Effect of Physical Activity on Psychophysical Abilities and Speech Perception in Noise

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This Dissertation is submitted as part fulfillment

for the Degree of Master of Science in Audiology

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CERTIFICATE

This is to certify that this dissertation entitled **"Effect of Physical Activity on Psychophysical Abilities and Speech Perception in Noise"** is the bonafide work submitted in part fulfilment for the degree of Master of Science (Audiology) of the student Registration Number: 17AUD011. This has been carried out under the guidance of the faculty of the institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru
May, 2019

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CERTIFICATE

This is to certify that this dissertation entitled **"Effect of Physical Activity on Psychophysical Abilities and Speech Perception in Noise"** has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru
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DECLARATION

This is to certify that this dissertation entitled **“Effect of Physical Activity on Psychophysical Abilities and Speech Perception in Noise”** is the result of my own study under the guidance of Dr. Chandni Jain, Reader in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru **Registration No: 17AUD011**

May, 2019

Dedicated to,

My mom,

My dad,

My sister

&

My guide

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Abstract

The aim of the study was to assess the effect of different levels of physical activity on some psychophysical abilities and speech perception in noise in middle-aged adults. A total of 52 participants in the age range of 40 to 60 years participated in the study. Further, these participants were categorized into four different groups as an active group, moderately active group, moderately inactive group and inactive group based on The General Practice Physical Activity Questionnaire (GPPAQ) validated screening tool. In psychophysical tests, intensity and frequency difference limen were measured at 1000 Hz while the gap detection threshold was calculated for 500 ms broadband noise. The speech perception in noise was tested by using a quick speech perception in noise test in Kannada. The results showed that there was a significant difference among active and inactive groups for gap detection threshold, frequency difference limen and for speech perception in noise. In conclusion, the physically active middle-aged individuals showed better performance in psychophysical abilities and speech perception in noise as compared to physically inactive middle-aged individuals.

Keywords: Gap detection threshold, intensity difference limen, frequency difference limen, speech perception in noise, GPPAQ, maximum likelihood procedure

Chapter 1

Introduction

Physical activity has been shown to have physical and emotional benefits. Long-term participation in physical activity can improve cardiovascular functioning, increase muscle strength**,** and enhance balance and flexibility (Chodzko-Zajko, 2012). Studies related to cardiovascular exercise and central nervous system (CNS) health on animal models have shown positive effects of aerobic fitness on a wide range of brain health markers (Hawkins, Kramer, & Capaldi, 1992). These effects are seen due to the increased levels of brain-derived neurotrophic factor, serotonin, capillary density, and neurogenesis (Van Praag, 1999) It is also reported that there is increased brain-derived neurotrophic factor (nutrition for the brain) in individuals who are physically active which leads to the promotion of neurogenesis, and improvements in learning (Cotman, 2002).

Regular physical activity has shown to have a positive impact on mental, emotional (Kirk-Sanchez, & McGough, 2014), as well as on auditory system performance (Yagi, Coburn, & Estess, 1999). Several studies have shown that physical exercise attenuates the age-related declination in cognitive performances (Bashore, 1989; Dustman, Emmerson, & Shearer, 1994; Dustman, Emmerson, Ruhlinig, Shearer, Steinhaus, Johnson, 1990; Hawkins, Kramer, & Capaldi, 1992; Spirduso, 1980). Electroencephalogram (EEG) studies suggest that physical activity increases the alpha activity in the brain (Kamp & Troost, 1978; Wiese et al., 1990).

In an animal study, it was reported that regular exercise delays the onset of age-related hearing loss (Han, Ding & Lopex, 2017). Further, numerous epidemiological studies have suggested that physical activity is associated with improved hearing sensitivity (Chen et al., 2014; Gispen et al., 2014; Loprinzi et al., 2012; Loprinzi et al., 2015; Mikkola et al., 2015; Tomioka et al., 2015), whereas slower gait speed, a robust indicator of health status, is associated with hearing loss among older adults (Li et al., 2013).

Further, age-related decline have been reported on various psychophysical abilities. Age-related decline is reported in terms of frequency discrimination (He, Dubno, & Mills, 1998; König, 1957), intensity discrimination (Harris, Mills, & Dubno, 2007), duration discrimination (Abel, Krever, & Alberti, 1990; Fitzgibbons & Gordon-Salant, 1994), gap detection (Fitzgibbons & Gordon-Salant, 1995; Phillips, Gordon-Salant, Fitzgibbons, & Yeni-Komshian, 1994), amplitude modulation detection (He, Mills, Ahlstrom, & Dubno, 2008), and temporal ordering skills (Fitzgibbons & Gordon-Salant, 1998; Humes & Christopherson, 1991; Kolodziejczyk & Szelag, 2008; Trainor & Trehub, 1989)). This could be attributed to the anatomical and physiological changes taking place in the auditory system. Thus, whether different levels of physical activity would show a different effect on psychophysical abilities with aging needs to be studied. In the present study, the effect of different levels of physical activity was studied on some psychophysical measures and speech perception in noise in middle-aged individuals.

1.1. Need for the Study

Studies in the past have shown that physical activity has a positive effect on hearing sensitivity and cognitive abilities (Bashore, 1989; Dustman, Emmerson & Shearer, 1994; Dustman, Emmerson, Ruhlinig, Shearer, Steinhaus, & Johnson, 1990; Hawkins, Kramer, & Capaldi, 1992; Spirduso, 1980). However, these studies have mainly been done using electrophysiological measure namely P300, and most of these studies have been done on one particular group of physical activity like aerobics (Hawkins, Kramer, & Capaldi, 1992), Thi Chi Exercise (Kim & Nam, 2015). We hypothesize that, as suggested by physiological studies, if various forms of physical activity result in reorganization of neuronal circuitry and improve cognitive abilities then this beneficial effect should also be reflected in the auditory domain. Further, as mentioned above it has been reported in animal studies that physical activity slows down the age-related hearing loss (Han, Ding & Lopex, 2017). Thus, in this study, the effect of different levels of physical activity was evaluated on some psychophysical abilities and speech perception in noise.

1.2. Aim of the study

The aim of the study was to assess the effect of different levels of physical activity on some psychophysical abilities and speech perception in noise in middle-aged adults.

1.3. Objectives of the study

- To assess gap detection thresholds in middle-aged adults with various levels of physical activity.

- To assess intensity difference limen in middle-aged adults with various levels of physical activity.
- To assess frequency difference limen in middle-aged adults with various levels of physical activity.
- To assess speech perception in noise in middle-aged adults with various levels of physical activity.

1.4.Hypothesis

The null hypothesis was assumed for the current study were:

1. There is no significant difference in gap detection thresholds among middle-aged individuals with different levels of physical activity.
2. There is no significant difference in intensity difference limen among middle-aged individuals with different levels of physical activity.
3. There is no significant difference in frequency difference limen among middle-aged individuals with different levels of physical activity.
4. There is no significant difference in speech perception in noise among different levels of physical activity in middle-aged individuals.

Chapter 2

Review of Literature

Day to day life involves various physical exercises such as swimming, jogging, aerobics, football, tennis, gym workout. The physical activities are also involved in different work professions such as the work which requires physical effort like- plumber, electrician, carpenter, hospital nurse, postal delivery workers, etc. Studies have shown various benefits of different forms of physical activity including reduction in chances of coronary heart disease (Gregg, Gerzoff, & Caspersen, 2003; Haapanen, Miilunpalo, Vuori, Oja & Pasanen 1997), decline in cognition (Laurin, Verreault, Lindsay, Macpherson & Rockwood 2001; Middleton, Barnes, Luims & Yaffe 2010; Yaffe, Barnes, Nevitt, Lui, & Covinsky, 2001). Further, numerous epidemiological studies have shown that physical activity is associated with improved hearing sensitivity (Chen et al., 2014; Gispen et al., 2014; Loprinzi et al., 2012; Loprinzi et al., 2015; Mikkola et al., 2015; Tomioka et al., 2015).

2.2. General Benefits of Physical Activity

The physical activity has numerous beneficial effects on physical health. Various studies have shown that different forms of physical activity has a positive impact on human well-being as it improves blood circulation, reduces chances of cardiovascular disorders and hypertension (Haapanen, Miilunpalo, Vuori, Oja & Pasanen, 1997), diabetes mellitus (Gregg, Gerzoff & Caspersen 2003), and also cognitive impairment. (Laurin, Verreault, Lindsay, Macpherson & Rockwood, 2001)

Haapanen, Miilunpalo, Vuori, Oja, and Pasanen (1997) studied the association between physical activity and three different metabolic disorders such as coronary heart disease, hypertension, and diabetes. Total 1340 men and 1500 women were tested in the age range of 35 to 63 years. Total leisure time and physical activity were assessed primarily from 23 questions- concerning exercise, sports, physical recreation, different leisure time and household chores and commuting to and fro from work. Results showed that there was a reduction in the risk of coronary heart disease in men but not for women. The hypertension was high for sedentary men as compared to active people, but no difference was noted for women. For men, an increase in intensity and leisure time physical activity significantly reduced diabetes mellitus disease. For women also low-total activity group were at risk of diabetes than the high active group.

Laurin, Verreault, Lindsay, Macpherson, and Rockwood (2001) examined the association between physical activity and the risk of cognitive impairment and dementia on a total of 9008 random sample. Results suggested that increased physical activity was associated with a low risk of Alzheimer's disease, cognitive impairment, and dementia when compared to the non-exercise group.

In another study, Yaffe, Barnes, Nevitt, Lui, and Covinsky (2001), studied the relationship between physical activity and cognitive decline in elderly women. Participants included 5925 women who were greater or equal to 65 years old. The modified mini-mental state examination was done at the baseline and also after 6-8 years. The physical activity was measured by asking how many flights of stairs they climbed each day as a part of their routine activities or how many city blocks, (1 block = 160 m) the women walked each day for exercise. Results revealed that women having high physical baseline were less likely to develop cognitive decline.

Caspersen, Gregg, and Gerzoff (2003) studied the association between walking and mortality rate among diabetes individuals. A total of 2896 individuals were considered for the study. The physical activity was assessed by asking questions related to the frequency of exercise per week, duration of exercise, how much heat and breathing rate increased. The mortality assessment was determined by matching the respondent to the National Death Index. Results showed that walking was associated with lower mortality across a diverse spectrum of adults with diabetes.

Weuve, Kang, Manson, Breteler, Ware, and Grodstein (2004) examined the relationship between long term regular physical activity, including walking and cognitive function. Participants included 18766 women aged 70 to 81 years, and they were monitored for over two years. The cognitive functioning was assessed by TICS (Telephone Interview for Cognitive Status). The physical activity assessment was done by the biennial questionnaire. A linear regression model was used to estimate the mean difference between baseline cognitive performance and cognitive decline over two years. Results reported that long-term regular physical activity, including walking, is associated with significantly better cognitive function and less cognitive decline in older women.

Middleton, Barnes, Luims, and Yaffe (2010) studied the effect of physical activity at various ages over the life course on cognitive impairment in a cross-sectional study. A total of 9344 women, aged 65 years and older were included in the study who self-reported the physical activity performed during their teenage, at 30 years of age, at 50 years of age, and late-life physical activity. The modified mini-mental state examination (mMMSE) was used to assess the cognitive level. The result showed that the women who reported physical activity at any point over the life course especially during teenager period had a lower risk of cognitive impairment in later life.

Thus, from the above studies discussed, it can be concluded that physical activity not only improves blood circulation but also has several other health benefits such as it lowers the risk of Alzheimer's disease, cognitive impairment, dementia, hypertension, cardiovascular disorders and also it lowers the mortality risk in adults with diabetes.

2.3. Effect of Physical Activity on the Auditory System

Studies have shown that different types of physical activity have effect on hearing as well as in cognition and memory (Laurin, Verreault, Lindsay, Macpherson & Rockwood 2001; Middleton, Barnes, Luims & Yaffe 2010; Yaffe, Barnes, Nevitt, Lui, & Covinsky, 2001;), and brain health markers in the brain (Hawkins, Kramer, & Capaldi, 1992).

Polisch, and Lardon (1996) studied the effect of physical activity on EEG in subjects who were engaged in low physical activity and compared with subjects with high physical activity usually ‹5 hours/week and ›5 hours per week respectively. P300 was recorded in both auditory as well as visual modality using odd ball paradigm. Results showed that P300 amplitude was higher in subjects with high physical activity. This difference was slightly better for visual mode. But, latencies of P300 did not differ among the two groups.

Cristell, Hustchinson, and Alessio (1998) studied the effect of two months of aerobic exercise training on cardiovascular fitness and hearing sensitivity on 27 low to moderate fit individuals. Participants were tested for cardiovascular fitness, and peak oxygen consumption (VO_2), pure tone thresholds and temporary threshold shift (TTS) at 2000, 3000 and 4000 Hz before and following 10 minutes of noise exposure. Results showed that both the pure tone thresholds and TTS improved following two months of exercise training at the evaluated frequencies. It was also reported that cardiovascular health as indicated by VO_2 peak was associated with improved hearing sensitivity.

In contrary, Dowell, Kerick, Maria, and Hatfield (2003) studied the effect of age and different levels of physical activity on P300. The participants were divided into different groups based on the Average Daily Exercise Kilocaloric Expenditure (ADEKE) tool. For P300, latency, amplitude, and area under the curve were measured with an odd ball paradigm. Results showed that low active older adults had a larger area under the curve than the high elderly and young active adult group, while high amplitude was noted for low active elderly participants compared to high active young group participants

Kutlu, Buyukyazi, Kapan, Selcuki, and Artug (2015) studied the effect of long term physical exercise on P300 in elderly male individuals. A total of 30 participants were recruited for the study who were divided into three different groups based on different levels of physical activity. Results showed a significant difference among sedentary elderly volunteer group and healthy sedentary middle-aged group in terms of amplitude and latency. The healthy sedentary middle-aged group showed better amplitude as well as latency. It was also reported that the cognitive decline due to aging slowed down with long term exercise. In a similar study, Kim and Nam (2015), examined the effect of Thi Chi Exercise on P300 in older adults. Results showed that the P300 amplitude was better among older adults who performed exercises and P300 latencies remained shorter in them.

Park, Yoo, Woo, Kim, and Cho (2017) conducted a cross-sectional study in South Korea to assess the prevalence of hearing loss and associated factors. The regular walking was considered as one of the associated factors among many factors. Total 7434 participants ≥ 40 years were considered to study the effect of frequency of regular walking on hearing loss. The results showed that regular walking had a negative association with hearing loss. In another study, Pedroso, Frag, Ayan, Carral Scarpari and Santos-Galduroz (2017), did a meta-analysis on 14 articles related to the influence of physical activity on P300. They reported shorter latencies and higher amplitude of P300 among physically active individuals. It was hypothesized that physical activity, as well as physical exercise, has a positive impact on cognitive functions.

Thus, it is evident across studies that physically active individuals exhibit better P300 amplitude, especially in visual mode as compared to auditory mode with no latency differences. Furthermore, such individuals also show a large area under the curve for P300.

2.3.1. Effect of physical activity on psychophysical measures and speech perception in noise.

Studies related to the effect of physical activity on psychophysical abilities such as gap detection threshold, intensity difference limen, frequency difference limen and speech perception in noise are limited. However, few studies have been done to assess the effect of meditation on psychophysical abilities and speech perception in noise.

In a study by Kumar, Sangamanatha, and Vikas (2013), the effect of age and meditation on temporal processing and speech perception in noise was studied. Results showed that backward masking thresholds, duration discrimination thresholds, duration pattern scores, and speech perception scores were better in meditator adult group as compared to the non-meditator group. The modulation detection threshold was also better in effective meditator group than young adults group and non-meditator group. The significant poor speech recognition scores were noted for the non-meditator group compared to meditator and young adult group.

In another study, Taneja et al., (2015) studied the effect of different types of yoga on hearing the performance, and they reported that gyan mudra helps in regenerating the hearing areas and cerebral cortex while bhramari pranayama helps in regaining better speech recognition abilities.

From the above studies, it is evident that the meditator group has positive impact on psychophysical measures such as duration discrimination test, duration pattern test and speech perception in noise. Furthermore, yoga also helps in better speech recognition and regenerating cerebral cortex. Thus, it still needs to be studied whether different physical activities would have an effect on speech perception in noise and psychophysical abilities among middle-aged adults.

Chapter 3

Methods

3.1. Research Design

A cross-sectional descriptive research design was used in the study (Schiavetti, Orlikoff, & Metz, 2015).

3.2. Participants

A total of 52 participants within the age range of 40 to 60 years (Mean Age: 49.65, ± 5.41 years) participated in the study. The participants were selected based on convenient sampling and were equally divided into four groups as Active (A), Moderately active (MA), Moderately inactive (MI) and Inactive (I) groups based on The General Practice Physical Activity Questionnaire (GPPAQ) (Health, 2006).

3.2.1. Inclusion Criteria

- All the Participants with hearing sensitivity within normal limits (≤ 15 dB HL) at all octave frequencies from 250 Hz to 8000 Hz [ANSI S3.1 (1991)].
- Normal functioning of the middle ear as indicated by bilateral 'A' type of tympanogram with acoustic reflex (ipsilateral and contralateral) present within normal sensation levels at 500 Hz and 1000 Hz.
- Speech recognition threshold and speech identification scores proportional to hearing thresholds.

3.2.2. Exclusion Criteria

- Participants with a history of otologic, neurologic problems and reported illness on the day of testing.
- Participants with a history of alcohol consumption, smoking, diabetes, hypertension, cardiovascular diseases.

3.3. Test Environment

Pure tone audiometry was performed in an acoustically treated room with noise levels as per ANSI S 3.1 (1999) standards. All other experiments were done in a quiet room with good illumination, ventilation, and minimum distraction.

3.4. Instrumentation

1. Inventis Piano two channel audiometer with Telephonics TDH39 supra-aural headphones housed with MX-41/ AR ear cushions and a bone vibrator (Radioear B71) was used to perform pure tone audiometry and speech audiometry.
2. GSI Tympstar (Grason- Stadler Inc. USA) middle ear analyzer was used for tympanometry and reflexotometry.
3. Dell laptop loaded with MATLAB version 7.9 (The Math Works, Inc., MA, USA, 2009) incorporating the Maximum Likelihood Procedure (mlp, Pentland, 1980; Green, 1990, 1993; Shen & Richards, 2012) toolbox was used to perform the psychophysical tests and to assess speech perception in noise.

3.5. Materials

1. Psychophysical testing: The stimuli for all the psychophysical tests were generated through mlp toolbox (mlp toolbox, Grassi&Soranzo, 2009) using MATLAB

2. Speech perception in noise: The quick speech perception in noise test in Kannada (Methi, Avinash, & Kumar, 2009) was used for speech perception in noise assessment.

3.6. Stimulus and Procedure

Written informed consent was taken from all the participants for willingly participating in the investigation. All psychophysical tests such as intensity difference limen (IDL), frequency difference limen (FDL) and gap detection threshold (GDT) were carried out using mlp toolbox in MATLAB. It estimates the likelihood of arriving at a listener's response for all the stimuli presented by calculating the psychometric function after every trial. The MLP can arrive at a fairly stable approximation of most probable psychometric function within about 12 trials which are used to approximate thresholds. This procedure has a good reliability and validity and it was used to assess psychophysical abilities. Speech perception in noise test was measured at different SNR starting from +8 dB to -10 dB in 3 dB steps in each successive sentence. All the above stimuli were presented binaurally through the calibrated headset (Sennheiser HDA 200) and presented at 70 dB SPL level. The output of the headphones was calibrated using Larsen and Davis, Sound Level Meter (SLM) type 824 with 1" pressure mic Type 2575, with Larsen and Davis Artificial Ear Type No AEC 100.

3.6.1 Assessment of Physical Activity based on GPPAQ

GPPAQ questionnaire was administered on the participants to group them into different groups based on their level of physical activity. GPPAQ questionnaire is developed by the World Health Organization for physical activity surveillance in countries. It probes information on physical activity participation in three domains (activity at work, travel to and from places and recreational activities) comprising of 16 questions (P1 – P16). The GPPAQ version 2 was used for the present study which is a validated screening tool that assesses adult (with the age range of 16 – 74 years) physical activity levels. Based on this questionnaire the participants were classified as Active, Moderately Active, Moderately Inactive, and Inactive.

3.6.2 Routine Audiological evaluations

The case history was taken from the participants to rule out any otological, neurological and any other medical history as mentioned in the exclusion criteria. Otoscopy was done to examine the status of the external ear canal and tympanic membrane. Further, pure tone audiometry was done to assess the air conduction thresholds at all octave frequencies from 250 Hz to 8000 Hz and bone conduction thresholds from 250 Hz to 4000 Hz. Thresholds were established using a modified version of Hughson Westlake procedure (Carhart & Jerger, 1959). Speech recognition threshold with Kannada paired words (Rajashekar, 1976) and speech identification scores with Kannada PB words (Yathiraj & Vijayalakshmi, 2005) in quiet was obtained for both the ears.

The 226 Hz probe tone was used for tympanometry and reflexometry. Static compliance, equivalent ear canal volume, tympanic membrane peak pressure was measured through tympanometry followed by ipsilateral and contralateral acoustic reflex threshold was measured at 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz.

3.6.3. Procedure for Experimental tests

Gap detection threshold. This test involved the identification of the temporal gap centered in a 500 ms broadband noise (Harris et al., 2010). A broadband noise cosine ramped at 0.5 ms was used as the stimuli. The minimum and maximum gap duration used was 0.1 ms and 64 ms. A three alternate forced choice method was used in which out of three blocks, two blocks had standard stimuli without a gap, and one block had variable stimulus with a gap. The participants were asked to identify the block with the variable stimuli. The minimum gap duration corresponding to 79.4% confidence level in the psychometric function was calculated using mlp.

Intensity difference limen. The minimum intensity difference required to discriminate two otherwise same sounds was measured using a 1000 Hz pure tone which was 250 ms long and cosine ramped with 10 ms onset and offset (Grassi & Soranzo, 2009; Jain et al., 2014). The minimum and maximum intensity differences used was 0.99 and 10 dB respectively. A three alternate forced choice method was used in which out of three blocks, two blocks had the standard stimuli, and one block had variable stimuli. The intensity of the variable stimuli was always higher than that of standard stimuli. The participants were asked to identify the block with the variable stimuli. The difference in intensity corresponding to 79.4% confidence level in the psychometric function was calculated using mlp.

Frequency difference limen. The minimum frequency difference required to discriminate two otherwise same sounds was measured using a standard 1000 Hz pure tone which was 250 ms long and cosine ramped with 10 ms onset and offset (Grassi & Soranzo, 2009; Jain et al., 2014).). The minimum and maximum frequency differences used was 0.1 Hz and 100 Hz respectively. A three alternate forced choice method was used in which out of three blocks, two blocks had the standard stimuli, and one block had variable stimuli. The frequency of the variable stimuli was always higher than that of standard stimuli. The participants were asked to identify the block with the variable stimuli. The difference in frequency corresponding to 79.4% confidence level in the psychometric function was calculated using mlp.

Quick speech perception in noise. A list of seven sentences (List 2) with five key words in each was taken from the sentence list of Kannada quick speech perception in noise developed by Avinash, Methi, and Kumar (2010). The sentences were mixed with a 8 talker babble noise at different SNR starting from +8 dB to -10 dB in 3 dB steps in each successive sentence. The task of the participant was to repeat the sentences. A score of 1 was given for every correctly identified key word. The SNR required to identify 50% of the key words was calculated using the Spearman-Karber equation (Finney,1978) which is given below:

SNR-50=I + ½ (d) - (d) (# correct) / (w)

Where;

i = the initial presentation level dB (S/B);

d = the attenuation step size (decrement);

w = the number of keywords per decrement;

Correct = total number of correct key words.

3.7 Statistical Analyses

Statistical analyses were carried out using statistical software for the social sciences (SPSS). The normality of the collected data was tested, and descriptive statistics were carried out to obtain mean and standard deviation. The Kruskal Wallis test was done to assess the significant difference in GDT scores across groups. One way ANOVA was done to assess the significance difference in IDL, FDL and quick speech perception in noise between the groups

Chapter 4

Results

The current study highlights the effect of physical activity on `psychophysical abilities and speech perception in noise. Table 4.1 shows the total number of participants in each physically active group. The data was subjected to a normality test, and the Shapiro Wilk test revealed that the gap detection threshold (GDT) test did not fulfill the assumptions of normality ($p>0.05$). All other tests such as intensity discrimination (IDL), frequency discrimination (FDL) and speech perception in noise test followed normality criteria ($p<0.05$). Hence, for the analysis of gap detection threshold non-parametric test was used and for the analysis of the other tests parametric test was used.

Table 4.1.

Total number of participants in each group.

Group	Total number of participants
Active	14
Moderately active	13
Moderately inactive	11
Inactive	14

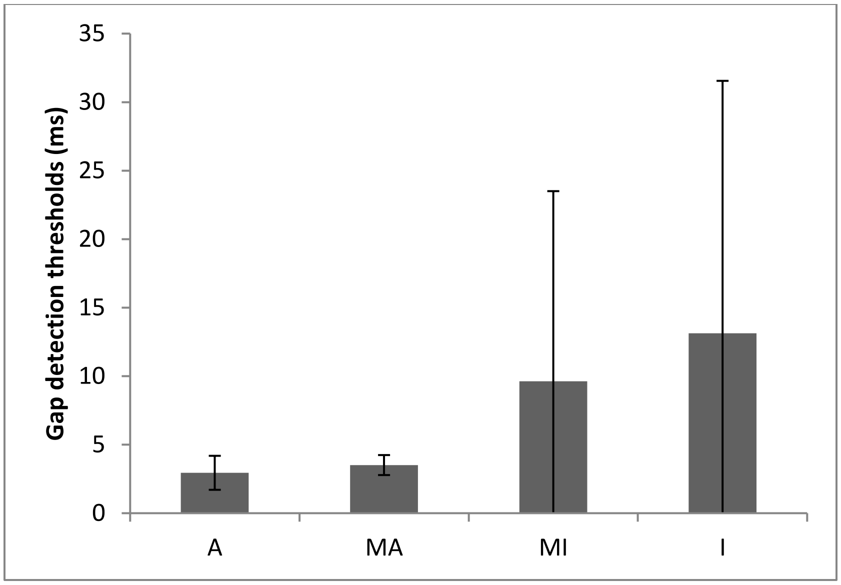
4.1. Effect of Physical Activity on Gap Detection thresholds

The mean, one standard deviation (SD), median and range of GDT across different physically active groups are depicted in Table 4.2. Figure 4.1 shows the mean and SD of GDT for four different groups. From Table 4.2 and Figure 4.1, it can be noted that there is a difference in GDT mean scores across different physically active groups. As mentioned earlier since the data was not normally distributed non-parametric statistics were used to assess the significance of the difference in GDT across different groups. The Kruskal Wallis test showed a significant effect of physical activity on GDT scores ($\chi^2(3)=15.190$, $p<0.05$). Further, Mann Whitney test was done to perform the pair wise analysis, and results showed a significant difference in GDT ($Z= -2.859$, $p<0.05$) among the active group and inactive group.

Table 4.2

Mean, SD, median and range of GDT across different physically active groups.

Groups	Mean (ms)	SD	Median	Minimum	Maximum
Active	2.94	1.24	2.87	1.48	6.61
Moderately active	3.51	0.72	3.79	2.22	4.37
Moderately inactive	9.63	13.87	4.13	2.52	49.50
Inactive	13.12	18.42	4.13	2.27	49.80

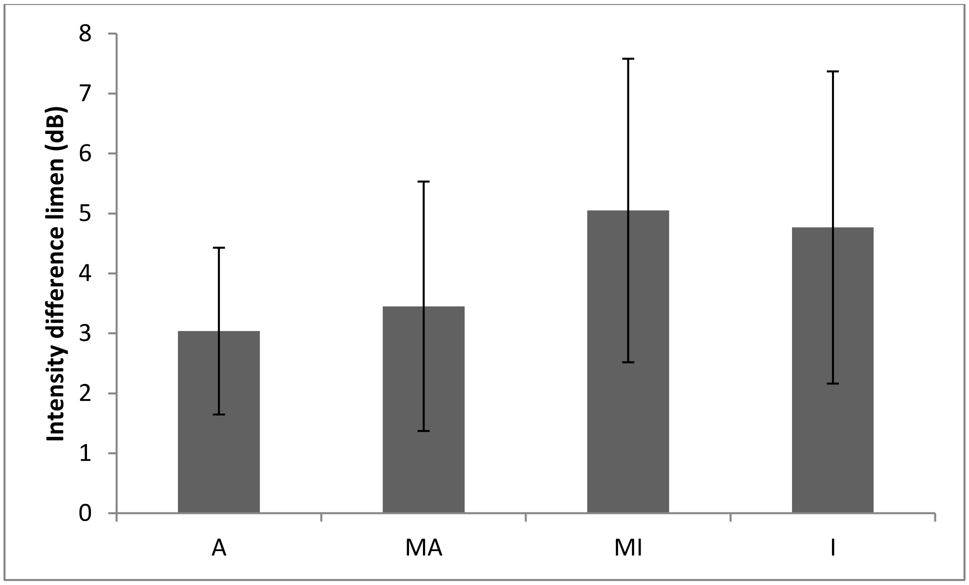


Note: A-Active, MA- Moderately Active, MI- Moderately Inactive, I- Inactive

Figure 4.1. Mean GDT with SD across different physically active groups.

4.2. Effect of Physical activity on Intensity Difference Limen

The mean and one SD of IDL across different physically active groups are shown in Figure 4.2. From Figure 4.2, it can be noted that the active groups had better mean IDL scores compared to both inactive groups. Further, One-way Analysis of Variance (ANOVA) was done to assess the significance difference in IDL between the groups. The results of ANOVA showed no significant main effect of the groups on the IDL [$F(3, 48) = 2.592$, $p>0.05$]. Since the present study showed no significant difference between the groups, post hoc analysis was not performed to do the pair wise analysis.

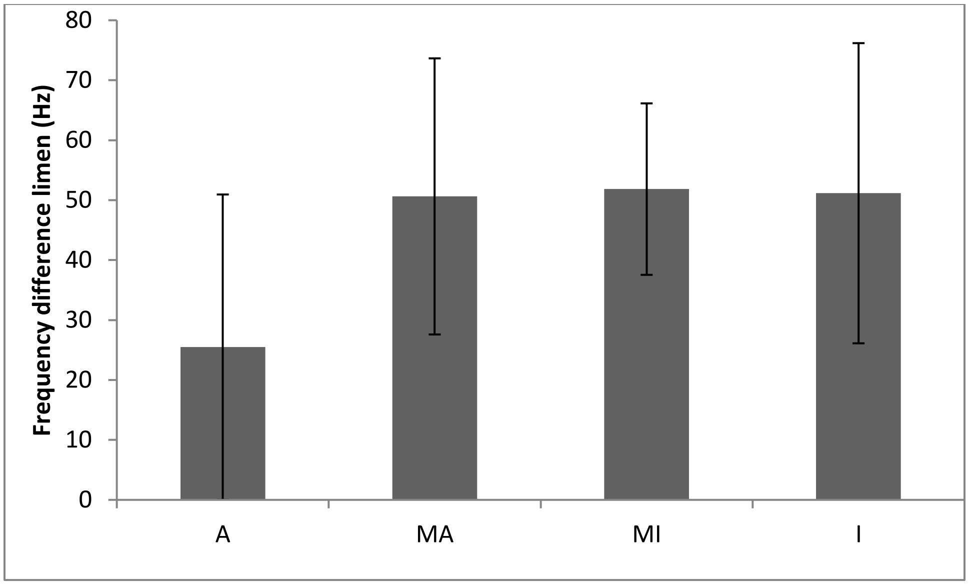


Note: A-Active, MA- Moderately Active, MI- Moderately Inactive, I- Inactive

Figure 4.2. Mean IDL with SD across different physically active groups.

4.3. Effect of Physical Activity on Frequency Difference Limen

Figure 4.3 shows the mean and one SD of FDL across different physically active groups. From Figure 4.3, it can be noted that the mean FDL was better for the active group compared to the other three groups. One way ANOVA was done to assess the statistical significance in the FDL across different physical activity groups. Results showed a significant main effect of different physically active groups [$F(3, 48) = 4.331$, $p<0.05$] on FDL. Further, pair wise comparison was done among different groups using Bonferroni multiple comparison post hoc analysis. Table 4.3 depicts the results of pair-wise comparisons between the FDL of different groups. From Table 4.3, it can be noted that the active group had significantly better IDL compared to all the other three groups.



Note: A-Active, MA- Moderately Active, MI- Moderately Inactive, I- Inactive

Figure 4.3. Mean FDL with one SD across different physically active groups

Table 4.3

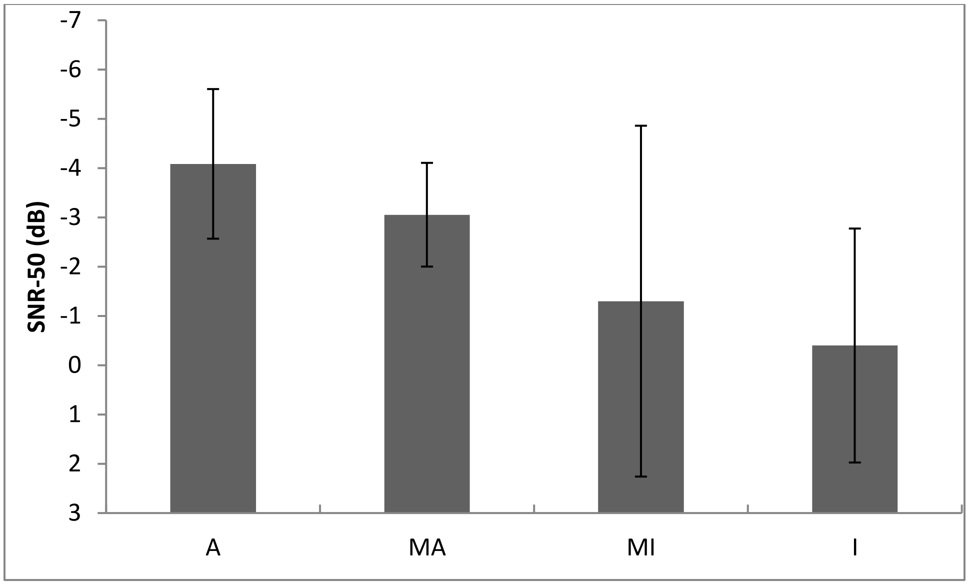
Results of pair-wise comparison across different physically active groups for FDL.

Groups	Active	Moderately active	Moderately inactive	Inactive
Active				
Moderately active	S			
Moderately inactive	S	NS		
Inactive	S	NS	NS	

Note: S-Significant, NS-Not significant at 0.05 level (adjusted for Bonferroni's multiple comparisons)

4.4. Effect of Physical Activity on Speech Perception in Noise

The signal to noise ratio (SNR) required to identify 50% of the keywords was calculated using the Spearman-Karber equation (Finney, 1978). The mean and SD of SNR-50 across different physical activity groups are depicted in Figure 4.4. From Figure 4.4, it can be noted that the mean SNR-50 scores are higher for active groups compared to the inactive groups. One way ANOVA was done to assess the statistical significance of the SNR-50 across different physically active groups. Results showed a significant main effect of different levels of physical activity [$F(3, 48) = 7.461$, $p<0.05$] on SNR-50. Further, Bonferroni multiple comparison post hoc analysis was done for pair wise analysis among groups to examine the significance of the difference in SNR-50. Table 4.4 shows the pair-wise comparisons between SNR-50 of different physical activity, and it can be noted that both the active groups had significantly better scores than the inactive groups.



Note: A-Active, MA- Moderately Active, MI- Moderately Inactive, I- Inactive

Figure 4.4. Mean SNR-50 with one SD across different physically active groups

Table 4.4

Results of pair-wise comparison across different physically active groups for SNR-50

Physical activity level	Active	Moderately active	Moderately inactive	Inactive
Active				
Moderately active	NS			
Moderately inactive	S	NS		
Inactive	S	S	NS	

Note: S-Significant, NS-Not significant at 0.05 level (adjusted for Bonferroni's multiple comparisons)

Chapter 5

Discussion

The study aimed to assess the effect of different levels of physical activity on some psychophysical abilities and speech perception in noise in middle-aged adults. The results of the study are discussed below:

5.1. Effect of Physical Activity on different Psychophysical measures

The present study examined the effect of different levels of physical activity on gap detection thresholds (GDT), intensity difference limen (IDL) and frequency difference limen (FDL). Results showed that the GDT and FDL were significantly better in the active group as compared to the inactive group. However, IDL did not differ significantly among groups. Based on these observations null hypothesis 2 and 3 stating "There is no significant difference on gap detection threshold among different levels of physical activity in middle-aged individuals" and "There is no significant difference on frequency difference limen among middle-aged individuals with different levels of physical activity" was rejected. Null hypothesis 1 stating "There is no significant difference in intensity difference limen among different levels of physical activity in middle-aged individuals" was accepted.

Similar results are reported by Kumar, Sangamanatha, and Vikas (2013). They also found that temporal processes such as backward masking thresholds, duration discrimination thresholds, duration pattern scores, and the modulation detection threshold were better in effective meditator group compared to young adults group and non-meditator group. Further studies have also shown that increased physical activity has an effect on auditory abilities (Chen et al., 2014; Gispen et al., 2014; Loprinzi et al., 2012; Loprinzi et al., 2015; Mikkola et al., 2015; Tomioka et al., 2015). Studies related to cardiovascular exercise and central nervous system (CNS) health on animal models have shown positive effects of aerobic fitness on a wide range of brain health markers (Hawkins, Kramer, & Capaldi, 1992). This can lead to an increase in the levels of brain-derived neurotrophic factor, serotonin, capillary density and neurogenesis (Van Praag, 1999) which leads to the promotion of neurogenesis.

Long term benefits of physical exercises have also shown to improve cognition in individuals (Weuve, Kang, Manson, Breteler, Ware, & Grodstein, 2004). Further, studies have also shown that there is a relationship between working memory and auditory abilities (Jain, 2016). Thus, it can be hypothesized that the improvement in psychophysical abilities in physically active individuals could be due to improvement in cognitive abilities. However, in the present study, no significant difference in IDL was seen among the different physically active groups. There are no supporting studies for this. But we assume that IDL is an easier task compared to FDL and GDT and also it is difficult to conclude as the number of participants was less in each group.

5.2. Effect of Physical Activity on Speech Perception in Noise

The results of the present study showed that SNR-50 was significantly better in active group as compared to the inactive group and it was noted that as the level of physical activity increased from inactive to active there was an improvement in speech perception in noise. Based on these observations null hypothesis 4 stating "There is no significant difference in speech perception in noise among different levels of physical activity in middle-aged individuals" was rejected.

These results are in consensus with the study done by Kumar, Sangamanatha, and Vikas (2013). They also reported poor speech recognition scores for non- meditator group as compared to the meditator and young adult group. Similarly, Taneja et al., (2015) reported that bhramari pranayama helps in regaining better speech recognition abilities. We hypothesize that, as various forms of physical activity results in reorganization of neuronal circuitry, improves cognitive abilities, this beneficial effect would also be reflected in the auditory domain. Further, studies have shown that there is a relation between cognition and speech perception in noise (Jain, C. 2016). Also, as mentioned earlier increased physical activity improves cognitive abilities, and thus we can conclude that this would affect speech perception score also.

Chapter 6

Summary and Conclusion

Physical activity has been shown to have physical and emotional benefits. Regular physical activity has shown to have a positive impact on mental, emotional as well as on auditory system performance. The present study was aimed to assess the effect of different levels of physical activity on some psychophysical abilities and speech perception in noise in middle-aged adults. A Total of of 52 participants in the age range of 40 to 60 years participated in the study. Further, they were categorized into four different groups based on their physical activity level as active, moderately active, moderately inactive and inactive using The General Practice Physical Activity Questionnaire (GPPAQ) validated screening tool. Psychophysical abilities were assessed using gap detection threshold (GDT), intensity difference limen (IDL) and frequency difference limen (FDL). These tests were done through Maximum Likelihood Procedure (MLP) toolbox using MATLAB. The speech perception in noise was assessed using quick speech perception in noise test in Kannada at different SNRs using Kannada sentence list. All the above stimuli were presented binaurally and presented at 70 dB SPL level.

The results of the study showed that:

i. The mean GDT differed significantly among active and inactive group indicating that physical activity had an effect on GDT.
ii. The mean IDL did not differ significantly among active and inactive group indicating that physical activity had no effect on IDL.

iii. The mean FDL scores differed significantly among groups with the active group having better FDL compared to all other three physically active groups.

iv. The mean SNR-50 also differed significantly among groups, and active group had significantly better scores compared to the inactive group.

6.1. Implications of the Study

- It is a prospective study which highlights, the importance of different levels of physical activity on auditory abilities.
- Further, the study would help in counseling individuals regarding the importance of physical activity and its impact on hearing.

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APPENDIX 1

Informed Consent Form

Title: Effect of physical activity on psychophysical abilities and speech perception in noise.

I have been informed about the aims, objectives and the procedure of the study. The possible risks- benefits of my participation as human subject in the study are clearly understood by me. I have understood that the research aims at obtaining voluntary responses from me and the total duration of this would be around 1 hour. I am also aware that by subjecting to this investigation, I will have to give time and that these assessments may not result in any benefits to me. I understand that I have a right to refuse participation or withdraw my consent at any time. I am interested in participating in the study and hereby give my written consent for the same.

I, ______________________________, the undersigned, give my consent to be participant of this research.

Signature of Individual　　　　　　　　Signature of the Researcher

(Name and Address)

____

____

Appendix 2

General Practice Physical Activity Questionnaire

Developed by World Health Organization, 2006

Date………………………

Name……………………..

1. Please tell us the type and amount of physical activity involved in your work.

		Please mark one box only
a	I am not in employment (e.g. retired, retired for health reasons, unemployed, full-time carer etc.)	
b	I spend most of my time at work sitting (such as in an office)	
c	I spend most of my time at work standing or walking. However, my work does not require much intense physical effort (e.g. shop assistant, hairdresser, security guard, childminder, etc.)	
d	My work involves definite physical effort including handling of heavy objects and use of tools (e.g. plumber, electrician, carpenter, cleaner, hospital nurse, gardener, postal delivery workers etc.)	
e	My work involves vigorous physical activity including handling of very heavy objects (e.g. scaffolder, construction worker, refuse collector, etc.)	

2. During the *last week* , how many hours did you spend on each of the following activities?

   Please answer whether you are in employment or not

Please mark one box only on each row

		None	Some but less than 1 hour	1 hour but less than 3 hours	3 hours or more
a	Physical exercise such as swimming, jogging, aerobics, football, tennis, gym workout etc.				
b	Cycling, including cycling to work and during leisure time				
c	Walking, including walking to work, shopping, for pleasure etc.				
d	Housework/Childcare				
e	Gardening/DIY				

3. How would you describe your usual walking pace? Please mark one box only.

Slow pace (i.e. less than 3 mph) ☐

Steady average pace ☐

Brisk pace ☐

Fast pace (i.e. over 4 mph) ☐