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Usage pattern of personal stereo players and its potential effect on the hearing of teenagers in Hong Kong

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Doris, Wong Chau Min

Abstract

There is rising concern over the use of personal stereo players (PSPs) and its effect on hearing. The study served as the first in Hong Kong to investigate the teenagers' usage pattern of PSPs and its relationship with their hearing. Subjects from a local secondary school were asked to fill in a self-reported questionnaire on PSP usage, pure-tone audiometry (PTA) was performed to evaluate hearing status, and transient-evoked otoacoustic emissions (TEOAEs) were measured to reveal minimal subclinical damage done to the inner ears. The subjects were found to expose to PSPs with a potentially hazardous duration. Mild subclinical damage to the inner ear might have been present in a significant proportion. Teenagers are to be reminded about the need of hearing conservation.

Introduction

There has been a rising popularity of personal stereo players (PSPs), especially MP3 players, among the teenage population through recent years. Teenagers in Hong Kong are found wearing headphones in public transports, on streets, in shopping malls, and the places. Accompanying this rise in popularity of PSPs is the hearing experts' increasing concern over the risk of acquiring noise-induced hearing loss (NIHL) due to 'undisciplined' listening to these devices (Fligor, 2006). Researches and surveys were conducted in different countries to investigate the prevalence of early signs of NIHL, the usage pattern of MP3, or the hearing status of different age groups in the population (e.g. Williams, 2005; Serra & Biassoni, 2005; Mostafapour, Lahargoue, & Gates, 1998). With reference to the results from these studies, recommendations were given to help prevention of NIHL due to PSP use, however, legal regulations are yet to be implemented. This study was aimed to investigate PSP usage pattern and its relation to the hearing status of teenagers in Hong Kong.

The rising popularity of PSPs

Among recreational activities in teenagers, prevalence of the use of personal stereo players (PSPs) (e.g. MP3, MP4) has increased drastically in recent years. According to the data from Euromonitor International (2006), the sales volume of personal/portable audio devices in the world is forecasted to rise from 117,314,610 units in 2004 to 147,471,790 units in 2008. While the actual retail volume of personal/portable audio devices in Hong Kong rose from 378,180 units in 1998 to 739,980 units in 2003. The sales volume of personal/portable audio devices in Hong Kong is expected to increase to 1,675,650 units in 2008.

Americian Speech-Language-Hearing Association (ASHA) (2006) conducted a poll on usage of electronic devices and hearing status in 301 American students aged 14 to 18. Results showed that the majority of students (62%) used a Walkman or portable CD player, while 36% and 25% used an Apple iPod and other brands of MP3 player respectively. In the United Kingdom, Deafness Research UK (2006) surveyed the use of PSPs in 1000 British

aged 16 to 34. Results showed that ‘more than three quarters of people owned a personal music player’. In Hong Kong, a research project jointly conducted by The Hong Kong Society for the Deaf, Hong Kong Playground Association, and Division of Otorhinolaryngology, Department of Surgery, the University of Hong Kong (2007) found that among the 1025 people aged 12 to 24 years interviewed, 975 of them (95%) possessed and listened to PSPs.

Overall, the above data suggested that owning and listening to PSPs has become a worldly trend.

Noise-induced hearing loss (NIHL)

Noise-induced hearing loss (NIHL) occurs with one-time exposure to very loud sound or by continuous and repeated exposure to different sounds at high levels over time (Haller & Montgomery, 2004). National Institute on Deafness and Other Communication Disorders (NIDCD) (2002) suggests that the one-time loud sound such as from firearms or firecrackers that could result in NIHL is about 120 to150dBA. Exposure to other loud sounds that are 90 dBA or above for an extended period of time, also poses risk of NIHL to an individual (Mayo Clinic, 2006).

According to Rose (1981), exposure to excessive noise (high, intense stimuli) ‘causes eddy current to develop in the fluid of cochlea’. The sensory hair cells are thus torn away from their supporting structures. Decrease in hearing sensitivity thus results is demonstrated as noise-induced hearing threshold shift (NITS). As sensory hair cells pose a certain level of self-recovery ability, NITS could be temporary. However, if there is chronic exposure, the NITS becomes permanent and NIHL occurrs (Niskar et al., 2001). NIHL is characterized by a substantial loss at 3k to 4k Hz, resulting in a ‘noise notch’ in the audiogram (Rose, 1981). According to Patuzzi (1992), NIHL is frequency specific but not related to the frequency of the traumatic exposure.

The damage done to hearing is irreversible and additive in nature (Patuzzi, 1992) and could accumulate painlessly over one's lifetime (Niskar et al., 2001). The onset of symptoms of NIHL is also a slow process. A common symptom is tinnitus (ringing in the ears) (Axelsson & Barrenas, 1992). Noise-induced permanent tinnitus (NIPT) occurs with continuous exposure to loud noise. According to Axelsson and Barrenas (1992), there is no specific precipitation prior to onset of NIPT and the onset is usually slow. Other possible symptoms include hearing distorted or muffled sounds after noise exposure, and understanding speech gradually becomes more difficult (Niskar et al., 2001). NIDCD (2002) stated that individuals may not be aware of the loss without undergoing hearing tests. Hall and Lutman (1999) found that minor damage done in NITS may not even be revealed by traditional audiometry but more sensitive otoacoustic emission (OAE).

Acquisition of NIHL in adults through exposure to occupational noise had long been studied in various countries (LePage, 1998). Different countries have enacted preventive measures such as setting maximum intensity level and exposure hours to minimize the risk of acquiring NIHL in noisy work environment. Public awareness of the problem is also raised through civic education. However, there is no specific regulation, public measure or published guideline concerning safety use of PSPs in order to prevent NIHL.

The output levels of PSPs and their potential risks

In recent decades, there has been increasing concern over the risk of acquiring NIHL from non-occupational/recreational activities in youngsters. Studies were conducted to investigate the intensity level of recreational noise (e.g. electronic arcade games, baby toys, hobby motors, impulse generating items, musical activities) (Hellstrom, Dengerink, & Axelsson, 1992; Plakke, 1983). The output levels of these devices were measured and the risks from listening to PSPs on hearing were studied. This issue was brought up widely in press.

Fligor and Cox (2004) reported maximum output levels of headphones as 124dBA. The output levels of cassette players could reach 60dBA to 110-114dBA (Catalano & Levin, 1985). Mostafapour et al. (1998) suggested that PSPs were potentially hazardous to the hearing system as they could produce sound levels in excess of 100dBA. If these systems are used for more than 8 hours per day, the amount of exposure would exceed the maximum allowable limits recommended in most countries. Fligor and Cox (2004) selected six brands of CD players and measured the mean output levels at different volume control settings. They found that the mean output levels at the maximum control setting ranged from 95dBA to above 115dBA; at a given volume control setting, the output levels were higher in smaller headphones.

There are no legal regulations on the safety limit for leisure noise including PSPs. Mayo Clinic (2006) stated that exposure to sound levels of 90 dBA for a prolonged period of time poses risks of NIHL. Hitti (2006) quoted the saying by Director James Battey of the National Institute on Deafness and other Communication Disorders (NIDCD) that 'youth worldwide are exposed to harmful levels of noise every day…over time, this can lead to permanent noise-induced hearing loss by damaging and/or destroying the inner ear's sensory cells'. Based on the assumption by Fligor and Cox (2004) that occupational noise and music posed equal damage risk to hearing ability, we refer to the governmental safety criteria for occupational noise exposure. According to Hong Kong Government (2006), the first action level above which certain basic actions or safety measures have to be taken by the employers is 85dBA. Daily personal noise exposure should therefore be below 85dBA.

Therefore, the output sound pressure levels of PSPs demonstrate a potential risk in damaging listeners' hearing ability.

Usage pattern of PSP and its relation to hearing damage

Owe to the potential risks to hearing ability from PSPs, research investigating the prevalence of hearing damage and its relation to PSP usage in adolescents and/or the middle-aged populations were conducted in different countries.

In Australia, Williams (2005) tried to measure the actual sound output levels of PSPs in passers-by on a busy street to estimate the upper levels of exposure. Results from 55 people aged 15 to 48 showed output levels between 73.7-110.2dB with a mean of 86.1dB, while the listening time ranged from 40 minutes to 13 hours per day. These findings suggested possible at risk usage pattern. LePage and Murray (1998) examined the potentially harmful effects on hearing in PSP users using transient-evoked otoacoustic emission (TEOAE). They found greater OAE strength in those with lower PSP use, suggesting that lower sensory hair cell sensitivity was resulted with longer PSP use.

In Argentina, Serra and Biassoni (2005) found sound output levels of 75dBA to 105dBA in personal music players of 10 adolescents. They found mean hearing threshold levels at high frequencies of 106 teenagers to increase at the fourth year of the study.

In the United States, Mostafapour et al. (1998) examined the hearing level and the exposure to different leisure noise in 50 subjects aged 18 to 30 and did not find a correlation between the presence of noise notch and any source of noise exposure (including PSPs). Niskar et al. (2001) conducted a study to estimate the prevalence of NITS in 5249 children aged 6 to 19, they found an overall prevalence to be 12.5% in one or both ears. A trend of increasing prevalence of NITS by age was observed, though the noise source was not identified in the study. According to the poll conducted by ASHA (2006) on 301 high school students, 37% of them listened to MP3 for 30 minutes to 1 hour each day, 59% of them described the volume level of their MP3s as loud, and 49% of subjects perceived themselves as not having signs of hearing loss. However, the exact relation between listening to PSPs and hearing loss could not be drawn from this poll.

In France, Meyer-Bisch (1996) found positive correlation in the use of PSP with cochlear/audiometric damage in 1364 subjects, the majority aged 15 to 25.

In Britain, Deafness Research UK (2006) found that 14% of the 1000 people surveyed spent 28 hours a week listening to PSPs. More than one-third of the people listened to their MP3 players every day, and they had also experienced tinnitus. Meyer-Bisch (1996) stated that teenagers in Britain liked to set the volume of their PSPs at 100 to 126dBA, as they seemed to enjoy the music more with the volume control turned up.

In Hong Kong, The Hong Kong Society for the Deaf et al. (2007) had surveyed 1025 subjects aged 12 to 24. It was found that 55% of the subjects reported listening to PSPs for one hour or less, the majority (43.7%) would tune their volume to about 60 to 70% of the maximum volume. About one-third of the subjects perceived themselves to have poorer hearing since PSP exposure, while 19.8% experienced different degrees of tinnitus. The study also found that in a background noise of 85dBA, around 38% of the subjects would tune up their PSP volume to above 90dBA.

Findings from the above studies revealed that people in different countries or cultural backgrounds seemed to have entirely different PSP usage patterns, and hence the potential risks of acquiring NIHL from them. The present study serves as the first in Hong Kong to investigate the PSP usage pattern and its relation to hearing status of teenagers. Findings from this research will help identify the risks listening to PSPs poses on teenagers in Hong Kong, and hence the need for promoting public awareness on safe usage of PSP.

Method

Data/subjects

Data for this study was collected in a program jointly organized by the Hear Talk Foundation and the Bauhinia Junior Chamber for promoting hearing care in the teenage population. Subjects were recruited from a local secondary school (Lions College). Informed consent were obtained from parents (n = 327). The testing procedures took place in Lions

College during the period 26-29 September, 2006. The purpose of this study was to determine the use of personal stereo players (PSPs) and to examine whether PSP use related to hearing status among teenagers.

Self-reported questionnaire

Prior to all the testing procedures, subjects were asked to read an instruction sheet (see Appendix A). All subjects completed a non-standardized questionnaire suggested by American Speech-Language-and Hearing Association (ASHA) and modified by the Hear Talk Foundation (see Appendix B). There were three parts in the questionnaire. The first part aimed to find out the subjects' self-perception of hearing status and the extent of hearing handicap. A total of 15 Yes-No questions were included, such as whether they heard better with one ear than the other on the phone, whether they had problem following the conversation when two or more people were talking, whether they had tinnitus or ringing in the ears, whether they found people appeared to mumble or speak with muffled voices, whether they perceived their hearing sensitivity as worsened, etc.

The second part focused on the subjects' usage pattern of PSPs. Subjects were asked the brand and model of the PSP(s) they own, the duration of ownership, the number of hours listening to PSPs with headphones on weekdays and weekends, the volume they set, the number of hours using headphones to play computer games on weekdays and weekends, and the type of headphone they used (insert type or over-the-ear type).

In the last part, the subjects were asked to fill in personal information such as their age, sex and class.

Audiologic examination

Then the subjects proceeded to audiologic examination (see Appendix C for the recording form). During screening, otoscopic examinations were first carried out by an ENT doctor. Middle ear pathologies such as perforated tympanic membranes were identified.

Impacted ear wax, if noticed, was cleared at this stage before proceeding to pure-tone audiometry.

Pure-tone audiometry was then performed. The audiometers and sound booths were provided by the school. The screening environment met the ANSI S3.21-2004 standards for audiometric screening. The subjects' hearing of both ears was screened by volunteer audiologists or audiology technicians using AD226 or GSI68 audiometers. Air conduction thresholds were measured for each ear at 500Hz, 1000Hz, 2000Hz, 3000Hz and 4000Hz, with testing repeated at 1000Hz to examine test-retest reliability. If a subject failed the screening at either frequency in either ear, a detailed audiometric evaluation was performed to obtain the subject's pure-tone audiogram.

After the audiometry, the subjects were led to a conference room, transient-evoked otoacoustic emissions (TEOAE) were obtained there by another audiologist using the OAE machine Otodynamics ILO292 in conjunction with an IBM PC. A B-type adult probe was used with standard disposable foam probe tips. The test was started when the check-fit procedure was satisfied. The standard QuickScreen procedure was performed. Broadband clicks in the nonlinear mode were used as stimuli. The stimulus intensity was between 71 and 85 dB peak SPL. A total of 260 responses to click stimuli were recorded for each participant. OAE was obtained to determine individual's risk of hearing loss because it could reveal mild or minimal cochlear damage in subjects with normal audiometric thresholds (LePage & Murray, 1998). It was found that noise of different types (e.g. white noise and speech babbles) would have a considerable effect on the size of TEOAE and reproducibility (Rhoades, McPherson, Smyth, Kei, & Baglioni, 1998; Smith, Kei, McPherson, & Smyth, 2001). However, according to Rhoades et al. (1998) and Smith et al. (2001), the QuickScreen program used in the current study could remain without contamination at a white noise level of 55 dBA (Rhoades et al., 1998) and speech babble level of 70 dBA (Smith et al., 2001). The

noise level recorded in the testing room (45 dBA) was below these two levels and thus the TEOAE results were regarded uncontaminated.

The time required for TEOAE testing was longer then the previous testing procedures. When the queue for TEOAE testing was too long, subjects were selected by random sampling and TEOAEs were obtained on 228 subjects. The passing criteria of TEOAE were response level of over 3dB and reproducibility of over 70% at each frequency tested.

Subjects with previously known hearing impairment were excluded from the testing. The subjects who failed pure-tone audiometric screening even after ear-wax clearing were referred to ENT doctors for further referral to find out the nature of hearing loss.

Statistical analysis

Data were analyzed using the computer software SPSS 15.0 version. Descriptive statistics were performed to evaluate the questionnaire results, PSP usage pattern, hearing status and OAE. Analyses of variance (ANOVA), chi-square tests and independent samples t-tests were calculated, the level of significance was set at $p<0.05$.

Results

Among the 327 subjects, there were 175 males, 152 females, with an age range from 11 to 20 (mean: 14.29). Subject characteristics were summarized in Table 1.

Table 1

Subject Characteristics

		Age (%)									
Mode	No.	11	12	13	14	15	16	17	18	19	20
Male	175	7.2	22.4	17.8	17.1	9.9	8.6	7.2	7.9	2.0	0.0
Female	152	6.3	13.1	23.4	12.0	9.1	12.0	16.0	4.6	2.9	0.6
All	327	6.7	17.4	20.8	14.4	9.5	10.4	11.9	6.1	2.4	0.3

Questionnaire results

Table 2

Results from questions on hearing condition experienced

Question no.	Conditions	No. of 'Yes' (%)	No. of 'No' (%)
1	Have a problem hearing over the telephone at home	18 (5.5)	307 (93.9)
2	Feel that one of the ears can hear better over the telephone	54 (16.5)	271 (82.9)
3	Have problem following conversation when two or more people are talking	38 (11.6)	286 (87.5)
4	Being complained that they turn the TV volume up too high	44 (13.5)	282 (86.2)
5	Have to strain to understand conversation	79 (24.2)	247 (75.5)
6	Have trouble understanding the speech of others in restaurants	45 (13.8)	279 (85.3)
7	Have dizziness, pain in the ears, tinnitus or ringing in the ears	46 (14.1)	280 (85.6)
8	Find yourself asking people to repeat themselves	104(31.8)	222 (67.9)
9	Your parents/classmates feel that you always can not hear them	35 (10.7)	291 (89.0)
10	Find people appear to mumble or speak with muffled voices	30 (9.2)	296 (90.5)
11	Misunderstand what others are saying and respond inappropriately	63 (19.3)	263 (80.4)
12	Have trouble understanding the speech of women and children	18 (5.5)	308 (94.2)
13	Others get annoyed because you misunderstand what they say	52 (15.9)	274 (83.8)
14	Perceive your hearing sensitivity as worsened	48 (14.7)	277 (84.7)

The results of questionnaire as seen in Table 2 showed that the most handicapping condition experienced was 'finding oneself asking people to repeat' (104 or 31.8% of subjects). This was followed by the condition 'having to strain to understand conversation' (79 or 24.2% of subjects). A total of 63 subjects (or 19.3%) misunderstood what others were saying and responded inappropriately.

When subjects' hearing handicap level was classified by the number of positive responses (answered 'yes') to the 14 questions in the questionnaire, 59% of the subjects were experiencing 'mild' handicap level (1-5 positive responses), while 32.1% were not handicapped at all. (see Table 3)

Table 3

Hearing handicap level of 327 teenagers aged 11-20.

Hearing handicap level (No. of 'Yes')	Number of subjects (%)
None (0)	105 (32.1)
Mild (1-5)	193 (59.0)
Moderate (6-10)	26 (8.0)
Severe (11-14)	3 (0.9)

Among all, 164 subjects (50.2%) reported that they would listen to PSPs (94 females, 70 males). A total of 178 (54.4%) subjects owned PSPs: 20 (6.1%) and 150 (45.9%) subjects reported they owned and Apple iPod and MP3 respectively, while another 13 (4.0%) subjects owned other types of PSPs such as mobile phone, Discman, Walkman, etc. Most of the subjects failed to recall the brand or the model of PSPs they owned. Among those who owned or had listened to PSPs, 204 (93.6%) subjects used insert type ear phones, 12 (5.5%) used over-the-ear type while the rest had both types. The duration of ownership and the listening hours for PSP users among the subjects were summarized in Table 4. The majority of the subjects owned their PSPs for no longer than 1 year (114 or 89% of subjects), listened to PSPs for one hour or less in weekdays (83 or 47.7% of subjects) and also in weekend (66 or 37.1% of subjects).

Table 4

The duration of ownership of PSPs and average usage among PSP users

	Duration of ownership/mths	ALH* in weekdays/hrs	ALH* in weekend/hrs
Mean (SD)	13.8 (16.2)	2.4 (2.7)	2.8 (3.2)
Range	0.5-106.0	0.1-20.0	0.1- 24.0
Group distribution	0-12 months: 114(89.0%) 12-24 months: 2 (1.6%) 24-36 months: 1 (0.8%) 36-48 months: 7 (5.5%) > 48 months: 4 (3.1%)	0-1 hours: 83 (47.7%) 1-2 hours: 40 (23.0%) 2-4 hours: 25 (14.4%) > 4 hours: 26 (14.9%)	0-1 hours: 66 (37.1%) 1-2 hours: 39 (21.9%) 2-4 hours: 47 (26.4%) > 4 hours: 26 (14.6%)

*ALH = Average Listening Hours

Table 5

Comparison between genders in duration of ownership and average usage of PSP users

	Duration of ownership/mths		ALH in weekdays/hrs		ALH in weekend/hrs	
Sex	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Male	10.9 (12.8)	0.5 – 60.0	2.6 (2.7)	0.5 – 14.0	2.8 (3.3)	0.1 – 24.0
Female	16.5 (18.5)	1.0 – 106.0	2.3 (2.7)	0.1 – 20.0	2.9 (3.1)	0.3 – 24.0
All	13.8 (16.2)	0.5 – 106.0	2.4 (2.7)	0.1 – 20.0	2.8 (3.2)	0.1 – 24.0

Usage pattern across two genders was shown in Table 5. Independent sample t-test was performed to evaluate gender difference in reported usage. For the duration of ownership, female subjects owned their PSPs for significantly longer period of time than male subjects ($t = 2.29$, $df = 151$, $p<0.05$). There was no significant difference in the average usage between genders in terms of weekday listening hours ($t = -0.88$, $df = 169$, $p>0.05$) and weekend listening hours ($t = 0.169$, $df = 159$, $p>0.05$).

Table 6

Comparison between age groups in duration of ownership and average usage of PSP users

	Duration of ownership/mths		ALH in weekdays/hrs		ALH in weekend/hrs	
Age	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
11-13	9.7 (16.0)	0.5 – 106.0	2.0 (2.3)	0.1 – 14.0	2.7 (3.7)	0.1 – 24.0
14-16	13.3 (16.4)	0.5 – 100.0	2.8 (3.2)	0.5 – 20.0	3.2 (3.5)	0.5 – 24.0
17-20	20.2 (14.8)	2.0 – 60.0	2.5 (2.3)	0.5 – 11.0	2.5 (1.4)	0.5 – 6.0
All	13.8 (16.2)	0.5 – 106.0	2.4 (2.7)	0.1 – 20.0	2.8 (3.2)	0.1 – 24.0

Table 6 showed the comparison of average usage across age groups. One-way ANOVA and post-hoc Bonferroni test were performed to evaluate the differences in usage among age groups. A main effect of age group was revealed for duration of ownership ($F(2, 324) = 11.27$, $p<0.05$) and weekday listening hours ($F(2, 324) = 5.39$, $p<0.05$). Post hoc analysis showed that duration of ownership differed across all age groups, with increasing duration of ownership as the children become older. It also showed that there was significant difference between "11-13" and "14-16" group ($p<0.05$) and "17-20" group ($p<0.05$) on weekday listening hours, but not between "14-16" group and "17-20" group ($p>0.05$). For weekend listening hours ($F(2, 324) = 2.72$, $p>0.05$), there was no significant difference between age groups.

The self reported listening volume ranged from 1-80 based on individual rating scales of PSPs, with a mean of 16.0 (SD= 10.6). Because the maximum volume setting and the actual output sound levels of the PSPs were not known, it was difficult to assess the difference in exposure volumes among users.

Pure-tone audiometry results

Concerning the screening results, the total number of subjects failed in either or both ears was 22 (6.7%). 12 of them failed in both ear, 4 of them failed in right ear only while 6

failed in left ear only. For those who passed the screening (305 subjects), 181 or 59.3% of them would listen to PSPs. Compared with those subjects who failed in the screening (22 subjects), a similar percentage (59%) of them would listen to PSPs. The usage pattern of those who failed screening was summarized in Table 7, and compared with those who passed in Table 8. The majority 75% of the subjects who failed owned their PSPs for less than a year, 41.7% of them listened for one hour or less a day in weekdays. However, 58.3% of them listened 2-4 hours a day in weekend, and one-fourth of them listened to more than 4 hours a day during weekdays, which was potentially damaging to their hearing.

Table 7

The duration of ownership of PSPs and average usage of PSP users who failed in PTA

	Duration of ownership/mths	ALH in weekdays/hrs	ALH in weekend/hrs
Mean	11.5 (12.1)	4.0 (5.6)	2.5 (1.7)
Range	2.0 – 36.0	0.5 – 20.0	0.5 – 6.0
Group distribution	0-12 months: 6 (75.0%) 12-24 months:1 (12.5%) 24-36 months:1 (12.5%)	0-1 hours: 5 (41.7%) 1-2 hours: 3 (25.0%) 2-4 hours: 1 (8.3%) > 4 hours: 3 (25.0%)	0-1 hours: 4 (33.3%) 1-2 hours: 0 (0.0%) 2-4 hours: 7 (58.3%) > 4 hours: 1 (8.3%)

Table 8

Comparison between PSP users who pass/fail in PTA screening in duration of ownership and average usage

	Duration of ownership/mths		ALH in weekdays/hrs		ALH in weekend/hrs	
Results	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Pass	14.0 (16.5)	0.5 – 106.0	2.3 (2.3)	0.1 – 14.0	2.9 (3.3)	0.1 – 24.0
Fail	11.5 (12.1)	2.0 – 36.0	4.0 (5.6)	0.5 – 20.0	2.5 (1.7)	0.5 – 6.0
All	13.8 (16.2)	0.5 – 106.0	2.4 (2.7)	0.1 – 20.0	2.8 (3.2)	0.1 – 24.0

Independent samples t-tests results showed that for the duration of ownership ($t = -0.553$, $df = 8$, $p>0.05$), there was no significant different between those who passed or failed the screening. For weekday listening hours ($t = 1.02$, $df = 11$, $p>0.05$) and weekend listening hours ($t = -0.554$, $df = 18$, $p>0.05$), the two groups also had no significant difference.

TEOAE results

Among the 228 OAE samples obtained (111 males, 117 females), 84 (36.8%) of them failed in either ear, 26 failed in the right ear only, 28 failed in left ear only, while 30 failed in both ears. (It was noted that the background noise level in the conference room carrying out the OAE testing was around 45dBA.) A significantly larger proportion of those who listened to PSPs failed the OAE screening than those who did not listen ($\chi2 = 5.329$, $df = 1$, $p<0.05$) (see Table 9).

Table 9

Comparing results of OAE between those who listened to PSPs and those did not

Listen to PSPs	OAE results	
	No. of pass (%)	No. of fail (%)
Yes	77 (33.8)	58 (25.4)
No	67 (29.4)	26 (11.4)

The PSP usage pattern of those PSP users who failed the OAE testing (84 subjects) was summarized in Table 10, and compared with those who passed the OAE testing in Table 11. Independent samples t-test was performed to evaluate the difference in usage pattern. There was no significant difference between the groups in terms of duration of ownership ($t = 1.07$, $df = 107$, $p>0.05$), weekday listening hours ($t = -1.08$, $df = 123$, $p>0.05$) and weekend listening hours ($t = -0.7$, $df = 121$, $p>0.05$).

Table 10

The duration of ownership of PSPs and average use of PSP users who failed OAE testing

	Duration of ownership/mths	ALH in weekdays/hrs	ALH in weekend/hrs
Mean	15.8 (15.3)	2.3 (2.2)	2.5 (1.9)
Range	0.5 – 60.0	0.5 – 10.0	0.1 – 10.0
Group distribution	0-12 months: 29 (59.2%) 12-24 months:9 (18.4%) 24-36 months:6 (12.2%) > 36 months: 5 (10.2%)	0-1 hours: 25 (49.0%) 1-2 hours: 10 (19.6%) 2-4 hours: 10 (19.6%) > 4 hours: 6 (11.8%)	0-1 hours: 15 (28.3%) 1-2 hours: 13 (24.5%) 2-4 hours: 22 (41.5%) > 4 hours: 3 (5.7%)

Table 11

Comparison between PSP users who pass/fail in OAE testing in duration of ownership and average usage

	Duration of ownership/mths		ALH in weekdays/hrs		ALH in weekend/hrs	
Results	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Pass	12.6 (16.0)	1.0 – 106.0	2.6 (3.0)	0.1 – 20.0	3.2 (4.3)	0.3 – 24.0
Fail	15.8 (15.3)	0.5 – 60.0	2.3 (2.2)	0.5 – 10.0	2.5 (1.9)	0.1 – 10.0
All participated in OAE	14.1 (15.7)	0.5 – 106.0	2.4 (2.7)	0.1 – 20.0	2.9 (3.5)	0.1 – 24.0

There were 24 of the subjects referred for further diagnostic pure-tone audiometry after the screening (excluding those with previously known hearing impairment), but only 9 of them showed up in the further assessment. Among those, 4 of them were confirmed to exhibit normal hearing, 2 had mild impairment at high-frequency, 1 with unilateral 4 kHz notch, and 2 with conductive hearing loss.

Discussion

This study aimed to identify PSP usage pattern and prevalence of hearing loss among teenagers and possible relationships between them. It serves as the first study in Hong to investigate detailed PSP use pattern of Hong Kong teenagers. The following discussion provides a general interpretation of the descriptive and inferential statistics, and comparison with results in other recently conducted researches/surveys and their implications. Limitations of the current research and future research directions are also discussed.

Self-reported hearing status

Based on the results from the questionnaire on self-reported hearing loss conditions, the majority of teenagers surveyed (59%) had mild handicap. This proportion is somewhat surprising. A similar survey conducted in the United States (ASHA, 2006) suggested 49% of high school students reported no problem with any of the items, and 28% reported mild handicap. Therefore, subjects in this study seemed to perceive themselves to have poorer hearing. The high noise level in Hong Kong may lead to poorer self-perception of hearing. Hong Kong Environmental Protection Department (HKEPD) (2007) reported the noise level at 25 meters from a distributor road to be about 70dBA while rail noise at a distance of 25 meters about 80dBA. High background noise reduces the signal-to-noise ratio and reduces hearing sensitivity, people may find it difficult to hear the signals in noisy environment and perceive themselves to have poor hearing.

It is noted that 14.1% of subjects experienced tinnitus or pain in the ears. Tinnitus is known to be a common symptom of hearing loss caused by noise (Axelsson & Barrenas, 1992; Folmer, Martin, & Shi, 2004). It has slow onset and serves as an early physiological warning sign of NIHL. The presence of this symptom is alarming. Future research should specifically evaluate the presence of tinnitus in this population.

PSP usage pattern of teenagers

A significant number of subjects (54.4%) claimed to own a PSP, and the majority owned an MP3 (45.9%). The subjects' mean duration of ownership was 13.8 months, the average usage in weekdays and weekends were 2.4 hours and 2.8 hours respectively. The majority of our subjects were rather disciplined and listened to their PSPs one hour or less a day. However, there were also around 15% of the subjects listened for an astonishing period of more than four hours a day during weekdays or weekend. Therefore, the average use of PSPs depends on individual discipline, or the teenagers' knowledge and awareness of the potential effect of listening to PSPs for long period. Comparing with data from ASHA (2006), 69% of the subjects listened to PSPs below 1 hour a day, while 7% listened more than 4 hours a day. We find that the subjects in the current study generally listened to the PSPs for a longer period of time. There was a lower percentage of them listened less than 1 hour a day and a higher percentage listened to more than 4 hours a day. This may due to some cultural differences between the United States and Hong Kong. According to Larson and Seepersad (2003), American teens spent more than half of their free time in social interaction and youth activities such as partying and sports, while East Asian teens spent only around one-fourth on these activities. Therefore, American teens have greater tendency than East Asian teens to spend time with peers rather than in self-engaged activities such as listening to PSPs.

It was found that female subjects had owned PSPs for a significantly longer period of time than male subjects. It may due to the nature of listening to music as a quiet hobby which meets with the quiet nature of most of the females, so females favour this hobby more than males and tend to own their PSPs earlier in life. Serra and Biassoni (2005) also found that females (15%) liked listening to music more than males (10%), which contrasted with other activities such as attending discos. Concerning the weekdays and weekends average listening time, there was no significant gender difference.

When comparing the usage pattern in different age groups, there was a natural predictable trend of increasing duration of ownership when the subjects got older. Among the

three groups, subjects aged 11 to 13 was found with significantly less average use in weekdays than the other two groups, while the '14-16' and '17-20' groups did not differ significantly. The average use in weekend had no significant difference among the age groups. The subjects in the age 11 to 13 may still be disciplined by their parents, with a heavy load of school work, they may not be allowed to listen too long during weekdays. As teenagers get older, they want to assert more independence and may spend more time to explore their interests (Larson & Seepersad, 2003).

The average usage in weekdays and weekends of the subjects were 2.4 hours and 2.8 hours respectively. Fligor (2006) suggested that, to use PSPs safely, one should limit the listening time to below one hour per day, with a volume about 60% of the maximum volume of the players. As the actual exposure volume of the subjects in this study was not known, it is not possible to conclude if the subjects in this study are at risk of hearing loss. However, according to The Hong Kong Society for the Deaf et al.'s (2007) survey, 12.3% of 1025 teenagers aged 12 to 24 would turn their volume to a level above 90dBA. And 38.6% of them used a volume above 90dBA in a background noise at 92dBA simulating listening in a subway train. According to HKEPD (2007), the noise level at 25 meters from a distributor road is about 70dBA while rail noise at a distance of 25 meters is about 80dBA. Given the high population density and heavy traffic in Hong Kong, the volume of PSPs is probably going to exceed safety limits. Therefore, the risk of hearing damage with the listening hours found in our subjects cannot be ruled out.

Hearing status of teenagers

Two procedures were used to evaluate hearing status in this study: Pure-tone audiometry (PTA) and transient-evoked otoacoustic emissions (TEOAE). Results from the pure-tone audiometry (PTA) suggested that only 22 subjects (6.7%) failed the screening at 25dBHL in either ear. The small proportion of failed subjects suggests that most subjects had hearing within normal limits, despite PSP use. There was no significant difference in PSP

usage and duration of ownership between those who passed and failed the screening. Although long listening hour may be damaging to hearing (Meyer-Bisch, 1996), other factors such as the volume of listening to PSPs, exposure to other environmental noise, or the subjects' individual susceptibility to NIHL (Henderson & Hamernik, 1996) may also play a role. Because NIHL is additive in nature (Patuzzi, 1992), the subjects might not yet have reached a noise dose to manifest hearing loss through the screening results (Redhead, 1998). Therefore, it is important to educate the teenagers about the nature of noise-induced hearing loss, the effects in the long run of listening to PSPs at loud volume for long period.

Another screening test conducted was TEOAE. TEOAE is a highly sensitive and objective measure reflecting the motility of outer hair cell, which magnifies stimuli entering the ear internally to provide a normal hearing threshold (Redhead, 1998). A total of 84 subjects (36.8%) failed TEOAE screening. This means that more than one third of the subjects had diminishing OAE, which is associated with outer hair cell damage, and in turn is believed to be mainly caused by acoustic over-stimulation (Rosanowski, Eysholdt & Hoppe, 2006). There was a great difference in passing rates between the TEOAE and the PTA results. Comparing the results of those who listened to PSPs and those who did not, greater proportion of subjects who listened to PSP failed OAE screening than those who did not use PSPs. These results implied that subtle damage in the inner ear due to noise exposure to PSPs might have been present, although they were not detectable using PTA. The usefulness of TEOAE in detection of subclinical damage to the inner ears before measurable pure-tone audiometric hearing loss could be identified had been recognized in many studies (LePage & Murray, 1998; Lucertini, Moleti & Sisto, 2001; Redhead, 1998; Rosanowski et al., 2006). Therefore, the possibility that subjects might have already acquired early stage hearing damage cannot be ruled out.

When the average use of PSPs was compared between the PSP users who failed and passed TEOAE testing, no significant difference between them was found. We see that only

knowing the average usage hours alone cannot determine the effect. This agrees with the experts' suggestions that we should not only pay attention to the average usage hours, listening volume was another factor determining the effect on hearing (Fligor, 2006). Therefore, further research on how the interaction of average use and exposure volume affects hearing status has to be conducted.

Although the screening was performed in settings meeting ANSI S3.21-2004 standard for pure-tone audiometry and with noise below a level that would affect OAE results, the actual hearing status and the nature of hearing loss of those who had failed the screening could not be confirmed because insufficient number of people referred for further assessment came to the reassessment. Therefore, it is difficult to conclude the exact relation between PSP use and NIHL.

Long-term effect of continuous exposure to PSPs

The results in this study showed that a significant proportion of teenagers were listening to their PSPs long enough to pose a risk of hearing damage, and that subtle damage on hearing might occur.

Owing to advances in technology, newly launched PSPs have longer battery life, larger music capacity and thus can hold more songs (Spencer, 2006). The implication is that people can listen to PSPs non-stop for longer periods of time, and duration of exposure is one of the factors determining noise-induced hearing damage. The most worrying aspect is the additive and cumulative nature of NIHL, such that early damage done may not be detectable by oneself or even by pure-tone audiometry (Folmer, Griest, & Martin, 2002). Early mild loss 'may well deteriorate to a debilitating degree in later life' (Folmer et al., 2002). By the time when the loss is readily recognizable, the damage might already be substantial and irreversible. LePage and Murray (1998) noted that the damage done to the inner ear by PSPs was 'analogous to rapid ageing of the cochlea, and comparable to hearing loss from industrial noise trauma'.

In addition to NIHL, noise-induced permanent tinnitus (NIPT) also has a slow and gradual onset (Axelsson & Barrenas, 1992), and it should be marked as another long-term effect of exposure to noise.

According to Neitzel and Meinke (2006), the emotional, psychological and sociological effects associated with NIHL and NIPT could not be ignored. For example, sleep disturbance, stress and annoyance are commonly associated with NIPT and/or NIHL. For teenagers in particular, the effects of NIPT and/or NIHL would be magnified when they are actively involved in social activities and start to develop intimate relationships later in life.

Therefore, people should pay special attention to the issue of hearing conservation against PSP noise. Due to lack of observable symptoms, public education should be promoted starting from early childhood. Otherwise, the consequence will be devastating and irreversible.

Limitations of the study and suggestions for further research

The subjects in this study were attending the same school, it was likely that their social circles were overlapped and their habits might be affected by each other. Therefore, the listening habits of the teenagers in this study may not be representative of the whole teenage population in Hong Kong.

The self-reported questionnaire used was not a standardized one, thus the results could just provide an overview of the subjects self-perception of hearing status without diagnostic value. The subjects' honesty in completion was a limitation. Despite clear instruction, some of the subjects might fill in the questionnaire in a playful manner due to individual personality or maturity level. As the data collection took place during lesson time, some of the subjects completed the questionnaire in a rush without careful consideration. These might affect the accuracy of the information given. The questionnaire focused on the subjects' habit of listening to PSPs. There was no question regarding other popular activities among teenagers involving exposure to extensive noise, such as attending karaoke,

discotheque, concert, game arcade, cyber café, etc. A comprehensive noise exposure history of the subjects was not obtained. Therefore, this study cannot eliminate possible noise factors other than PSP use leading to the damage of hearing.

This study did not focus on the quantification of exposure level to PSPs. The volume the subjects listened to was just collected in a self-reported format. While different brands and types of PSPs have different sound output levels, and the subjects' perceptual judgment of loudness provided little information, the exposure level was actually unknown. The effect of noise exposure depends on both the exposure level and the exposure duration (Portnuff & Fligor, 2006), so limited conclusion could be drawn without any of these aspects.

To estimate the actual effect on hearing due to PSP use, we need to collect data on the exposure level, exposure duration and the hearing status of the same group of subjects. However, this and previous researches focused on either one or two of the above but not all. Therefore, further research to investigate the effect on hearing due to exposure to PSPs has to take into account these aspects. The selection of subject would better involve random sampling and a comprehensive noise exposure history could be collected.

Consensus was not reached on whether using different types of earphones had an effect one's exposure level. Some stock type earphones had been launched by manufacturers claiming to be able to reduce the background noise and the exposure level to music, which could then reduce risk of acquiring hearing loss. Research on this area could be conducted to compare the exposure level using different types of earphones.

Conclusion

The teenagers in this study exposed to PSPs with a potentially hazardous duration. Mild subclinical damage to the inner ear might have been present in a significant proportion. Though a definite relation between listening to PSPs and noise-induced hearing loss was not drawn, the damage risk on hearing due to PSP use cannot be ruled out. Public awareness and education has to be enforced, teenagers are to be reminded about the need of hearing conservation.

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Appendix A: Instructions for subjects

關懷耳聰齊參與

請仔細閱讀以下資料。如有疑問，歡迎隨時向工作人員提出。

檢查目的：

探討一般中學青少年的聽力狀況。

步驟：

1. 請如實填妥問卷，並在背頁記錄表填上你的姓名、年齡(已過生日)、出生日期、性別、班別、學號等。
2. 醫生會簡單觀察檢查你的耳朵，如有需要會在記錄表上記錄。
3. 請你帶記錄表到 102 室或 123A 室(學生活動中心)進行聽力檢查。
4. 將記錄表交給聽力學家，聽力學家會為你戴上耳筒，請你在小房間內坐好，依照指示，每一隻耳朵聽到「嘟嘟」聲時按掣(或舉手)表示，無論「嘟嘟」聲多麼微弱亦要按掣(或舉手)。
5. 工作人員會再指示你帶記錄表到 111 室檢查。
6. 將記錄表交給聽力學家，聽力學家會為你每一隻耳朵戴上耳塞，請安靜及放鬆地坐好，你從耳塞中會聽到一些「噠噠」聲，你不需作任何反應。
7. 工作人員將收回你填妥的問卷及記錄表。
8. 以上過程共約須時 10 分鐘。
9. 如果在檢查過程中發現你今天不適合接受檢查，工作人員會為你預約另一個時間及通知老師。

Appendix B: Questionnaire 編號 #_____

耳聽心言基金及紫荊青年商會
「關懷耳聰齊參與」問卷調查

這份問卷目的在於了解中學生聆聽聲音的狀況。請細心閱讀以下每條問題，提供最貼切你自己情況的答案。

甲部: 請圈出最合適的答案 。例如： 是 (否)

1.	當你在家裡與人傾談電話時，聆聽對方的說話是否感到困難?	是	否
2.	你是否感到有一隻耳朵聽電話是較為清楚?	是	否
3.	當你跟兩個或以上的人交談時，是否感到較難跟上傾談的內容?	是	否
4.	當你聽不清楚電視機或收音機的廣播而將音量調高時，別人是否投訴你將音量調得過大?	是	否
5.	當你與別人談話時，是否需要很用心才能聽得清楚對方的說話?	是	否
6.	你在快餐店或茶餐廳裡聆聽別人說話是否感到困難?	是	否
7.	你是否有暈眩、耳朵疼痛或耳鳴的情況?	是	否
8.	你是否發覺自己經常要求別人將說話重覆一遍?	是	否
9.	你的家人或同學是否覺得你經常聽不到他們說話?	是	否
10.	你是否覺得別人的說話總是含糊不清?	是	否
11.	你是否會理解錯誤別人的說話且答非所問?	是	否
12.	你是否感到聆聽女士們的說話較為困難?	是	否
13.	當你聽不清楚而誤解了別人的說話時，對方是否因此而感到不悅?	是	否
14.	你是否感到自己的聽覺能力較弱?	是	否
15.	你是否利用 iPod 或 MP3 這些隨身音響器材收聽歌曲?	是	否

乙部：請將適當的答案填在橫線上或在空格內加上『√』。

1. 你所擁有的 iPod 是屬於那種牌子及型號 ？(如未擁有 iPod，請填寫『沒有』)
   牌子_____ 型號_____
2. 你所擁有的 MP3 是屬於那種牌子及型號？ (如未擁有 MP3，請填寫『沒有』)
   牌子_____ 型號_____
3. 你從什麼時候開始經常使用 iPod 或 MP3 收聽歌曲 (大約有多少個月)?
   _____個月
4. 於星期一至五，你每天大約花多少時間使用耳筒收聽 iPod 或 MP3 播放的歌曲? _____小時
5. 於星期六及日，你每天大約花多少時間使用耳筒收聽 iPod 或 MP3 播放的歌曲?
   ____小時
6. 當你使用耳筒收聽 iPod 或 MP3 播放時，通常調校的音量度數是多少？_____
   度
7. 你是使用哪一類型的耳筒收聽 iPod 或 MP3 播放的歌曲?
   □ 入耳式耳筒 
   □ 耳罩護耳式耳筒 
8. 於星期一至五，你每天大約花多少時間是使用耳筒玩電腦遊戲? _____小時
9. 於星期六及日，你每天大約花多少時間是使用耳筒玩電腦遊戲? _____小時

丙部: 請將合適的答案填在橫線上或在空格內加上『 √』。

1. 年齡：_____ (至 2006 年 9 月 1 日)
2. 性別： □ 男 □ 女
3. 班級 : _____
4. 如你對這次問卷調查有任何意見，請寫在以下的橫線上:

_____

_____

_____

*** 完 ***

多謝你利用寶貴時間參與此項問卷調查。

Appendix C: Audiologic Screening Form

Ear Caring for Youth
關懷耳聰齊參與

個人資料 (請同學自行填寫)

姓名: _____ 年齡: _____ 性別: _____

出生日期: _____年 _____月 _____日 班別: _____ 學號: _____

Otoscopic Examination by ENT Doctor: _____

- ❑ N.A.D.
- ❑ Current Hearing Aid User
- ❑ Impacted wax (❑ cleared)
- ❑ Perforated t.m.
- ❑ Other diagnosis _____
- ❑ Comments _____

Audiometry Screening – air conduction (if fail, please check AC thresholds)

✓ = Pass at ____ dB HL × = Fail at _____ dB HL

Frequency	500 Hz	1000 Hz	2000 Hz	3000 Hz	4000 Hz
Right ear					
Left ear					

❑ AD 226 ❑ GSI 68

Reliability ❑ Good ❑ Fair ❑ Poor

PTA Audiologist: _____

Otoacoustic Emissions:

	Total	1k	1.5k	2k	3k	4k
(R) Reproducibility (%)						
(R) Response (dB)						
(L) Reproducibility (%)						
(L) Response (dB)						

Recommendations:

- ❑ No further action
- ❑ Medical Referral
- ❑ Others _____

_____

OAE Audiologist: _____

Date: _____