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Personal Music Devices: An Assessment of User Profile and Potential Hazards

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Abstract

Objectives: To profile the use of personal music devices (PMDs) in the study cohort, evaluate their output levels, and assess the users with regard to listening habits, symptomatology and hearing thresholds.

Study design: A randomised prospective study including 500 individuals aged between 16 and 30 years.

Methods: A questionnaire-based assessment included their demographic profile, PMD usage history and symptomatology and then they were classified into high (286) and low risk (214) groups.

Results: The average weekly usage of PMDs was 5.39 days/week, mean volume was 4.88, which increased to 5.9 in noisy areas, and average output used was 66.04 dB. Evaluation by pure tone audiometry (PTA) showed average hearing loss of 21.35 dB in the high risk group.

Conclusions: In total, 57.2% of the individuals included in this study demonstrated high risk behaviour for use of PMDs. Those with risky listening behaviour showed audiometric evidence of early noise-induced hearing loss (NIHL).

Keywords: Personal music devices (PMD); Noise-induced hearing loss (NIHL); Excessive noise

Introduction

Exposure to excessive noise is a major cause of hearing disorders worldwide. The World Health Organization programme for Prevention of Deafness and Hearing Impairment (WHO 1997,) stated [1]: Exposure to excessive noise is the major avoidable cause of permanent hearing impairment worldwide. Noise-induced hearing loss is the most prevalent irreversible industrial disease, and the biggest compensatable occupational hazard. According to WHO estimates, in 2005, there were 278 million people worldwide with bilateral moderate to profound hearing loss with two-thirds living in the developing world [2]. In addition to noise at the workplace, loud sounds at leisure times may also reach excessive levels, for instance, with Personal Music Devices (PMDs) and in discotheques. Over the two decades since the 1980s, the number of young people suffering from social noise exposure has increased and, in contrast, the number suffering from occupational noise exposure has decreased [3]. The increase in unit sales of PMDs has been phenomenal in Europe over the last 4 years [3].

According to one report, [4] 16% of disabling hearing loss in adults is attributed to occupational noise ranging from 7% to 21% in various sub-regions. Serra et al. [5] reported that sound levels of PMDs ranged between 75 and 105 dB and levels in discotheques ranged between 104.3 and 112.4 dB and that prolonged exposure to such levels leads to noise-induced hearing loss (NIHL). This can be prevented to a large extent by reducing exposure time and levels.

International Organization of Standardization (ISO) (1999) [6] and OSHA (Occupational Safety and Health Administration) guidelines [7] define a time-weighted average level of 85 dB for 8 h per day as the maximum permissible limit with a 3 dB increase between exposure time and sound level.

Over the last few years, there has been a trend towards an increasing population risk due to PMDs as their sound quality has improved and as they have been adopted by an increasing proportion of the population. In view of this increasing trend in PMD usage, our study was done to profile the use of personal music devices (PMDs) in the study cohort, evaluate their output levels, and assess the users with regard to listening habits, symptomatology and hearing thresholds.

Materials and Methods

This was a randomised prospective study conducted by the Department of Otorhinolaryngology and Head and Neck Surgery at Maulana Azad Medical College, New Delhi, India.

Study population

The study population included 500 individuals who were between 16 and 30 years of age without any history of ear disorder or systemic illness. Those with pre-existing ear disorders or hearing loss as well as those with associated confounding factors such as occupational exposure, or use of ototoxic medications were excluded from the study.

Following informed consent, a questionnaire was filled by each person. This included type of device, duration of usage, volume at which the device was commonly used, and any symptoms associated with persistent usage. Based on the survey, the subjects were divided into high and low risk groups.This division was done on the basis of the intensity and duration of exposure, and OSHA [7] guidelines for occupational exposure were followed. Those individuals who repeatedly exceeded the prescribed limits of exposure were assigned to the high risk group, whereas those whose exposure occasionally or never exceeded the prescribed limits were assigned to the low risk group.

Fifty individuals each from the high and low risk groups were then randomly selected and these 100 candidates underwent a detailed systemic examination, otoscopic examination and pure tone audiometry (PTA). The results were compared after taking the average of threshold levels at 0.5, 1, 2, 4 and 6 kHz. A separate analysis was carried out for the hearing threshold at 4 kHz.

Assessment of output of various devices

A total of 110 devices were assessed which included 90 mobile phones, 10 Apple iPods and 10 music players.

The output of all of the devices was calculated using an Affinity Interacoustics Sound Pressure Level (SPL) meter attached to computer software. The testing was done in a soundproof room. A B&K Sound Level Calibrator Type 4231 was used. The same pieces of music were used in each device.

The earphones of the device being tested were connected to the SPL meter and sealed to avoid sound dissipation. Two different pieces of music, one of high pitch and the other of low pitch were played each for duration of 30 s. The average of the outputs estimated during the 30 s was calculated for both pieces of music. The average of the levels of sound generated by the two different pieces was taken as the output level. The minimum and maximum outputs of the device, the output at the most commonly used volume and at the volume used in noisy areas were calculated in decibels.

Results and Analysis

A total of 500 healthy young individuals in the age group 16-30 years were included in the study, of which 286 were demonstrating high risk behaviour and 214 were showing low risk behaviour. Their mean age was 22.59 years; 54% of the high risk and 70% of the low risk individuals were in the age group 20–24 years. Of the 500 individuals, 273 were males. Of all individuals in our study group, 202 were undergraduates. In the high risk group, 64% were undergraduates compared to 74% in the low risk group. The majority (306) were cohabitating with their parents and siblings; 62% of the high risk users lived with their parents and siblings compared to 54% in the low risk group. This is significant as household members often warn the users against high risk usage of PMDs.

In the high risk group, most of the individuals were using both mobile phones as well as other devices as a source of music whereas in the low risk users, 68% were using only mobile phones as their personal music device; 451 were using earbud type earphones. None of the 500 individuals knew about the use of a noise limiter. In total, 410 were not being warned by anybody about the high risk use of PMDs.

Weekly usage of PMDs varied between 1 day and all 7 days per week with an overall mean weekly usage of 5.39 days. The mean was 6.88 days/week in the high risk group compared to 3.42 days/week in the low risk group and this turned out to be highly significant. The daily duration of usage varied between 0.2 h/day and 12 h/day with a mean of 2.034 h/day. The mean daily duration was 3.62 h/day in the high risk group with a constant usage for 1.5 h compared to 1.003 h/day in the low risk group with a constant duration for 0.45 h and the daily duration of usage was highly significant. The high risk users were listening music for more than 5yrs compared to low risk users who were listening for less than 1yr The volume at which PMDs were used varied from 1 to 10 with a mean volume of 4.88. The mean volume used by high risk users was 7 compared to 2.6 by low risk users. In noisy areas, volume commonly used was 8.2 in the high risk group, compared to 3.64 in the low risk group Table 1.

The outputs of all of the devices were measured using an Affinity Interacoustics SPL meter. The minimum and maximum outputs of all of the devices were of almost equal range but the output was significantly different in both the high and low risk groups in terms of volume commonly used. In the high risk group, the mean output at commonly used volume was 76.75 dB compared to 55.33 dB in the low risk group. Similarly, the output in noisy surroundings was 82.10 dB in the high risk group compared to 60.76 dB in the low risk group (p value being <0.001) Table 2.

Symptomatology was also assessed in both groups. Headache was a predominant complaint in 54% of the candidates indulging in high risk behaviour; 22% of the high risk candidates had to raise the volume of their TVs to hear properly compared to 8% of low risk individuals (p=0.05). In total, 16% of the relatives of high risk candidates felt that they had to talk loudly compared to 4% in the low risk group (p=0.04). When we compared the two groups for these symptoms, they were significantly more prevalent among the high risk subjects. Other symptoms were also assessed such as ringing sensation in the ears (p=0.153), complaints of hearing loss, difficulty in understanding speech, and difficulty in hearing the telephone bell/doorbell. All of these symptoms were not significant in the two groups. In total, 12% of the high risk candidates compared to 6% of the low risk individuals had to take a break from music as they felt that the sound became too loud with the continuous use of headphones. Some even had earache due to excessive use of their earphones.

Sub Group	N	Mean frequency of use (days/week)	Mean duration of use (h/day)	Mean volume used	Mean volume in noisy areas
High risk group	50	6.88	3.62	7.08	8.24
Low risk group	50	3.42	1.003	2.66	3.64
Total	100	5.15	2.312	4.87	5.94

Table 1: Usage pattern of PMDs in high and low risk groups.

Sub Group		Minimum (dB)	Maximum dB	Commonly used volume	Noisy surroundings
High Risk	N	50	50	50	50
	Minimum	48	74	54	54
	Maximum	58.5	102.5	102.5	102.5
	Mean	49.92	90.86	76.75	82.1
Low Risk	N	50	50	50	50
	Minimum	48	76	48	48
	Maximum	64.5	102.5	86	99
	Mean	50.09	88.46	55.33	60.76

Table 2: Output levels of PMDs in high and low risk groups.

Otoscopic examination revealed bilateral normal tympanic membrane in both groups.

Pure tone audiometry (PTA) findings were significantly different in both groups. These showed a hearing loss of 20.9 dB in the right ear with 19 dB at 4 kHz and 21.8 dB in the left ear with 21.5 dB at 4 kHz in the high risk group. The findings for the low risk group were 14.7 dB with 14.8 dB at 4 kHz for the right ear and 13.4 dB with 13.5 dB at 4 kHz for the left ear. The results of the chi square test were highly significant in terms of PTA findings at the consecutive frequencies of 1, 2, 4 and 6 kHz as well as at 4 kHz (p=0.000) Table 3.

Sub Group		PTA findings: HL at 1, 2, 4, 6 kHz, right ear	PTA findings: HL at 1, 2, 4, 6 kHz, left ear	HL at 4 kHz, right ear	HL at 4 kHz, left ear
High Risk	N	50	50	50	50
	Minimum	10	12.5	10	10
	Maximum	42.5	45	40	50
	Mean	20.9	21.825	19.05	21.5
Low Risk	N	50	50	50	50
	Minimum	10	10	10	10
	Maximum	20	25	20	20
	Mean	14.725	14.86	13.4	13.5

Table 3: Audiometric findings for right and left ear in high and low risk groups.

Discussion

The huge increase in popularity of PMDs has dramatically increased exposure to high sound levels amongst the youth. Studies have reported that increasing numbers of adolescents and young adults now experience symptoms indicative of poor hearing, such as distortion, tinnitus, hyperacusis or threshold shifts [8,9]. The present study analysed the behaviour and usage pattern of PMDs in individuals between 16 and 30 years of age. In 2009, Vogel et al. concluded that adolescents are much more likely to engage in risky behaviour in terms of usage pattern of PMDs [10]. In 2000, Smith et al. found that the numbers of young people with social noise exposure had tripled (to around 19%) since the early 1980s [11]. Agarwal et al. observed that, in 2003-4, 16.1% of US adults had hearing loss of which 8.5% was exhibited in the age group of 20-29 years and the prevalence seemed to be growing among this age group [12]. Studies done in the past by Niskar et al. [9] in 2001 and Chung et al. [8] in 2005 reported that a large number of adolescents and young adults are experiencing hearing loss.

In the present study, the usage pattern of PMDs was almost comparable amongst males and females but a greater number of males listened at high volume and for longer duration compared to females. This finding was different to that of Vogel et al. [10] who found that both males and females were likely to be at risk of hearing loss. In 2001, Niskar et al. [9] estimated the prevalence of noise-induced hearing threshold shift (NITS) among children aged 6-19 years in the Third National Health and Nutrition Examination Survey, 1988-1994 in USA. They found that 12.5% had NITS in one or both ears, with a higher prevalence in boys (14.2%) compared to girls (10.1%).

In the present study, undergraduate students demonstrated higher device usage compared to graduates and postgraduates. A study by Shah et al. [13] found that only 5% of undergraduates and 27% of graduates reported listening for less than 1 h/day and undergraduates were listening at higher volumes.

Parental monitoring is widely recognised as playing an important role in reducing an adolescent's risky health behaviour. We found that 62% of individuals having high risk habits of listening to PMDs were warned by their parents against the dangers of high volume music. The warnings by parents were heeded by most part of the time and ignored at other times.

None of the 500 individuals enrolled in our study knew about the use of a noise limiter. Several studies have shown that, even when individuals are aware of the risk of noise exposure, they are reluctant to use hearing protection [14]. A study by Vogel et al. [10] demonstrated that risky listening behaviour ranged between 33.2% and 93.2% and rates of protective listening behaviour ranged between 6.6% and 18.5%. They found that 32.8% were frequent users of PMDs, 48% listened at high-volume settings and 6.8% always or nearly always used a noise-limiter.

In the present study, we observed that most individuals were using mobile phones as a mode of listening to music but in the high risk group, the majority were using other sources of music along with their mobile phones. There has been a phenomenal increase in unit sales of portable audio devices including MP3 players in the EU over the last 4 years (2004-2007) [3]. A study by Shah et al. [13] on the type of PMD usage concluded that mobile phones were the most commonly used PMDs, followed by DVD players and iPods.

The usage of earphones has a significant impact on the damage caused by PMDs as their usage increases the amplitude of sound reaching the cochlea. Out of all 500 individuals in our study, 451(90.2%) were using earbud type earphones and results were similar in the high risk group. Studies by Vogel et al. [10] and by Shah et al. [13] have shown similar findings.

Regardless of socio-demographic characteristics, we found that weekly usage of PMDs varied between 1 day and all 7 days per week. The average duration and volume at which PMDs were being used was higher in the high risk group compared to the low risk group. The minimum and maximum outputs of all of the devices being used in our study were of almost equal range but the output varied with respect to the listening habits of the individual. In the high risk group, the mean outputs at commonly used volume and in noisy areas were both higher compared to the low risk group.

All of the enrolled individuals were evaluated for symptoms relating to hearing loss. We found that 28% of the high risk group occasionally suffered a ringing sensation in their ears, and 14% had difficulty in hearing; 22% of the high risk individuals had to raise the volume of their TVs to hear properly. Relatives of the candidates felt that the individuals talked loudly, and had difficulty in understanding speech, etc. Others received complaints from relatives who told them that they were speaking loudly (16%) and some had difficulty in understanding speech.

When assessed using PTA, the high risk group was found to have greater hearing loss at frequencies of 0.5, 1, 2, 4 and 6 kHz compared to the low risk group. We found that people listening to music at high volume and for longer durations were experiencing NIHL, which was documented by PTA.

Similar results were reported by Vogel et al. [10] who found that frequent users reported a much higher frequency of risky listening behaviour than infrequent users, ranging from twice as high to nearly five times as high. These users also reported a frequency of protective listening behaviour that was 2 to 3 times lower than that of infrequent users. A survey by Rice et al. [15] concluded that personal cassette player users suffering from post-exposure tinnitus or dullness of hearing should regard these symptoms as a sign of possible sensitivity to NIHL. Sometimes before subjective deafness becomes apparent to the individual, the changes can be picked up by audiometry.

In conclusion, we found that 57.2% of the individuals included in this study demonstrated a high risk behaviour (i.e. listening to music for >1 h/day and at high volume) for use of personal music devices. In the high risk group, individuals were listening to music with a mean weekly usage of 6.88 days/week, a mean daily usage of 3.62 h/day, and an average 1.5 h/day of continuous use. On a scale of 1–10, the average volume at which they were listening to music was 7, and 8 in noisy areas.

Risky listening behaviour can lead to the development of noise-induced hearing loss amongst exposed individuals, as demonstrated by the rise in audiometric hearing thresholds. It is essential that adolescents should be made aware of healthy listening habits and the potential risks of continued misuse or overuse of personal music devices.

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