Work Out Your Body, Not Your Ears!

Noise-Induced Hearing Loss and Leisure Activity

BY LAURA GAETA AND ANDREW B. JOHN

The increasing prevalence of noise-induced hearing loss among adults has been associated with exposure to occupational as well as non-occupational sources of noise. Noise levels and participants' hearing were assessed after a group fitness class, revealing a significant change in hearing thresholds.

Hearing loss due to noise exposure, or noise-induced hearing loss (NIHL), affects 15 percent of adults between the ages of 20 and 69 (Hoffman et al, 2006). Initially, NIHL may present as a temporary threshold shift (TTS), or a transient decrease in hearing sensitivity that recovers, though not completely, after exposure to the stimulus has ended. The traditional view of NIHL has suggested that repeated TTS eventually lead to a permanent threshold shift (PTS), in which a patient's hearing does not recover as well after repeated TTS-inducing exposures.

However, attempts to predict PTS from a history of TTS have shown mixed results (e.g., Melnick, 1991; Themann et al, 2015), largely due to individual variability. Research in animal models has suggested that the mechanisms of TTS and PTS may be dissimilar (Nordmann et al, 2000). It is likely, however, that noise exposures that result in TTS are also related to synapse loss and neural pathology in the auditory pathway that are characteristic of PTS (Kujawa and Liberman, 2009).

Most traditional public health and education efforts have been focused on the prevention of hearing loss from occupational noise exposure (HHS, 1996). However, several

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recent studies have identified a disturbing trend of increasing prevalence of NIHL in young adults, likely related to noisy leisure activities (e.g., Shargorodsky et al, 2010). The increasing prevalence of NIHL among young people and associated with leisure activity makes it a significant public health concern and is an important area of Healthy People 2020 (HHS, 2014).

In recent years, hearing conservation efforts have been implemented in schools and occupational settings, supported by initiatives of the Occupational Safety and Health Administration (OSHA) and the National Institute of Occupation Safety (NIOSH) (1998). To promote behavior change and reduce the prevalence of NIHL, the Dangerous Decibels (http://dangerousdecibels.org) public health campaign provides resources and education to school-aged children, and the American Academy of Audiology's campaign, Turn it to the Left (www.turnittotheleft.org), addresses NIHL in children and promotes research on NIHL.

In spite of these efforts, there is a lack of awareness and a need for more effective dissemination of information regarding NIHL and hearing conservation in occupational and non-occupational sources of noise exposure (Berger and Royster, 1987). The gradual onset and insidious nature of NIHL present a particular challenge for educators, given that hearing conservation efforts necessarily emphasize long-term effects of noise exposure rather than any immediately perceptible benefit of healthy-hearing behavior. In addition, it can be very difficult to recommend noise abatement or avoidance strategies for leisure activities in which participants derive enjoyment from the presence of that dangerous noise. One example of this is high-volume music used in popular group fitness classes.

Fitness and Hearing

Healthy People 2020 not only seeks to address NIHL but increase physical exercise among children and adults. The majority of adults and adolescents do not participate in enough physical aerobic and muscle-strengthening exercise recommended by the 2008 Physical Activity Guidelines for Americans (HHS, 2008). Physical exercise is important, regardless of age, to improve

quality of life and overall health. Exercise decreases the risk of cardiovascular disease, diabetes, osteoporosis, depression, and premature death (Warburton et al, 2006). In addition, a healthy lifestyle incorporating a nutritious diet and physical exercise may have protective effects against hearing loss (Ismail et al, 1973; Curhan et al, 2013; Spankovich and Le Prell, 2014).

Since the advent of aerobics classes and health clubs in the 1970s and 1980s, interest in physical fitness has risen. Since the 1990s, the term "group fitness" has been used to reflect aerobic strength-training classes such as Pilates, outdoor classes like boot camp, and dance-based programs (Schroeder and Friesen, 2008). Membership in health clubs has increased from 41.3 million in 2005 to over 55.3 million in 2015 (International Health, Racquet, and Sportsclub Association, 2016).

TABLE 1. Questionnaire

On average, how many group fitness classes per week do you attend?
Do you enjoy the music during the class?
How would you rate the loudness of the music during the class?
If you could change the volume of the music during class, you would prefer it to be:
How often do you wear ear plugs or hearing protection during the class?
If hearing protection (e.g. earplugs) were provided for the class, how likely would you be to use it?
Are you aware that exposure to loud sounds can cause hearing loss?
Have you experienced ringing in your ears (tinnitus) after the class?
Have you noticed that speech sounds muffled for a while after class?

The growing popularity of fitness centers, development of initiatives to encourage physical activity, and the advent of wearable health technology have led to the creation of novel group fitness classes of varying intensities for all ages (President's Council, 2016). Moderate- to high-intensity classes are typically fast-paced and use music to motivate and create a dynamic atmosphere for participants. Previous research has demonstrated the impact of music tempo (Schwartzmiller, 2003; Gordon, 2007) and music choice (Johnson, 2004) on participants' exercise performance and intensity.

Group fitness instructors use music that features a tempo (i.e., beats per minute [BPM]) that corresponds to the intensity of the exercise class (e.g., tempo of less than 100 BPM for yoga or between 130 and 160 BPM for mid-to-high impact fitness classes) (Mansour, 2011). The music, along with the instructor's voice, can create an environment in which noise levels can easily exceed the OSHA-recommended permissible exposure limits.

Hull (1991) measured music levels in health clubs and spas, and found that 80 percent of the centers had music that exceeded 105 dB(A) over 60 minutes and the instructor's voice averaged about 110 dB(A). In a more recent study, Beach and Nie (2014) compared noise levels in fitness classes in 1997–1998 and 2009–2011, and found that the average noise level in high-intensity classes in 2009–2011 was 93.1 dB(A), an increase of 3-dB from 1997–1998. The music levels observed by Hull (1991) and Beach and Nie (2014) were in excess of 85 dB(A). NIOSH (1998) guidelines establish a time-weighted average limit of 85 dB(A) for eight hours, with a 3-dB(A) time-intensity exchange rate. Therefore, participants in the classes observed by Hull (1991) and Beach and Nie (2014) may have been at risk of permanent hearing loss after a 60-minute class.

Given the high levels of noise in group fitness classes measured in these studies, and because participation in these classes is on the rise, the first author (LG) led an investigation which evaluated both noise and TTS risk in one group fitness class type (Zumba) at a local fitness center. In addition, we surveyed participants' attitudes and behaviors regarding noise exposure and group fitness to determine receptivity to adapting healthy-hearing behaviors (such as decreased music volume or use of hearing protection) during those classes (see TABLE 1 for survey questions). This study was approved by the University of Oklahoma Health Sciences Center Institutional Review Board.

Before and after a 60-minute Zumba class, all participants' (n=16) pure-tone thresholds were measured at octave frequencies from 1000 to 6000 Hz binaurally using a calibrated portable pure-tone audiometer under

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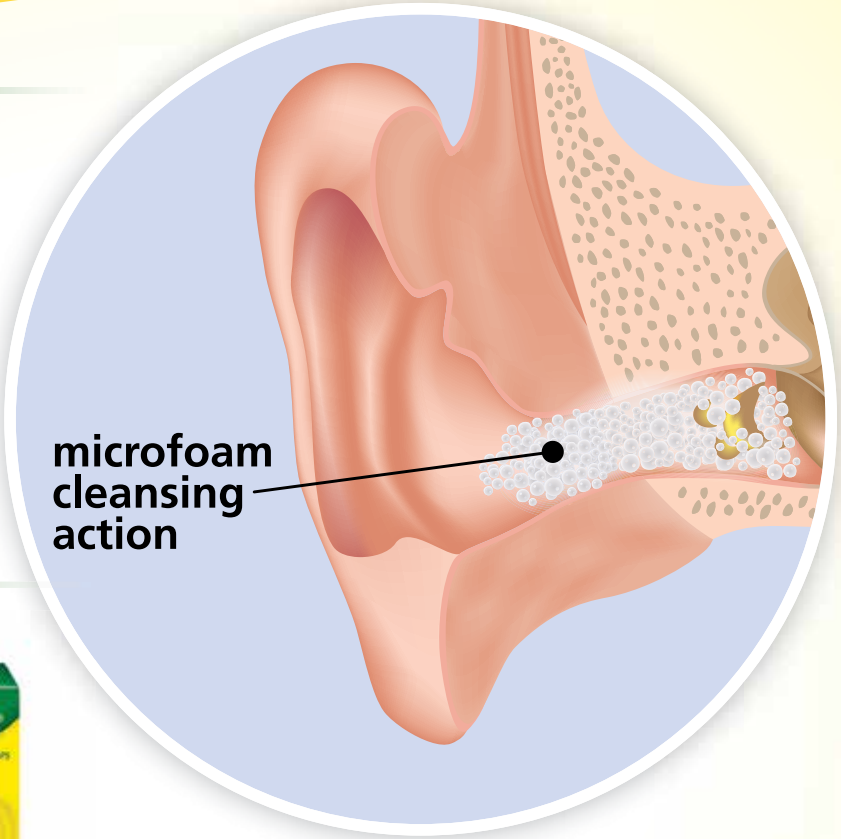

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Sennheiser HDA 300 circumaural headphones in a quiet room in the facility. During the class, music levels were monitored and recorded using a Type II sound level meter at various pre-determined locations throughout the room (FIGURE 1). A brief questionnaire about frequency of group fitness class attendance, enjoyment of the music, knowledge of/opinions about practices of hearing conservation, and impact on auditory function was administered to all participants.

Similar to the findings of Beach and Nie (2014) reported above, Zumba class sound levels averaged 91.2 dB(A) over 60 minutes with peak values up to 101.4 dB(A). A significant groupwise change in pure-tone thresholds was measured between pre- and post-class hearing thresholds (mean=2.6 dB; 95 percent CI [1.2, 3.9]). Individually, 13 of 16 participants experienced a threshold shift of at least 10 dB in one or both ears for at least one audiometric frequency (estimated using a standard 5-dB step size) (FIGURE 2).

In addition, questionnaire responses revealed that half of the participants reported experiencing tinnitus and/or muffled speech following a class. Although all participants were aware that exposure to loud sounds can cause damage to the auditory system, only two of 16 participants reported that they would be willing to wear hearing protection during the class if it were provided. When asked whether they would like for the music played in class to be louder, softer, or about the same, nine of the 16 participants would prefer "slightly" or "much lower" music volume while seven participants reported that the music volume should remain the same (n=5) or be louder (n=2). Combined with the results of earlier studies, the results of our investigation provide additional evidence that noise exposure in fitness classes is a public health concern, and may be related to risk of NIHL.

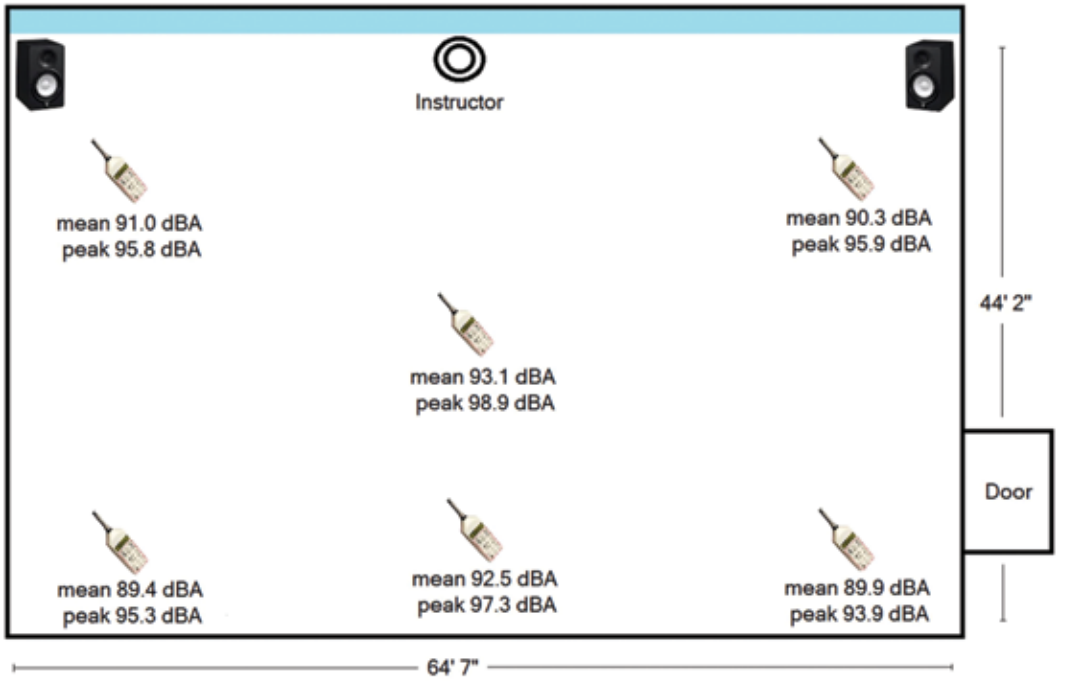

FIGURE 1. Diagram of Zumba class gymnasium with average sound pressures (in dB(A)) at locations throughout the room.

Factors Affecting TTS and PTS Risk in Fitness Classes

The studies discussed earlier support the hypothesis that high levels of noise in group fitness courses can result in TTS. While not studied directly, it is reasonable for hearing professionals to be concerned about PTS among noise-exposed group fitness class participants as well. Interestingly, there is evidence that noise exposure during physical activity may increase TTS risk. This increased susceptibility to TTS may be attributable to changes in the body's temperature regulation, circulatory, and metabolic activity during physical exertion.

In 1988, Lindgren and Axelsson observed a significant increase in TTS at 5000 and 6000 Hz for participants who exercised while exposed to 10 minutes of noise at 105 dB SPL. In another study, Vittitow et al (1994) found that use of an exercise bicycle increased susceptibility to noise-induced temporary threshold shifts when combined with loud music. Engdahl (1996) measured significant increases in TTS and decreases in DPOAE amplitude in participants

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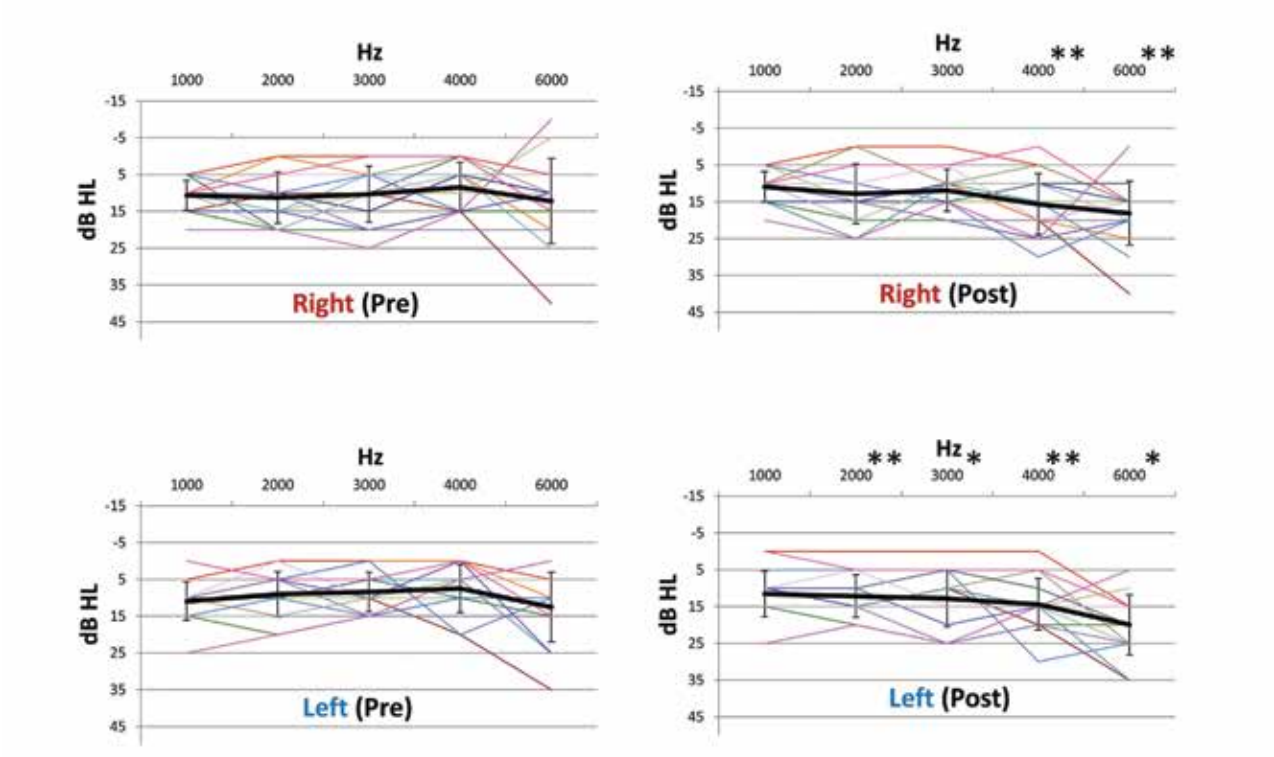

FIGURE 2. Pre- and post-class audiometric thresholds. Heavy black line indicates mean threshold. Bars reflect one standard deviation of the mean threshold. Asterisks indicate a significant pre-/post-change in average threshold at a given frequency (*=p <.05, **=p <.01).

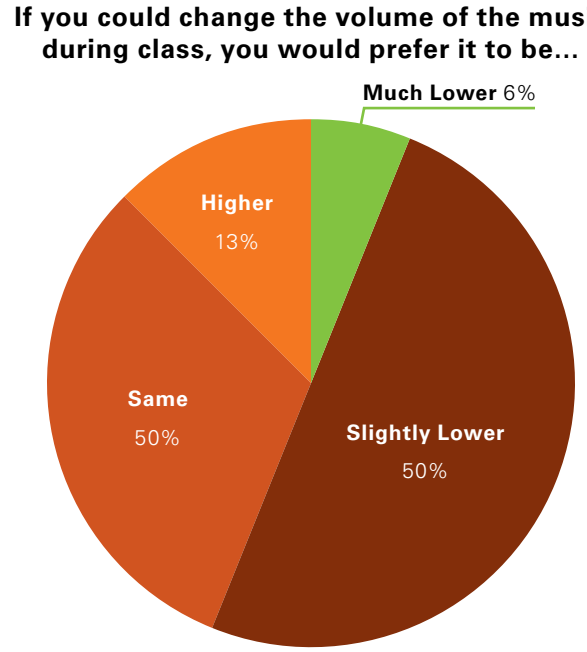

FIGURE 3. Responses to questionnaire item probing preference for music volume in Zumba class.

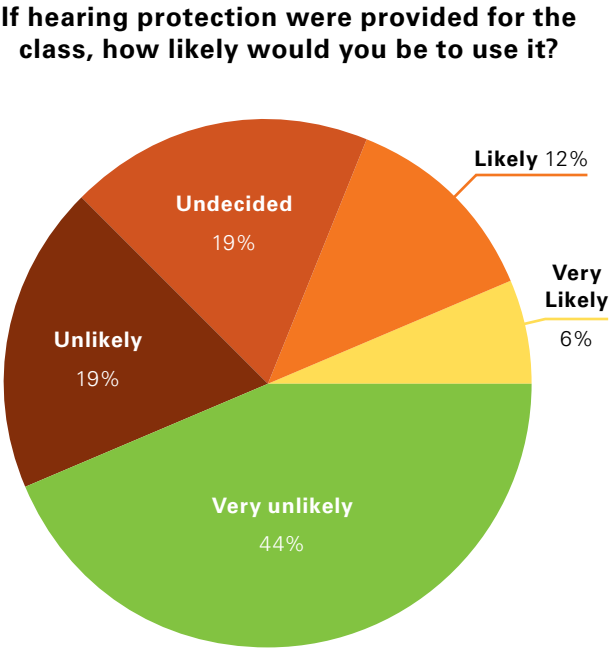

FIGURE 4. Responses to questionnaire item probing receptivity to use of hearing protection during Zumba class.

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after 10 minutes of exercise using a bicycle ergometer. In each of these studies, the authors attributed the immediate-term changes in auditory function to a stressor effect of the exercise, causing changes such as increased release of adrenaline, increased demand for oxygen, and temporary changes in metabolism.

As the noise associated with fitness activities is usually music, it is worth noting that the listener's enjoyment of a sound has been shown to have a relation to that listener's risk of TTS with exposure to that sound. For example, Lindgren and Axelsson (1983) found that teenage music listeners experienced a significantly greater TTS at 2000 and 4000 Hz when exposed to loud music that they did not enjoy, compared to comparably loud music that they enjoyed. Wilson and Herbstein (2003) also noted a significant association among music intensity, perceived loudness, enjoyment of the music, and motivation to exercise reported by fitness class participants.

A Challenge for Hearing Professionals

The studies reported here, including our own, support the concerns of hearing health professionals that

1. Risk of NIHL related to leisure activity is significant and may be increasing and
2. Exposure to loud music during group fitness classes is one element of this NIHL/leisure noise association.

Unlike many noisy activities, such as recreationally using firearms or riding all-terrain vehicles, noise in fitness classes (in this case, music) seems inextricable from the activity itself and, indeed, it increases the motivation of the participant to engage in a behavior that is healthy both in general and for long-term hearing ability. Like many other group fitness classes, music is an essential element and motivator for participants in Zumba. Our questionnaire responses revealed, unsurprisingly, that some participants who seek out group fitness are resistant to turning down the volume or using hearing protection (FIGURES 3 AND 4).

The question for audiologists as advocates for healthy hearing, then, is how to recommend healthy-hearing behaviors without discouraging participation in an element of a positive and fit overall lifestyle? This is a question without a simple answer, but some potential strategies and recommendations include:

Recommend use of musicians' earplugs as a strategy to encourage use of hearing protection while maintaining enjoyment of the music in the class.

1. Recommend that group fitness participants position themselves away from music speakers in the exercise room, if possible. In our study, speakers were located at the front two corners of the room, and sound pressure levels were somewhat lower in the rear corners. Since each exercise space will have its own acoustic characteristics, participants might be able to locate less noisy locations through trial and error.
2. Recommend use of musicians' earplugs as a strategy to encourage use of hearing protection while maintaining enjoyment of the music in the class. While more than half of our participants indicated unwillingness to use earplugs, it is possible that education about improved sound quality from custom musicians' plugs (compared to standard earplugs) may improve receptivity to their use.
3. Communicate directly with fitness instructors in the area where you practice about healthy hearing as an element of an overall healthy lifestyle. Note that the American Council on Exercise (www.acefitness.org), a certifying (and educational) body in the fitness industry, recommends that music levels not exceed

85 dB(A) during fitness courses. Work with instructors to measure noise levels in classrooms and help set volume levels for use in class. Counsel them on the benefits not only to the class participants, but themselves as well. If they are unwilling to keep the music set at a safe listening level throughout the entire class, make suggestions such as lowering music volume during less intense portions of the class, such as the warmup, cooldown, and recovery, to reduce the total noise exposure.

4. Provide educational materials and recommendations to fitness clubs and facilities in your area. After he was presented with the results of our study, the director of the fitness center where our study was conducted began measuring noise levels in his fitness classes using a smartphone application to set appropriate maximum volume levels and indicated a willingness to provide hearing protection to the members of his facility.

5. Be reasonable in expectations regarding behavior change. Adoption of any new healthy behavior is difficult, particularly when the positive impact of that behavior is not immediately apparent. Present healthy hearing as an element of an overall healthy lifestyle, similar to the protective effects of aerobic exercise for cardiovascular health later in life. Empowered with this information, group fitness participants may become advocates for use of safe listening levels in their own group fitness classes, as well as elsewhere.

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