FOCUS ON COLLEGES, UNIVERSITIES, AND SCHOOLS
VOLUME 6, NUMBER 1, 2012

Earphone Volume of Cardiovascular Entertainment Systems May be Harmful to Hearing Health

Jeffrey Burnett, EdD
Associate Professor
Department of Health & Human Performance
Fort Hays State University
Fort Hays, KS

Aaron Yoder, MS
Assistant Cross Country Coach
Bethany College
Lindsborg, KS

C. Fred Britten, PhD
Professor
Department of Communication Disorders
Fort Hays State University
Fort Hays, KS

Kayla Peak, EdD
Assistant Professor and Graduate Coordinator
Department of Kinesiology
Tarleton State University
Stephenville, TX

Tara Tietjen-Smith, DA
Associate Professor and Graduate Coordinator
Department of Health & Human Performance
Texas A&M University-Commerce
Commerce, TX

Acknowledgements

The authors would like to thank graduate assistants, Caleb Weigmann and Jessie Mizer, of Fort Hays State University for assistance with data collection.

Abstract

Little research exists on hearing health of individuals using cardiovascular entertainment (CE) systems while exercising. The purpose of this study was to investigate preferences for volume settings of CE systems within the environment of a university fitness center. Participants (N=104) completed a cardiovascular workout while listening to music and/or television on a CE system with earphones. All participants exceeded the manufacturer's suggested volume setting levels, thus endangering hearing health.

The increased popularity of indoor exercise has spurred a growth in the number fitness facilities. According to the International Health, Racquet, and Sportsclub Association (IHRSA) (2010), the number of wellness and fitness centers increased from 17,807 in 2001 to 29,750 in 2010. The number of health club memberships in the United States grew to over 45 million people with industry revenues in excess of $19 billion in 2009. Americans' concern for health has not been limited to the for-profit fitness facilities. For instance, according to the National Intramural-Recreation Sports Association (NIRSA), college campuses have spent over $1.7 billion dollars in new construction, renovations, and expansions of campus recreation facilities (2010). New facilities being constructed may include state-of-the-art fitness equipment as well as elaborate sound systems and entertainment equipment. Entertainment systems may include video and audio capabilities that can be controlled by the user. According to Florez (2008), "the lines between exercise and entertainment have blurred…" (p. 52).

Sound Intensity Levels and Hearing Loss

The National Institute on Deafness and Other Communication Disorders (NIDCD) states that exposure to excessive sound intensity levels has been directly related to an increased risk for hearing loss (2008b). Approximately 26 million adult Americans have "high frequency hearing loss due to exposure to loud sounds or noise at work or in leisure activities" (NIDCD, 2011b, para. 6). Noise can be measured by frequency, measured in Hertz (Hz), and intensity pressure, measured in decibels (dB). Normal conversational speech is generally measured to be 60 to 70 decibels (Martin & Clark, 2010). If the auditory system is exposed to excessive sound intensity levels, the normal ear may experience hearing loss. The American Speech-Language-Hearing Association (ASHA) asserts that loud noise in excess of 85 dB can cause permanent hearing loss (2008).

Young people are progressively showing increasing symptoms of hearing damage such as distortion, tinnitus, hypersensitivity to sound, or loss of hearing (commonly referred to as noise-induced hearing loss or NIHL) (Vogel, Brug, Hosu, Van der Ploeg, & Raat, 2008). Tinnitus, ringing in the ears, may be a symptom of permanent hearing damage (NIDCD, 2008a). Unlike many tissues in the body, hair cells and nerve fibers of the ear do not regenerate when damaged

(World Health Organization, 2010). Tinnitus is a common hearing condition, especially in those exposed to excessive and constant sound (ASHA, 2008).

Music and Fitness

Morata and Johnson (2011) have expressed concern for musicians and others working in the entertainment and sports industry by referring to the negative effect of sound intensity on hearing as a 'music-induced hearing loss' (MIHL). Music has long been an important component of the fitness culture. Mechelle Meadows (2011, para. 1), a Certified NASM Performance Enhancement Specialist, stated "when it comes to exercising, sometimes the music selections are just as important as the physical activity." Music can positively influence exercise motivation (Karageorghis et al., 2010). In fact, Edworthy and Waring (2007) found that up-tempo, loud music may positively affect exercise performance.

Even though exercise performance may be enhanced, loud music may affect hearing health. According to the National Institute for Occupational Safety and Health (NIOSH) (2012), NIHL may occur when the sound intensity level is above 85 dB. Yet the American Speech-Language-Hearing Association (2011) found that "portable music players are capable of producing sound levels ranging…from 60 to 120 decibels (dB). With the volume approximately one-quarter of the way up, you hear about 85dB…with the volume all the way up, you could hear about 120 dB" (p. 1). One-hundred and twenty dB is consistent with the sounds of a chain saw or ambulance siren (NIDCD, 2011b).

With 48% of U.S. adults believing that they have suffered some hearing loss (Centers for Disease Control & Prevention, 2011), appropriate sound intensity levels of music has become a current health issue for those in the fitness industry. Music is a vital part of American culture; but if it is played too loud, music can have lasting negative effects on hearing. Employees of nightclubs may also be at a higher risk of NIHL due to their repeated exposure to music and noise above the suggested limit of 85 dB (Morata & Johnson, 2011).

Gymnasiums, fitness centers and health clubs are increasingly becoming environments of hazardous noise exposure. In 2006, the American-Speech-Language Hearing Association listed health clubs as environments that commonly exceed the desired decibel level of 85 dB. Audiology expert have recommended that the maximum amount of time a person should spend listening to music through earphones is 15 min at 115 dB, which is roughly equivalent to the sound intensity levels at a fitness center or health club (ASHA, 2011).

Nassar (2001) found that the sound intensity of music when set at 90 dB and maintained throughout an aerobics class supported the idea that prolonged exposure could cause permanent hearing damage. Yaremchuk and Kaczor (1999) measured noise levels in 125 aerobic classes. Readings were collected every five minutes using a portable sound level-meter. Noise levels ranged from 78 dB to 106 dB. Seventy-nine percent of the readings measured between 90 and 98 dB with six readings above 100 dB. The study concluded that a majority of the aerobic classes tested were significantly above the recommended 85 dB level. Interestingly, in the classes that exceeded 100 dB the instructor used a microphone to amplify voice commands (Yaremchuk & Kaczor, 1999). Another study conducted by Burnett and Britten (2008) reiterated previous studies that a typical group exercise class can repeatedly exceed the recommended decibel level.

Vogel et al. (2008) stated "MP3 players may be the most important risk factor for music-induced hearing loss…" (p. 400). Thus, personal use of CE Systems may also be a significant risk factor for MIHL. Due to the increase in the use of earphones in fitness settings, the purpose of this study was to investigate typical earphone volume settings of individuals using CE systems while exercising. Another purpose of the study was to compare gender differences.

Methods

Participants

The participants in this study were individuals utilizing a fitness center on the campus of a rural, midwestern university in the United States. A convenience sample of 104 volunteers (52 females and 52 males) was selected at random. Participants completed a cardiovascular workout using a treadmill, cross trainer, or bike while listening to a CE system (Cardio Theater®) with earphones.

Procedures and Equipment

The CE system was utilized for a post-test assessment of individuals' preference to volume levels while exercising on cardiovascular equipment. According to their website, Cardio Theater's creators state that "Cardio Theater's full line Exercise Entertainment™ systems enable health club members to listen to individually selected audiovisual entertainment choices while exercising on cardiovascular equipment" (2012, para. 3). CE systems acquire sound from multiple televisions or individual units mounted on fitness equipment and then transfer that sound to cardiovascular machines that may be accessed with the use of personal earphones. The volume controls were located on each cardiovascular machine and were fully controlled by the individual exercising on that particular machine. Each volume control relayed sound from a corresponding LG® Infinia plasma television to the participant's earphones. Apple® MA662G/B earbuds were chosen as the earphones for each participant because of compatibility with the CE system and consistency of participant use. The Apple® earbuds were directly inserted into the volume setting controls.

The default volume control on each cardio fitness machine was set at a volume level of two (66 dB) as determined by the CE system manufacturer. The CE system manufacturer suggested that the volume setting should not be set beyond a volume setting of six (85.26) to ensure hearing health. Each cardio fitness machine contained the same volume control setting. The maximum volume setting on each machine was level sixteen (111.91 dB).

Participants were randomly tested over duration of a six-week period. Maximal volume levels were recorded at the end of each exercise session, and means were recorded for the whole group and by gender.

Results

The group volume setting mean of 11.69 greatly exceeded the volume setting level suggested by the CE system manufacturer (level 6). Mean, median, and mode of voluntary volume setting levels by group and gender are recorded in Table 1.

Table 1

Mean, Median, and Mode of CE System Voluntary Volume Setting Levels by Gender

	Female (*n*=52)	Male (*n*=52)	Group (*N*=104)
Mean	11.46	11.92	11.69
Median	12	12	12
Mode	12	12	12

When the data was analyzed according to gender, the female participants' mean of 11.46 also exceeded the suggested volume setting levels. The male participants' volume levels revealed a mean of 11.92. Both genders exceeded the manufacturer's suggested volume setting level of six with the males having a higher volume setting level than the females, although this difference was not statistically significant ($p<.05$). In other words, the volume setting levels set by individuals, as a group and by gender, were almost twice the manufacturer's suggested volume setting level that is meant to ensure safe hearing health as illustrated in Figure 1.

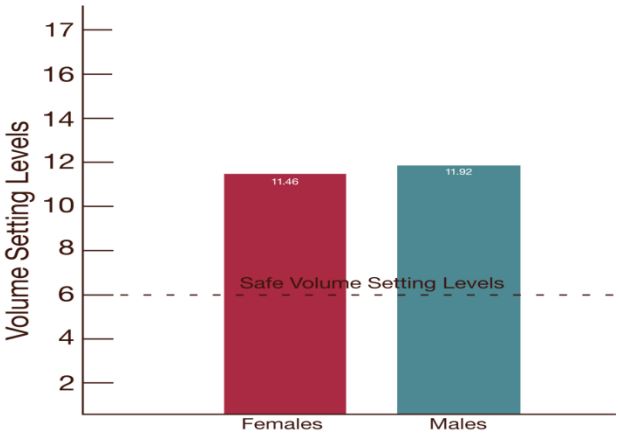

Figure 1. Volume levels by gender in relation to recommended levels.

Table 2 shows noise levels in decibels that corresponded with CE levels in this study. Examples related to each decibel level as well as apparent loudness and possible effects on hearing are also depicted.

*Table 2

Noise (dB) and CE Levels: Examples, Apparent Loudness, and Possible Effects on Hearing

Noise (dB)/ CE Levels	***Example***	****Apparent Loudness***	***Possible Hearing Effect from Daily Exposure***
180	Rocket launch	2048	Death of hearing tissue
140	Gunshot	1024	Danger; Immediate
130	Jackhammer	512	Pain response; Immediate
120	Car horn	256	Damage after 15 sec
110/16	Night club	128	Damage after 2 min
105	Lawn mower	96	Damage after 7 min
100/12	Pneumatic drill	64	Damage after 15 min
90	Screaming child	32	Damage after 2 hours
85/6	Electric shaver	24	Damage after 8 hours
80	Blow dryer	16	Borderline
70	Vacuum cleaner	8	No risk
65/2	Conversation	6	No risk
0-10	Sound Threshold		No risk

NOTE: *Adapted from Abelard Public Ed (1999); CHC (2012); and OHSU (2012)
**Apparent Loudness- Number shown is that many times as loud as previous dB level. (For instance, 60 dB is 2 times as loud as 50 dB)

Discussion

The results of this study revealed that participants who utilized a CE system while exercising exceeded the manufacturer's suggested volume setting levels, thus endangering hearing health. According to the National Institute on Deafness and Other Communication Disorders (2008b), "Long or repeated exposure to sounds at or above 85 decibels can cause hearing loss" (p. 1). With volume setting levels almost double recommendations, individuals may experience a decrease in hearing health due to prolonged exposure to intense sound. Popular CE systems are viewed as 'must haves' for providing a positive fitness experience for patrons (Florez, 2008). Although wellness center and health club staff should not be expected to monitor the patrons' use of personal listening devices such as iPODs, MP3 players, smartphones, or radio devices, the use of earphones with the CE systems should be identified as a possible hearing health risk. The results of this study revealed that the average individual who uses a CE system may be listening to volumes that have shown marked hearing damage in individuals of all ages (NIDCD, 2011a).

Background noise from external sound sources in fitness facilities might include noise from cardiovascular machines, weights banging, and individuals talking. Background noise in a gymnasium or fitness facility has been found to be as 'noisy as in factories' (Jiang, 1997, para. 3). This background noise may influence an individual to increase the volume of their portable music device or cardiovascular entertainment system in order to hear music or dialogue from a television.

Listening to music, through earphones, while engaging in exercise is considered 'basic gym gear' for most fitness patrons, and the trend will most likely continue (Florez, 2006). Music can positively influence exercise motivation with louder music corresponding with higher exercise performance (Edworthy & Waring, 2007; Karageorghis et al., 2010). Exercise has been linked to improved health (Garber et al., 2011); yet, using a high volume level on earphones may somewhat counter this improvement by contributing to negatively altered hearing. Exercise has also been recommended to reduce a person's risk of hypertension and depression (Garber et al., 2011), but exposure to loud noise can contribute to hypertension and other health problems (Passchier-Vermeer & Passchier, 2000).

The ACSM has recommended engaging in aerobic activity for at least 30 minutes a day on most days of the week plus resistance and flexibility training for two to three days per week (Garber et al., 2011). This recommendation may inadvertently encourage exercisers to listen to loud music for long periods of time which may affect their hearing. The participants in this study listened to the CE System at decibel levels that could cause hearing damage after exposure of 15 minutes or more daily (See Table 2). Fitness center and health club patrons should be informed of appropriate sound levels related to music and volume controls (Center for Hearing and Communication, 2012).

Conclusion

Burnett et al. (2008) suggested administrators should closely monitor the volume level on music within the facility in order to assure sound level for its patrons. Professionals within health and wellness along with fitness directors should take a more active role and collaborate

with audiologists to educate fitness administrators and fitness center patrons concerning the increased risk for hearing loss when CE systems are played above the suggested volume setting levels (Burnett et al., 2008). Furthermore, CE system manufacturers should consider noting a hearing health warning on their products.

According to the Center for Hearing and Communication (2012b), "although guidelines in the workplace have been established to protect a worker's hearing, the same protection is not available for the use of personal stereo systems with headphones" (p. 1). Therefore, individuals who exercise are responsible for monitoring their own listening habits. The good news is that NIHL is preventable (NIDCD, 2008b). Awareness and education may contribute to decreasing the incidence of NIHL in individuals who frequently use CE systems.

References

Abelard Public Education. (1999). *Loud music and hearing damage*. Retrieved from http://www.abelard.org/hear/hear.php

American Speech-Language-Hearing Association (ASHA). (2008). *Incidence and prevalence of hearing loss and hearing aid use in the United States.* Retrieved from http://www.asha.org/research/reports/hearing.html

American Speech-Language-Hearing Association (ASHA). (2011). *Unsafe usage of portable music players may damage your hearing*. Retrieved from http://www.asha.org/ about/news/atitbtot/mp3players.html

Burnett, J., Britten, F., & Dearden, L. (2008). Sound intensity levels in a university wellness center. *Recreational Sports Journal, 32*, 11-15.

Burnett, J., & Britten, F. (2008). Sound intensity levels of a typical group fitness class. *Athletic Business*. Retrieved from http://athleticbusiness.com/articles/article.aspx?articleid=3352&zoneid=7

Centers for Disease Control and Prevention (CDC, 2011). *Workplace safety & health topics: Noise and hearing loss prevention; noise-induced hearing loss – attitudes and behaviors of U.S. adults*. Retrieved from http://www.cdc.gov/niosh/topics/noise/research/attitudes.html

Cardio Theater (2012). *Total entertainment solutions for fitness facilities*. Retrieved from http://www.cardiotheater.com/index.php

Center for Hearing and Communication (CHC). (2012a). *Noise in health clubs*. Retrieved from http://www.chchearing.org /noise-center-home/facts-noise/noise-health-club

Center for Hearing and Communication (CHC). (2012b). *Personal stereo systems and headsets*. Retrieved from http://www.ch chearing.org/noise-center-home/facts-noise/personal-stereo-systems-headsets

Edworthy, J., & Waring, H. (2007). The effects of music tempo and loudness level on treadmill exercise. *Ergonomics*, *49*(15), 1597 – 1610.

Florez, G. (2006). Entertainment responds to personal devices. *Fitness Business Pro*, *22*(12), 26.

Florez, G. (2008). Industry should develop technology partnerships. *Fitness Business Pro, 24*(11), 52.

Garber, C.E., Blissmer, B., Deschenes, M.R., Franklin, B.A., Lamonte, M.J., Lee, I.,…Swain, D.P. (2011). Quantity and quality of exercising for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Medicine & Science in Sports & Exercise, 43*(7), 1334 – 1359. doi: 10.1249/MSS.0b013e318213fefb

International Health, Racquet & Sportsclub Association (IHRSA). (2010). *Industry research.* Retrieved from http://www.ihrsa. org/industry-research/

Jiang, T. (1997, June). *Can noise levels at school gymnasia cause hearing loss: A case study of a physical education teacher*. Paper presented at the Noise-Con 97 Meeting, State College, PA.

Karageorghis, C.I., Pries, D.L., Williams, L.S., Hirani, R.M., Lannon, K.M., & Bates, B.J. (2010). Ergogenic and psychological effects of synchronous music during circuit-type exercise. *Psychology of Sport and Exercise, 11,* 551 – 559.

Martin, F.N., & Clark, J.G. (2010). *Introduction to audiology* (11th ed.). Boston, MA: Pearson Education.

Meadows, M. (2011). *Using music in corporate fitness programs to pump up the motivation*. Retrieved from the National Institute for Fitness and Sport website: http://www.wellness. nifs.org/blog/bid/43844/Using-Music-in-Corporate-Fitness-Programs-to-Pump-Up-the-Motivation

Morata, T.C., & Johnson, R. (2011). *These go to eleven*. Retrieved from the Centers for Disease Control and Prevention website [NIOSH Science Blog]: http://www.cdc.gov/niosh/blog /nsb012511_music.html

Nassar, G. (2001). The human temporary threshold shift after exposure to 60 minutes of noise in an aerobics class. *British Journal of Audiology, 35,* 99-101.

National Institute on Deafness and Other Communication Disorders (NIDCD). (2008a). *The noise in your ears: Facts about tinnitus.* Retrieved from http://www.nidcd.nih. gov/health /hearing/noiseinear.asp

National Institute on Deafness and Other Communication Disorders (NIDCD). (2008b). *Noise induced hearing loss*. Retrieved from http://www.nidcd.nih.gov/ health/hearing/pages/noise.aspx

National Institute on Deafness and Other Communication Disorders (NIDCD). (2011a). *Healthy hearing 2010.* Retrieved from http://www.nidcd.nih.gov/health/ healthyhearing/what_hh/Pages/Objectives.aspx

National Institute on Deafness and Other Communication Disorders (NIDCD). (2011b). *Quick statistics*. Retrieved from www.nedcd.nih.gov/health/statistics/pages/quick.aspx

National Institute for Occupational Safety and Health (NIOSH). (2012). *NIOSH safety and health topic: Noise and hearing loss prevention - Noise*. Retrieved from http://www.cdc.gov/niosh/topics/noise/abouthlp/nihlattitude.html

National Intramural-Recreation Sports Association (NIRSA). (2010). *Collegiate Recreational Sports Facilities Construction Report 2010-2015*. Retrieved from http://www.nirsa.org/AM/Template.cfm?Section=Research_Central&Template=/MembersOnly.cfm&ContentFileID=10403

Oregon Health & Science University (OHSU). (2012). *Dangerous decibels*. Retrieved from http://www.dangerous decibels.org/

Passchier-Vermeer, W. & Passchier, W.F. (2000). Noise exposure and public health. *Environmental Health Perspectives, 108*(S1), 123 – 131.

Vogel, I., Brug, J., Hosu, E.J., Van der Ploeg, C.P.B., & Raat, H. (2008). MP3 players and hearing loss: Adolescents' perceptions of loud music and hearing conservation, *Journal of Pediatrics, 152*(3), 400 – 404.

World Health Organization (WHO). (2010). *Deafness and hearing impairment. Fact sheet*. Retrieved from http://www.who.int/ mediacentre/factsheets/fs300/en/

Yaremchuk, K., & Kaczor, J (1999). Noise levels in health club settings. *Nose and Throat Journal, 78*(1), 54-57.