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TECHNICAL NOTE

Fitness Instructors and Noise Exposure: Spreading the Hearing Health Message

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Abstract This study investigated self-reported indicators of noise exposure, symptoms of hearing loss and awareness of hearing problems in 76 Australian fitness instructors working in the Newcastle area (NSW) 1997–1998 and Sydney in 2009–2011. Nineteen Newcastle instructors also submitted for audiometry. Instructors spent an average of 11.5 h/week in fitness classes, 30.3 % did other paid work involving noise exposure for all or most of the time and for an average of 25 h/week and 72.4 % attended music entertainment venues for an average of 4 h/week. The loudness categories and previously recorded noise levels were used to estimate Pascal-squared hours of noise exposure, and instructors were classified into low- and high-exposure groups. 64 % of instructors reported experiencing at least one of the symptoms of tinnitus, temporary hearing loss, dizziness, or the need to turn up the volume on the radio and there was a non-significant correlation between the occurrence of symptoms and noise exposure. More instructors reported no symptoms in the low- compared with the high-exposure group. Audiogram hearing thresholds were compared against the 10th percentile of gender- and age-matched normal subjects. 68.8 % of audiograms revealed an elevated threshold in at least one ear and 37.5 % showed an auditory notch at 6000 Hz. Overall the findings showed that more than half of fitness instructors had signs or symptoms of hearing loss and were potentially exposed to excess noise. It is important to communicate the risks of loud music in fitness classes and partner with media outlets to publicise research findings and raise awareness amongst those at risk.

Keywords Noise · Noise-induced hearing loss · Hearing · Audiogram · Fitness

1 Introduction

Live and recorded loud music has been known for several decades to present a risk of harm to hearing, and noise-induced hearing loss (NIHL) has been demonstrated in a diverse range of musicians and listeners [1–5]. Music venues are associated with leisure and enjoyment and generally are unlikely to focus on harm, so awareness of potential hearing loss by those who frequent such venues might be expected to be fairly low. Beach et al. [6] surveyed 1000 young people about their attendance at a range of music venues and their perceptions of risk to hearing. They found nightclubs were noisiest and posed the greatest risk to hearing, but self-perception of noise-induced risk increased with increased noise exposure, suggesting that many of those at risk have some insight into the potential for noise to cause hearing damage.

Loud music also occurs in fitness classes, but again, the focus is on enjoyment of healthy exercise and not on hearing health. Music noise in fitness activities has been measured and found to be consistently high across several studies [7–9]. Beach and Nie [9] conducted a study of noise levels in selected NSW fitness classes and found the mean class noise level, measured as the equivalent continuous A-weighted

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sound pressure level (L_{Aeq}) was in excess of 90 decibels (dB) and posed a potential risk to hearing for fitness instructors.

The current study is an analysis of additional questionnaire data and audiograms obtained by Beach and Nie [9] during data collection in 1997–1998 and 2009–2011. The objectives of the current investigation are to assess:

- The weekly duration of time spent instructing or participating in fitness classes, other paid work and attending music venues to allow estimation of noise exposures and risk of harm to hearing;
- The self-reported presentation of symptoms associated with hearing loss;
- Self-reported hearing difficulties and
- Audiometric signs of hearing loss;

to determine whether instructors accumulate weekly noise exposures in excess of the equivalent of the workplace noise exposure standard [10], if they experience symptoms or signs of hearing loss, and if they are aware of hearing difficulties. The study aims to characterise the extent of the risk to hearing for fitness instructors so that it can be publicised within the industry, with a view to raising instructor awareness and promoting strategies for risk minimisation.

2 Methods

Informed consent was sought and obtained from two urban fitness gyms in Newcastle and Lake Macquarie (NLM) in 1997–1998 and eight gyms in Sydney in 2009–2011. All instructors at the two NLM gyms were invited to complete paper questionnaires and submit for audiometry. Sydney instructors were asked to complete the same questionnaire on line, but were not offered audiometry. The University of Newcastle and the Australian Hearing Human Research Ethics Committees granted approval for the NLM and Sydney data collections, respectively, in accordance with the Helsinki Declaration.

2.1 Questionnaire

The questionnaire consisted of 35 questions arranged in 5 sections. Some questions were not part of the current study, but those that were relevant sought information as follows:

- Demographics, to ascertain gender, age and duration of work as a fitness instructor;
- Fitness instructing, to ascertain the hours per week spent instructing and participating, and symptoms of tinnitus, temporary threshold shift (TTS), temporary dizziness and 'the need to turn up the volume on the radio or TV' (TUV), after fitness classes or at other times;
- Other paid work, to determine if other work was done, the type as categorised by the Australian and New Zealand Standard Industrial Classification [11], whether it involved exposure to noise, the proportion of the work day involved, the perception of loudness and whether it was enjoyable, acceptable, annoying or distressing;
- Attendance at music entertainment venues, to determine if live or recorded music venues were ever visited, the hours per week spent there, the perceived loudness, whether it was enjoyable, acceptable, annoying or distressing and whether symptoms of tinnitus, TTS or TUV were experienced after listening to the music;
- Hearing health awareness, to determine if there were current or past hearing problems, and if a health practitioner had ever been consulted about them.

Questionnaire data were analysed using the SPSS Statistics Standard Package [12]. Missing data were excluded from analyses.

2.2 Audiometry

Arrangements for audiometry were made with each consenting instructor. It was not possible to insist on at least 12 h of prior quiet time, but all subjects were encouraged to maximise preceding quiet when scheduling audiometry. Audiograms were recorded at different times of the day and in different environments to suit the particular needs of the subjects, but all were conducted under minimal background noise conditions, mostly in quiet residential locations.

Pure tone audiograms were obtained using a Welch Allyn AM232 audiometer and manually recorded on charts. Each ear was tested at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hertz (Hz) using headphones adjusted to fit the subject. Subjects were asked to confirm the prior period of quiet and to indicate if they had any previously diagnosed hearing problems, including from childhood. Any unusual circumstances or interferences in the recordings were noted.

2.3 Study Participants

Twenty seven instructors from NLM completed the paper questionnaire, 47 Sydney instructors completed the questionnaire online and 2 Sydney instructors completed the paper version, totalling 76 instructors in the study. The gender distribution was 77.6 % females, 22.4 % males, with a mean instructor age of 33 years (range 20–55) and mean length of employment at fitness gyms of 73 months (range 2–300).

The Australian Fitness Industry Workforce Report 2010–2020 estimated 56 % of all registered exercise professionals were female and 62 % were in the age range 22–39 years [13].

In the current study, the sample was younger and included a greater proportion of females: 77.6 % of instructors were female, with an almost identical gender distribution in NLM and Sydney, and 72.4 % were aged 22–39 years, with the NLM cohort being a little younger than the Sydney instructors. However, the 2010–2020 workforce report [13] covered many different types of exercise professional, all formally registered, whereas the current study involved only fitness class instructors of unknown registration status. There are no precise data on the gender and age profile of fitness class instructors per se, and the current study participants were considered to be representative of the industry in Australia over the time period 1997–2011, with regard to vulnerability to the potential effects of noise on hearing.

Seventeen of the 27 NLM instructors completing a questionnaire presented for audiometry. Two, both females, presented for audiometry but did not complete questionnaires and were of unknown age. All NLM instructors were aged 20–39 years and the majority presenting for audiograms were aged 20–29 years.

3 Results

3.1 Questionnaire Responses

The survey results from the NLM and Sydney cohorts were compared to determine if there were differences between the two groups with regard to the various measures of noise exposure and hearing health assessed in the questionnaire, i.e. hours per week instructing or participating in fitness classes, the presence of hearing-related symptoms, hours spent in other paid work and entertainment venues and awareness of hearing health problems. Apart from a significant difference in age (NLM: 26.4 years vs Sydney: 35.9 years, $t(74) = 5.3,\ p < .01$), there were no other significant differences between the groups, and therefore the data from both cohorts were analysed together.

The instructors instructed or participated in fitness classes for an average of 11.5 h per week (h/week) (median 10.0; range 2–37). They were asked about the occurrence of symptoms after instructing or participating in fitness classes, and/or at other times. Over six percent (6.6 %) reported tinnitus, 12 % TTS, 7 % dizziness and 15 % TUV, after fitness classes, but 54.7 % reported at least one of these hearing-related symptoms after fitness classes and/or at other times.

Most instructors (73.7 %) did other paid work for an average of 25 h/week (median 25; range 1–45). Only 40 of the 56 reported on work type, with the majority reporting work in a service industry. Of the 53 who reported on the type of noise, over half (52.8 %) reported no exposure to significant noise and 34.0 % exposure to music noise. Typical industrial noise was not a common source of exposure. For the 25 who reported doing other paid work with noise exposure, the proportion of time exposed to noise at work was: all or most of the time for 68 %, half of the time for 16 % and occasionally for 16 % of respondents. Overall 22.4 % of all instructors reported doing other paid work involving noise exposure for all or most of the time. No instructors reported work noise as very loud, but 12.9 % reported it as loud, 51.6 % as moderately loud and 35.5 % as soft.

The majority of instructors (72.4 %) visited music entertainment venues for an average of 4 h/week (median 3; range 0–40). Nearly, a third (32.1 %) reported the music was very loud, 28.6 % loud, 28.6 % moderately loud and 10.7 % soft. 16.4 % considered the music volume to be annoying or distressing, whereas 83.6 % considered it to be acceptable or enjoyable. More than half (53.7 %) reported experiencing tinnitus and/or TTS and/or TUV for a short time after attending music entertainment venues. Altogether 64 % of all instructors experienced at least one of the symptoms of tinnitus, TTS, dizziness or TUV after fitness, or music entertainment, or at other times (reported in questions on symptoms associated with fitness or other and symptoms associated with music entertainment or other).

A fifth (20.5 %) of instructors were aware of current hearing problems, but only 5 of 75 (6.7 %) reported past hearing problems, with one indicating it was related to childhood disease. 12 % of instructors had consulted a medical practitioner for hearing problems.

3.1.1 Estimates of noise exposure and their relationship to symptoms of hearing problems

Each instructor's total estimated hours of noise exposure was calculated by summing the average h/week spent in (1) fitness; (2) music entertainment venues; and (3) other paid work, the latter adjusted by multiplying the reported h/week by 1.0 if the instructor was exposed to noise all of the time, 0.75 for most of the time, 0.5 for half of the time and 0.25 if exposed occasionally. The average total adjusted hours of noise exposure was 21.5 h/week (median 17; range 2–108).

The instructors were divided into two groups for total adjusted h/week noise exposure: low exposure: ≤median 17 h/week and high exposure: >median 17 h/week, and scored as to whether they had sometimes or never reported the symptoms, tinnitus, TTS, dizziness or TUV at any time. As shown in Fig. 1, hours of noise exposure was compared to the symptom report and there were more subjects *never* reporting symptoms in the low-exposure compared to the high-exposure group, but those who reported that they had experienced symptoms at least sometimes were evenly distributed across the two groups. The same trend of more subjects never reporting symptoms in the low-exposure compared to the high-exposure group was also apparent for fitness

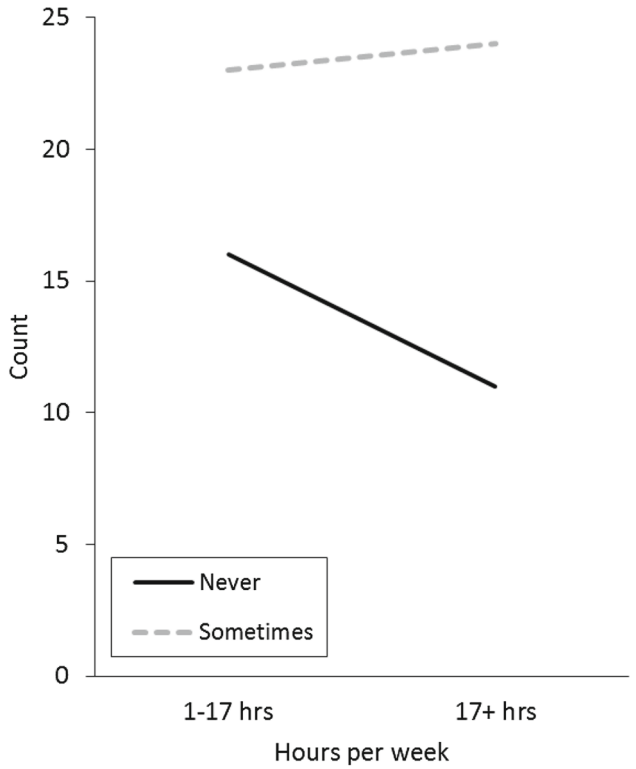

Fig. 1 Adjusted all hours per week noise exposure groups against whether any symptoms were never or sometimes reported

h/week and entertainment h/week, but again there was no clear trend for those reporting symptoms.

Duration is only an indirect estimate of noise exposure and does not factor in the intensity of noise, so it was decided to calculate each instructor's estimated total Pascal-squared hours (Pa^2h) per week for the time spent instructing and participating in fitness classes, in paid work and at entertainment venues, using the formula: $4 \times T\ (h) \times 10^{\cdot 1(L_{Aeq}-100)}$ [14]. L_{Aeq} values for the fitness classes were drawn from Beach and Nie [9] who reported an average L_{Aeq} for instructors of 90.1 dB and for participants of 88.9 dB. Other paid work and entertainment venue L_{Aeq} values were conservatively estimated according to the loudness categories: 90 dB for very loud, 85 dB for loud, 80 dB for moderately loud and 75 dB for soft.

Each instructor's total reported symptoms were calculated by allocating 1 point each to tinnitus, TTS, dizziness and TUV experienced after fitness or at other times, and to each of tinnitus, TTS or TUV after attending music entertainment venues, making a possible total of 7 points per instructor.

36 % of instructors reported no symptoms ever and had an average estimated noise exposure of 11.7 Pa^2h, whereas 64 % reported at least one symptom and had an average estimated noise exposure of 14.3 Pa^2h. A Student t test showed no significant difference in Pa^2h between the two groups ($p > .4$), and a Pearson correlation between the Pa^2h and symptom scores showed a non-significant but positive correlation ($r = 0.13$).

3.2 Audiometry

Of the 19 NLM instructors who presented for audiometry, most reported a period of quiet of at least 12 h, minimum 6 h, prior to the recording. One instructor reported having ear disease and deafness since childhood and was excluded from analysis. Three others reported hearing problems but did not specify diagnoses and were included in analysis. Audiograms for 18 instructors (15 female, 3 male) were analysed, with 16 of them also completing questionnaires. Thirteen of the 16 were aged 20–29 years and 3 were aged 30–39 years. The 2 additional female instructors of unknown age were conservatively assumed to be in the age range 30–39 years, for the purpose of comparing their hearing thresholds against those of otologically normal subjects. Two of the 18 instructors had audiograms only for the right ear, therefore there were 16 bilateral and 2 further right ear records analysed. The 16 instructors who completed a questionnaire spent an average of 10 h/week (range 2–31.5) in fitness classes and had worked as an instructor for an average of 64 months (range 2–192).

The 4-frequency average hearing loss (4FAHL)[1] was computed and thresholds at 4000, 6000, and 8000 Hz were identified for each audiometric subject, for each ear. These values were then subtracted from the corresponding indices derived for the 10th percentile of an otologically normal population matched for gender and age range, sourced from ISO 7029 [15]. Pearson correlations between the ears for the four hearing threshold differences were computed. The correlation between the left and right ear 4FAHL differences was highly significant ($p = 0.002$), and although there was no significant correlation at 4000 Hz, the correlations between the left and right ears at both 6000 and 8000 Hz were significant (6000 Hz: $p = 0.032$; 8000 Hz: $p = 0.024$), Since there should be no difference between left and right ear thresholds in otologically normal and most NIHL subjects, these significant correlations are evidence of the reliability of the audiometric recordings.

The hearing threshold differences for left and right ears at 4FAHL, 4000, 6000 and 8000 Hz, shown in Fig. 2, reveal that 12 of the 18 subjects had at least some threshold differences above zero. Threshold differences above zero indicate more hearing loss than expected when compared to the 10th percentile of otologically normal ISO subjects, and differences below zero are within the range expected for 90 % of the population. Most of the threshold differences above zero were observed at 6000 and 8000 Hz—11 of the 16 instructors (68.8 %) demonstrated more hearing loss at 6000 Hz in

[1] 4FAHL is the average threshold at 500, 1000, 2000 and 4000 Hz.

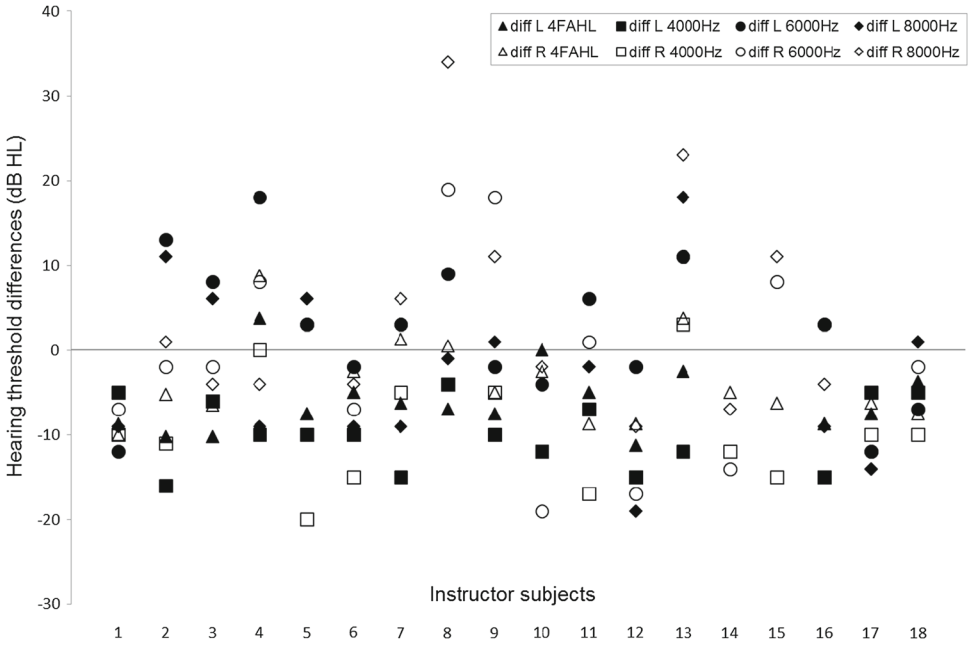

Fig. 2 Hearing threshold differences of all subjects compared to the 10th percentile of an otologically normal population matched for gender and age range, for 4FAHL, 4000, 6000 and 8000 Hz (No left ear audiograms for subjects 14 and 15)

at least one ear, and 6 (37.5 %) showed an auditory notch at 6000 Hz.

Subject 4 had a hearing threshold difference above zero for 4FAHL and also demonstrated an auditory notch at 6000 Hz, in both ears. Subject 4 was female, 22 years of age and had been instructing for 42 months. Subject 8 showed more hearing loss at 6000 and 8000 Hz compared with 90 % of otologically normal males of the same age range and demonstrated an auditory notch in the left, but not right, ear at 6000 Hz. Subject 8 was male, aged 32 and had worked as an instructor for 24 months. Both subjects 4 and 8 reported awareness of current hearing problems.

4 Discussion

This study suggests that fitness instructors are at risk of hearing damage, arising from their cumulative noise exposure from fitness classes, other paid work and music entertainment venues. Not only do instructors spend an average of 11.5 h/week in fitness classes where the average noise levels exceed 90 dB L_{Aeq}, but they are also spending on average 25 h/week in other paid work, with 25–30 % reporting being exposed to loud or moderately loud noise for all or most of that time. Furthermore, nearly three quarters of the instructors attended music entertainment venues for an average of 4 h/week and most thought the music volume was loud or very loud. Previous research suggests that music venues, such as nightclubs, pose a significant risk to hearing [16]. Average noise levels are reported to be 97 dB L_{Aeq}, and the average duration of a nightclub visit is 3.3 h, resulting in exposure that exceeds the weekly workplace noise exposure limit [6]. In the current study, 72.4 % of instructors attended music entertainment venues, frequently reported as nightclubs, for an average of more than 3.3 h/week. These leisure activities therefore added significantly to the instructors' overall noise exposures and their risk of NIHL. Instructors generally found entertainment music volumes acceptable or enjoyable, despite the reported loudness and potential harm to hearing. In a previous study, Beach and Nie [9] showed that the instructors regarded increasing the music volume in fitness classes to be motivating rather than stressful and preferred higher volumes than their clients for high intensity classes. This indicates instructors' perceptions of the acceptability of loud music are at odds with the risks posed to hearing.

Symptoms of hearing damage were widespread amongst instructors, with almost 55 % reporting at least one of the symptoms of tinnitus, TTS, dizziness or TUV. This indicates that half of the instructors may be experiencing hearing problems consistent with excess noise exposure. Furthermore, three times as many instructors indicated they had a hearing problem at the time of completing the questionnaire compared with those reporting problems in the past. They represented approximately a fifth of all instructors. However, since over 50 % reported symptoms of hearing loss, it may be that many instructors had not interpreted their symptoms as indicative of hearing problems. Although the relationships between symptoms and the measures of noise exposure (adjusted h/week and estimated Pa^2h) were not statistically significant, there was a positive correlation between symp-

toms and Pa^2h and there were clear trends in the data, with those that had never reported symptoms more likely to be in the low- rather than the high-exposure group.

Interestingly, when the results from 1997–1998 and 2009–2011 were compared, we found that, despite a significant age difference, both cohorts reported similar rates of hearing-related symptoms and spent a similar amount of time in fitness classes, other paid work and music entertainment venues. Given that our previous study showed that average noise levels in fitness classes also remained similar from 1997–1998 to 2009–2011 [9], this suggests that the risks associated with instructing fitness classes have not changed during this time period.

Notwithstanding the limitations of small sample size and differing test environments for the collection of audiometric data, the fitness instructors' hearing thresholds were indicative of noise-induced hearing damage, with a number of audiograms strongly suggestive of mild NIHL. In particular, subjects 4 and 8 showed audiometric signs of hearing loss consistent with excess noise exposure. Together they represent 11 % of the 18 instructors who provided audiograms. 68.8 % of instructors showed higher thresholds and 37.5 % demonstrated an auditory notch, at 6000 Hz. Although NIHL classically produces a notch at 4000 Hz, there have been a number of studies showing a notch at 6000 Hz. A study of Indian Air Force personnel exposed to high levels of noise noted a significantly greater prevalence of NIHL notches at 6000 Hz compared with 4000 Hz [17]. It was argued that the shift of the notch from 4000 to 6000 Hz resulted from a greater proportion of higher frequencies in the aviation noise spectrum. This may be relevant to noise from music exposure, which also might be expected to have a different frequency spectrum when compared with industrial noise. In a 2010 investigation of student musicians aged 18–25 years, 45 % of the students demonstrated an auditory notch and 72 % of notches were at 6000 Hz [2]. These students were comparable in age range and the prevalence of auditory notches at 6000 Hz, to the fitness instructors in the current study.

When considering the audiometric results, it should be noted that most subjects did report at least 12 h free from exposure to loud noise prior to the test, but this was not verifiable and the elevated thresholds therefore may be, at least partly, a result of TTS rather than permanent NIHL. Nevertheless, taken together, the findings from the questionnaires and the audiometry indicate that at least half of fitness instructors may be experiencing some symptoms of hearing problems consistent with temporary and/or permanent hearing loss. Fitness instructors are generally relatively young and in good health, so the numbers experiencing hearing symptoms are of concern.

5 Conclusions and Implications for the Fitness Industry

This study has suggested that many fitness instructors are exposed to excessive noise through work in the fitness industry, other paid work and visiting music entertainment venues, and as a result more than half may be experiencing symptoms of hearing damage. With no significant differences in noise exposure or symptoms experienced by the NLM and Sydney cohorts, it seems that little has changed in the period between 1997–1998 and 2009–2011. The estimated noise exposures present a real risk of harm to hearing and the audiograms reveal that some instructors already have elevated hearing thresholds consistent with TTS and/or NIHL. To mitigate their risk, instructors can adopt behaviours such as turning down the music volume in fitness classes. Hearing risks from other paid work can be reduced through adherence to workplace hearing conservation policies and use of appropriate hearing protection. Moving away from the speakers, limiting the time spent there and/or using appropriate earplugs can reduce the risk of exposure to noise at music venues. The key to the adoption of protective behaviours is awareness of the risks.

Spreading awareness beyond the professional and academic community and targeting at-risk groups such as fitness instructors presents a challenge for researchers. In the long term, hearing awareness training should be incorporated into formal fitness trainer programmes, but in the meantime, awareness can be raised in newsletters, other widely read publications or social media, to encourage changes in behaviour. Beach [18] took this approach in an article for *Australian Fitness Network*, which described the benefits of using faster rhythms rather than raised volume to motivate fitness classes. This article, which drew on the findings of Beach and Nie [9], was promoted via social media, and over several months attracted local and international media coverage. It was covered by Channel 10's *The Project*, *The Age/Sydney Morning Herald*, and overseas media outlets such as *The Daily Mail UK*, *WAAY-TV Alabama*, and *WJXT Florida*. Although the widespread media coverage suggests there is an interest in this topic, it is difficult to gauge whether fitness instructors or gyms have taken notice. Apart from one national employer providing staff gymnasium facilities, which used our work to raise awareness in their monthly newsletter, we have had no other industry feedback. Nevertheless, noise researchers are encouraged to disseminate their findings widely through interested media outlets, to raise public awareness. Articles written in non-technical language and published in appropriate print and online forums should become part of our repertoire as we seek to spread the noise exposure control message, both in work and leisure activities.

Compliance with ethical standards

Human Research Ethics Committee The University of Newcastle Human Research Ethics Committee granted approval for the 1997–1998 data collection, requiring informed consent by the Newcastle and Lake Macquarie fitness instructors prior to the completion of questionnaires or audiometry. The Australian Hearing Human Research Ethics Committee granted approval for the 2009–2011 Sydney data collection, also requiring informed consent prior to questionnaire completion.

Conflicts of Interest There were no financial or non-financial conflicts of interest in data collection, analysis, or preparation of the manuscript. The University of Newcastle and Australian Hearing funded the study.

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