Hearing Profile in Orchestral Performers

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ಸಮರ್ಪಣೆ


ನನ್ನ ಬಾಳಿನ ಮೂಲ ಶಿಲ್ಪಿಗಳಾಗಿ
ನನ್ನ ಏಳು ಬೀಳಿನಲ್ಲಿ ಸದಾ ನನ್ನ
ಜೊತೆಯಾಗಿದ್ದು ನನ್ನ ಈ ಸ್ಥಿತಿಗೆ ಕಾರಣಕರ್ತರಾಗಿರುವ
ನನ್ನ ದೇವರುಗಳಾದ ತಂದೆ ತಾಯಿಗಳಿಗೆ
ಈ ಕಿರುಕಾಣಿಕೆಯನ್ನು ಅರ್ಪಿಸುತ್ತಿದ್ದೇನೆ.

CERTIFICATE

This is to certify that this dissertation entitled **"Hearing Profile in Orchestral Performers"** is the bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student with Register Number M2K19.

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CERTIFICATE

This is to certify that this dissertation entitled **"Hearing Profile in Orchestral Performers"** has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other university for the award of any diploma or degree.

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DECLARATION

I hereby declare that this dissertation entitled **"Hearing Profile in Orchestral Performers"** is the result of my own study under the guidance of Ms. **Manjula P.,** Lecturer, Department of Audiology, AIISH, Mysore, and has not been submitted earlier at any University for any other diploma or degree.

Mysore

May, 2002

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ಒಬ್ಬರನ್ನೇ ಪ್ರೀತಿಸುವುದಾದರೆ, ಪರಮಾತ್ಮನನ್ನು
ಪ್ರೀತಿಸು, ಅನೇಕರನ್ನು ಪ್ರೀತಿಸುವುದಾದರೆ
ಸರ್ವ ಜೀವಿಗಳನ್ನು ಪ್ರೀತಿಸು

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INTRODUCTION

Industrial and recreational noises have been recognized as potential causes of noise induced hearing loss for quite some time. It is only recently that the sound levels within symphony orchestras have been implicated as a possible source of noise. It has been reported by Teie (1998) that not only there is dangerous levels of noise present within the symphony orchestras, but also there is an evidence of noise induced hearing loss among symphony orchestral performers.

Orchestras are a body of instrumental performances. Orchestras, rock bands, personal stereo system produce SPLs intense enough to cause permanent hearing loss. The problem of occupational hearing loss among classical singers and other musicians is less obvious but equally important. Various investigations have found an increased incidence of high frequency sensori-neural hearing loss among professional orchestral musicians as compared to the general public (Sataloff and Sataloff, 1993).

The revised 1964 American Medical Association "Guide for conservation of hearing in noise" says that when exposure to broad band noise is habitual, continuous, less than five hours a day and the average level of noise from 300 Hz to 2,400 Hz is 105 dB SPL more that 16 minutes of exposure a day can be expected to cause noise induced hearing loss.

Musicians (with amplifier system) must generate sufficient sound for an audience to hear at considerable distances, from the actual instrumentalists. Sound pressure at the site of music generation is intense (Axelsson and Lindgren, 1981; Westmore and Eversden, 1981). Mean intensity of 99 dB in the frequency range from 0.063 to 2 kHz within 3.66 meters of musicians has been found (Rintelmann and Borus, 1968). Speaks, Nelson and Ward (1970, cited in Sataloff and Sataloff, 1991) found noise levels from 90 dBA to 110 dBA in orchestral parties and most sessions were less than four hours. Sataloff and Sataloff (1993) have reported sound levels within orchestras to be between 83 and 112 dBA. Exposure to very high sound levels at which pop music is presented generally gives listeners the impression that music causes hearing loss not only in these performing music but also who are exposed to it.

Hearing loss may be accompanied by tinnitus or diplacusis that may also interfere with performance. Diplacusis poses many problems for musicians because it may make it difficult for them to tell whether they are playing or singing correct pitches.

Musicians depend on their hearing almost as much as they do on their voices/instruments. They depend on good hearing to match pitch, monitor vocal quality and provide feedback and direction for voice/instrument adjustments during performance. The importance of good hearing has been under appreciated, while well-trained singers are usually careful to protect their voices, they may subject their ears to unnecessary damage and thereby threaten their musical career. (Sataloff and Sataloff, 1993).

Musical performance may create sounds intense enough to cause sensori-neural hearing loss and this may interfere with musician's ability to perform the daily tasks of his or her profession. However, none of the musicians claim or would admit that they had any problem during performance (Sataloff and Sataloff, 1991). The ear is the critical part of the musicians "instruments". Hence, good hearing is of special vocational importance in musicians. It is important to be alert for hearing loss from all causes in performers, recognize it early and treat it or prevent its progression, whenever possible.

Performing artists have vocational hearing demands that are much greater than those required in most professions. They must be able to do more than simply understand conversational speech. They are required to accurately match frequencies above those required for speech comprehension.

Music tends to be more "intermittent" which is thought to reduce a musicians risk for hearing loss as compared with that of industrial noise exposure Such differences caution us against generalizing the results of industrial noise induced hearing loss to music induced hearing loss (MIHL).

Like noise induced hearing loss, the hearing loss due to music exposure is related to intensity of music, duration of exposure, total exposure time (month/year), personal liking for music, etc. There are number of studies that confirm the effect of industrial noise exposure on hearing. There are certain differences between the industrial noise exposure and exposure to music. There are only a few studies on the effect of exposure of music on hearing. There is a dearth in literature regarding the use of extended high frequency audiometry and otoacoustic emission as early identifiers of hearing loss in musicians. Also, the spectral distribution of Indian orchestral music may be different from that of western orchestral music causing a different pattern of music induced hearing loss. With the above speculations, this study was undertaken with the aim of investigating the effects of music on hearing measures, such as CFA, HFA and OAE in orchestral performers.

REVIEW OF LITERATURE

Musician's audiological assessment takes a different slant than that of a typical hearing assessment in that it is preventive and educational in nature, rather than just diagnostic. Hearing losses due to noise exposure and music exposure have many similarities and in many cases cannot be distinguished. The primary method to distinguish between the two causes in the case history.

Rosenberg (1978) overviewed two case history approaches a) Easy conversational approach and b) Authoritarian approach. Audiologists typically know very little about the life and work of musicians. Therefore, as easy conversational approach may be more useful to obtain as much knowledge of the potential noise and/or music sources to which musician is a subject. The authoritarian approach does seem to glean the required information in a very short time relative to earlier discussed method. Therefore it is used by most of the audiologists.

The audiological assessment begins with an extensive case history, so that all sources of noise and music exposure can be evaluated. The case[1] history would include details of music noise exposure.

The review is focused on three major issues in audiological assessment of musicians.

a) Conventional frequency audiometry (CFA)
b) High frequency audiometry (HFA)
c) Evaluation of Oto acoustic emission (OAE).

CONVENTIONAL FREQUENCY AUDIOMETRY (CFA)

Hearing loss was observed in musicians in the higher tones (Gryczenska and Czyzewski, 1977). Threshold levels compatible with noise induced hearing loss were found in 15.5% of symphony musicians and 3.9% of music students (Flach, 1972) and 33.8% or orchestral musicians (Westmore and Eversden, 1981). Ostri, Eller, Dalhin and Skylv (1989) audiologically examined 95 symphony orchestral musicians, aged 22 to 64 years, to elucidate the presence of noise induced hearing loss among classical musicians. It was found that 58% of musicians had hearing impairment. The audiograms of music performers have indicated a dip at 6 kHz (Karlsson, Lundquist, Olaussen, 1983) and sometimes between 3 kHz to 6 kHz (Axelsson and Lindgren, 1978)

Roddel and Lelso (1972) reported a sensori neural dip at 6 kHz in 43 pop musicians with a mean age of 22 years. Royster, Royster and Killion (1991) assessed noise induced hearing loss among musicians in the Chicago symphony orchestra. Initially using personal dosimeter, noise exposure measurements were done during rehearsals and concerts. The Leq ranged from 79 to 99 dB (A). The mean hearing threshold level for 59 musicians were better than those for an unscreened non - industrial noise exposed population (NINEP). However, 52.5% of individual musicians showed notched audiograms consistent with NJHL (Noise Induced Hearing Loss).

Woolford (1984) studied the SPLs in symphony orchestras and hearing level among 38 Australian orchestral musicians. Using appropriate equipment they found potentially damaging sound levels 18 of 38 musicians had hearing loss, 14 of those had threshold shift in the area of 4000 Hz and four had slight losses at low frequencies only.

Axelsson and Lindgrcn (1972) in their study determined hearing threshold in 83 pop musicians with an average age of 26 years. The factors that had a statistically significant influence on hearing were aging and had brief exposure per session. Results have shown that right ear was slightly better than left ear in low frequency region and that the left ear was conversely better than right ear in high frequencies.

When the younger half of the pop musicians (mean age 22.5 years) were compared with older half (mean age 30.5 years). It was found that hearing in younger musicians were better at every frequency particularly at 6 and 8 kHz. The data were divided into those having the longest exposure (13 years) and shortest exposure (5 years). The hearing was somewhat inferior in those who had played pop music longest. The difference was statistically significant only at 2 kHz. When the data were analysed with regard to weekly exposure time, it was found that the hearing was similar in those musicians playing a lot (average 28 hours a week) and in those playing a little (average 8.5 hours week). Marked difference was at 6 kHz where those performing a lot were inferior. Surprisingly, those musicians performing only a few hours per session (average 2.1 hours) had statistically worse hearing than those performing many hours per session (average 4.7 hours).

When the hearing in pop musicians was related to the instrument they played, there were only minor differences. Bass players had somewhat better hearing at 250, 500 and 6000 Hz than those playing drums and guitar, guitarists had some what better hearing at 2.4 kHz than drummers and bass players.

In a study by Axelsson, Eliasson and Israelsson (1975), hearing threshold levels of 83 Swedish and British pop/rock musicians were examined with pure tone audiometry and the results indicated that 13% of the musicians had hearing loss of >20 dB HL at high frequency pure tone average (4,6 and 8 kHz).

HIGH FREQUENCY AUDIOMETRY (UFA)

High frequency audiometry refers to hearing testing of frequencies above 8000 Hz. It is a procedure, which can be used with air conduction or bone conduction, usually by air conduction, to test frequencies from 8,000 Hz to 20,000 Hz. Weigel (1932) first reported that the total frequency response of the human ear to be approximately upto 16,000 Hz to 24,000 Hz. Audiological assessment in high frequency range between 8,000 - 18,0000 Hz is very useful to judge internal ear damage by noxious agents such as noise or ototoxic drugs (Dieroff, 1982).

Hallmo, Borchgrevink and Mair (1995) measured the air conduction and bone conduction threshold in the conventional audiometric frequency ranges and air conduction alone in the extended high frequency range of 9 - 18 kHz in 167 males with history of occupational noise exposure. Results indicated that elevation of AC threshold in NIHL occurred both at 3-6 kHz and throughout the extended high frequency ranges from 9 to18 kHz. Fletcher (1973) also reported a sensory neural hearing loss at very high frequencies > 8 kHz in young pop musicians.

Johnson, Sherman, Aldridge, Lorraine (1985) evaluated 60 (42 males and 18 females) musicians aged 24 to 64, all symptomatic for hearing problems or ear diseases, were evaluated with a hearing history questionnaire, ENT examination and pure tone audiometry for the conventional (0.25 to 8 kHz) and extended high frequency (9 to 20 kHz) ranges. Results showed no significant correlation between hearing loss and type of instrument played and position on the orchestral stage.

Jerger and Jerger (1970) found that eight of the ten rock musicians who had their hearing measured prior to and one hour after performance had temporary threshold shift. Speaks, Nelson and Ward (1970) measured the hearing of 25 rock musicians at 20 minutes prior to and again at 40 minutes after a performance and found only 7-8 dB of TTS (Temporary Threshold Shift) in the higher frequencies.

OTO ACOUSTIC EMISSION (OAEs)

Oto acoustic emissions are defined as "sounds generated within cochlea, by the outer hair cells (OHC), which can be detected at/near the tympanic membrane" (Norton and Stover, 1994). Most people with normal hearing have emission emnating from the outer hair cells of the inner ear. These OAEs can be measured in the outer ear canal and have been used as indicators of hearing function. (Lonsbury-Martin, Harris, Hawkins, Stagner and Martin, 1990).

There are two basic OAE phenomena (Norton and Stover 1994) - Spontaneous OAE (SOAE), Evoked OAE (EOAE). Spontaneous Oto Acoustic Emission (SOAE) occurs in the absence of external stimulation, whereas, evoked OAEs occur during or after an external stimulation. Further, evoked OAEs include, Transient Evoked OAE (TEOAE), Distortion Product OAE (DPOAE) and Stimulus Frequency OAE (SFOAE).

Hall (2000) has reported that SOAEs are prevalent in 60% of normal ears and the TEOAEs and DPOAEs in 99+% normal ears. TEOAEs, are evoked by clicks or tone bursts. Distortion product Oto acoustic emissions are recorded using two pure lone and they have good clinical value.

OAE evaluation is objective in nature and does not require patient's co-operation for it to be administered. Thus it may be conveniently used for assessing hearing in musicians.

The origin of the Oto acoustie emission is believed to be the hair cells specifically the outer hair cells (OHC), (Davis, 1983; Zwicker,, 1983). Many pathologies causing hearing loss such as noise induced hearing loss, ototoxicity are known to selectively damage the outer hair cells (OHC). Hence, in these cases a measure of DPOAE may indicate the severity of the OHC (Probst and Harris, 1993)

Distortion product Oto acoustic emission (DPOAE)

They are emitted in response to two simultaneously presented puretones, these characteristically are found to occur at specific frequencies, which are related to the two stimulus frequencies. These are found to occur in all ears with hearing acuity levels within 25-30 dBHL (ANSI, 1969, Wilber, 1994). It gives highly precise frequency specific information. DPOAE as a clinical tool provided several advantages, hitherto not provided using other contemporary tools for the purpose (Martin, Ohlms, Franklin, Harris, Lonsbury and Martin, 1990). This has opened up the possibilities of using Oto acoustic emissions to measure the place and extent of damage of outer hair cells on the basilar membrane such as in patients exposed to noise or other causes like ototoxicity.

Noise exposure is believed to influence cochlear functions especially in high frequency thus altering the amplitude on frequency composition of oto acoustic emissions. Many musicians with normal audiogram exhibit results on Oto acoustic emission tests that suggest noise - induced damage to hair cell in the cochela (Hall and Santucci, 1995).

DPOAE has been found to correspond well with behavioral audiometric threshold (Harris, 1990; Probst and Harris, 1993). However, the efficiency of DPOAE in differentiating between normal hearing and hearing loss is high at frequencies above 1000 Hz. (Gorga, Neely, Bergman, Beauchaine, Kaminski, Peters, Schulte and Jesteadt, 1993).

Oto acoustic emission testing can be thought of as a very early warning indicator, If our clinical function is to warn our patients of any impending damage, Oto Acoustic Emission testing should be a part of the audiometric test battery. Oto acoustic emission testing is one alternative assessment procedure that may indicate pathology before it is observed in conventional pure tone audiogram (Attias, Furst, Furman, Reshef, Horowitz and Bresloff, 1995).

Abnormal results in Oto Acoustic Emission test may show up prior to an audiometric loss using conventional frequencies. If the goal is to educate the musicians about the potential for future hearing loss. Such a testing protocol is practical. (Attias et. al., 1995; Hall and Santucci 1995)

Parameters to be considered in recording DPOAE:

Frequency:

This determines the range of frequencies being tested. This was set to 250 Hz to 8000 Hz respectively. Since this range would encompass the frequencies tested in routine audiological evaluation.

F_2/F_1Ratio:

The ration of stimulus frequencies (primaries) at which the distortion product occurs has been determined by various studies. The maximum distortion in produced al F_2/F_1 ratio being 1.22. Hence F_2/F_1 ratio of 1.20 was set.

L_1 & L_2 Levels:

This refers to the intensities of the stimulus frequencies, It has been clearly established that very high level of stimulus gives a 'non - vocal response' i.e., the distortion product does not respond to a specific area in the basilar membrane

(Avans, 1993). Keeping this in mind stimulation levels of 65dB SPL & 55 dBSPL were used in the present study.

DP - Frequency:

It refers to the frequency of emission. The emissions were recorded at $2F_1 - F_2$

Number of sweeps:

The number of stimulus used to record the DP gram were 112 and if emissions were not seen at this, the member of sweeps were increased from 150 - 108 to confirm the results.

S/N VALUE:

After recording, DPOAE (Disotortion Product Oto Acoustic Emission) and the level of noise floor (S/N value) was noted at 86% replicability.

METHOD

The present study aimed at evaluating the hearing profile of orchestral performers, including evaluation of high frequency audiometry and distortion product oto acoustic emission, in orchestral performers. In order to investigate this, the following method was used.

The study was carried out in two phases:

Phase I: Measurement of sound levels of music during orchestral performance

Phase II: Audiological evaluation of orchestral performers

PHASE I:

For this purpose, a calibrated digital SLM (B & K Type 2231) with half inch free field microphone (B & K Type 4165) with extension cable, (B & K Type AO 0027) and tripod stand (B & K Type UA 0587) were used. The position of microphone was in front of the instrument and singers on the stage at a distance of 3 feet from the singers. The placement of measurement microphone was as shown in the Figure 1.

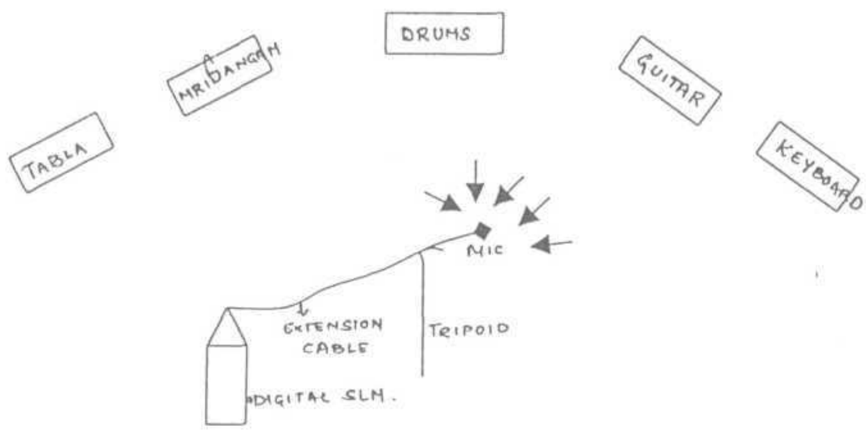

Figure 1: Illustration of location of musical instruments, singers and measuring equipment.

The measurement was carried out and levels tabulated with following scales:

1. 'A' weighting network and slow scale
2. 'C' weighing network and slow scale
3. At octaves and mid octaves

The same measurement procedure was performed during two different orchestral performances and the values averaged.

PHASE II:

Audiological Evaluation:

SUBJECTS:

Two groups of subjects were taken for the study.

Group I: EXPERIMENTAL GROUP

Group II: CONTROL GROUP

Group I: EXPERIMENTAL GROUP

A group of 25 orchestral musicians served as the subjects for the present study each of their ears, totalling 50 ears, was subjected to audiological evaluation

Selection Criteria:

a) Age ranging from 18 to 40 years.
b) History of at least 2 years of exposure and 2 hours of practice (solo or group) per day.
c) Normal middle car functioning confirmed through immittance evaluation.
d) No history of other conditions such as ototoxicity, neurological disorders.
e) The subjects were not exposed to music for at least 16, hours prior to testing.

GROUP II: **<u>CONTROL GROUP:</u>**

A group of 25 subjects in the age ranging from 18 to 40 years served as control group. There was no significant history of noise exposure and ototoxicity, normal middle ear functioning and hearing thresholds in the conventional frequency audiometry was < 20 dBHL.

TEST ENVIRONMENT:

The tests were carried out in an air-conditioned, sound treated room with the ambient noise levels within permissible limits. (ANSI, 1991, cited in Wilber, 1994)

The conventional and high frequency audiometry were carried out in an air conditioned sound treated double room situation, where as, case history, immittance evaluation and distortion product oto acoustic emission (DPOAE) measurements were carried out in a single room situation.

EQUIPMENT/ MATERIALS:

1. Otoscope
2. A calibrated immittance meter (GSI-33 version-2)
3. A calibrated diagnostic audiometer with facility for conventional frequency audiometry and high frequency audiometry model GSI-61
4. 1LO-OAE 292 (version 5)

TEST PROCEDURE:

The tcsling was carried out in the following steps.

A. Case history

B. Otoscopic examination

C. Immittance evaluation

D. Conventional audiometry

E. High frequency audiometry

F. Recording of DPOAE (Distortion Product Oto Acoustic Emission)

A. *Case history:*

A detailed case history (Appendix I) was taken to collect information about demographic data, and to rule out any significant history of exposure to loud music or other noise in the control group. Detailed noise/music exposure information was included for the experimental group, such as, types of instrument used, any change in the instrument, hours of exposure, were collected.

B. *Otoscopic examination:*

An otoscope was used in order to rule out any contra indication for carrying out the audiological evaluation.

C. *Immittance evaluation:*

A calibrated Grason Stadler Incorporation Model 33, GSI 33, (version-2) middle ear analyzer was used to rule out middle ear pathology. Tympanometry, acoustic reflex thresholds and reflex decay test were administered to confirm normal middle ear functioning.

D. ***Conventional audiometry and high frequency audiometry:***

A calibrated diagnoistic audiometer Grason Stadler Incorporation, Model - 61 (GS1 - 61) connected to TDH-50 P headphones encased in MX 41/AR ear cushions, B-71 bone vibrator was used for conventional frequency audiometry. The same audiometer connected to HDA 250 Sennheiser headphones for high frequency audiometry was used. The subject was seated comfortably in the patient room. He was instructed to raise the forefinger whenever, a tone, even when softest signals, was heard. Then using modified Hughson - Westlake method (1959, cited in Silman and Silverman, 1991) the thresholds were obtained for the audiometric frequencies from 250 Hz to 8000 Hz. The bone conduction thresholds were found out for audiometric frequencies from 250 Hz to 4000 Hz.

In order to ensure the subject met the specified selection criteria the above method was used. The hearing threshold levels of the subjects at the frequencies 10,000 Hz, 12,500 Hz, 14,000 Hz, 16,000 Hz, and 18,000 Hz and 20,000 Hz were also found out using the above procedure.

The conventional frequency audiometry and high frequency audiometry threshold of each subject was tabulated for statistical analysis.

E. ***Recording of distortion product oto acoustic emission:***

A calibrated ILO- 292 Otodynamics DP echoport plus (version 5) was used for recording of DP gram. For this, the subject was made to sit comfortably and relax and to minimise the extraneous movements. During testing, after using an appropriate probe tip, the probe was inserted gently in to the car canal.

From the menu, the DP gram option was selected and the test protocol was chosen. The click stimulus, check fit routine was carried out to ensure that the fit of the probe was achieved. Followed by this, the instrument automatically adjusted to the DP tones to the pre set levels. After performing these preliminaries, the actual test (DP gram) was carried out using the protocol given in Table 1

PARAMETER	**PROTOCOL**
Display type	DP gram
Frequency	250 Hz to 4000 Hz
F_2/F_1 ratio	1.20
L_1 & L_2 levels	65dBSPL&55 dBSPL .
Points per octave	3 points octave
DP - frequency	$2F_1 - F_2$
No. Of sweeps	112

Table 1: Showing the protocol for Dp gram

Data on threshold of CFA, HFA and S/N value of DPOAE were tabulated and statistically analysed.

RESULTS AND DISCUSSION

The present study was undertaken with the aim of evaluating the hearing profile of orchestral performers. The Study was done in two stages - Stage I and Stage II.

Stage I Measurement of sound levels in orchestral performance.

Stage II Audio logical evaluation of orchestral performers

Stage I: RESULTS OF SOUND LEVELS MEASUREMENT OF ORCHESTRAL SITUATION

Average values of the two measurements are as follows

'A' weighting network slow scale = 93.1dB

'C weighting network slow scale = 102.45 dB

Table 2 shows the sound levels in octaves and midoctaves.

Table 2: Sound levels in octaves and mid-octaves

Frequency (Hz)	dBspl	Frequency (Hz)	dBSPL
20	47.1	630	81.63
25	55.3	800	85.25
31.5	61.7	Ik	86.3
40	49.75	1.2k	88.35
50	54.6	1.8k	83.6
63	61.75	2k	79.9
80	61.7	2.8k	76.6
100	66.08	3.15k	75.9
125	71.95	4K	72.45
100	72.65	5K	74.95
200	77.67	6.3k	70.95
250	77.6	8k	69.5
315	79.45	10k	68.05
400	81.85	12.5 k	65.65
500	81.95	16k	63.1
		20 k	61

Stage 11: The data obtained from conventional frequency audiometry (CFA), High frequency audiometry (HFA) and oto acoustic emission (OAEs) were tabulated and analyzed using SPSS software (Statistical Program software system Inc., New York, Version 10)

The data were analyzed under the following headings.

1. Average thresholds in CFA and HFA in experimental group and control group.
2. Average DPOAEs in experimental group and control group.
3. Comparison of CFA and HFA and DPOAEs in experimental and control group.
4. Comparison of DPOAEs in experimental group and control group.
5. Percent failures in CFA, HFA and DPOAE

1. Average thresholds at each frequency for conventional frequency audiometry and high frequency audiometry

The thresholds obtained for the subjects in control group and experimental group were averaged at audiometric frequencies. The average thresholds levels obtained at each audiometric frequency for control group and experimental group from 250 to 20,000 Hz are shown in Table 3

Table3: Average threshold for audiometric frequencies from 250 to 20,000 Hz in right and left ear for control group and experimental group.

Frequency (11/)		250	500	1000	2000	4000	8000	10k	12.5k	14k	16k	18k	20k
Control Group (N=25)	R	1.20	.20	1.00	-2.00	-1.20	.40	.20	.40	.80	-.20	1.20	1.00
	L	80	3.6	-.20	2.20	.80	1.00	2.20	2.20	.60	-.20	.60	.20
Experimental Group(N =25)	R	8.4	11.4	12	13.4	15	29.2	44.6	44.6	58.8	43.8	41.4	16
	L	16.5	10.4	11.4	12.4	12.4	29	39.8	29.8	51.8	40.6	38.8	14.4

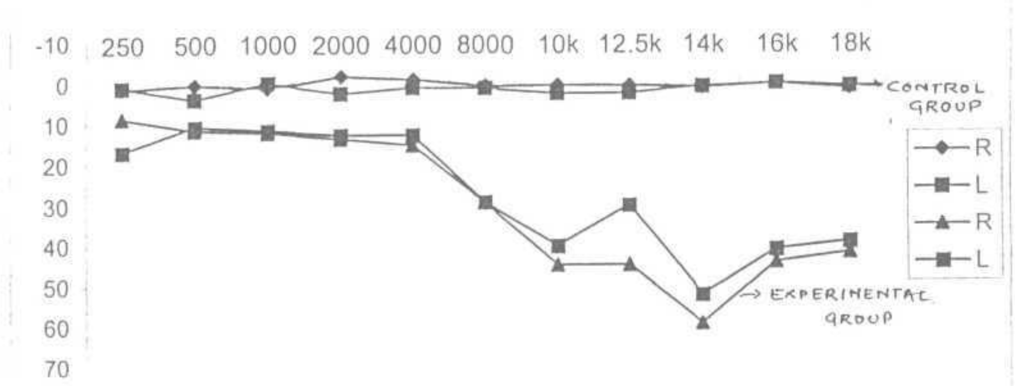

Figure 2: Average thresholds from 250 to 20000Hz in experimental group and control group

Further, t- test revealed that there was no significant difference between the right and left ears in the control group and in the experimental group. Hence, the right and left ears data were combined to form 50 ears in the control group and 50 ears in the experimental group. Figure 2 depicts the hearing thresholds, from 250 to 20000 Hz, in the control group and experimental group

2. Average levels of DPOAE at each frequency:

DPOAE levels at different frequencies obtained for the subjects in the control group and experimental group were averaged. The average DPOAE levels at each of the different frequency for control group and experimental group are shown in Table 4.

Table 4: Average DPOAE levels at different frequencies from 0.452 to 4.053 kHz in right and left ear for control group and experimental group.

Frequencies KHz		0.452	0.537	0.635	0.818	1.025	1.270	1.611	2.026	2.503	3.250	4.053
Control Group	R	24.91	23.81	22.66	27.45	17.86	25.03	24.488	23.47	25.92	27.56	21.78
N=25	L	16.58	20.28	22.84	25.018	26.20	25.47	25.61	25.49	24.36	26.01	24.62
Experimental	R	11.26	10.956	11.052	10.004	9.58	9.584	9.88	9.176	9.98	9.72	9.60
Group N=25	L	9.34	9.65	9.83	8.57	9.88	10.03	9.76	9.77	9.73	10.25	0.43

Further, t- test revealed that there was no significant difference between the right and left ears in the control group and in the experimental group. Hence, the right and left ears data were combined to form 50 ears in the control group and 50 cars in the experimental group.

3. Comparision of CFA, HFA and DPOAE in experimental and control group

The data obtained from conventional frequency audiometry and high frequency audiometry were statistically analyzed for the significant difference in the control group and experimental group and the analyzed scores are show in Table 5.

Table 5: Mean standard deviation and 't' value, of'CFA and HFA experimental group and control group (N = 50)

Frequency	Group	N	Mean	S. D	t Value
250 Hz	Control	50	1.60	4.89	6.291**
	Experimental	50	7.80	4.96	
500 Hz	Control	50	1.90	5.96	7.84**
	Experimental	50	10.70	5.15	
1000 Hz	Control	50	.40	5.70	8.557**
	Experimental	50	11.70	7.39	
2000 Hz	Control	50	.10	6.96	8.979**
	Experimental	50	12.90	7.29	
4000 Hz	Control	50	-.20	5.14	10.594**
	Experimental	50	13.30	7.39	
8000 Hz	Control	50	.70	7.49	14.321**
	Experimental	50	29.10	11.85	
10000 Hz	Control	50	1.20	9.34	16.775**
	Experimental	50	42.20	14.53	
12500 Hz	Control	50	-.70	10.83	4.792**
	Experimental	50	67.0	99.89	
14000 Hz	Control	50	.10	7.85	22.554**
	Experimental	50	55.80	15.59	
16000 Hz	Control	50	*-120*	13.73	15.885**
	Experimental	50	42.20	12.94	
18000 Hz	Control	50	-90	10.28	21.695**
	Experimental	50	41.70	8.42	
20000 Hz	Control	50	.60	7.53	11.754**
	Experimental	50	15.20	4.51	

** = Significant at 0.01 level

From Table 5, it is evident that thresholds of subjects exposed to music differed significantly at 0.01 level from those who were not exposed to music, in both conventional frequency audiometry and high frequency audiometry. In conventional frequency audiometry the hearing loss was more evident at 8000 Hz followed by 4000 Hz, 2000 Hz, 1000 Hz, 500 Hz and 250 Hz. If 3000 Hz and 6000 Hz were included during the CFA, results might have supported those in the literature (i.e, more hearing loss at 6kHz).

In the high frequency audiometry, the hearing loss was more in 12,500 Hz followed by 18,000 Hz, 14,000 Hz, 16,000 Hz, 10,000 Hz and 20,000 Hz

The above results support that of Ostri, Eller, Dalhin and Skylv (1988) who said that noise induced hearing loss is evident among classical musicians; Woolford (1984) who has said that threshold shift was noticed in the area of 4000 Hz; Axelsson, Eliasson and Israelsson (1975) who indicated that musicians had hearing loss of > 20 dBHL at high frequency pure tone average (4, 6 and 8 kHz); also Hallmo, Borchgrevink and Mair (1995) who have shown hearing loss in extended high frequency range of 9-18 kHz and Fletcher (1973) has reported sensori neural hearing loss at very high frequencies > 8 kHz.

4. Comparision of distortion product oto acoustic emssion (DPOAEs). in control group and experimental group:

The data obtained for DPOAEs were statistically analyzed for significant difference in the control group and experimental group and the analyzed scores are shown in Table 6

Table 6: Mean standard deviation and 't' value, of DPOAE of experimental group and control group (N = 50)

Frequency (kHz)	Group	N	**Mean**	SD	**t-value**
0.452	Control	50	20.58	6.17	-10.65**
	Experimental	50	10.32	2.87	
0.587	Control	50	21.77	5.00	-4.714**
	Experimental	50	12.17	13.49	
0.635	Control	50	22.57	4.71	-15.87**
	Experimental	50	10.44	2.64 '	
0.818	Control	50	26.05	5.91	-18.85**
	Experimental	50	9.28	2.17	
1.026	Control	50	21.93	5.61	-14.65**
	Experimental	50	9.73	2.47	
1.270	Control	50	25.15	5.82	-16.53**
	Experimental	50	9.80	3.03	
1.611.	Control	50	25.05	6.02	-16.64**
	Experimental	50	9.57	2.63	
2.026	Control	50	24.48	5.93	-16.68**
	Experimental	50	9.47	2.28 '	
2.563	Control	50	28.94	26.57	-5.85**
	Experimental	50	9.85	28.37	
3.250	Control	50	27.03	6.38	-17.49**
	Experimental	50	9.98	2.58	
4.053	Control	50	23.20	5.46	-15.74**
	Experimental	50	9.51	2.80	

** = Significant at 0.01 level

From Table 6, it can be inferred that there was reduction in the DPOAE amplitude in the subjects who were exposed to loud music and the reduction of amplitude was more in 2.026, followed by 4.053, 1.611, 1.025, 1.270, 2.563 and 3.250 kHz (excluding the lower frequency DPOAE as they could be contaminated by noise)

5. *Percent of failures in CFA, HFA and DPOAE:*

The norms (cut-off for pass vs fail) for high frequency audiometry was considered as 20 dBHL and that for DPOAE 18.27 dB (i.e., Mean - 2SD = 18.27) using these norms, subjects who exceeded 20 dB in high frequency audiometry and/or whose DPOAE was below 18.27, were considered to be failed. The number of subjects failed with respect to conventional frequency audiometry, high frequency audiometry and Distortion Product Oto Acoustic Emissions are shown in Table 7

Table 7: Percent failures in CFA, HFA and DPOAE

CFA		**UFA**		**DPOAE**	
Frequency (Hz)	Fail (%)*	Frequency (Hz)	Fail (%)*	Frequency kHz	Fail (%)*
250	0(0)	10000	45(90)	0.452	50(100)
500	1(2)	12500	49(98)	0.587	50(100)
1000	5(10)	14000	50(100)	0.635	50(100)
2000	4(8)	16000	49(98)	0.818	50(100)
4000	5(10)	18000	50(100)	1.025	50(100)
8000	30(60)	20000	10(20)	1.270	49(98)
				1.611	50(100)
				2.026	50(100)
				2.563	50(100)
				3.250	50(100)
				4.053	49(98)

* = Numbers with in brackets indicate percentage (%) failures

From Table 6 it is evident that more failures were in DPOAE followed by HFA and CFA. i.e., the hearing loss is first evident in DPOAE followed by HFA and CFA. The above results supports that of Gorga et. al., (1993) study who has reported the efficiency of DPOAE in differentiating hearing loss is high at above 1000 Hz.

SUMMARY AND CONCLUSION

Hearing is one of the most important senses. There are various causes, which can lead to hearing loss. One of them is loud noise/music. People who are exposed to loud music, such as orchestras, acquire hearing loss. A reported by Teie (1998) says that not only there is a dangerous level of noise present within orchestra, but there is an evidence of noise induced hearing loss among orchestral performers.

Hence the present study sought to investigate the hearing in orchestral performers. 25 subjects with normal hearing with no history of noise exposure (control group) and 25 subjects who were exposed to orchestral music (experimental group) served as subjects for the present study.

The subjects were evaluated using the Conventional Frequency Audiometry, High Frequency Audiometry and Distortion Product Oto Acoustic Emissions. The results of the present study indicated that the incidence of hearing loss was more in experimental group exposed to orchestoral music compared to that of control group, in the CFA and HFA. The hearing loss was more evident at 8000 Hz followed by 4000 Hz, 2000 Hz, 1000 Hz, 500 Hz and 250Hz in CFA and hearing loss was more in 12,500 Hz followed by 18000 Hz, 14000 Hz, 16000 Hz, 10000 Hz and 20000 Hz in HFA. In DPOAE, reduction in the amplitude was more in 2.026, 4.053, 1.611, 1.025, 1.270, 2.563 and 3.250 kHz (excluding lower frequency DPOAE as they could be contaminated by noise), and it is also evident that more failures were in DPOAE followed by HFA and CFA.

The implications of the present study were:

1. Establishment of hearing profile of orchestral performers.
2. This evidence may be used during counseling the musicians/performers and also while giving orientation programme regarding the noise levels in orchestral situations and its effect on hearing.

Hence, it can be concluded saying that the people exposed to loud music are prone to develop hearing loss and from the present study, it can also be inferred that failures were more in DPOAE followed by HFA and CFA.

Recommendations:

The recommendations for future research include the following:

- Testing the musicians hearing at 3000 Hz and 6000 Hz in conventional frequency range.
- The performers can be evaluated individually based on the musical instrument used and number of years of exposure with the musical instrument.
- Sensitivity and specificity can also be calculated for the data obtained through DPOAE and HFA.

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APPENDIX-1

CASE HISTORY

Name: Age / Sex:

Occupation: Instrument / Singer:

1. What is your primary instrument and Secondary instruments?
2. Did you play any instrument(s) previous to this (these)/ If so, how long?
3. How long have you been playing this (these) instruments?
4. How many hours each week do you perform/ Practice (solo)/ Rehearse with others?
5. Do you like the music that you play?
6. How many years have you played in the above arrangement/ Location of other instruments/ monitors/ amplifiers?
7. Do you smoke or is there second-hand smoke in the venue?
8. Do you exercise vigorously while performing?
9. Are you in good physical shape?
10. Do you feel you have any hearing loss?
11. Do you have any tinnitus or ringing in your ears/ nature of the tinnitus?
12. Have you had any previous hearing tests/ results?
13. Do you have any other problems or concerns or questions relating to your hearing?