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Effects of cardiovascular exercise on the selection of preferred listening levels using iPods

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EFFECTS OF CARDIOVASCULAR EXERCISE ON THE SELECTION OF PREFERRED LISTENING LEVELS USING IPODS

by

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ABSTRACT

The present project evaluated the effect of cardiovascular exercise on the selection of preferred listening levels using iPods. The participants in this study included 15 Louisiana Tech University students ranging in age from 19 and 30 years. The inclusion criteria for participants was as follows: (1) normal hearing sensitivity; (2) no known neurological, cognitive, or otologic impairment; (3) removal from excessive noise for at least 48 hours prior to testing; and (4) endurance in running on a treadmill for the duration of ten minutes.

Pre-test audiometric thresholds and distortion product otoacoustic emissions (DPOAEs) were obtained in a sound treated booth. Participants were then instructed to set the level of an iPod to his/her preferred listening level while running on a treadmill. Real ear SPL measurements of the iPod output were obtained. Lastly, post-test audiometric thresholds and DPOAEs were re-obtained in the sound treated booth. Mean data results showed that when listeners' set their iPod at their preferred listening level while running on a treadmill, hazardous music intensity levels may not have been selected. However, results of the individual data analysis revealed that five of 15 listeners set their iPods at intensity levels above 90 dB SPL. Results of pre- and post-test audiometric thresholds revealed that participants selected iPod intensity levels that resulted in a clinically significant temporary threshold shift at 2000 and 4000 Hz in the right ear and at 1000 and 8000 Hz in the left ear. Results of the pre- and post-test

DPOAEs revealed that participants selected iPod intensity levels that resulted in a clinically significant decrease in DPOAE amplitude responses at 1001, 1501, 2002, 4004, and 6006 Hz in the right ear and at 1501, 3003 and 4004 Hz in the left ear. Collectively, these results indicate that when selecting music intensity levels while running on a treadmill, temporary noise-induced hearing loss may occur.

Lastly, the effect of environment on the selection of preferred listening levels using iPods was evaluated. The results indicated that participants selected louder intensity levels when in an indoor, gymnasium environment as compared to a quiet, outside listening environment. Therefore, environment/level of background noise affects the loudness intensity level selected when listening to iPods.

Keywords: iPods, noise induced hearing loss, preferred listening levels, physical exercise

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CHAPTER I

INTRODUCTION

The occurrence of listeners with hearing impairments has increased tremendously over recent years, and it is predicted that the numbers will continually rise in the near future. Recent statistics show that approximately 34.25 million people in the United States have some form of hearing loss (Kochkin, 2009). Furthermore, over 10% of the population within the United States has a hearing loss, with sensorineural hearing loss being the third most chronic disability in the United States (Tye-Murray, 2009; McCormick & Matusitz, 2010). Due to these growing numbers, hearing loss has become a common health concern in society today.

A serious problem impacting younger generations is the occurrence of noise induced hearing loss (NIHL). NIHL can be attributed to a variety of factors; however, the growth in popularity of personal music systems (i.e., iPods, MP3 Players, compact disk players) plays a key role (Harrison, 2008). Voluntary damage to hearing through the use of personal music systems is, therefore, a prevalent problem in our society (Daniel, 2007). Furthermore, the effects of NIHL are irreversible and can result in tinnitus, decreased speech understanding, temporary threshold shifts, and/or a permanent hearing loss (Daniel, 2007). Hearing loss can also cause a variety of different effects on an individual's overall social development, including limitations in activity level, social isolation, and an overall negative psychological outlook (Harrison, 2008).

Recreational and leisure activities are common listening situations where the use of personal music systems has become increasingly popular. Torre (2008) reported that participants use personal music systems during physical exercise more than any other setting. Additionally, during physical exercise one may have increased heart rate and high levels of motivation. For this reason, people often reported enjoyment in listening to high intensity music (Wilson & Herbstein, 2003). Just as motivation and enjoyment can influence preferred listening levels, the presence of background noise also plays a key role when setting preferred listening levels during exercise. Recent studies have shown that listeners set personal music systems at higher levels in the presence of noise as opposed to quiet situations (Hodgetts, Rieger, & Szarko, 2007).

According to OSHA, the permissible noise limit is currently 90 dB A-weighted scale for an eight hour period of exposure (OSHA, 2000). Personal music systems can produce dangerous levels of output reaching more than 90 dB A-weighted scale (Farina, 2007). Furthermore, the duration of time spent listening to personal music systems can have an effect on future hearing. Adults and teenagers reported listening to their personal music systems between 30 minutes to more than five hours during one session (Torre, 2008).

In summary, hearing damage caused by the use of iPods is a well-researched topic due to its effect on personal health and lifestyle. The research has shown controversial results related to hearing damage caused by iPod usage in quiet settings. According to Bridge (2009), listeners on average do not select listening levels that are hazardous to their hearing. On the contrary, a study completed by Farina (2007) revealed that many listening devices produced high-risk output levels of 90 dBA or higher, which can result in hearing damage. Multiple studies have been completed related to hearing damage caused by iPods; however, conflicting results have been documented. Furthermore, research on the selection of preferred listening levels while participating in cardiovascular exercise is scarce. Therefore, the purpose of the present study was to determine the preferred sound pressure levels of iPod users during physical exercise. One outcome may reveal that cardiovascular exercise and background noise had no effect on the selection of hazardous output levels, indicating that cardiovascular exercise and background noise will not result in the selection of elevated listening levels, thus, eliminating the potential risk of future NIHL due to iPods usage during exercise. On the other hand, participants may select elevated intensity levels during cardiovascular exercise and in the presence of background noise. This outcome would indicate that cardiovascular exercise in the presence of background noise has a direct relationship with the selection of elevated preferred listening levels, thus, resulting in the potential risk of NIHL.

A secondary purpose of this project was to note any significant changes in pre- and post-test DPOAE responses and audiometric thresholds. One outcome may reveal no significant changes in DPOAE responses and audiometric thresholds, indicating that participant's do not select preferred listening levels that could potentially lead to temporary and/or permanent hearing damage. Another outcome may reveal significant changes in pre- and post-test DPOAE responses and audiometric thresholds, indicating that participants selected intensity levels potentially leading to temporary and/or permanent hearing damage.

CHAPTER II

REVIEW OF LITERATURE

Noise Induced Hearing Loss

NIHL has recently become a growing concern in healthcare. Harrison (2008) discussed the growing prevalence of NIHL among young people in society. Surveys show that between 12% and 15% of school age children have hearing loss that may be related to exposure to noise. Harrison (2008) continued to explain that NIHL can cause permanent damage to the inner ear hair cells, in which, restoration is currently impossible. NIHL can also lead to tinnitus and problems associated speech intelligibility. The author concluded by stating the importance of awareness in the potential dangers associated with loud intensity levels. Harrison (2008) also advised users not to listen to their music systems for long durations of time and to consider noise-reducing ear bud inserts.

In a similar review, Daniel (2007) discussed the relationship between noise and hearing loss. He stated that approximately 14 million Americans have a hearing loss that might be related to noise damage. Furthermore, recently there has been a growth in popularity of personal music systems (i.e., I-pods, MP3 Players) leading to increasing concerns for overall hearing. According to the National Institute of Occupational Safety and Health (NIOSH), hearing loss can begin to occur when noise reaches hazardous levels exceeding 85 decibels A-weighted (dBA). He continued to explain that the effects of cochlear hair cell damage are irreversible. Daniel (2007) explained the necessity of health education programs to educate people on measures to improve hearing impairments.

Furthermore, Rawool and Colligon-Wayne (2008) evaluated various aspects of auditory exposure and potential hearing loss. The participants in this study included 238 (40 men and 198 women) first year college students. Participants were asked to complete a survey related to their hearing lifestyle. The survey evaluated multiple areas including noise exposure, hearing protection, awareness of hearing loss, and tinnitus. The results of this study revealed that half of the participants were exposed to music intensity levels that could potentially damage their hearing. The results of the study also revealed that 44% of the students were exposed to noisy equipment and 29% were exposed to occupational noises without any assisted hearing protection. Appropriately three-fourths of the students (75.62%) expressed that they associated hearing loss as something they would experience when they were older. Furthermore, over half (66%) of the students reported some degree of tinnitus. The authors explained that the participants viewed themselves as invulnerable to the damaging effects of noise exposure on their hearing, thus, eliminating the use of hearing protection. Collectively, the results of this study indicated that the use of noisy equipment and occupational noise without hearing protection are potential risk factors for NIHL. Specifically, Rawool and Colligon-Wayne (2008) stated that by simulating hearing loss, one may be able to promote the use of hearing protective devices.

Prevalence and Usage of Personal Music Systems

Personal music systems, namely iPods, are growing in popularity due to their compact size and their ability to store large amounts of music. iPods are also convenient personal music systems, in that; they are easily and discretely used in public areas. Furthermore, iPods and other personal music systems are typically coupled with headphones or earphones (Health Canada, 2009).

The iPod was released in 2001 by Apple® in order to provide consumers with a portable device to store and play audio files (Apple, 2009). The Apple® iPod is capable of storing many hours of music due to its ability to compress large files into smaller, more manageable files. Furthermore, music can easily and quickly be transferred from a computer to the iPod. As of January 2009, Apple's® fiscal quarterly sales revealed that 22,727,000 iPods have been sold since the release date in 2001. Furthermore, Apple® reported a 3% increase in sales from year to year (Apple, 2009). Worldwide it is projected that Apple® will ship approximately 268.6 million iPods by the year 2011 (McCormick & Matusitx, 2010).

Recent studies have been conducted to evaluate consumer usage of personal music systems. Zogby International (2006) evaluated the use of various electronic devices and headphones among both teenagers and adults. The participants included 1,000 adults and 301 high school students. Participants were asked to complete an interview to evaluate numerous aspects related to the use of personal music systems, such as duration, volume level, and concern for hearing loss. Results of this study revealed that 15% of adults and 11% of teens listen to their iPods for more than four hours a day. Participants were then asked to rank their perception of loudness levels when using their iPods through the use of a survey. The levels that the participants were given to choose from in the survey were: (1) very loud, (2), somewhat loud, (3) loud, (4) medium, (5) somewhat low, (6) very low and (7) low. Results revealed that 6% of adults and 13% of teens reported listening to their iPods at very loud levels. The results of the survey further revealed that 38% of adults and 41% of teens reported listening at loud levels while approximately 16% of adults and 7% of teens reported listening at low levels. Results of the study also revealed that 58% of adults and 54% of high school students expressed concern about their hearing status due to noise exposure. Collectively, these studies indicate that personal listening devices are commonly used in the United States today. Furthermore, many individuals who use these devices report listening to them at levels that they deem to be loud or very loud for long periods of time, thus possibly increasing the risk for NIHL.

iPod Usage and Hearing Loss

Various studies have been completed in order to examine a possible correlation between the use of iPods and potential hearing loss. First, Fligor (2007) discussed the connection of hearing damage to the use of iPods. The author explained that the use of iPods can possibly contribute to potential hearing loss caused by elevated levels of music intensity. Fligor (2007) continued to explain that individuals are responsible for monitoring the level set by their iPods, and listening to iPods for long durations at very loud levels (i.e., 100 dBA) can result in hearing loss. Furthermore, portable music player [PMP] headphones can create levels ranging from 110 to 125 dBA. According to Fligor (2007), headphone output is sufficient to result in over exposure to noise depending on the duration length. He further explained that although headphones can produce hazardous levels of output, people ultimately are responsible for the amount of noise exposure they sustain (Filgor, 2007).

In continuance with the evaluation of iPod usage and hearing loss, Farina (2007) examined in-ear sound pressure levels at listener's preferred listening levels. Thirteen high school students (age range 15-18 years) were asked to bring their personal music systems to the research location while leaving the output level set to their preferred listening level from the previous usage. The volume control was held constant and measurements were made on an Ambassador binaural dummy head in order to evaluate the preferred listening levels of the high school students. The researchers used two different signals for the completion of this project including an IEC test signal and a music signal. The results of the SPL measurements revealed that only one of the devices produced levels higher than 100 dBA using headphones. However, many of the devices produced high-risk output levels of 90 dBA or higher. These results indicated that many of the devices should only be used for certain periods of time due to their potential to damage hearing (Farina, 2007).

Goshorn, White, and Kemker (2009) evaluated the preferred listening levels of college students when using personal listening devices. Thirty-one college age students (age range: 18 to 23 years) with normal hearing were asked to set the volume wheel on personal portable music devices to their preferred listening level while listening to a popular song. The participants were instructed to adjust their personal listening device to their preferred listening level within 1 minute and 10 seconds of the beginning of the tune. The Frye-Fonix Model 7000 real ear system was used in order to make SPL measurements of the music loudness levels. In order to verify the accuracy of the measured music levels, measures were also taken of an uploaded steady state broadband noise. The results revealed that 55% of the participants set their volume control to levels greater than 85 dB SPL ("very loud levels") while 26% of the participants set their devices between 70 to 85 dB SPL ("loud levels"). Only 19% of the participants set their volume to levels less than 70 dB SPL ("moderate levels"). Furthermore, results of the study revealed that participants listened at the highest individual settings with rock (107 dB SPL) and rap music (100 dB SPL). Results of this study indicated that participants listened to their personal music systems at levels that could potentially cause future hearing damage. Although no participants had current hearing loss, the authors noted that the participants had not had enough exposure to cause permanent hearing loss at the point of the study. The authors stated that listening to personal music systems for long durations at hazardous levels could result in future permanent NIHL. Lastly, the authors concluded by stating that white noise can be used as a substitute for music when evaluating the intensity levels that personal listening devices might produce (Goshorn et al., 2009).

Bridge (2009) evaluated the preferred listening level of iPod users. The author also evaluated the effect of gender and iPod usage (i.e. experienced versus non-experienced) on the selection of preferred listening levels. Forty young adults (20 males and 20 females) with normal hearing were divided into two groups (i.e. experienced group and non-experienced group). Participants were provided with a 60 GB Apple iPod and were instructed to select their preferred listening level while walking outside. Probe microphone measurements were obtained using the Audioscan RM500SL. Results of the study revealed that gender and experience level did not have a significant effect on the selection of preferred listening levels of participants. Furthermore, on average participants did not listen to the iPod at hazardous listening levels, according to OSHA standards. However, a secondary data analysis was completed in order to evaluate individual selected intensity levels. Although the average data didn't show hazardous noise levels, it is important to note that upon examination of individual data, results showed that seven participants selected intensity levels above 90 dB SPL (Bridge, 2009).

Lastly, Torre (2008) completed a two phase study on young adults and their use and preferred listening level settings of personal music systems. In the first phase, Torre (2008) asked 1,016 college students (615 women and 401 men) to complete a questionnaire related to their use of personal music systems. Results of this study revealed that students use their personal music system most when exercising (44.5%). Half of the students reported listening to their personal music systems between one to three hours a day. The majority of participants (53%) reported listening to their personal music systems at a medium level (i.e., 71.6 dB SPL), and approximately 35% of the participants reported listening to their personal music systems at loud levels (i.e., 87.7 dB SPL). Six percent of the participants reported listening to their personal music systems at very loud levels (i.e., 97.8 dB SPL). The results of the questionnaire further revealed the students reported a concern for having some type of hearing loss (11.2%) or tinnitus (15.9%). Also, men were more likely to listen to their personal music systems for longer periods of time, at higher levels of volume, and report hearing loss more commonly than women, and African Americans listened for longer time periods (13.6%) and at higher levels (28.8%) than any other race. Lastly, American Indians reported the highest incidence of hearing loss (18.2%). Results of this study indicated that personal music system use can vary based on gender, race, and activity level. Results also indicated that the use of personal music systems can lead to complaints of hearing loss and tinnitus (Torre, 2008).

In the second phase, Torre (2008) examined the preferred output settings of personal music systems. Twenty-one women and 11 men (mean age = 23.1 years) with normal hearing were asked to complete a short survey on earphone style, volume preference, and length of use. Probe microphone measurements were also completed after the participants were instructed to blindly set the volume wheel to four different loudness categories (i.e. low, comfortable or medium, loud, and very loud). Results of the study revealed that most participants deemed the following SPL levels as low, medium, loud, and very loud: 62.0 dB SPL = low volume, 71.6 dB SPL = medium or comfortable volume, 87.7 dB SPL = loud volume, and 97.8 dB SPL = very loud volume. The results of this study also revealed that men set their loudness levels about 5-6 dB SPL higher than the women. Based on these results, the author concluded that further research would be beneficial on this topic in the area of examining recreational noise exposure and personal music systems (Torre, 2008).

Effect of Environmental Noise on the Selection of Preferred Listening Levels

The following research studies evaluated the effect of environmental noise on the selection of preferred listening levels using personal music systems. The first study completed by Hodgetts, Rieger, and Szaeko (2007) examined the effect of environmental noise and earphone style on the selection of preferred listening levels using an MP3 player. The participants included 15 males and 23 females (mean age = 27.5 years) with normal hearing. Participants were required to listen to a previously selected song using the MP3 player in three different environments (quiet, street noise, and babble) and using three different styles of headphones (earbud ITE, supra-aural headphone, and supra-aural headphone with noise reduction). Participants were instructed to set their preferred listening level while the song was being played. Probe-microphone measurements were taken using the Audioscan Verifit. Results of this study revealed that participants listened at the loudest levels when using the earbud style insert. Headphones with the noise reduction feature showed the lowest levels of volume selection. Results of this study also revealed that participants listened at the lowest volume in quiet (earbud ITE=77.8 dBA, supra-aural headphones=75.2 dBA, supra-aural headphones with noise reduction=75.2 dBA). Listeners listened at levels significantly higher levels in multi-talker babble (earbud ITE=86.7 dBA, supra-aural headphones=82.9 dBA, and supra-aural headphones with noise reduction=81.6 dBA). Listeners set preferred output levels at the highest when listening in street noise (earbud ITE=88.8 dBA, supra-aural headphones=84.5 dBA, and supra-aural headphones with noise reduction=83 dBA). Results of this study indicated that environment (i.e., street noise, quiet, and multi-talker babble) has a direct influence on the selection of output levels when using an MP3 player. Results also indicated that the earphone style affects the selection of preferred output levels (Hodgetts et al., 2007).

The second study completed by Williams (2005) examined the preferred listening levels of personal stereo systems in a "real-world" setting. The author of this study also evaluated the level chosen by participants in order to note any potential damaging noise exposure. Individuals (15 females and 40 males; age range: 15-48 years) were randomly approached in two separate locations on the street in order to simulate various noisy environments. All participants were asked to complete a questionnaire about their use of personal stereos. Then, participants were asked to choose their preferred listening level while using the personal music system. Results were then analyzed by placing the personal stereo on Knowles Electronics Manikin for Acoustic Research (KEMAR). The ear phones of the portable stereo device were placed over the ears of KEMAR, and the noise level was recorded. Results of this study revealed that males (80.6 dBA) listen to personal music systems at a higher level than females (75.3 dBA). The results further revealed that the majority of the population does not listen to music at dangerous listening levels; however, 25% of the population selected listening levels that were considered at-risk. The results of this study indicated that a small amount of participants were exposed to harmful noise with personal stereo use and that this effect was larger for males than females (Williams, 2005).

Kumar, Mathew, Alexander and Kiran (2009) examined the effect of background noise on preferred listening levels. Furthermore, the study evaluated the output produced by personal music systems (PMSs) on hearing thresholds and distortion product otoacoustic emissions (DPOAEs). Seventy adults (35 males and 35 females; age range: 17-24 years) separated into two groups served as the participants in this study. The control group consisted of 30 participants with normal hearing who rarely listened to their PMS. The experimental group consisted of participants who had been using their PMS for at least two years. Participants in the control group were required to have hearing thresholds less than 15 dB HL from 250-8000 Hz. Furthermore, participants in both groups had no evidence of outer or middle ear pathology and no history of exposure to occupational noise or ototoxic medication. Two phases were completed for this experiment. In Phase I, the subjects set their personal listening device to their preferred listening level, and PMS output was measured using a Siemens Unity probe microphone system in the following three conditions: (1) quiet, (2) background noise of 65 dB SPL produced by a bus, and (3) at the maximum volume control setting. Only the experimental group was allowed to participate in Phase I of the study. Results of this study were converted from dB SPL to dBA weighted values by adding the A-weighting adjustment values. Then, eight hour equivalent continuous A-weighted noise exposure was calculated using a logarithmic formula. Results of Phase I revealed that participants listened on average at 73dBA for mobile phones, 76 dBA for iPods, and 79 dB dBA for MP3 players in the quiet condition. Results did not indicate a significant increase in SPL output with the presence of background noise. Results revealed that the majority of participants (70%) did not listen to music higher than 80 dBA in the presence of bus noise. However, the authors noted that results may have been affected by the type of insert earphones being used in the study. The authors explained that insert earphones offer attenuation to sound. Furthermore, at the maximum volume control, output levels increased when compared to the participants' preferred listening levels setting. In Phase II of the experiment, pure tones and DPOAEs were measured. Results indicated no statistical significance between pure tones and DPOAEs of participants who set output levels above 80dBA and participants who set output levels below 80dBA. However, correlation analysis revealed that participants who listened at the higher levels showed higher pure tone thresholds at 6000Hz. Furthermore, the results also revealed that individuals who listened at the higher output levels showed reduced DPOAE amplitudes in the high frequencies. Results of this research study indicated that listening to personal music systems at high intensity levels can cause subtle damage to the auditory system through an extended time period (Kumar et al., 2009).

Contrary to the previous article on background noise presented by Kumar et al. (2009), Fligor (2007) explains that background noise directly affects the selection of preferred listening levels. The author continues to explain that 6% of listeners chose levels above 85 dBA when in a quiet sound booth; however, 80% of listeners chose levels above 85 dBA when exposed to 80 dBA of airplane cabin noise. He further noted that by blocking out background noise through the use of sound-isolating earphones, the effects of NIHL can be reduced. Fligor (2007) further states that approximately 5-15% of people who use iPods listen at levels and durations that could potentially damage their hearing. Furthermore, Fligor (2007) explained that by listening to iPods for approximately 90 minutes a day at 80% of the maximum volume level (instead of 100% volume), people can possibly decrease their chances of NIHL.

Collectively, the previous studies indicate different results concerning the effects of background noise on the selection of preferred listening levels. On one hand, some literature was found to support the theory that background noise causes an increase in the selection of preferred listening levels. However, other literature stated that there is no correlation between background noise and the selection of preferred listing levels.

iPod Usage during Physical Activity

Various studies have been completed to examine the relationship between exercising and the selection of preferred listening levels using iPods. First, Hooks-Horton, Geer, and Stuart (2001) evaluated the effect of physical exercise and noise on auditory thresholds and DPOAEs. Participants in the study included 16 adults (8 male and 8 female; mean age = 24.5 years) in good physical condition with no noted hearing abnormalities. DPOAEs and pure tone thresholds were evaluated in 4 conditions: (1) quiet only, (2) exercise only, (3) noise only, and (4) exercise with noise. The quiet condition required that the participants engage in quiet sedentary activity for ten minutes (e.g., reading); the exercise only condition required that the participants be involved in ten minutes of bicycling. The noise only condition required that the participants be exposed to a 105 dBA 2000 Hz narrow band noise while engaged in quiet activity for ten minutes. The combination of exercise and noise required that the participants be engaged in bicycling while listening to a 105 dBA 2000 Hz narrow band noise for ten minutes. The participants were given 48 hours between each test condition. Results of the study revealed that the conditions including noise resulted in greater auditory threshold shifts (6 to 13 dB HL) than those without noise. The results of this study also revealed decreased levels of DPOAEs when using the test conditions involving noise (6 to 7 dB in DPOAE levels). The study also explained that a significant change was not noted (TTS or DPOAEs) between the noise-only condition and the combined exercise with noise condition. The results of this study indicated that the addition of noise has an effect on auditory thresholds and DPOAE results (Hooks-Horton et al., 2001).

Secondly, Vittitow, Windmill, Yates, and Cunningham (1994) examined the effect of cardiovascular exercise and noise on temporary and permanent NIHL. The participants included 12 females (mean = 24.1 years, range = 21-29 years) with no noted hearing impairments and normal systolic and diastolic blood pressure. Noted threshold shifts were evaluated in three different categories: (1) music only, (2) exercise only, and (3) music with exercise. Music was presented to the participants via Ear Tone 3A insert earphones with foam tips. In the music conditions, participants were required to listen to pop songs at a level of 96.4 dBA for 20 minutes. In the exercise conditions, participants were required to ride a bicycle for 20 minutes. Participant heart rate and blood pressure were evaluated throughout the study in order to guarantee stable results. Post-study thresholds were then evaluated in a sound-treated booth. Results of the study concluded that noticeable temporary or permanent threshold shifts were documented for both conditions in which music was present. Furthermore, music with exercise revealed greater temporary or permanent threshold shifts than any other condition. The exercise only conditions revealed no threshold shifts. The results of this study indicated physical exercise in combination with noise can increase the likelihood of noise induced temporary threshold shifts and the possibility of permanent hearing loss. The author concluded by noting a need for a follow-up study in order to evaluate exercise combined with music and the effect that it has on hearing (Vittitow et al., 1994).

Lastly, Wilson and Herbstein (2003) evaluated the influence of motivation during physical exercise on the selection of preferred listening levels. The authors also examined the participant's awareness of TTS and/or NIHL caused by elevated music intensity. The participants included 236 participants (29% male and 71% female) ranging from 18 to 50 years old. The participants were divided into the following class groups: (1) high risk (97 dBA), (2) at-risk (89dBA), (3) low risk (85 dBA), and (4) very low risk (80 dBA) for TTS or NIHL. Participants were exposed to the above levels of music for 60 minutes in a typical aerobics classroom through the use of a soundfield amplification system. Following the aerobics session, participants were asked to complete a questionnaire in order to evaluate their opinion on motivation and enjoyment when exercising to the selected intensity of music. The results revealed that participants were more motivated and reported higher levels of enjoyment when listening to music at higher intensities. Furthermore, the results revealed that half of participants (51%) in the 80dBA class were unaware of the risks (TTS/NIHL) associated with listening to music at elevated levels. The results of this study indicated that listening to music at higher intensity levels resulted in increased motivation for physical exercise (Wilson and Herbstein, 2003).

CHAPTER III

METHODS

Participants

The participants included 15 college-aged students (6 men and 9 women) with normal hearing. The age range of participants was between 19 and 30 years (M= 22.8, SD=2.678). Participants were recruited from Louisiana Tech University through an email blast, Department of Speech undergraduate classes, and friends and family of the researchers. The inclusion criteria for participants in this study included: (1) hearing thresholds of 25 dB HL or better bilaterally at the frequencies 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz, which is indicative of normal hearing according to the American Speech and Hearing Association Preferred Practice Guidelines (ASHA, 1997); (2) no known neurological, cognitive, or otologic impairment; (3) removal from excessive noise for at least 48 hours prior to testing; and (4) endurance in running on a treadmill for the duration of ten minutes.

Materials and Procedures

Location. The proposed project was completed at two different sites. First, the subjects were escorted to Louisiana Tech Speech and Hearing Center's sound treated booth (IAC, Model 30 2.4384m x 2.2352m x 1.9812m) for pre-screening of hearing thresholds and pre-tested diagnostic Distortion Product Otoacoustic Emissions (DPOAE) testing. The subjects then traveled to the Louisiana Tech University Intramural Center

Gymnasium, where they set the personal listening device while running on a treadmill. This setting was chosen because it produced natural levels of background noise in a gymnasium setting. The participants were then escorted back to the Louisiana Tech Speech and Hearing Clinic for sound pressure level measurements, post-test DPOAE measurements, and re-screening of hearing thresholds in the sound treated booth.

Equipment. Multiple pieces of equipment were used for the completion of this research project. A diagnostic audiometer Grayson-Stadler 61 [GSI 61] (serial # 53200082329) calibrated to specifications and supra-aural (TDH-39) headphones were used in order to obtain audiological data (i.e., pure tones). The ILO Clinical OAE system from Otodynamics (serial # 5320008394) was used to obtain DPOAEs in the sound treated booth. A treadmill at the Louisiana Tech Intramural Center was used to simulate physical activity. An iPod (80 GB classic iPod, serial # 8M746QCNYMV) with previously installed varying genres of music was used in order for the participant to select from during exercise. The Extech 407768 sound level meter (serial # Z169750) was used to obtain background noise measurements during physical activity. Lastly, a portable calibrated Audioscan RM500SL (serial #53200081587, dimensions 15.5"x12.75"x4.25") was used to determine the output selected by the participant. The RM500SL was appropriately calibrated in both the left and right probe module prior to each test session in order to ensure accurate results.

Qualification Criteria. Initially, each participant received (i) a verbal description of the study; (ii) read and signed the Informed Consent Form (see Appendix A), and (iii) completed a questionnaire about their weekly/monthly/yearly physical activity exposure (see Appendix C). Furthermore, otoscopy was performed in order to rule out any obstruction of the canal or any significant ear disease. Hearing thresholds were obtained at 500, 1000, 2000, 3000, 4000, 6000, and 8000Hz to ensure thresholds of 25 dB or better bilaterally. If participants did not pass this hearing screening, they were excluded from the study and referred to the Louisiana Tech Speech and Hearing Center for a complete audiological examination.

Test Procedures. After inclusion criterion procedures were completed, pre-test distortion product otoacoustic emissions (DPOAEs) were obtained in the sound treated booth for each participant. Participants were then escorted to the Louisiana Tech Intramural Center and instructed to run on a treadmill in order to simulate physical activity. Each participant selected a song on the provided iPod from the list of different genres (Rock/Alternative, 80s, Country). Each participant was asked to run ten minutes and set the iPod to his/her preferred listening level while running. Sound level measurements in dBA-scale and dBC-scale were made at five minutes and seven-minute intervals to note the level of background noise in the room during the experiment. The recording maximum/minimum feature of the sound level meter was utilized to produce two values over a 30-second time period. The minimum and maximum values were then averaged to produce one recorded value for each time interval (i.e., 5 and 7 minutes) and scale (i.e., A and C). The selected intensity, chosen by the participant while exercising, on the iPod was locked at that level, and the participants were then escorted back to the Louisiana Tech Speech and Hearing Center's sound-treated booth.

A probe tube was placed in the patient's ear canal (28mm for females and 30 mm for males) along with the iPod ear bud (RM500SL Test Manual, 2009). The Audioscan RM500SL was used to obtain real ear SPL of the iPod output (see Appendix D for specific instructions on obtaining real ear measures). Four separate frequency response curves were taken while the song was playing. The obtained probe microphone measurements consisted of 65 data points that are measured in 1/12th octave steps over a frequency range from 200 to 8000 Hz. The recorded frequency response curves were downloaded and stored to a personal computer system for subsequent data analysis. Post-test audiometric thresholds were obtained in the sound treated booth to note temporary threshold shifts at 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. Lastly, post-test DPOAEs were obtained in the sound treated booth to note any changes in responses. It should be noted that all experimental testing for this research project was completed in a sound-treated examination room with ambient noise levels appropriate for testing unoccluded ears (ANSI S3.1-1991).

CHAPTER IV

RESULTS

The purpose of the present study was to determine preferred listening levels of participants during cardiovascular exercise. Pre-test DPOAEs and audiometric thresholds were obtained. Participants were then instructed to set the iPod to their preferred listening level during cardiovascular exercise at the Louisiana Tech Intramural Center. Probe microphone measurements were then obtained utilizing the Audioscan RM500SL. Four frequency response curves were obtained while the music was playing. The data was then extracted from the Audioscan and placed into an excel file for subsequent data analysis. Post-test DPOAEs and audiometric thresholds were then re-obtained to note threshold shifts.

Descriptive Data Analysis

For the purposes of the present research study, a descriptive data analysis was used to determine averages of the obtained participant frequency response curves. The long term average speech spectrum [LTASS] was measured using the Audioscan RMSL500 in order to calculate the preferred listening levels for each participant. The LTASS consists of the peaks, averages, and valleys speech. Specifically, the LTASS displays a 30 dB range of speech to include +12 dB SPL for the peaks of speech and a -18 dB SPL range for the valleys of speech, both in comparison to the average frequency response curve (RMSL500 Test Manual, 2009). The averages within the LTASS are estimates of normal conversational levels. For the purposes of this research study, the peaks were primarily evaluated to measure the highest intensity level selected by participants. For data analysis purposes, the data were compiled in Microsoft Excel. The peaks, averages, and valleys of all four frequency response curves were averaged for each participant at all octave frequencies from 200 to 6000 Hz. For analysis purposes, a frequency range of 200 to 6000 Hz was evaluated specifically due to a decrease in frequency response of the iPod output (i.e. roll off) from 6000 to 8000 Hz. Averages were then taken again across participants to obtain one measurement for the mean peak, average, and valley of the LTASS. Participants' peak, average, and valley measurements of iPod output are shown in Figure 1 and Table 1.

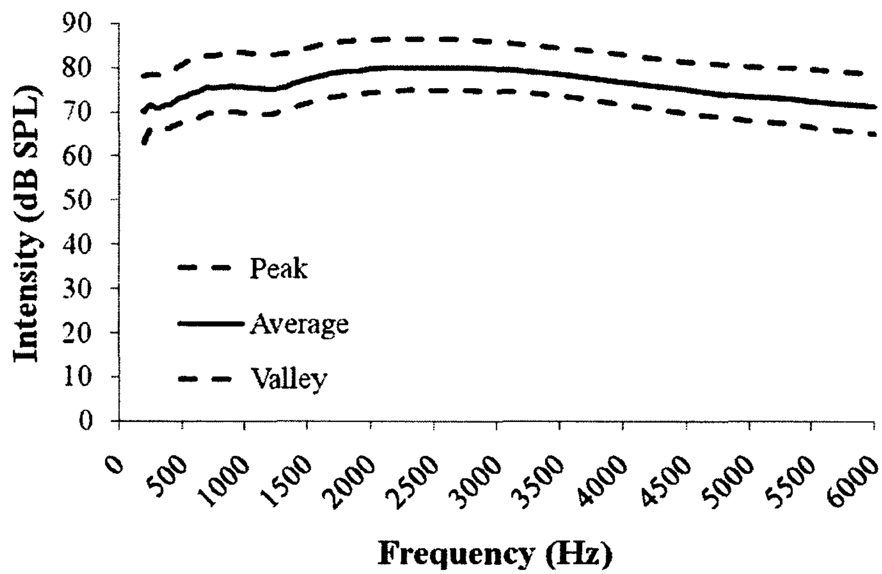

Figure 1. LTASS peak, average, and valley measurements of iPod output (dB SPL) for all participants combined.

Table 1. LTASS peak, average, and valley means and standard deviations for sound pressure levels (SPLs) for all participants combined.

	Mean	Std. Deviation
Peak	82.2664	5.87203
Average	75.1565	6.38777
Valley	69.6212	7.47001

Furthermore, participants were given a questionnaire to evaluate their daily/weekly exercise, iPod use, and personal loudness perception when listening to their iPod during cardiovascular exercise (see Appendix C). It should be noted that question one of the questionnaire was a qualification criteria ensuring that all participants had been removed from excessive noise for 48 hours. All participants met these criteria, allowing them to participate in this study. Responses to the questionnaire are shown in Tables 2 and 3.

Table 2. Subject questionnaire responses for questions 4, 6, 7 and 8.

Question	Yes	No	Other
Q4 – Do you run during CVE?	12	3	0
Q6 – Can you run for 10 min on a treadmill?	15	0	0
Q7 – Can you run 1 mile on a treadmill?	15	0	0
Q8 – Do you routinely listen to an iPod during CVE?	8	6	1

Note: See Appendix C for specific questions. Abbreviations: CVE = cardiovascular exercise.

Table 3. Subject questionnaire responses for questions 2, 3, 5 and 9.

Question	A	B	C	D	E
Q2 – Frequency of participation in CVE	9	5	0	1	NA
Q3 – Length of participation in CVE	10	5	0	0	NA
Q5 – Running length during CVE?	3	5	3	2	2
Q9 – Preferred headphone to use during CVE?	2	8	0	5	NA

Note: See Appendix C for specific questions. Abbreviations: CVE = cardiovascular exercise.

Furthermore, participants were asked two post-test questions. First, participants were asked if they experienced tinnitus (i.e. ringing) following testing procedures. Of the 15 participants, one participant reported that they experienced post-test tinnitus. The remaining 14 participants reported that they did not experience tinnitus following testing. Secondly, participants were asked to rank their personal loudness perception of the selected iPod intensity in the sound treated booth following testing. Responses to the participants' loudness perception are shown in Table 4.

Table 4. Participant iPod loudness perception questionnaire responses.

Loudness Category	Number of Listeners
1 = very soft	0
2= soft	0
3= comfortable, but slightly soft	0
4= comfortable	2
5= comfortable, but slightly loud	4
6= loud, but ok	8
7 = uncomfortably loud	1

Furthermore, sound level measurements in dBA-scale and dBC-scale were made at five minute and seven-minute intervals to note the level of background noise in the room during the experiment. The recording maximum/minimum feature of the sound level meter was utilized to produce two values over a 30 second time period. The minimum and maximum values were then averaged to produce one recorded value for each time interval (i.e., 5 and 7 minutes) and scale (i.e., A and C). Results of sound level measurements are displayed in Table 5.

Table 5. Mean (range) sound level meter data at five and seven minutes in dBA and dBC scale.

	5 Minutes	**7 Minutes**
dBA	75.8 (66.7-87.7)	76.5 (66.9-91.2)
dBC	79.9 (73.2-86.3)	80.0 (73.5-87.1)

Statistical Analysis

Effect of Gender on Intensity Level. Three one-way analyses of variance (ANOVAs) were completed to determine if gender had a significant effect on the selection of preferred listening levels using iPods. The dependent variable was sound pressure levels (i.e., peak, average, and valley). The grouping variable was gender with two levels (male, female). Statistical analysis showed no significant difference in sound pressure levels for male versus female peak values ($F\ (1, 13) = 0.008$, $p = 0.93$), average values ($F\ (1, 13) = 0.043$, $p = 0.84$), or valley values ($F\ (1.13) = 0.090$, $p = 0.77$). These results indicate that an individual's gender does not affect the selection of preferred listening levels of iPods during cardiovascular exercise. These results are displayed in Figure 2.

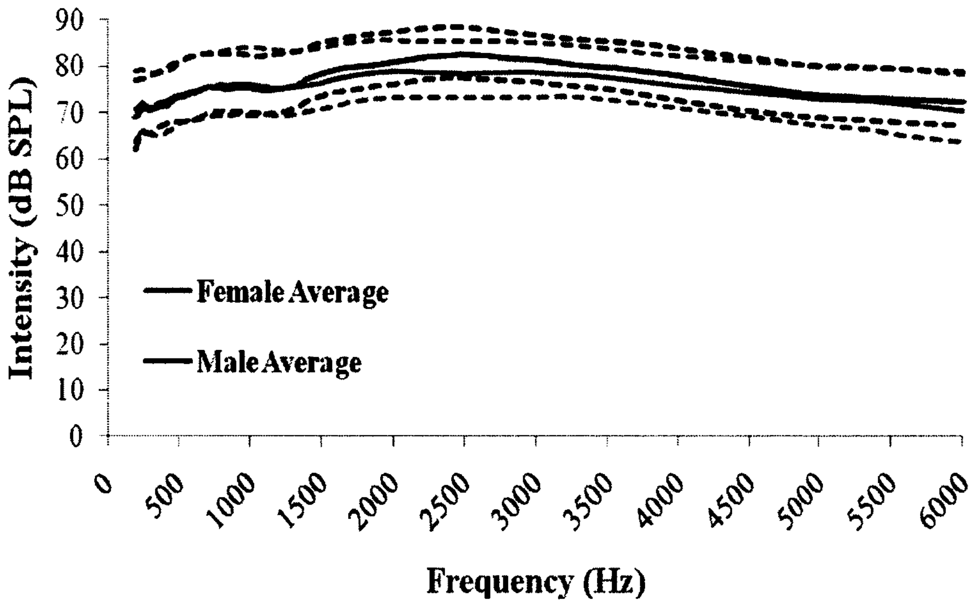

Figure 2. LTASS peak, average, and valley measurements for iPod output as a function of gender.

Pure-Tone Results. A one-way repeated measures ANOVA was completed to determine the effect of selected SPL on pre- versus post-test pure tone results for each ear. The grouping variables were ear (i.e., left or right) and pure tone frequency (i.e., 500, 1000, 2000, 3000, 4000, 6000, and 8000Hz). Please note, within this ANOVA, 14 comparisons were completed (i.e., seven for the left ear and seven for the right ear); a Bonferroni adjustment for multiple comparisons was completed within the analysis. Statistical analysis revealed that there was a significant change in pre- versus post-test pure tone data at 4000 Hz ($F=6.000$, $p<.05$) in the right ear and at 8000 Hz ($F=4.846$, $p<.05$) in the left ear. All other pre- versus post-test comparisons for pure tones were non-significant. These results indicate that participants selected intensity levels that resulted in hearing damage (temporary and/or permanent) at specific frequencies (i.e. 4000 and 8000 Hz).

As a part of this ANOVA, partial eta squared (partial η^2) values were calculated to determine effect sizes of clinical significance (Nolan & Heinzen, 2007). Nolan and Heinzen (2007) state that the ranges for effect sizes of clinical significance for partial eta squared are evaluated as follows: (1) large effect size ≥ 0.138, (2) medium effect size ranged from 0.059 to 0.137, and (3) a small effect size ranged from 0.01 to 0.058. For the purposes of this study, large effect size and medium effect size only were evaluated. Statistical analysis showed that there was a clinically significant large effect size at 4000 Hz (partial η^2 =.300) in the right ear and at 8000 Hz (partial η^2 =.257) in the left ear. Statistical analysis showed that there was a clinically significant medium effect size at 2000 Hz (partial η^2 =.133) in the right ear and at 1000 Hz (partial η^2 =.067) in the left ear. These results indicate that there was a large clinical significance in pure tone data at 4000 Hz in the right ear and at 8000 Hz in the left ear when comparing pre- and post-test data. Furthermore, these results indicate that there was a medium clinical significance in pure tone data at 2000 Hz in the right ear and at 1000 Hz in the left ear when comparing pre- and post-test data. Conclusively, the results indicate that participants selected preferred listening levels that resulted in significant changes to pre- and post-test hearing sensitivity at some frequencies, which can potentially lead to temporary and/or permanent hearing damage at those frequencies. Tables 6 and 7 show the results of the one-way repeated measures ANOVA results displaying the comparison of pure tone results for the right and left ears, respectively.

Table 6. Means (SDs), t-values, p-values, and partial eta squared for pure tone pre- and post-test data for the right ear.

Comparison of...	Mean (SD)	F-value	p-value	Partial Eta Squared
Pre-test pure tone @ 500 Hz	4.667 (3.159)			
Post-test pure tone @ 500 Hz	5.000 (3.273)	0.318	0.582	0.022
Pre-test pure tone @ 1000 Hz	5.333 (5.499)			
Post-test pure tone @ 1000 Hz	5.333 (5.499)	0.000	1.000	0.000
Pre-test pure tone @ 2000 Hz	5.333 (5.815)			
Post-test pure tone @ 2000 Hz	6.000 (6.036)	2.154	0.164	0.133 ○
Pre-test pure tone @ 3000 Hz	6.000 (6.866)			
Post-test pure tone @ 3000 Hz	6.333 (7.432)	0.318	0.582	0.022
Pre-test pure tone @ 4000 Hz	5.667 (5.627)			
Post-test pure tone @ 4000 Hz	7.667 (5.300)	6.000	0.028 *	0.300 ▲
Pre-test pure tone @ 6000 Hz	10.333 (7.898)			
Post-test pure tone @ 6000 Hz	9.667 (6.399)	0.384	0.546	0.0270
Pre-test pure tone @ 8000 Hz	12.000 (6.211)			
Post-test pure tone @ 8000 Hz	12.000 (4.928)	0.000	1.000	0.000

Note: ▲ = large effect size, ○ = medium effect size, * = significant at the 0.05 level.

Table 7. Means (SDs), t-values, and p-values for pure tone pre- and post-test data for the left ear.

Comparison of...	Mean (SD)	F-value	p-value	Partial Eta Squared
Pre-test pure tone @ 500 Hz	4.000 (2.070)			
Post-test pure tone @ 500 Hz	3.667 (2.968)	0.318	0.582	0.022
Pre-test pure tone @ 1000 Hz	4.000 (4.706)			
Post-test pure tone @ 1000 Hz	4.333 (4.577)	1.000	0.334	0.067 ○
Pre-test pure tone @ 2000 Hz	6.333 (7.669)			
Post-test pure tone @ 2000 Hz	6.000 (8.062)	0.318	0.582	0.022
Pre-test pure tone @ 3000 Hz	5.667 (6.779)			
Post-test pure tone @ 3000 Hz	6.000 (6.866)	0.318	0.582	0.022
Pre-test pure tone @ 4000 Hz	5.667 (6.230)			
Post-test pure tone @ 4000 Hz	6.000 (6.036)	0.318	0.582	0.022
Pre-test pure tone @ 6000 Hz	11.000 (6.866)			
Post-test pure tone @ 6000 Hz	11.333 (6.114)	0.189	0.670	0.013
Pre-test pure tone @ 8000 Hz	15.000 (6.268)			
Post-test pure tone @ 8000 Hz	18.000 (7.270)	4.846	0.045*	0.257 ▲

Note: ▲ = large effect size, ○ = medium effect size, * = significant at the 0.05 level.

DPOAE Results. Pre-test diagnostic DPOAEs were measured prior to testing at the Louisiana Tech Intramural Center. DPOAE amplitudes and noise levels were measured for 1001, 1501, 2002, 3003, 4004, 6006, and 7996 Hz. Using amplitudes and noise levels, DPOAE signal to noise ratios were calculated at each frequency. Post-test DPOAEs were also measured, and DPOAE signal to noise ratios were calculated at the same frequencies. Signal to noise ratios for post-test DPOAEs were then compared to pre-test results to note any changes in signal to noise ratio using a one-way repeated measures ANOVA. The grouping variables were ear (i.e., left or right) and DPOAE frequency (i.e., 1001, 1501, 2002, 3003, 4004, 6006, and 7996 Hz). Therefore, within this ANOVA, 14 comparisons were completed (i.e., seven for the left ear and seven for the right ear); a Bonferroni adjustment for multiple comparison was completed within the analysis. Statistical analysis revealed a significant change in pre- versus post-test DPOAE data at 4000 Hz ($F=5.304$, $p<0.05$) in the left ear. Furthermore, statistical analysis showed that there was a clinically significant large effect size at 1001 Hz (partial $\eta^2=.146$) in the right ear and 4004 Hz (partial $\eta^2=.257$) in the left ear. Statistical analysis showed that there was a clinically significant medium effect size at 1501 Hz (partial $\eta^2=.128$), 2002 Hz (partial $\eta^2=.070$), 4004 Hz (partial $\eta^2=.086$), 6006 Hz (partial $\eta^2=.090$) in the right ear and at 1501 Hz (partial $\eta^2=.130$) and 3003 Hz (partial $\eta^2=.082$) in the left ear. Tables 8 and 9 show the comparison of DPOAE pre- and post-test data for the right and left ears, respectively.

Table 8. Means (SDs), t-values, and p-values for DPOAE pre- and post-test data for the right ear.

Comparison of…	Mean (SD)	F-value	p-value	Partial Eta Squared
Pre-test OAE @ 1001 Hz	9.900 (11.323)			
Post-test OAE @ 1001 Hz	7.200 (8.758)	2.401	.144	0.146 ▲
Pre-test OAE @ 1501 Hz	15.760 (7.523)			
Post-test OAE @ 1501 Hz	13.940 (7.884)	2.056	.174	0.128 ○
Pre-test OAE @ 2002 Hz	16.027 (8.512)			
Post-test OAE @ 2002 Hz	14.780 (7.381)	1.056	.322	0.070 ○
Pre-test OAE @ 3003 Hz	15.787 (6.202)			
Post-test OAE @ 3003 Hz	14.773 (5.760)	0.612	.447	0.042
Pre-test OAE @ 4004 Hz	17.780 (7.341)			
Post-test OAE @ 4004 Hz	16.540 (8.932)	1.323	.269	0.086 ○
Pre-test OAE @ 6006 Hz	14.487 (4.988)			
Post-test OAE @ 6006 Hz	13.100 (6.437)	1.388	.258	0.090 ○
Pre-test OAE @ 7996 Hz	.873 (15.448)			
Post-test OAE @ 7996 Hz	.720 (13.763)	0.006	.937	0.000

Note: ▲ = large effect size, ○ = medium effect size, * = significant at the 0.05 level.

Table 9. Means (SDs), t-values, and p-values for DPOAE pre- and post-test data for the left ear.

Comparison of…	Mean (SD)	F-value	p-value	Partial Eta Squared
Pre-test OAE @ 1001 Hz	7.320 (8.138)			
Post-test OAE @ 1001 Hz	6.480 (11.036)	0.139	.715	0.010
Pre-test OAE @ 1501 Hz	15.393 (9.610)			
Post-test OAE @ 1501 Hz	17.193 (7.894)	2.088	.170	0.130 ○
Pre-test OAE @ 2002 Hz	16.240 (10.121)			
Post-test OAE @ 2002 Hz	17.333 (9.026)	0.528	.479	0.036
Pre-test OAE @ 3003 Hz	14.180 (10.138)			
Post-test OAE @ 3003 Hz	12.427 (11.320)	1.254	.282	0.082 ○
Pre-test OAE @ 4004 Hz	18.000 (5.133)			
Post-test OAE @ 4004 Hz	15.720 (7.370)	5.307	.037 *	0.275 ▲
Pre-test OAE @ 6006 Hz	13.413 (9.236)			
Post-test OAE @ 6006 Hz	13.313 (12.035)	0.004	.951	0.000
Pre-test OAE @ 7996 Hz	-1.580 (13.465)			
Post-test OAE @ 7996 Hz	-2.080 (12.231)	0.148	.706	0.010

Note: ▲ = large effect size, ○ = medium effect size, * = significant at the 0.05 level.

Individual Data Analysis

A secondary data analysis was completed in order to evaluate individual selected intensity levels. Although the average data didn't show hazardous noise levels, it is important to note that upon examination of individual data, results showed selected intensity levels above 90 dB SPL for five of the 15 participants. Therefore, the results of the individual data analysis indicated that approximately 33% of the participants preferred listening levels reached intensities that could potentially cause damage to hearing.

Bridge-Newman Comparison

Because this study was a follow up study to Bridge (2009), data analysis also included a comparison of data from the present study to data taken from Bridge (2009). To review, Bridge (2009) evaluated the preferred listening levels of iPod users in everyday listening situations in 40 young adults with normal hearing. Participants were provided with a 60 GB Apple iPod and were instructed to select their preferred listening level while walking outside. In contrast, the current study evaluated the preferred listening levels of iPod users during cardiovascular exercise at an intramural center gymnasium. Sound pressure level measurements were obtained using identical procedures in both studies with the Audioscan RM500SL.

To compare the two studies, a one way repeated measures ANOVA was performed to evaluate the effect of environment on the selection of preferred listening levels using iPods (see Table 10 and Figure 3 for mean data). The within subject variable was speech level with three levels (peak, average, and valley measurements of the LTASS). The between subject variable was environment with two levels (quiet daily listening environment versus an intramural gymnasium environment during cardiovascular exercise). Not surprisingly, there was a significant difference ($F(2, 106) = 1599.6$, $p < 0.001$) between the peak, average, and valley measurements. As predicted, these results indicate that the peaks of speech produced louder sound pressure levels than the averages of speech on the LTASS. Furthermore, the results indicate that the valleys of speech produced softer sound pressure levels than the averages of speech on the LTASS. Results of the Bridge-Newman comparison are shown in Table 10 and Figure 3.

Table 10. Means (standard deviations) comparing Bridge (2009) peak, average, and valley SPL measures to the current study.

	Bridge	**Newman (Current Study)**
Peak	75.09 (8.92)	82.27 (5.87)
Average	68.36 (8.91)	75.16 (6.39)
Valley	64.49 (8.90)	69.62 (7.47)

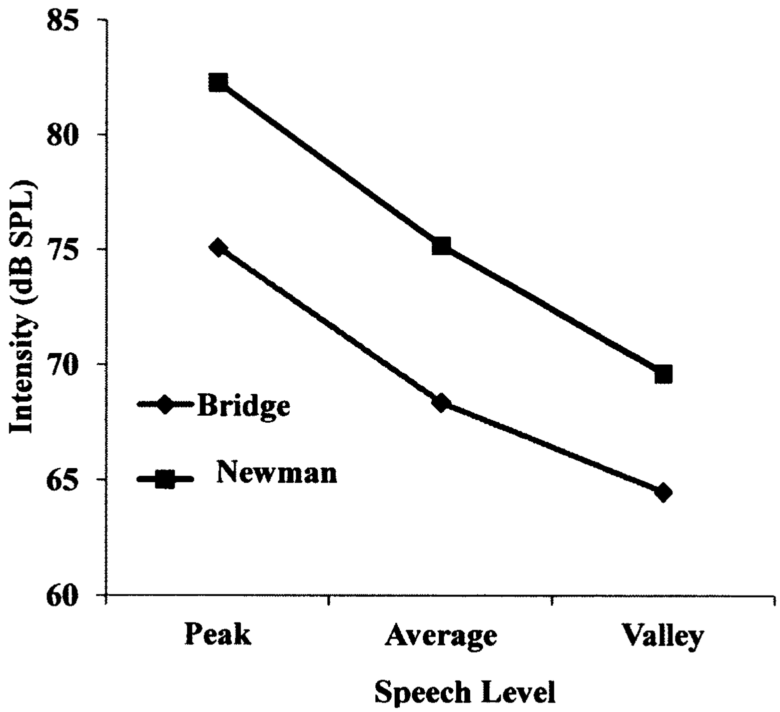

Figure 3. A comparison of peak, average, and valley measurements between Bridge (2009) and Newman (i.e., current) data.

Furthermore, results of the one-way ANOVA revealed that there was a significant difference for environment ($F (1, 53) = 6.38$, $p = 0.015$). To investigate the environmental difference for each of the three speech levels (i.e., peaks, averages, and valleys), three independent t-tests were completed to determine the effect of environment on the peaks, averages, and valleys of speech. T-tests revealed that there was a significant difference in the peak ($t=2.882$, $p= .006$) and average ($t=2.698$, $p= .009$) measurements for the two environments. Furthermore, statistical analysis revealed that the valley measurements ($t=1.984$, $p= .052$) approached significance. Statistical analysis also showed that there was a clinically significant medium effect size (partial $\eta^2 =.107$) when comparing environments of the two studies. These results indicate that participants listen at louder sound pressure levels in an indoor workout facility setting while running (current study) as opposed to an outdoor setting while walking (Bridge, 2009).

Lastly, statistical analysis revealed a significant level by environment interaction ($F (2,106) =13.8$, $p < 0.001$). Specifically, the difference between two sound pressure levels for the environment for peak and average measurements were slightly larger than the sound pressure level differences between the two valley measurements (see Figure 3).

CHAPTER V

DISCUSSION

One purpose of this study was to determine preferred listening levels of participants during cardiovascular exercise. Pre-test DPOAEs and audiometric thresholds were obtained in a sound treated booth. Participants were then instructed to run for 10 minutes on a treadmill and select their preferred listening level using an iPod. Probe microphone measurements were made utilizing the Audioscan RM500SL. Four frequency response curves were obtained for each participant, and the frequency response curves were averaged together to obtain a single number for the peak, average, and valley measurements for each participant. Lastly, post-test DPOAEs and audiometric thresholds were made to note any temporary threshold shifts.

The mean peak, average, and valley iPod output was measured in dB SPL for all participants (N=15). Measurements were made for the frequency range of 200-6000 Hz. According to the OSHA Resource Guide, 90 dB-A is the permissible noise level for an eight-hour period of exposure (OSHA, 2000). Results of the descriptive data analysis indicated that iPods may not produce hazardous music intensity levels when selected while running on a treadmill for ten minutes. Specifically, the results revealed that the combined peak averages for all participants was 86 dB SPL. However, results of the individual data analysis further revealed that five listeners set their iPods at intensity levels above 90 dB SPL, which could be hazardous to their hearing, potentially causing hearing damage.

Previous studies have been completed to evaluate the effect of the selection of preferred listening levels using iPods on an individual's hearing. To compare, Bridge (2009) found that listeners on average do not select listening levels that are hazardous to their hearing; however, Bridge (2009) found that seven participants did select individual intensity levels that exceeded 90 dB SPL when listening to their iPods. Furthermore, Vittitow et al. (1994) examined the effect of cardiovascular exercise and noise on temporary and permanent NIHL. Results of the study concluded that noticeable temporary or permanent threshold shifts were documented for conditions in which music was present. Specifically, the results indicated that physical exercise in combination with noise can increase the likelihood of noise induced temporary threshold shifts and the possibility of permanent hearing loss (Vittitow et al., 1994). Lastly, Wilson and Herbstein (2003) evaluated the influence of motivation during physical exercise on the selection of preferred listening levels. The results of this study indicated that listening to music at higher intensity levels resulted in increased motivation for physical exercise (Wilson and Herbstein, 2003). Collectively, the previous research is in agreement with the current study, revealing that the selection of hazardous listening levels can cause potential hearing loss.

Effect of Gender on Intensity Level

Another purpose of the present study was to determine the effect of gender on selection of preferred listening levels while participating in cardiovascular exercise. Results indicated no significant difference in the selection of SPL levels between male (N

= 6) and female (N = 9) participants. These results indicate that gender does not have a significant effect on the selection of preferred listening levels using iPods during cardiovascular exercise. Bridge (2009) evaluated the effect of gender on the selection of preferred listening levels using iPods in an everyday, quiet environment (i.e., walking outside). Results of that study revealed that males and females listened to their iPods at similar volume levels (i.e., there was no difference in intensity selection). To compare, Bridge (2009) and the current study both found that gender does not have a significant effect on the selection of preferred listening levels using iPods.

Pure Tone Comparison

The present study also evaluated the effect of listeners' preferred listening levels on pre- and post-test audiometric thresholds using a one-way repeated measures ANOVA. Results of pre- and post-test audiometric thresholds revealed that participants selected iPod intensity levels that resulted in statistically significant temporary threshold shifts at 4000 Hz in the right ear and 8000 Hz in the left ear. These results indicate that listeners set their iPods at intensity levels that could be hazardous to their hearing and result in decreased hearing thresholds at specific frequencies (i.e., 4000 and 8000 Hz).

Furthermore, partial eta squared values were calculated to determine effect sizes for listeners' preferred listening levels on pre- and post-test audiometric thresholds. Data analysis indicated that there was a large clinical significance for pure tone data at 4000 Hz in the right ear and at 8000 Hz in the left ear when comparing pre- and post-test data. Furthermore, analysis revealed that there was a medium clinical significance in pure tone data at 2000 Hz in the right ear and at 1000 Hz in the left ear when comparing pre- and post-test data. Conclusively, the results of the pre- and post-test audiometric thresholds revealed that participants selected iPod intensity levels that resulted in clinically significant temporary threshold shifts at 2000 and 4000 in the right ear and at 1000 and 8000Hz in the left ear. The results indicated that the participants selected preferred listening levels which produced significantly poorer hearing thresholds at specific frequencies, potentially leading to temporary and/or permanent hearing damage.

DPOAE Results

The present study also evaluated the effect of listeners' preferred listening levels on pre- and post-test DPOAEs using a one-way repeated measures ANOVA. Results of pre- and post-test DPOAEs revealed that participants selected iPod intensity levels that resulted in a statistically significant decrease in DPOAE amplitude responses at 4000 Hz in the left ear. These results indicate that participants selected intensity levels that can be hazardous to their hearing and result in decreased DPOAE responses at specific frequencies (i.e., 4000Hz).

Furthermore, partial eta squared values were calculated to determine effect sizes of clinical significance of listeners' preferred listening levels on pre- and post-test DPOAEs. Statistical analysis showed that there was a clinically significant large effect size at 1001 Hz in the right ear and 4004 Hz in the left ear when comparing pre- and post-test DPOAE data. Statistical analysis showed that there was a clinically significant medium effect size at 1501, 2002, 4004 and 6006 Hz in the right ear and at 1501 and 3003 Hz in the left ear when comparing pre- and post-test data. Conclusively, results of the pre- and post-test DPOAEs revealed that participants selected iPod intensity levels that resulted in a clinically significant decrease in DPOAE amplitude responses at 1001, 1501, 2002, 4004, and 6006 Hz in the right ear and at 1501, 3003 and 4004Hz in the left ear. The results indicated that the participants selected preferred listening levels that resulted in a significant decrease in DPOAE amplitude at most frequencies, potentially leading to temporary and/or permanent hearing damage.

Personal Loudness Perception Scale

Furthermore, in the current study participants were asked to rank their personal loudness perception of the selected iPod intensity in the sound treated booth post-testing. Two of the 15 participants (i.e. 13%) responded that their post-test personal loudness perception of the selected iPod intensity in the sound-treated booth was comfortable. Four of the 15 participants (i.e. 27%) responded that their post-test personal loudness perception of the selected iPod intensity in the sound-treated booth was comfortable, but slightly loud. Eight of the 15 participants (i.e. 53%) responded that their post-test personal loudness perception of the selected iPod intensity in the sound-treated booth was loud, but ok. Lastly, one of the 15 participants (i.e. 7%) responded that their post-test personal loudness perception of the selected iPod intensity in the sound-treated booth was uncomfortably loud. Results of the loudness categorization revealed that all but two participants reported that the preferred listening level they selected while running on the treadmill was either loud or uncomfortably loud. This indicated that 87% of participants stated that the selected iPod intensity was loud or uncomfortably loud in the sound treated booth.

Bridge-Newman Comparison

The present study is a follow up study to research completed by Bridge (2009), who evaluated the selection of preferred listening levels in a quiet daily listening environment. Therefore, the effect of environment on the selection of preferred listening levels was evaluated when comparing the current study where listeners selected preferred listening levels in an intramural gymnasium to Bridge (2009) who instructed listeners to select listening levels in a quiet environment. The results revealed that there was a significant difference for environment. These results indicate that that participants selected louder sound intensities in the study completed by Newman (current) in an indoor, gymnasium environment as compared to in a quiet, outside listening environment. The results were expected based on previous research that states that preferred listening levels increase as background noise increases (Hodgetts et al., 2007).

Clinical Implications

Results of the present study produced a variety of clinically applicable findings related to hearing damage and iPod use during cardiovascular exercise. Mean data showed that when listeners' set their iPod at their preferred listening level while running on a treadmill, hazardous music intensity levels may not be selected. However, results of the individual data analysis revealed that five of 15 listeners set their iPods at intensity levels above 90 dB SPL. Furthermore, results of pre- and post-test audiometric thresholds revealed that participants selected iPod intensity levels that resulted in a significant temporary threshold shift at 4000 Hz in the right ear and 8000 Hz in the left ear. Results of the pre- and post-test audiometric thresholds revealed that participants selected iPod intensity levels that resulted in clinically significant temporary threshold shifts at 2000 and 4000Hz in the right ear and at 1000 and 8000 Hz in the left ear. Results of the pre- and post-test DPOAEs revealed that participants selected iPod intensity levels that resulted in a significant decrease in DPOAE amplitude responses at 4000 Hz in the left ear. Furthermore, results of the pre- and post-test DPOAEs revealed that participants selected iPod intensity levels that resulted in a clinically significant decrease in DPOAE amplitude responses at 1001, 1501, 2002, 4004, and 6006 Hz in the right ear and at 1501, 3003 and 4004Hz in the left ear. Collectively, these results indicate that when selecting music intensity levels while running on a treadmill, temporary and/or permanent noise-induced hearing loss may occur. Lastly, the Bridge-Newman comparison showed that participants selected louder intensity levels when selection occurred in an indoor, gymnasium environment as compared to a quiet, outside listening environment, indicating that the environment/background noise level does affect the loudness intensity level selected when listening to iPods.

APPENDIX A

HUMAN SUBJECTS CONSENT FORM

HUMAN SUBJECTS CONSENT FORM

The following is a brief summary of the project in which you are asked to participate. Please read this information before signing the statement below.

TITLE OF PROJECT: The Effect of Cardiovascular Physical Exercise When Selecting Preferred Listening Levels of iPods.

PURPOSE OF STUDY/PROJECT: The purpose of the proposed research project is to determine the effects of cardiovascular, physical exercise on the selection of preferred listening music levels when using an iPod.

PROCEDURE: If you volunteer to participate in this study, you must agree to have a hearing screening test, which will be provided to you free of charge. The screening test will take about 5 minutes. If the test results do not satisfy the subject eligibility criteria of the study, you will be excluded from further study participation. However, if the results of the test meet the subject eligibility criteria, you will be asked to perform the following tasks.

You will be instructed to run on a treadmill at the Louisiana Tech Intramural Center in order to simulate physical activity. You will also be asked to select a song on the provided iPod from the list of different genres (Rock/Alternative, 80s, Country). You will run for ten minutes and set the iPod to your preferred listening level. The selected intensity on the iPod will be held at that level, and you will then be escorted back to the Louisiana Tech Speech and Hearing Center's sound-treated booth. The Audioscan RM500SL will be used to measure the output of the iPod at your preferred listening level. Data will then be analyzed to determine the relationship among these variables and any changes in hearing status.

RISKS/ALTERNATIVE TREATMENTS: There are no risks associated with this study and participation is voluntary. All testing procedures are typical clinical procedures in audiology. Furthermore, all data will be kept strictly anonymous. Only numerical data such as hearing and output levels at your preferred listening level will be used in the presentation of results. Lastly, you are free to discontinue participation at any time.

BENEFITS/COMPENSATION: Each participant will receive a free hearing screening. Furthermore, the scientific and clinical communities will benefit from a better understanding of the effects cardiovascular exercise on preferred listening levels and these effects on hearing sensitivity.

I, ___________________, attest with my signature that I have read and understood the following description of the study, "The Effect of Cardiovascular Physical Exercise When Selecting Preferred Listening Levels of iPods," and its purposes and methods. I understand that my participation in this research is strictly voluntary and my participation or refusal to participate in this study will not affect my relationship with Louisiana Tech University, the Department of Speech, the Louisiana Tech Speech and Hearing Center, or my grades in any way. Further, I understand that I may withdraw at any time or refuse to answer any questions without penalty. Upon completion of the study, I understand that the results will be freely available to me upon request. I understand that the results of my survey will be confidential, accessible only to the principal investigators, myself, or a legally appointed representative. I have not been requested to waive nor do I waive any of my rights related to participating in this study.

____________________________ ________________________

Signature of Participant or Guardian **Date**

CONTACT INFORMATION: The principal experimenters listed below may be reached to answer questions about the research, subjects' rights, or related matters.

Jessica L. Newman, Doctoral Student — Department of Speech (318) 278-5320

Melinda F. Bryan, Assistant Professor / Project Manager — Department of Speech (318) 257-2146

Members of the Human Use Committee of Louisiana Tech University may also be contacted if a problem cannot be discussed with the experimenters: Dr. Les Guice (257-3056) Dr. Mary M. Livingston (257-2292 or 257-4315.

APPENDIX B

APPROVAL LETTER FROM IRB BOARD

LOUISIANA TECH
UNIVERSITY

OFFICE OF UNIVERSITY RESEARCH

MEMORANDUM

TO: Mrs. Jessica Newman and Dr. Melinda Bryan

FROM: Barbara Talbot, University Research

SUBJECT: Human Use Committee Review

DATE: October 18, 2011

RE: Approved Continuation of Study HUC 788

TITLE: **"The Effect of Cardiovascular Physical Exercise When Selecting Preferred Listening Levels of iPods"**

HUC 788 Renewal

The above referenced study has been approved as of October 18, 2011 as a continuation of the original study that received approval on December 2, 2010. **This project will need to receive a continuation review by the IRB if the project, including collecting or analyzing data, continues beyond December 2, 2012.** Any discrepancies in procedure or changes that have been made including approved changes should be noted in the review application. Projects involving NIH funds require annual education training to be documented. For more information regarding this, contact the Office of University Research.

You are requested to maintain written records of your procedures, data collected, and subjects involved. These records will need to be available upon request during the conduct of the study and retained by the university for three years after the conclusion of the study. If changes occur in recruiting of subjects, informed consent process or in your research protocol, or if unanticipated problems should arise it is the Researchers responsibility to notify the Office of Research or IRB in writing. The project should be discontinued until modifications can be reviewed and approved.

If you have any questions, please contact Dr. Mary Livingston at 257-4315.

A MEMBER OF THE UNIVERSITY OF LOUISIANA SYSTEM

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APPENDIX C

PARTICIPANT QUESTIONAIRE

Subject # __________ **Participant Questionnaire**

Gender: M / F Birthday:__________________

1. Have you been removed from excessive noise for 48 hours?
   a. Yes
   b. No

2. How often do you participate in cardiovascular exercise?
   a. 1-3 days per week
   b. 4-6 days per week
   c. 7 days per week
   d. Less than one day per week

3. How long do you participate in cardiovascular exercise per session?
   a. 30 minutes
   b. 1-2 hours
   c. 2-3 hours
   d. More than 3 hours

4. Do you run during cardiovascular exercise sessions?
   a. Yes
   b. No

5. Approximately how long do you run per session?
   a. ½ mile
   b. 1 mile
   c. 2 miles
   d. More than 2 miles
   e. I participate in other types of cardiovascular exercise

6. Do you have the endurance to run on a treadmill for 10 minutes?
   a. Yes
   b. No

7. Do you have the endurance to run for 1 mile on a treadmill?
   a. Yes
   b. No

8. Do you routinely listen to your iPod (or any personal listening device) during cardiovascular exercise sessions?
   a. NO
   b. YES
   c. Other device
      i. If it's not an iPod, please list the device you use:______________________

9. Through which type of headphone do you listen to your listening device through:
   a. Headphones c. Speakers
   b. Earbuds d. Other– please specify:______________

APPENDIX D

INSTRUCTION FOR CALIBRATION AND PROBE MICROPHONE MEASUREMENTS

Calibration

1. Hit *Tests* and go to *REM Calibration.*
2. Hold the microphone one meter from the test box.
3. Hit *Enter* button.
4. Calibration curve should be a flat response.

Directions for Probe Tube Measurements on Participants

1. Place participant at least 1.5 meters from the loudspeaker and located at 0° azimuth.
2. Pre-measure the probe tube and set at 30 mm for men and 28 mm for women. The black indicator should be visible at the intra-trageal notch in the participant's ear.
3. Place earbud headphone over probe tube so black marker can still be seen.
4. Turn the iPod on with the hold button set so the song is ready to play.
5. Hit *Test* and then hit *Real Ear Measurements – Speechmap.*
6. Go to left ear *REAR 1* and hit *Enter*
   - Stimulus should be set to live speech
   - Start the song
7. Hit *Continue* so that the Audioscan averages the music in the left ear for 10 seconds
   - Repeat this step four times: *REAR 1, REAR 2, REAR 3*, and *REAR 4*
8. Dump the data
   - Hit *Session* and then hit *export data to file on USB stick*
   - Hit the enter button to continue
5. Calibrate RM500SL in both the left and right probe module.
6. Place Audioscan RM500SL probe tube in patient's ear (28mm for females and 30 mm for males).

The data will be named Session C

1. Highlight the row of frequencies and copy them.
2. Paste into an Excel document.
3. Highlight data and hit *text to columns,*
4. Choose *fixed width* and hit *next* to break the data up into columns.
5. Hit *next* again and then hit *finish.*

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