using Electro-acoustic bridge and have found variations.

Review of literature is being carried out under three main subheadings. They are (a) tympanometry and static compliance, (b) reflexometry and (c) comparative studies.

(a) Tympanometry and Static Compliance

The static compliance of the normal middle ear varies uniquely with both age and sex of the subject. Significant sex differences with regard to static compliance were observed in older age groups when compared to younger age groups. The males showed higher compliance than the females Compliance declines as a function of age. (Jepsen, 1955; Zwislocki, 1965; Feldman, 1967; Liden.1970; Jerger, 1970, 1972; and Basavaraj, 1973). According to Feldmlan (1967) the mean in cc of equivalent air volume (compliance) ranged from 0.67 to 1.45 for a frequency range from 125 Hz to 1KHz. The static acoustic immittance norms obtained with subjects above 6 years were within a range of 0.50 to 1.75 ml with a median of 0.91 ml at a probe tone frequency of 226Hz with pump speeds in the vicinity of 30 daPa/sec (Margolis and Shanks, 1985). According to Northern and Grimes, (1978) a range between 0.28 and 2.5cc were considered as the normal values for static compliance (cited in Martin, 1986). The static acoustic admittance measures obtained at 220 Hz for ambient pressure and tympanogram peak pressure were 0.58 ml and 0.74ml respectively. The 90% normal range obtained at 220 Hz probe frequencies for ambient pressures and peak pressure were 0.27 to 1.0 and 0.33 to 1.28ml respectively (Wiley, et.al., 1987). The normal static compliance values were found to be between 0.25 cu cm to 2.0 cu cm according to Bess and Humes (1990). Peak static admittance at 226 Hz. averages 0.5 acoustic mmhos in children and 0.8 acoustic mmhos in adults, with 90% of normal persons falling between 0.2 and 1.4 acoustic mmhos (Shanks and Shelton, 1991) .

Feldman, (1967) conducted acoustic impedance studies of the normal ears and found that the mean in acoustic ohms (resistance) for a frequency range from 125 Hz to 1,500 Hz were within a range of 301 to 522. For older age groups there is no significant difference with regard to acoustic impedance between males and females, There is significant difference with regard to acoustic impedance between two male age groups. The older group shows higher impedance than the younger group. The normals obtained a wide range of 682 to 5840 acoustic ohms (Basavaraj,1973). For older children and adults the impedance values were found to be between 769 and 2564 ohms according to Jerger, (1970) and Jerger, et.al. ,(1972) (Silman and Silverman, 1991).

According to Feldman, (1967) the mean of the ear canal volume in cc is 0.56 and the range is 0.4 to 0.8. According to Shanks and Shelton, (1991) the mean of physical volume is 0.7 cc in children and 1.1 cc in adult males.

Paradise, et.al., (1976) considered a tympanometric peak pressure between -100 and +50 daPa with normal peak amplitudes as the criterion for normals (Margolis and Shanks, 1985). Acoustic immittance measures carried out in normal adult ears by Wiley, et.al., (1987) showed a mean peak pressure of 11.8 daPa and the 90% normal range extended, from -10 daPa to +34 daPa. A normal tympanogram for an adult has a peak pressure point between -100 and +40 daPa, which suggests that the middle ear functions optimally at or near ambient pressure (0 daPa) (Bess and Humes, 1990). According to Shanks and Shelton, (1991) normal middle ear pressure typically falls between +50 and -100 daPa Brooks (1980). Halmquist and Miller (1972), Peterson and Liden (1972) and Porter (1974) reported tympanometric peak pressures between +50 and -50 daPa in adults with normal middle ears. Brooks (1968, 1969), who used -170 daPa as the lower limit of the normal range of tympanometric peak pressures, considered middle ears to be normal if the acoustic reflex threshold did not exceed 95 dBHL at 2,000 Hz, bilaterally. Renvall, et.al.,(1975) considered -150 daPa to be the lower limit for normal middle ears Jerger, (1970) proposed -100 daPa as the lower limit of the normal range of tympanometric peak pressure. (Silman and Silverman, 1991).

Several methods for calculating tympanometric gradient or width have been suggested. In one method the tympanometric width or the ear canal pressure range, corresponding to a 50% reduction in static admittance is taken into account. The normal tympanometric width ranges from 50 to 150 daPa. In the other method tympanometric gradient, which is defined as the change in admittance between the peak value and the mean admittance value corresponding to a pressure interval of 50 daPa on both sides of the peak is taken into account. Gradient is more commonly used by equipment manufacturers. (Shanks and Shelton, 1991). According to Brooks (1969) and Paradise, Smith, and Bluestone (1976), a gradient is small if it is less than or equal to 0.15. According to Fiellau-Nikolajsen (1983), a gradient is small if it is less than as equal to 0.1. According to the American Speech - Language - Hearing Association (1989), the 90% ranges for tympanometric width (gradient) of normal persons are 60 to 150 daPa in children and 50 to 110 daPa in adults (silman and Silverman, 1991).

(b) Reflexometry

In the normal middle ear, the threshold of acoustic reflexes is normally distributed around a mean of approximately 85 dB (ISO 64) hearing threshold level (Jepsen, 1955; Zwislocki, 1965; Feldman, 1967; Liden, 1970; and Jerger, 1970, 1972). 100% acoustic reflex responses were observed only at 1 KHz and 2 KHz for all the normal ears (Basavaraj, 1973). In general, results indicated that reflex thresholds were better (lower) at 500 Hz, and poorer (higher) at 2KHz (Robertson, et.al., 1968). According to Jerger, et.al.,(1972) absent reflexes at 4 KHz do not necessarily have pathological significance. The acoustic reflex thresholds obtained for adults for a probe tone frequency of 220 kc/s was 80.2 dB respectively . According to Margolis and Popelka, (1975) mean acoustic reflex thresholds for normal adults were in the range of 88.55 dB SPL to 94.55 dB SPL. The frequency range were from 500 Hz to 4 KHz and Mair, (1980) conducted a study on the ipsilateral and contralateral acoustic reflex thresholds in dBSL in young adults with normal hearing and found no significant differences between the ipsilateral and contralateral **acoustic** reflex thresholds.

Numerous researchers have documented that the necessary intensity range to elicit the acoustic reflex at threshold for normal hearing subjects is 70 to 100 dB hearing level (Metz, 1946; Fria, et.al., 1975). The median threshold value for the stapedial reflex to puretone signals is approximately 85 dBHL. Early studies reported that the ipsilateral acoustic reflex can be elicited at lower intensities than the contralatera1 acoustic reflex. (Muller, 1961; Fria, et.al., 1975). Moller, (1961) states that the ipsilateral reflexes are between 2 dB and 16 dB more sensitive than contralateral reflexes.

Most, normal-hearing individuals will have a bilateral intraaural muscle reflex when pure tones are introduced to the ear at 65 dB to 90 dB above threshold (Martin, 1986). Mean of the acoustic reflex thresholds obtained for ipsilateral and contralateral stimulation by tones in normal hearing adults for the frequency range from 500 Hz to 4 KHz were within a range of 79.9 dBHL to 87.5 dBHL and 84.4 dBHL to 89.8 dBHL respectively (Wiley, et.al., 1987). According to Bess and Humes, (1990) in the normal ear, contraction of middle ear muscles occurs with pure tones ranging from 65 to 95 dBHL.

Persons with normal hearing thresholds have acoustic reflex thresholds of approximately 85-100 dBSPL for puretones between 250 and 4000 Hz. The acoustic reflex thresholds for males are essentially similar to those for females (Jerger, et.al., 1972; Osterhammel and Osterhammel, 1979; Silverman, Silman, and Miller, 1983). The ipsilateral acoustic reflex thresholds were found to be lower than the contralateral thresholds (Silman and Silverman, 1991).

(c) **Comparative studies**

When only the Zwislocki Acoustic Bridge (Grason-Stadler Company, Model 3) and the Madsen Acoustic Bridge (Model Z070) were available, comparative studies indicated that impedance **and** acoustic reflex values collected with the two instruments were similar, at least with normal middle ears. (Burke, et.al., 1970, Feldman, et.al., 1971). Later, comparative impedance results were found to be divergent with some types of pathological ears (Stone and Feldman, 1971). Some of the differences may have occurred because measurements with the Zwislocki Bridge must be made at atmospheric pressure, whereas discrete measurements with the Madsen Bridge are usually taken at the point of maximum compliance (Pressure equalized on both sides of the tympanic membrane), thus maximum point may vary from atmospheric pressure, depending upon the type of middle ear pathology involved. (Burke and Herer,1973).

On comparison of an Otoadmittance meter (GS Model 1720) with an attached GS Model 1701 X-Y recorder with a Madsen model Z070 electro acoustic bridge with an attached Hewlett-Packard Model 7035 B-01 X-Y recorder the following results were obtained. The Madsen Model Z070 electroacoustic bridge and the Grason Stadler Model 1720 Otoadmittance meter were both used to test two normal hearing groups, of ten young adults and ten children aged 6-11 years. The Z070 instrument indicated better acoustic reflex thresholds at 220 cps, higher negative middle ear pressure and at atmospheric pressure a higher middle ear impedance, than the GS 1720. Under the conditions of equalized pressure, however, impedance readings were similar for both instruments (Burke and Herer, 1973).

The mean value of the middle ear pressure recorded from the 35 ears, using the SA-100 meter, was -13.9 mm water (SE +-1.5; SD +-8.6) and using the Z072 bridge the mean middle ear pressure was -0.2 mm water (SE +-1.6; SD +-9.3). The compliance value recorded by SA-100 was a little higher when recordings were made from ears with less than or equal to 1 ml equivalent volume. Due to construction it was not possible to make a corresponding recording of the equivalent volume during a pressure change from minus to plus with the SA-100 meter. The two methods of recording the middle ear reflex are different since the SA-1OO meter works with an ipsilateral tone stimulus of 1 KHz and llOdB SPL and the middle ear reflex is recorded immediately after the acoustic stimulation, while the Z072 bridge works with contralateral tone stimulus of 1 KHz from 75 dB upto 115 dB SPL in 5 dB steps and with a recording of the middle ear reflex response during the tone stimulus. Using the SA-1OO meter, a middle ear reflex response was recorded in more than 5 out of 10 stimulations in 30 out of 35 ears (85%) using 1 KHz and 110 dB SPL as the stimulus. Using the Z072 bridge, a response **was** recorded in 33 out of 35 ears (95%) using 1 KHz and 115 dB SPL as the stimulus. As seen from the results this new technique gives reliable responses in 85% of the ears tested as compared to 95% when using conventional impedance technique, i.e. the methods are equally reliable. There was, however, a low correlation between the amplitudes recorded by the different methods which is hard to explain (Ivarsson, et.al., 1983).

Karlsson and Hagermann (1984) compared a commercial impedance audiometer the Granon-Stadler 1723 with a laboratory impedance audiometer to determine whether the normal values are valid, which were obtained using the laboratory impedance audiometer. They found that the GS ' 1723 audiometer gives reliable stapedial reflex thresholds, but at 2 to 4 dB higher levels. The reflex decay curves, however, are unsatisfactory. They have also proposed a modification of the recorder of the commercial audiometer. The study demonstrates that normal values cannot be transferred freely between different equipments.

In order to compare the impedance audiometer Z073 A with the impedance tympanoscope ZS330 (both from Madsen electronics). Birch, et.al., 1986 examined 50 children who had been admitted to the ENT department and 24 children from a kindergarten. There proved to be a good correlation between the middle ear pressure, except that ZS330 showed a rather lower middle ear pressure. As regards compliance too there was a good correlation. The ipsilateral stapedial reflex was rather labile and in 68% of the ears the two instruments showed conformity, while in 15% only Z073 A and in 17% only ZS 330 could elicit the reflex. When the middle ear pressure was lower than -100 mm H2o, the ipsilateral stapedial reflex could be elicited in only 25% of the cases, even though the middle ear pressure was equalized.

A study was conducted on 51 otherwise healthy children attending Kindergarten (100 ears) who underwent daily tympanometric screening with both the impedance tympanoscope ZS 331 (Madsen Electronics) and the clinical impedance audiometer AZ 7 (Inter Acoustics). The tympanoscope indicated a significantly larger number of type B tympanogram and in 16 cases the type B curves could be demonstrated on only one day, resulting in significantly higher point and period prevalences of type B tympanograms. The difference is mainly attributable to the different ways in which a type B tympanogram is defined by the two instruments. On the basis of the present study we conclude that the impedance tympanoscope is not well suited for this type of study. The prevalence of type B tympanograms is generally higher in all age groups when measuring with the tympanoscope (Birch and Elbrond, 1984, 1985, 1986; Birch et.al., 1984, 1986). This finding could not be confirmed when using other impedance audiometers. (Fiellan Nikolajsen, 1983; Fiellan Nikolajsen et.al., 1977; Toss, 1983, 1984; Toss and Paulsen, 1979; Tos, et.al., 1979, 1982, 1984). Daily measurements with the tympanoscope (Birch and Elbrond, 1985) showed peculiar conditions, such as a type B tympanogram of one day's duration in an ear displaying a type A tympanogram the day before and the day after. The conclusions of this study must be that the tympanoscope to a high degree overestimates the presence of type B curves, rendering it unsuited for this type of study (Miller and Mirko Tos, 1992)

In the present study (GSI33 Version 2) Middle Ear Analyzer a high tech microprocessor - based admittance instrument designed to be used in clinical and research setting is compared with an immittance Audiometer Z0174 which is widely used in the audiology department of All India Institute of Speech and Hearing.

METHODOLOGY

The methodology of the present study is discussed under the following headlines : subjects, instrumentation, test environment and procedure

Subjects

A total number of 60 subjects including 30 males and 30 females (120 ears) with the range of 18 to 25 years were taken for the study. The subjects selected met the following criteria:

a) They had no history of ear discharge, tinnitus, earache, giddiness, exposure to loud noise, or other otological abnormalities.

b) Their hearing sensitivity was within 15 dBHL (IS:1983) at the frequencies from 250 Hz to 8 KHz at octave intervals.

Instrumentation

In this study three instruments were used. They were two channel audiometer (OB-822) for determining the hearing sensitivity, middle ear analyzer (GSI 33) and immittance audiometer (ZO-174). The instruments were calibrated according to the specification given by the manual. The audiometer (0B 822) was equipped with earphones (ME-70) encased in earcushion (MX 41-AR). In immittance audiometer (ZO 174) the ipsilateral and contralatera1 stimuli used were continuous tones. Middle ear Analyzer (GSI33) made use of multiplexed stimulus as ipsilateral stimuli and continuous tone as contralateral stimuli.

Test Environment

The tests were conducted in sound-treated test and control **room** combination where ambient noise levels met the ANSK1977) criteria. The noise levels measured on the 'C scale and at octave intervals is given in Appendix C.

Procedure

Hearing the thresholds were obtained using a clinical audiometer (Madsen OB 822). The audiometer was equipped with earphones (ME 70) encased in earcushion (MX 41- AR). The hearing thresholds were evaluated using the Modified Hughson-west lake procedure.

The subjects were instructed as follows. " You will **hear a** tone. As soon as you hear the tone lift your finger up. As soon as you stop hearing the tone put your finger down. You should respond even for the lowest tone." The better ear of the subject was tested first. When the subjects did not report a significant difference between the ears, the right ear was always tested first.

The subject were to all comfortably in an arm chair and then the impedance values were obtained using middle ear analyzer (GSI 33) and immitance audiometer (ZO 174) at a pressure rate of 200 daPa/sec for a 226 Hz probe tone. The direction of pressure change was always from the positive side to the negative side. The parameters considered were physical volume , tympanogram typo, peak pressure, static compliance, gradient and acoustic reflexes. The subjects were instructed not to talk or move their heads or swallow when the test is in progress.

RESULTS AND DISCUSSION

The purpose of the present study was:

1) To provide normative data for Middle Ear Analyzer (GSI 33) for impedance values in subjects aged between 18 years and 25 years for both males and females.

2) To check whether there is any significant difference between Middle Ear Analyzer (GSI 33) and Immittance Audiometer (ZO 174) with respect to impedance values in both males and females.

The data was collected based on the methodology given in the previous chapter. These data were subjected to statistical analysis using parametric statistical test-paired and unpaired t-test.

As stated earlier the present study was designed to study tympanogram type, peak pressure, physical volume, static compliance, gradient, and ipsilateral and contralateral acoustic reflex thresholds. The results and discussions regarding each parameter studied are presented here.

The tympanogram type obtained is found to be Type A in all subjects. From Table 1 it can be seen that mean acoustic reflex thresholds are consistently higher at all frequencies for contralateral stimulation compared to ipsilateral

Table I. Impedance values and Acoustic Reflexs for males and females in the age group 18 to 25 years using Middle Ear Analyzer (GSI 33)

Parameters	Mean & Standard Deviation		Range in Males & Females	
	Males	Females	Minimum	Maximum
Physical Volume (cc)	1.39 0.309	1.16 0.23	0.8 0.8	2 1.8
Peak Pressure (daPa)	1.67 12.37	-0.58 10.5	-45 -30	25 45
Static Compliance (cc)	0.75 0.43	0.7 0.22	0.3 0.3	3.1 1.4
Gradient	81.75 30.05	74.58 18.74	15 25	150 110
Ipsilateral Reflexes (dB SPL)				
500 Hz	99.44 6.58	93.73 5.97	84.5 79.5	110 104.5
1 KHz	94.5 5.27	89.66 6.56	80.5 75.5	105.5 110
2 KHz	100.6 5.38	94.85 4.23	87 05	110 102
4 KHz	95.8 5.18	90.28 7.64	82 77	102 102
Contralateral Reflexes (dB SPL)				
500 Hz	104.92 4.67	99.93 6.54	94.5 79.5	110 110
1 KHz	99.23 5.58	94.33 5.65	90.5 81	110 106
2 KHz	104.44 5.37	98.04 5.81	92.5 82.5	110 110
4 KHz	99.29 6.4	91.38 6.74	85 75	110 105

stimulation in both males and females. This is in agreement with the result obtained by Si1man and Silverman, (1991). Within ipsilateral reflex thresholds at 1 KHz the mean reflex threshold are the lowest in both males and females. Within contralateral reflex threshold the mean reflex thresholds are the lowest at 1 KHz in males and at 4 KHz in females.

The value of physical volume obtained in Table 1 for females agrees with the findings of Shanks and She1ton (1991) which is 1.1 cc. Different authors have obtained different ranges for the peak pressure, static compliance and gradient. Acoustic reflex threshold were found to be lowest at 1 KHz except for the contralateral acoustic reflex threshold for females which is found to be lowest at 500 Hz. This is in contrast to the study by Robertson, et.al., (1968) where reflexes were found to be lowest at 500 Hz. Ipsilateral acoustic reflex threshold for both males and females showed higher reflexes at 2 KHz and contralateral reflex thresholds showed higher reflexes at 500 Hz.

Significant difference between mains and females were found for the following parameters upon statistical analysis when tested using middle ear analyzer (GSI 33) and immitance audiometer (ZO 174) at 1% level of significance. The parameters were peak pressure, physical volume, ipsilateral acoustic reflex thresholds and contralateral acoustic reflex thresholds. Hence while checking whether there is any significant difference between the two immitance audiometers using paired 't' test (Garrett, 1966) data for males and females were compared separately. Since no significant differences were found between right and left ears with respect to all the parameters upon statistical analysis at 1% level of significance, they are combined while comparing the two instruments.

With regard to static compliance no sex difference was noticed when the data were obtained using the two instruments. This is in contrast with the study by Jepsen, 1955; Zwislocki, 1965; Feldman, 1967; Liden, 1970; Jerger, 1970, 1972; and Basavaraj, 1973. However in . both the studies higher compliance values were obtained for males than females.

From Table 2 it is unambiguous that significant difference was not found between the two instruments with respect to five parameters viz. tympanogram type, peak pressure, static compliance, ipsilateral reflex thresholds at 500 Hz and 2KHz at 1% level of significance. (Fig.2 and Fig.3)

Table II Mean, standard deviation, 't' value, probability & significance of the impedance values & acoustic reflex thresholds between the Middle Ear Analyzer (GSI 33) and Immittance Audiometer (ZO 174) for males

Parameters	Mean & Standard Deviation		't' value	Probability
	GSI 33	ZO 174		
Physical Volume (cc)	1.39 0.309	1.55 0.4	-3.4021	0.0012 *
Peak Pressure CdaPa)	1.67 12.37	-9.5 24.92	1.757	0.0815 •*
Static Compliance (cc)	0.75 0.43	0.71 0.22	1.5968	0.1130 **
Ipsilateral Reflexes (dB SPL				
500 Hz	99.44 6.58	101.25 3.64	-2.2347	0.0292 *•
1 KHz	94.5 5.27	0.97 2.79	-4.0334	0.0002 *
2 KHz	100.6 5.38	98.75 2.37	2.6451	0.0104 ••
Contralateral Reflexs (dB SPL)				
500 Hz	104.92 4.67	107.83 2.22	3.0218	0.0038 *
1 KHz	99.23 5.58	104.27 4.62	-7.557	0.0 *
2 KHz	104.44 5.37	106.59 4.04	-3.885	0.0003 •
4 KHz	99.29 6.4	108.49 3.36 .	-10.3339	0.0 •

* Significant ** Not Significant

Significant difference was found between the two instruments with respect to six parameters viz. physical volume, ipsilateral reflex thresholds at 1 KHz and all the contralateral reflex thresholds at 1% level of significance. (Fig.l, Fig.3 and Fig.5)

The gradient values were not compared because the two instruments require different procedures for calculating the gradient value. Ipsilateral reflex thresholds at 4KHz were not compared because no response was obtained for majority of the ears at 4 KHz when tested using immittance audiometer (ZO 174). The acoustic reflex thresholds were found to bo significantly lower for both ipsilateral and contralateral stimuli when tested using middle ear analyzer (GSI 33), except that at 2 KHz the ipsilateral acoustic reflex thresholds for the immittance audiometer (ZO 174) were found to be significantly lower. The contralateral stimuli is presented through an earphone in the immittance audiometer (ZO 174) and through an insert receiver in middle ear analyzer (GSI 33). Hence better contralateral acoustic reflex thresholds obtained in the middle ear analyzer (GSI 33) could most probably be due to the influence of an insert receiver.

Table 3 makes it unequivocal that significant difference was not found between the two instruments with respect to five parameters viz. tympanogram type, physical volume, peak pressure, static compliance, and ipsilateral acoustic reflex

Table III Mean, standard deviation, 't^{1} value, probability & aignificance of the impedance values & acoustic reflex thresholds between the Middle Ear Analyzer (GSI33) and Immittance Audiometer (ZO174) for females

Paramotors	Mean & Standard Deviation		't ' value	Probability
	GSI 33	**ZO** *174*		
Physical Volume (cc)	1.16 0.23	1.21 0.34	-1.0484	0.2987 •*
Peak Pressure (daPa)	-0.58 10.5	3.25 10.37	–2 1534	0.0354 **
Static Compliance (cc)	0.7 0.22	0.67 0.17	1.4728	0.1461 •*
Ipsilateral Reflexes (dB SPL)				
500 Hz	93.73 5.97	99 5.43	–6 8754	0..0 *
1 KHz	89.66 6.56	94.17 8.03	-5.0331	0.,0 *
2 KHz	94.85 *4*.23	95.08 7.56	-2.3238	0.0235 **
Contralateral Reflexes (dB SPL)				
500 Hz	99.93 6.54	107.53 2.26	-5;.112	0.0 •
1 KHz	94.33 5.65	100 2.47	-8.5822	0.0 •
2 KHz	98.04 5.81	104.08 5.1	-9.3167	0.0 *
4 KHz	91.38 6.74	105.77 5.39	-17'.181	0.0 *

Significant * Not Significant *•

thresholds at 2 KHz at 1 % level of significance. (Fig. 1, Fig. 2 and Fig.4)

But significant difference was found between the two instruments with respect to six parameters viz. Ipsilateral reflexes at 500 KHz and 1 KHz and all the contralateral acoustic reflex thresholds at 1% level of significance. (Fig. 4 and Fig.6) As in the case of males here also the gradient values and ipsilateral acoustic reflex thresholds at 4 KHz were not compared due to same reasons. The acoustic reflex thresholds were found to be significantly lower for both ipsilateral and contralateral stimuli when tested using the middle ear analyzer (GSI 33). The significantly lower contralateral acoustic reflex thresholds could most probably be due to the influence of an insert receiver rather than a contralateral earphone.

Significant difference found in the present study between the two immittance audiometers were in agreement with the comparative studies conducted by Burke and Herer, 1973 ; Ivarson, et.al., 1983 and Karisson and Hagermann, 1984. All these studies throw light on the importance of collecting normative data with respect to a particular instrument and thus checking its validity too.

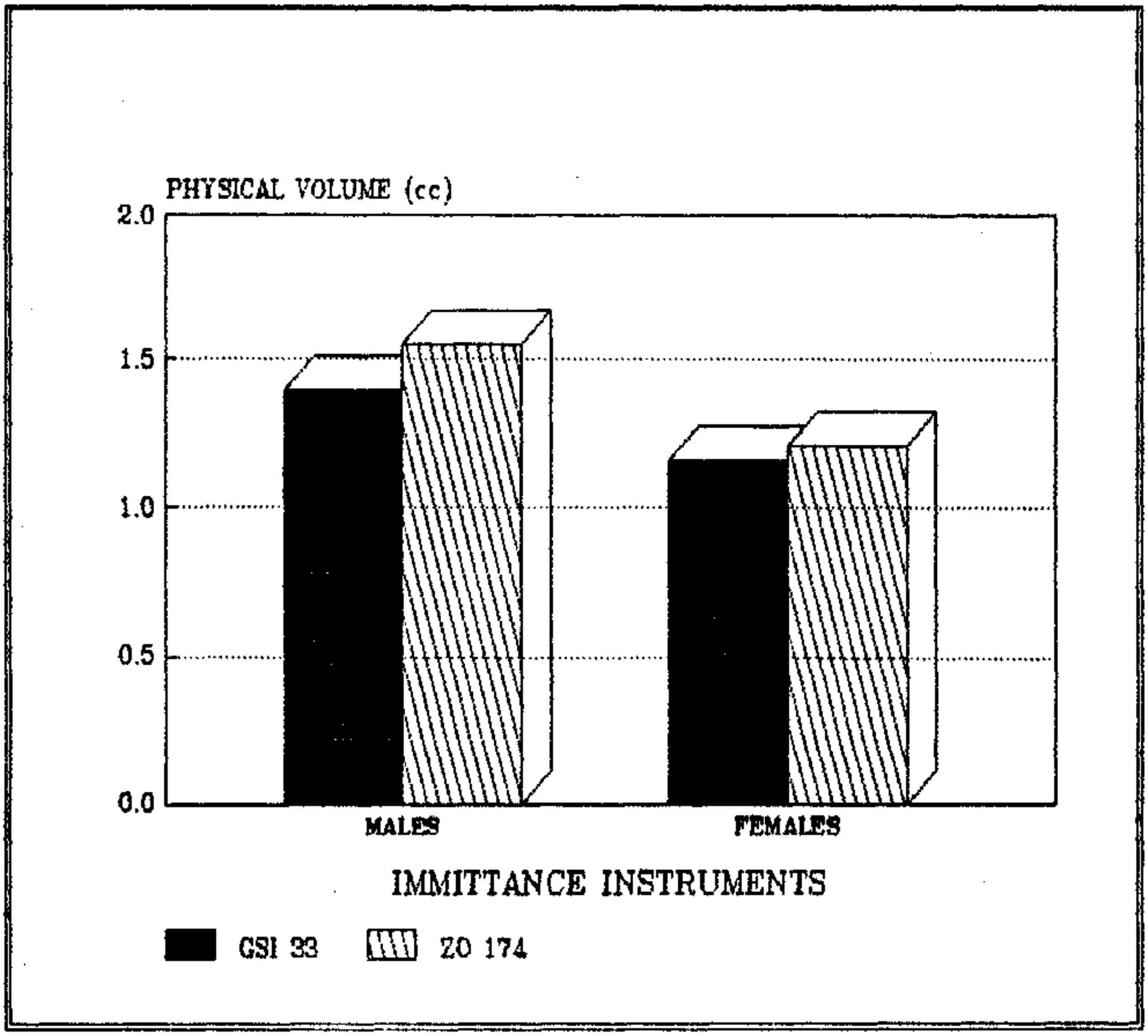

Fig.1: Graph showing mean Physical Volume of the two immittance instruments in males and females.

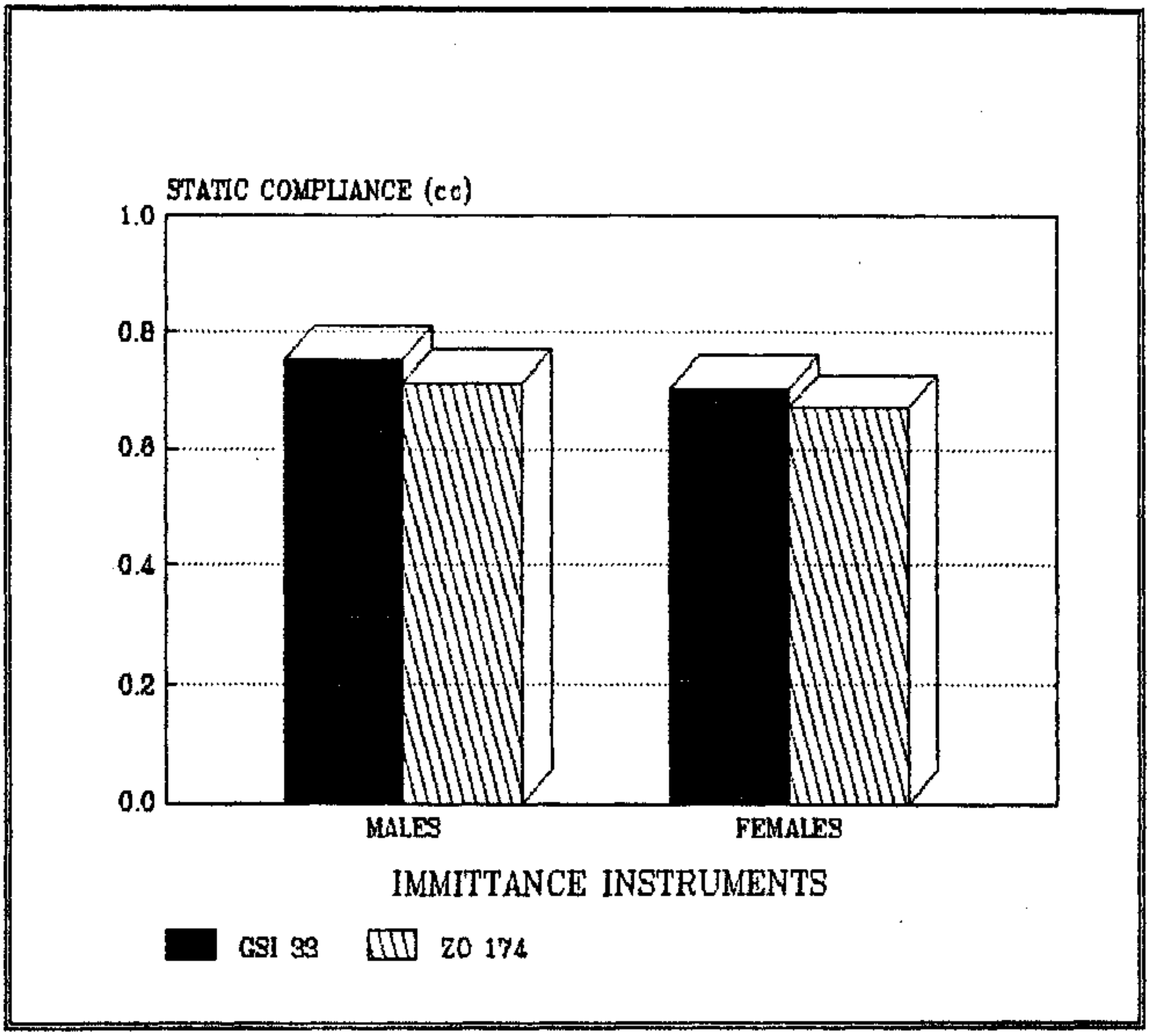

Fig.2 Graph Showing mean Static Compliance of the two Immittance instruments in males and females.

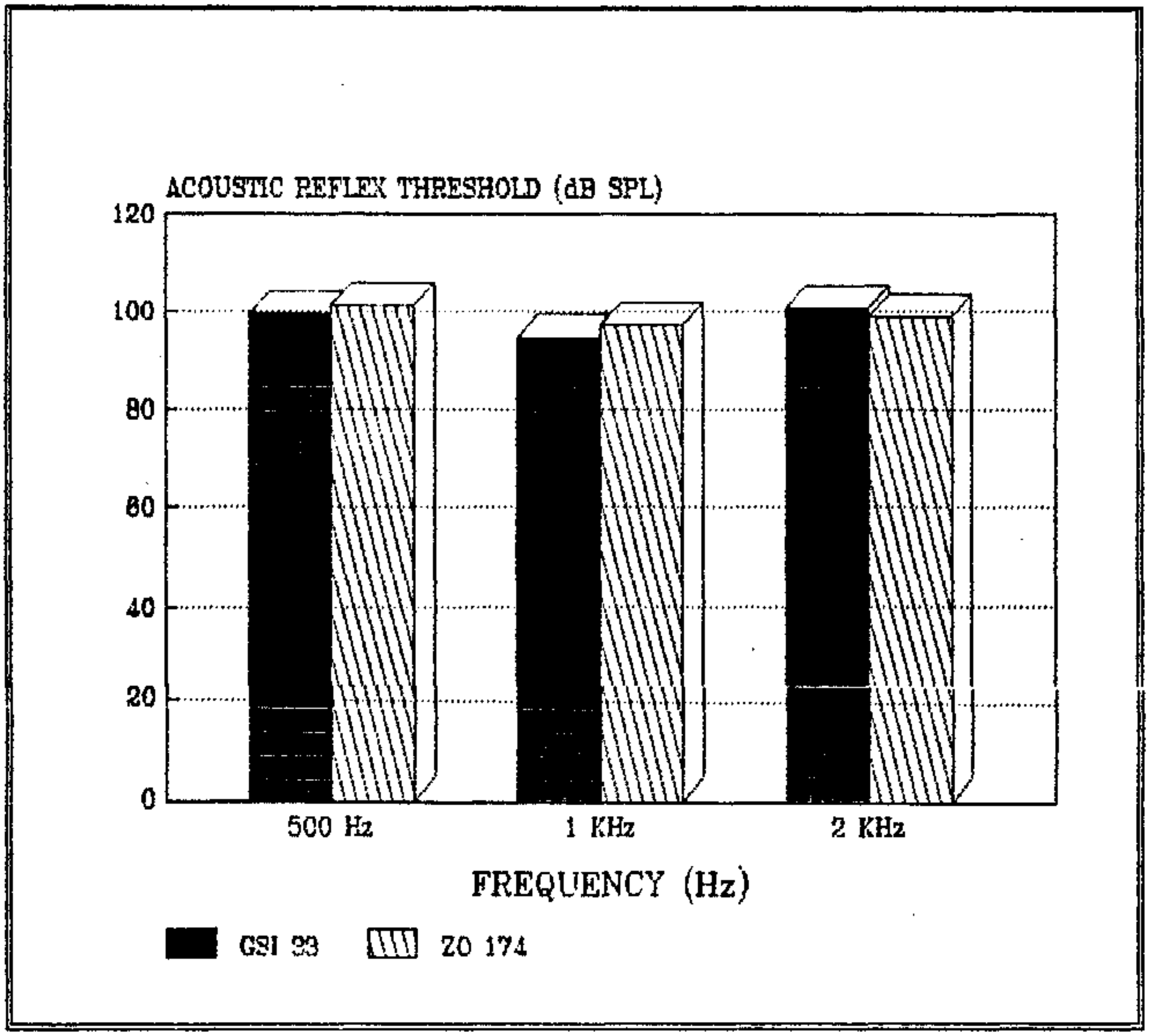

Fig.3: Graph showing mean Ipsilateral Acoustic reflex Thresholds of the two immittance instruments in males,

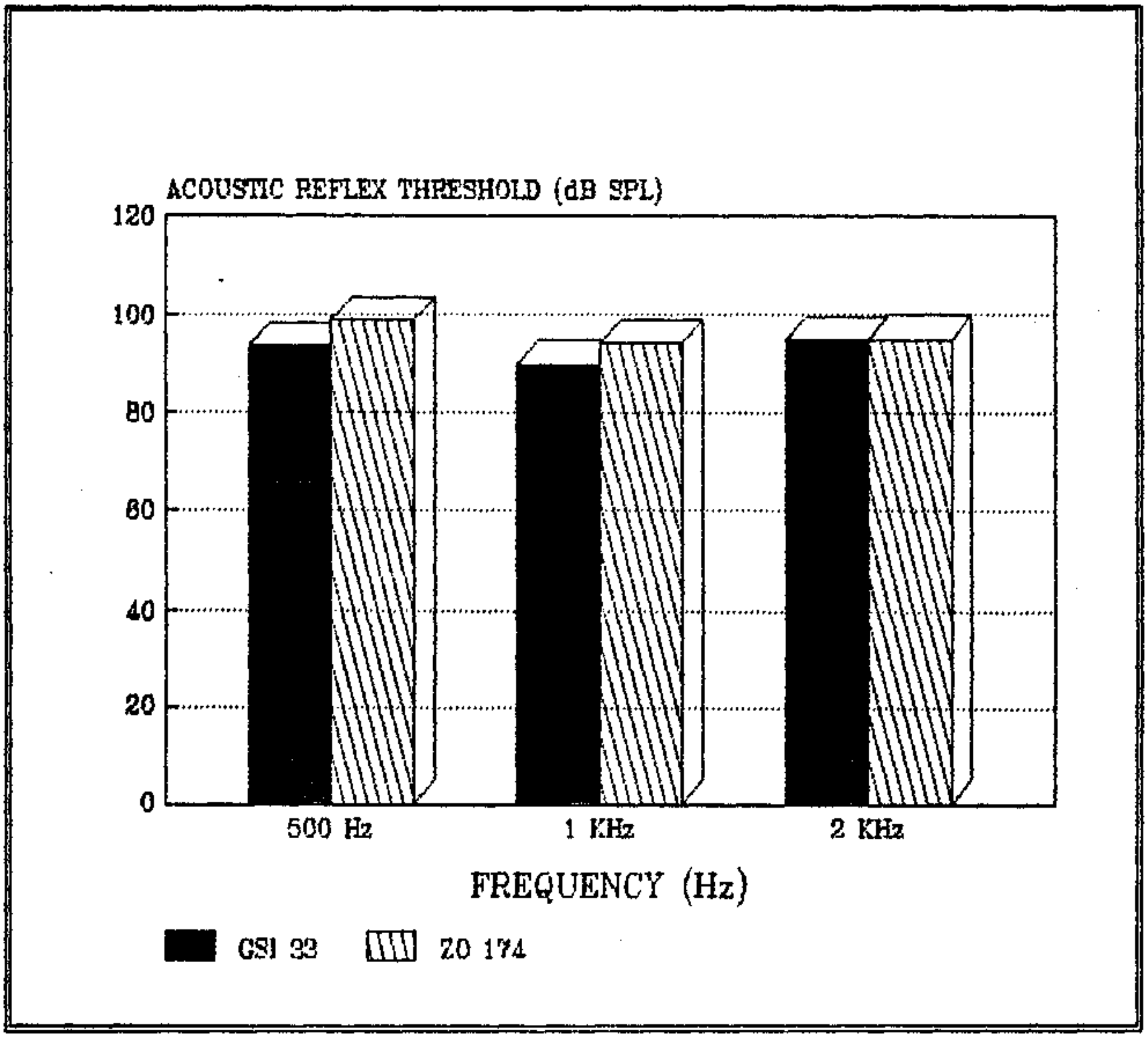

Fig.4:Graph showing mean Ipsilateral Acoustic Reflex Thresholds of the two immittance instruments in females.

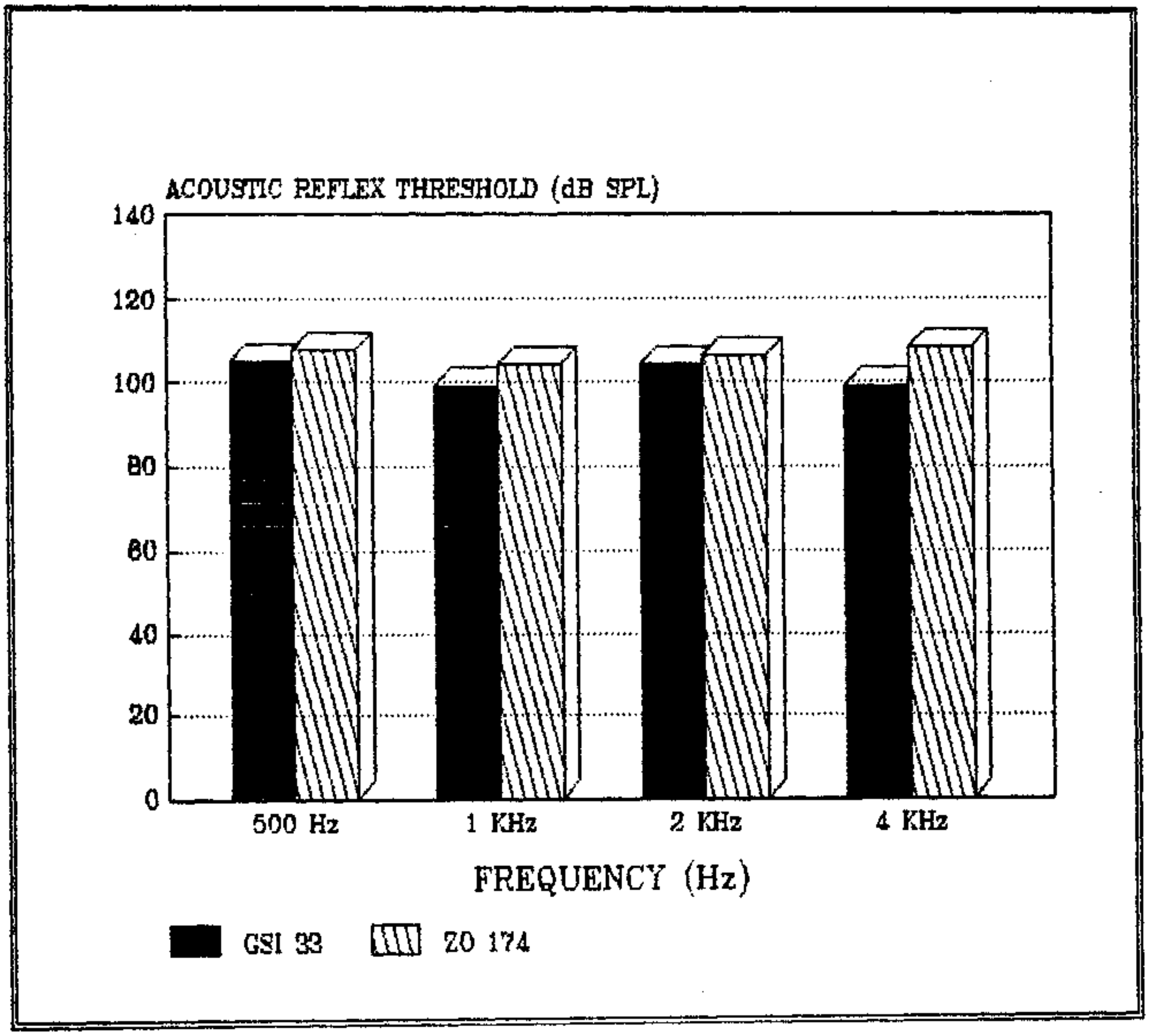

Fig.5: Graph showing mean Contralateral Acoustic Reflex Threshold of the two immittance instruments in males.

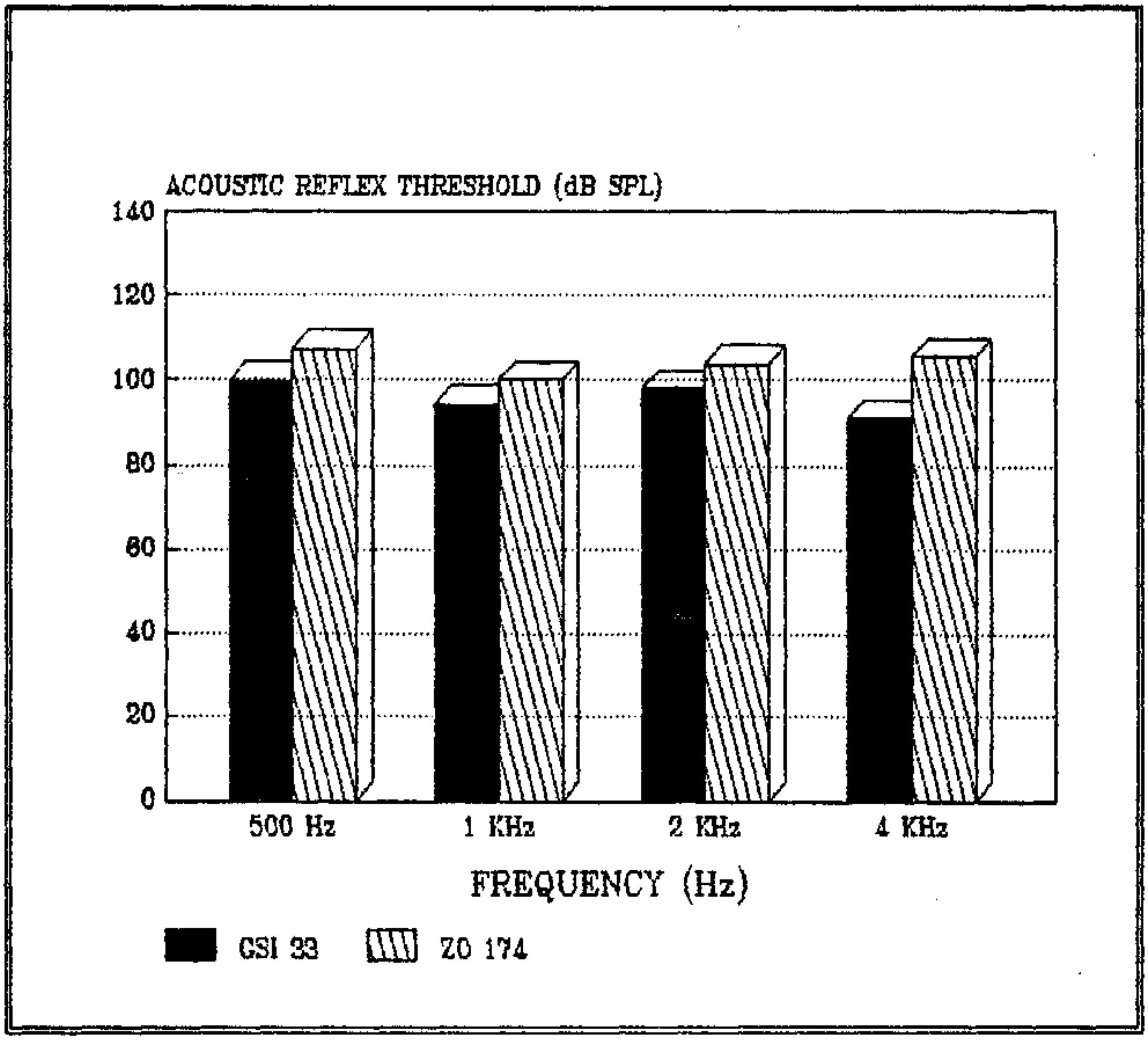

Fig.6: Graph showing mean Contralateral Acoustic Reflex Thresholds of the two immittance instruments in females.

The ipsilateral and contralateral acoustic reflex thresholds for both males and females for both the types of immittance audiometer were found to be lower at 1KHz except that contralateral acoustic reflex thresholds for females when middle ear analyzer (GST 33) was used were found to be lower at 4 KHz. Higher acoustic reflex thresholds were obtained at 500 Hz for both ipsilateral stimuli (immittance audiometer ZO 174) and contralateral stimuli (middle ear analyzer GSI 33) for both males and females. Higher acoustic reflex thresholds were obtained at 2 KHz for ipsilateral stimuli (middle ear analyzer GSI 33) for both males and females. Higher acoustic reflex thresholds for contralateral stimuli (immittance audiometer ZO 174) were obtained at 4 KHz in males and 500 Hz in females.

According to Jerger, et.al., (1972) absent reflexes at 4 KHz do not necessarily have pathological significance. Hence absent prelateral acoustic reflex thresholds at 4 KHz for both male and females when tested using the immittance audiometer (ZO 174) do not necessarily have pathological significance.

SUMMARY AND CONCLUSION.

The determination of acoustic immittance is am important aspect of the clinical audiologic test battery. Recent advances in computerized and digital technology made it possible for the manufacturers to come out with a wide variety of sophisticated instruments. With such wide varieties of immittance audiometers becoming commercially available it is incumbent on the part of an audiologist to check the validity of such instrument with the existing ones and to obtain normative data with respect to the population under concern.

The present study was designed to determine the following:

1) To provide normative data for the Middle Ear Analyzer (GSI 33) for impedance values in 18 to 25 year old males and females.

2) To check whether there is any significant difference between Middle Ear Analyzer (GSI 33) and Immittance Audiometer (ZO 174) with respect to impedance values in males and females.

This study was carried out in a sound-treated test and control room combinations where ambient noise levels met the ANSI(1977) criteria. A total of sixty subjects (30 males and 30 females) within the age range of 18 to 25 years who had normal hearing were taken for the study. Impedance values were obtained for all these subjects using both middle ear analyzer (GSI 33) and immitance audiometer (ZO 174) on 120 ears (60 right and 60 left) at a pressure rate of 200 daPa/second for a 226 Hz probe tone. The **parameters** considered were tympanogram type, peak pressure physical volume, static compliance, gradient, ipsilateral and contralateral acoustic reflex thresholds.

The results were subjected to statistical analysis using parametric statistical test-paired and unpaired 't' tests. The following conclusions were drawn based on the statistical analysis :

1) Normative data for impedance values obtained using the middle ear analyzer (GSI 33) for the age group 18 to 25 years for both males and females is given in Table 1.

2) Significant differences found between the middle ear analyzer (GSI 33) and immittance audiometer (ZO 174) were as follows.

a) Significant differences were found with respect to the following six parameter in males. They are physical volume, ipsilateral acoustic reflex thresholds at 1 KHz and all the contralateral acoustic reflex thresholds.

b) Significance differences were found with respect to the following six parameters in females. They are ipsilateral reflexes at 500 Hz and 1KHz and all the contralateral acoustic reflex thresholds.

3) The differences which were found to be not significant between the two instruments were as follows:

a) No significant differences were found with respect to the following five parameters in females. They are tympanogram type, peak pressure, static compliance, ipsilateral acoustic reflex thresholds at 500 Hz and at 2 KHz.

b) No significant difference were found with respect to the following five parameters in females. They are tympanogram type physical volume, peak pressure, static compliance and ipsilateral acoustic reflex thresholds and 2 KHz.

4) The acoustic reflex thresholds were found to be significantly lower for both ipsilateral and contralateral stimulation when obtained using the middle ear analyzer (GSI 33) except that at 2 KHz the ipsilateral acoustic reflex thresholds for the immittance audiometer (ZO 174) were found

to be significantly lower than the other one. Better contra1atera1 acoustic; reflex thresholds obtained using middle ear analyzer (GSI 33) could most probably be due to the influence of an insert receiver.

Since significant difference was found between the two immittance instruments in males with respect to the following parameters viz. physical volume, ipsilateral acoustic reflex thresholds at 1 KHz and all the contralateral acoustic reflex thresholds separate normative data were obtained for these parameters as shown in Table 1. No significant difference was found with respect to tympanogram type, peak pressure, static compliance and ipsilateral acoustic reflex thresholds at 500 Hz and 2 KHZ. Hence we can use a common normative data for these parameters.

Significant difference were found between the two immittance instruments in females with respect to the following parameters viz. Ipsilateral reflexes at 500 KHz and 1 KHz and all the contralateral acoustic reflex thresholds. Hence a separate normative data were obtained for these parameters as shown in table 3. No significant difference was found for the following parameters viz. tympanogram type, physical volume, peak pressure , static compliance and ipsilateral acoustic reflex thresholds at 2 KHZ. Hence we can use a common normative data for these parameters. These highlights the importance of checking instrumental variations and obtaining normative data according to that.

Implications of the study

(1) This study provides information regarding instrumental variations and the need to obtain normative data with respect to a particular equipment.

(2) It provides information regarding by what amount the contralateral acoustic reflex thresholds vary when it is presented through an insert receiver (in GSI33) than when it is presented through an ear phone (in Z0174).

(3) It also gives us a picture about the variation in terms of gradient. This is clinically important because the two instruments use different methods for calculating the gradient.

(4) It also provides information regarding impedance values between right and left ears and between males and females.

Recommendations for further study.

1) Normative data for impedance values using the Middle Ear Analyzer (GSI 33) has to be obtained across other age groups and using other probe tone frequencies.

BIBLIOGRAPHY

Basavaraj, V.C1973). Measurement of acoustic impedance in Indians. A dissertation submitted as a part fufilment for IT year M.Sc.,(Speech and Hearing) to the University of Mysore.

Bess, F.H., and Humes, L.E.U990). Audi logy: The fundamentals .Williams and Wilkins, Baltimore.

Birch, Elbrond, 0., **and. Kri**stiansen, L.(1986). Impedance audiometric study of children. Scandinavian Audiology, 15, 151-156.

Burke, K.S., and Herer, G.R.O973). Impedance and admittance bridge differences in middle ear study. Journal of Auditory Research.,13,251-256.

Feldman, A.S. (1967). Acoustic impedance studies of normal ear. Journal of Speech and Hearing Research. **10,2,165-176.**

Garrett, H.E., and Woodworth, R.S.(1966). Statistics in psychology and education. David Mckay Company, Inc. and Longman Group Ltd. 191-192,223,287,294 & 302

Instrumentation Manual (**1**984). *7.0* 174 immittance Audiometer II edition.

Instrumentation Manual (1989). Grason Stadler Version 2 Middle Ear Analyzer.

Ivarsson, A., TJernstrom, 0., Bylander, A., and Bennrup, S.(1983). High speed tympanometry and ipsilateral middle ear reflex measurements using a computerized impedance meter. Scandinavian **Audiology., 12,157-163.**

Jerger, J., Jergep, S., Mauldin. L and Houston (1972). Studies in impedance audiometry. Archives of Otolargngofogy.,96,6,513-523.

Karlsson, K., and Hagermann, B.O984). A clinical comparison between a laboratory and a commercial impedance audiometer.Scandinavian Audiology., 13,199-203.

Laukli, -E.", and Mair. I.W.S.(**1**980). Ipsi lateral and contralateral acoustic reflex thresholds Audiology.,19,6,469-479.

Margolis, R.H., and Popelka, G.R.(1975). Slatic and dynamic acoustic impedance measurements in infant ears. Journal of Speech and Hearing Research.,18,3,435-443.

Margolis, R.H., and Shanks, J.E.C1985). Tympanometry In Katz, J.(ed). Handbook of clinical audiology. Ed.3. Williams and Wilkins, Baltimore.

Martin, F.N.(19RB). Introduction to audiology. Prentice-Hall, Englewood Cliffs, NJ.

Moller, and Mirko.T. (1992). Daily impedance audiometric screening of children. Scandinavian Audiology, 21,1,9-14.

Northern, J.L., Gabbard, S.A., and Kinder, D.L.C1985). The acoustic reflex In Katz, J.(ed). Handbook of clinical audiology. Ed.3. Williams and Wilkins, Baltimore.

Poster, T.A.(1972). Normative otoadmittance values for three populations. Journal of Auditory Research., 12,1,53-58.

Shanks, J., **and** Shelton, C.(1991). Basic priciples and clinical applications of tymnpanometry in the oto1aryngo1ogic clinic of North America. Osguthorpe, J.D., and Melnick, W.(eds)., 24,2,299-328.

Silman, S. and Silverman, C.A.(1991). Acoustic immittance assessment. Auditory diagnosis principles and applications. Academic Press, Inc., San Diego., 29,71-132.

Susan, C.G.(1991). Selecting an impedance instrument for your choice. Hearing Instruments., 8, 16-17.

Wiley, T.L., Oviatt, D.L., **and** Block, M.G.(1987). Acoustic immittance measures in normal ears. Journal of Speech and Hearing Research., 30,2,161-170.

APPENDICES

APPENDIX A

The Madsen ZO 174 immitance audiometer is one of a series of instruments designed to measure middle ear function. It is a "computerized" instrument which uses microprocessors technology to provide a very versatile measurement system. Measurement are made quickly without patient discomfort. The ZO 174 is designed to measure the acoustic immittance of the ear in terms of sound flow, in contract to other ZO series. Madsen instruments which measure acoustic impedance. The basic principle of ZO 174 is that of measuring the amount of current required to maintain a specified sound pressure in a cavity. Thus ZO174 is designed to conduct manual, semi-automatic and automatic measurement of tympanometry, acoustic reflexes, expanded reflexes, averaged reflexes and reflex decay. The results can be viewed as they are obtained on the monitor. They can also be printed quickly or transmitted via the DATA XMIT option to another device such as computer. In ZO174 the contra latera1 stimuli will be presented through the earphone. In this instrument the gradient of the tympanogram is calculated by taking the average compliance at + and - 50 daPa divided by the total compliance at the peak pressure. Madsen ZO 174 immitance audiometer is calibrated according to the specifications given by the manual (ZO 174. I.A.II edn. Manual 1984).

APPENDIX B

The GSI 33 version 2 Middle Ear Analyzer is a high tech, microprocessor - based admit lance instrument designed to be used in a clinical or research setting. It contains total capabilities for complete, automatic or manual diagnostic testing for analysis of middle ear function. Admittance (Y), and its components susceptance (B) and conductance (G),may be measured with probe tone frequency of 226Hz, 678Hz, and 1KHz. The extensive battery of test mode choices include diagnostic tympanometry, acoustic reflex threshold and decay measurements, Eustachian tube function testing, screening tympanometry, acoustic reflex latency testing, acoustic reflex sensitization and multiple frequency tympanometry (250Hz to 2KHz). The operator has a choice of 3 mountings to support the probe box; the standard light weight shoulder mounting, standard clothes clip, as an optional operator wrist attachment. The probe box has two LED s to indicate test status and also a right and left switch to designate the ear to be tested. The GSI 33 calculates gradient as the average of the compliance points at an interval of + or - 50 daPa. In GSI 33 the contralateral stimuli is presented through an insert receiver. GSI 33 was calibrated according to the specifications given by ANSI S3.39-1987, ANSI S3.6-1969,(R1986), IEC 645-1979, IEC 126-1961, ISO 389 - 1975 and UL544 Listed Hospital and Dental Equipment. (GSI 33 version 2 MEA. Instruction Manual,1989). More in depth analysis of the acoustic reflexes, such as latency characteristics and the effects of high frequency sensitization, is possible with such sophisticated equipment. The need for manually written reports and bulky patient files even is being reduced. Test data may be stored in instrument memory and recalled for review prior to being transferred via an RS 232 interface to a PC.

APPENDIX C

Maximum Permissible Sound - Pressure Levels for Ambient Noise during Audiometric Testing (a)

Frequency (Hz)	Ears Uncovered		Ears Covered	
	Octave band	l\3-Octave band	Octave band	l\3-Octave band
125	28	23	34.5	29.5
250	18.5	13.5	23	18
500	14.5	9.5	21.5	16.5
750	12.5	7.5	22.5	17.5
1000	14	9	29.5	24.5
1500	10.5	5.5	29	24
2000	8.5	3.5	34.5	29.5
3000	8.5	3.5	39	34
4000	9	4	42	37
6000	14	9	41	36
8000	20.5	15.5	45	40

(a) Values for ears not covered apply to bone conduction and soundfield testing. Values for ears covered apply to air - conduction testing. Adapted from ANSI(1977). (Silman & Silverman, 1991).