Journal of Carcinogenesis
Covering Genesis to Therapeutics
Journal of Carcinogenesis, ISSN: 1477-3163
2024; Vol 23: Issue 1, https://carcinogenesis.com/

Impact of Cardiovascular Exercise on Functional Capacity and QoL in Athletes with Hearing Impairment

Muhammad Yamin[1], Basit Ansari[1], Muhammad Javed Bajwa[2]

[1]Department of Health, Physical Education and Sports Sciences, University of Karachi, Karachi, Pakistan

[2]Department Health, Physical Education and Sports Sciences University of Karachi, Karachi, Pakistan

Correspondences Author: Muhammad Yamin

Email: yaminsports1@gmail.com

ABSTRACT

Objectives: The study aimed to investigate the effects of cardiovascular training on physical fitness and quality of life (QoL) among hearing-impaired athletes (HIAs). Specifically, the study examined the impact of cardiovascular training (CVT) on endurance, speed, agility, strength, flexibility, and psychosocial well-being.

Methods: An experimental research design with pre-test and post-test assessments was used. A sample of HIAs was selected through purposive sampling from special education and sports institutions. Participants underwent a structured CVT program for a specified duration under supervised conditions. Physical fitness variables including endurance, speed, agility, strength, and flexibility were assessed using standardized fitness tests, while QoL was measured through the SF-36 QoL Questionnaire. Data were analysed using descriptive statistics and paired sample t-tests to determine significant differences between pre-test and post-test scores.

Results: The findings revealed significant improvements in all selected physical fitness variables and QoL after the CVT intervention. Mean endurance scores improved from 6.42 ± 1.15 minutes to 9.18 ± 1.27 minutes ($p < 0.05$). Speed performance improved from 14.76±0.89 seconds to 13.21±0.74 seconds, while agility scores improved from 18.34±1.41 seconds to 15.92±1.16 seconds. Muscular strength increased from 28.47±4.32 repetitions to 36.81±4.95 repetitions, and flexibility scores improved from 18.25±3.17cm to 24.63±3.48cm. QoL scores also showed substantial improvement, increasing from 58.42±6.85 to 76.94±7.21 after the intervention. Statistical analysis confirmed that CVT had a positive and significant effect on both physical fitness and QoL among HIAs ($p < 0.05$).

Conclusion: The study concluded that cardiovascular training is an effective intervention for improving physical fitness and QoL among HIAs. Regular cardiovascular exercise significantly enhances endurance, speed, agility, strength, flexibility, and psychosocial well-being.

Keywords: *Cardiovascular Training, Physical Fitness, Quality of Life, Hearing Impaired Athletes, Endurance, Agility, Strength, Flexibility, Adapted Physical Education.*

How to Cite: Muhammad Yamin, Basit Ansari, Muhammad Javed Bajwa, (2024) Impact of Cardiovascular Exercise on Functional Capacity and QoL in Athletes with Hearing Impairment, *Journal of Carcinogenesis*, *Vol.23*, *No.1*, 1129-1145

1. INTRODUCTION

The past few years have seen growing momentum for ending isolation of people with disabilities. Sport is part of these efforts, focused on inclusive practice and participation in all areas of life. Adapted and competitive sport is one of the best and most transformative means towards integration. Sports are a great medium for developing physical skills and the additional attributes of social involvement and psychological growth are especially valuable for disabled people [12]. HIAs, especially, have special challenges. Deaf athletes do not have physical disabilities like people with physical disabilities. However, they have to deal with communication barriers which heavily affect their social incorporation. These communicative disparities may lead to isolation and restriction in accessing wider communities [21]. Whether they are able to hear or not, competitive sports can break some of these barriers, build their confidence and give them a sense of identity and community.

Although the possibilities for hearing-impaired people in the domain of sports have grown, there are still few scientific studies on their physical fitness and health parameters. Despite the fact that the Deaflympics has a longer history, the majority of the research area has been on Paralympians, which creates an important lack of understanding regarding the Deanthletes physiological and psychological characteristics [12]. Physical fitness is a multi-dimensional concept, with both health-related and skill-related sub-components that are important to the overall functioning and success of an athlete. Several physiological, communication, and environmental conditions combine to create an opportunity and a challenge for optimizing physical fitness for deaf and hearing impaired persons. This section discusses these dimensions in relation to deaf athletes and the factors that could impact their fitness and performance in sport.

There are two types of physical fitness: health-related fitness, which encompasses cardiovascular endurance (CVE), muscle strength, muscle endurance, flexibility and body composition, and skill-related fitness, such as speed, agility, balance, coordination, power and reaction time [10]. All these are vital aspects and play a crucial role in the performance of sportspersons, particularly those who participate in competitive games. Coordinative skill based fitness areas are those areas that make good use of visual-spatial perception, and in these areas, Deaf athletes are often found to be comparable or even superior in some capacities compared to their hearing counterparts [16]. However, there are differences according to training exposure, communication challenges, and availability of suitable coaching and support. Cardiorespiratory fitness is an important benchmark of aerobic capacity and endurance performance. It represents how efficiently the heart, lungs and vascular system circulate oxygen to working muscles during continuous exercise. Limited participation in vigorous physical activities and organized sports in early years of development can affect deaf individuals in this area of development [24]. Research has indeed confirmed that the VO_2 max may be significantly lower for deaf children and young people than for their hearing peers, especially when physical education is not accessible or suitably tailored for deaf users. In fact, structured and inclusive fitness programs have been demonstrated to result in significant improvements in aerobic fitness in hearing-impaired individuals [25] achieving an 8-week aerobic training intervention that lead to significant improvements in VO_2 max and endurance in young HIAs, emphasizing the adaptability of the cardiovascular system in this population.

Muscular strength and endurance is a required ability in many sports and physical activities. Studies have shown that in some ways, deaf athletes appear to have similar or slightly less strength in their muscles compared to their hearing counterparts, which may be the result of resistance training or physical education participation issues with deaf athletes [13]. Furthermore, because impaired vestibular function is more prevalent in people with congenital deafness, coordination problems resulting from a loss of this function may affect neuromuscular function [14]. Balance is an important mechanism in all physical performances and often impaired in deaf individuals from abnormalities of the inner ear, which affect the vestibular system. It has been seen that Deaf athletes, especially congenital, are likely to have been found to demonstrate decreased postural control and dynamic balance in contrast to their hearing peers [3]. Such weaknesses can impact on their ability to perform in sports with rapid changes of direction, jumping and accurate movements. Communication is one of the major issues when trying to develop physical fitness of deaf athletes. But if coaches are not skilled in sign language or not aware of deaf culture, they may not be able to communicate effectively with students from a deaf community which in turn can lower motivation and participation levels for these students [20]. This information deficit may cause difficulties with learning and training in motor skills, contribute to inefficiency in training, and affect the ability to gain from motor skills training.

It is universally acknowledged that ordinary exercise plays a significant role in the levels of physical fitness and good health. In the realm of exercise modality, cardiovascular exercise becomes of significance when considering the effects of CVE, muscle efficiency, metabolism and mental health. Trained cardiac function and oxygen utilization with cardio activities such as running, biking and swimming may have benefits for athletes and health in general [1]. CVT can provide extra benefits in addition to making athletes fit for people with hearing loss. The benefits of controlled aerobic exercise programmes include enhanced social interaction, self-esteem, emotional stability and independence which are essential components of QoL. There have been some studies suggesting that physical exercise interventions are beneficial for both physiological and psychosocial outcomes for people with disabilities such as hearing impairment [7, 4]. CVE is an important aspect of athletics that requires physical fitness. Recent studies, however, indicate that hearing impaired students may show poorer cardiorespiratory fitness than their age matched hearing peers as a result of limited physical activity participation and environmental factors [19, 26]. Cardiovascular fitness could then improve the sports performance and health of athletes who are hearing impaired, with targeted training. QoL is another critical aspect of well-being and encompasses physical health, psychological status, social relationships, and environmental factors. People with hearing loss can experience difficulties completing sports due to communication issues, social isolation and reduced access to inclusive sports [17]. Exercise interventions, particularly delivered in supportive and inclusive environments, have been correlated with improvements in mental health, social connectedness and life satisfaction among individuals with disabilities [18] .

Motivation and Contribution

A remarkable work has been done by the reseachers on the effects of CVT on the human-being dealing with no disability [2, 8, 5, 22]. The CVT gaurentees the positive impacts through different techniques on the several health domains of human-kind [23, 11, 9, 15, 6]. Despite the recognized benefits of aerobic exercise, there is still limited research specifically examining the effects of CVT on both physical fitness and QoL among HIAs. The majority of existing literature is on general disability groups, or physiological or psychosocial aspects of fitness independently, as compared to a specifically combined model. This study aims to assess the effects of cardiovascular physical activity on the physical fitness and QoL of hearing-impaired male athletes. The plan of work is designed in a systematic manner to address the research objectives through the identification of the problem, a thorough literature review, the development of a hypothesis, participant selection, pre-intervention assessments, implementation of an 8-week intervention program, post-intervention assessments, and statistical analysis. The methodology is structured to ensure validity and reliability and places consideration to the needs of the hearing-impaired population. The method used in the study consists of:

1. The hypothesis for this study was created which states that CVT would have a significant impact on both the physical fitness and the QoL of HIAs.
2. Induction of a representative sample of male HIAs from a local special education institution.
3. Baseline testing to evaluate participants' baseline physical fitness status (CVE, strength, flexibility, agility and speed) and their QoL with standardised instruments.
4. Implementation of an 8-week CVT program.
5. Post-intervention re-assessment of physical fitness and QoL.
6. Appropriate statistical methods to determine the effects that the intervention has on physical fitness and QoL.

This method will give a structured methodology for assessing the effectiveness of CVT in the HIAs and help to identify the potential for improving their overall health and wellbeing.

Table 1: Abbrevation used in this Study

CVT	Cardiovascular Training	HIAs	Hearing Impaired Athletes
CVE	Cardiovascular Endurance	CHL	Congenital Hearing Loss
QOL	Quality of Life	AHL	Acquired Hearing Loss

2. MATERIALS AND METHODOLOGY

2.1. Design of Study

Due to the lack of randomisation in special education and the nature of the target population, a quasi experimental pre-test/post-test design was used. This design was chosen because it allows for a measurement of the effect of an intervention over time on a controlled group, or baseline measures are compared to the post intervention measures.The intervention was a series of physical activity classes, one hour per class, every two weeks. The purpose of these sessions is to enhance the following areas of physical fitness: CVE, strength, flexibility, agility and speed. The training period lasted for a period of 8 weeks, which was enough to provide an adequate amount of exposure to CVT in order to promote significant adaptations. Baseline physical fitness assessments were carried out prior to intervention and QoL assessments. To assess any changes in physical and mental health of the participants, post-intervention assessment were carried out at the end of 8 weeks of intervention. A pre-test/post-test design allows for a comparison of pre and post intervention data and provides useful information about the effectiveness of the CVT program in improving physical fitness and QoL in HIAs. The design helps to create a meaningful assessment of the impact of the intervention while still being feasible for an actual classroom environment.

2.2. Research Conduction

The study was carried out in the Department of Special Education at Government Degree College Bahawalpur, Pakistan. This facility offers special educational and recreational services for pupils with a hearing handicap. The setting was chosen because it had a particular interest in supporting students with hearing impairment and a history of supporting special education programs. This setting has several advantages as it offers direct access to the HIAs, the institution supports the inclusion of students with disabilities in physical activity, and it is located in a community that has limited accessibility of hearing impaired people in sport. In addition, the institution's history of working with students and their families made it a logical place to do a study with physical activity interventions. The students enrolled in this institution are involved in physical education programs, some of which include recreational sports. The setting is conducive to implementing a structured physical training program that can be monitored and evaluated throughout the study. The results of this study could be useful in other educational institutions especially those in Pakistan and in other parts of the world where there is a lack of resources for inclusive physical education in special education.

2.3. Participants and Sample Size

The study included 100 male athletes with hearing impairment aged between 15 to 25 years from the Government Degree College of Special Education, Bahawalpur, Pakistan. A non-probability convenience sampling approach was used in the selection of participants because the target population were easily accessible and the educational institution is a special school. This methodology, although not randomized, is common in intervention research with participants with disabilities, where access to a homogeneous sample is critical for intervention fidelity.

The number of participants was selected based on practical considerations, the availability of eligible participants and methodological precedents set in previous studies with similar objectives focused on the effects of physical training in people with special needs. Additionally, the number of participants included in the study was decided by the power considerations and the need for a meaningful pre and post intervention comparison, which resulted in a sample of 100 participants. Participants were all formally registered athletes participating in a regular school-based or recreational physical activities program. This group allowed for participants to have physical functionality at baseline to participate in the CVT protocols and reduced the risk of dropouts or adverse events during the intervention.

2.4. Inclusion and Exclusion Criteria

Maintaining internal validity, participant safety and consistency of intervention is dependent on the establishment of rigorous inclusion/exclusion criteria. The participants were pre-screened using medical records, guardian interviews and staff consultation to verify participant eligibility.

Inclusion Criteria

The following criteria holding participants were included in this study:

1. Male athletes in the age group 15-25.
2. Hearing loss (congenital or acquired).
3. Bilateral hearing loss.
4. Participated in athletic or organized physical activities regularly during the school curriculum or through extracurricular activities.
5. Skill to comprehend visual or sign language directions and follow training protocol.

This selection allowed participants to be physically fit to complete CVT and cognitively able to complete fitness assessments and QoL questionnaire tools, either on their own or in sign language.

Exclusion Criteria

The following exclusion criteria were used to protect the health of the participants and to provide uniformity in training results:

1. Any acute or chronic medical condition, such as cardiovascular, respiratory, neurological or musculoskeletal, which would preclude participation in physical training.
2. Temporary or permanent physical injury impairing mobility, strength or stamina.
3. Cognitive/aditional disabilities such as intellectual disability, visual impairment, autism spectrum disorder, that may be a barrier to comprehend training tasks or completing the QoL questionnaire.
4. A medical statement from a qualified healthcare professional that the person was physically unfit to undertake moderate to vigorous physical activity.

These criteria were carefully considered to help ensure homogeneity of the sample group and minimize confounds for the purposes of increasing the generalizability of findings within the population of HIAs.

3. RESEARCH PROCEDURE

This study used the quasi-experimental approach with pre and post tests in order to evaluate the effect of CVT program on physical fitness components and QoL in male athletes who are hearing impaired in 8 weeks. The structured research process involved the following main phases: pre-test assessment, intervention implementation, post-test assessment, and enabled comparisons within groups to be made over time of changes in physical and psychological health outcomes. All participants gave informed consent and were explained the research protocol using sign language interpreters to ensure that they understood. The data was collected in a controlled and standardized environment, which reduced external variability and increased the internal validity of the data.

3.1. Pre-Test Assessment

Before intervention, baseline data was collected to determine the pre-intervention physical fitness and perceived QoL of participants. The Physical fitness assessment focused on the five key areas that are important for sports achievement and physical well-being:

- *C*VE: The 20 meter shuttle run test is a valid and reliable field test for aerobic capacity (VO_2max) and endurance in youth populations and is used to assess CVE.
- *S*peed: Assessed by a 30 meter shuttle sprint test, with emphasis placed on the athlete's sprinting capability and on the explosive nature of their running.
- *A*gility: Defined by the t-Test, which evaluates the participant's capability to change their direction quickly with balance, coordination and speed key factors of athletic agility.
- *F*lexibility: Assessed with a standardized sit and reach test of lower back and hamstring flexibility, which is important in injury prevention and overall mobility.
- *M*uscular Strength: Evaluated by a field test known as the Push-Up Test, which is a measure of upper body muscular endurance and strength.

Aside from the physical tests, all participants filled out the Short Form Health Survey (SF-36). Multidimensional, psychometrically validated assessment of eight domains of health-related QoL such as physical functioning, bodily pain, role limitations, general health perceptions, vitality, social functioning, and mental well-being. SF-36 was administered with the help of an interpreter to ensure accessibility and understanding of the SF-36 to athletes who are hard of hearing.

3.2. Intervention: Cardiovascular Training Program

The participants then participated in an 8-week CVT intervention that had a structured approach to stimulate aerobic fitness, muscular endurance and overall physical functioning after the pre-test. The program was offered twice per week and each session was about 60 minutes. All training sessions were conducted by qualified physical education specialists, and included a scientifically based exercise protocol of:

- *W*arm-up (10 minutes): Light aerobic activities and dynamic stretching to get the body ready for the activity and to lessen the probability of injury.
- *M*ain exercise (40 minutes): A series of progressions of cardiovascular exercises such as running circuits, shuttle runs, aerobic exercises, endurance exercises using bodyweight and sport-specific conditioning exercises. Exercises were modified to accommodate the abilities and needs of the hearing impaired athlete and were to be designed to foster an increase in CVE, speed, agility, flexibility and muscular strength.
- *C*ool down (10 minutes): Light aerobic exercise and static stretches to aid recovery and flexibility.

All sessions were observed and held in a supportive and inclusive space, with a focus on communication needs being met, including using visual cues and gestures, and using the interpreter as appropriate.

3.3. Post-Test Assessment

At the end of the 8-week intervention period, all participants completed the same physical fitness test battery and the SF-36 QoL questionnaire that they had taken during the baseline period. This provided uniformity and comparability of the data for the different time points.

Post intervention results were obtained, recorded and analysed to observe the extent and direction of changes in the physical performance and health-related QoL outcomes. The purpose was to assess the benefits of CVE training on the physical and social health of HIAs.

The statistical analysis of the pre- and post-assessment data involved using the appropriate parametric tests (paired ttests) to determine whether significant differences exist and to draw conclusions only on the basis of empirical evidence.

3.4. Data Collection Tools

A combination of quantitative and standardized assessment tools was used to comprehensively assess the effect of CVT on physical fitness and the QoL among HIAs. These tools were chosen for their validity, reliability, and appropriateness for the population and research purposes.

Demographic and Health History Questionnaire

A semi-structured demographic questionnaire was created to gather baseline information from the participants. This included:

- Age
- Type of hearing impairment (congenital or acquired).
- The reason for the hearing loss (such as genetic hearing loss, trauma, illness).
- How long the hearing loss lasts for.
- The length and number of sports participation.
- Past medical history, any chronic medical conditions, medications and injuries.

This tool was designed to detect confounding variables, to meet the inclusion/exclusion criteria, and to describe the sample in terms of athletic and health backgrounds. This demographic information was also used to provide sub-group analysis as appropriate.

Physical Fitness Test Battery

A standardized field test battery was used to objectively assess changes in the physical fitness of participants pre and post intervention. Some of the tests were chosen because they were suitable for people with disabilities and were commonly used in sports science and physical education research. The following components were assessed:

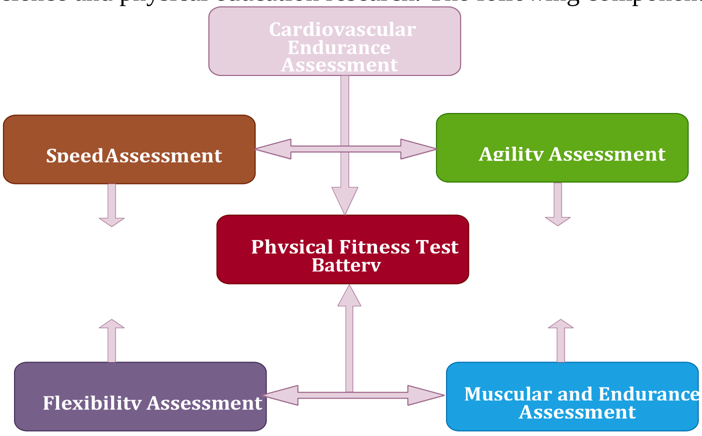

Figure 1: Flowchart of components of Physical Fitness Test Battery

- *C*VE: 20-meter Shuttle Run Test (Beep Test). This is an aerobic test to measure aerobic capacity and is a valid measure of cardiorespiratory fitness. Participants were instructed to run between two lines 20 metres apart at increasing speeds, depending on an visual signal.
- *S*peed: Measured by the 30-Meter Shuttle Run Test (sprinting speed and acceleration). The participants ran several short sprints in a given time, the times were measured in seconds.
- *A*gility:Assessed with the T-Test which is a widely used protocol to assess multi-directional movement, change of direction and balance. The participants sprinted, side-shuffled and backpedaled in a "T" shape path.
- *F*lexibility: Measured with the Sit and Reach Test, which tests the flexibility of the lower back and hamstring muscles. This test is especially important for the understanding of mobility and injury prevention, as well as functional capacity of athletes.
- *M*uscular Strength and Endurance: Push-Up Test which is a measure of upper body strength and endurance. Their task was to use as many push ups with correct form as they could till fatigue.

All physical fitness assessments were conducted under standardised conditions, instructions and demonstrations were given in sign-supported language, to facilitate understanding. Strict safety measures were implemented and each test was administered by trained assessors who had experience in administering tests with special populations.

QoL Assessment Tool (SF-36 Questionnaire)

The Short Form-36 Health Survey (SF-36) was used to assess the psychological and social impacts of CVT. A multidimensional, self-reported questionnaire widely-used in both clinical and general population with good sensitivity and reliability, even for people with disabilities. The 36 items of the SF-36 measure 8 health domains:

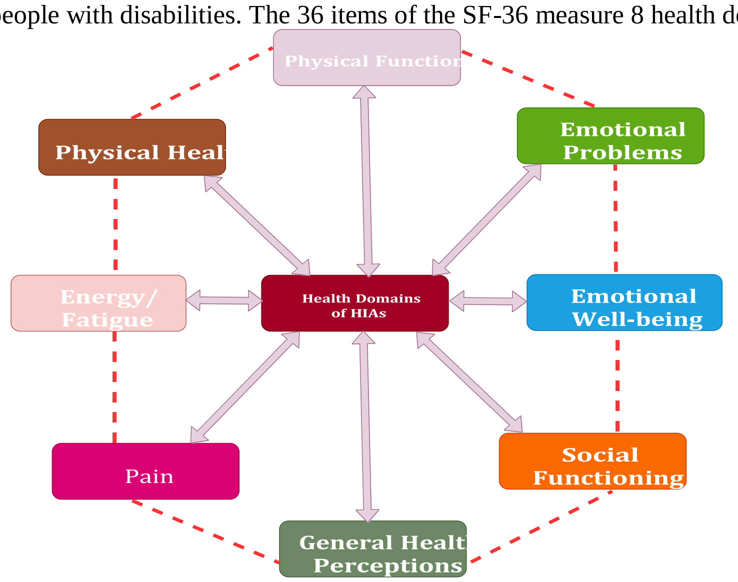

Figure 2: Health Domains of Hearing Impaired Athletes

- *P*hysical Functioning: Ability to carry out physical activities of daily living.
- *P*hysical Health: Effect of physical health on work and daily roles.
- *E*motional Problems: The role limitation due to emotional problems is an impact of emotional well-being on role performance.
- *E*nergy/Fatigue (Vitality): Awareness of energy and fatigue.
- *E*motional Well-being (Mental Health): Measures of psychological distress and well-being.
- *S*ocial Functioning: Interpersonal interactions and social engagement.
- *P*ain: Degree of pain in the body and effect on it.
- *G*eneral Health Perceptions: Overall self-rated health.

All SF-36 items were scored using standard scoring procedures, resulting in a domain-specific score and a summary score for physical and mental health components. In order to ensure understanding and correct response by the participants who have communication difficulties, the questionnaire was presented in simplified written Urdu with the help of interpreters who were fluent in Pakistan Sign Language (PSL).

3.5. Data Analysis

Data gathered from pre-test and post test were carefully coded, completeness checked and then entered in SPSS software (version 28.0) for detailed statistical analysis. In the first phase of the analysis, descriptive statistics were used to describe the baseline data of the study participants, including demographic data and the pre-test scores for physical fitness and QoL. Descriptive statistics, such as mean, standard deviation (SD), minimum and maximum values, were calculated to gain insights into the distribution of the variables and to detect any outliers or anomalies.

The study used paired sample t-test to compare pre and post-testing for each participant to assess the effect of the CVT intervention on physical fitness and QoL. This test was selected because the study used a within subject design in which the same subjects were tested pre-test and post-test. The paired t-test was used to assess if there was any statistically significant difference between the mean of the pre-test and post-test scores of the two related groups.

The t-test was used to analyze the physical fitness outcomes, in order to determine if the intervention had a meaningful effect on the various physical performance variables. Similarly, SF-36 data, which provided a measure of QoL in various areas, was analyzed using paired t-tests to assess whether significant improvements were seen after intervention.

Shapiro-Wilk tests were used to determine the normality of the data for each variable. When data were determined not to be normally distributed, a nonparametric test was used as an alternative, such as the Wilcoxon Signed-Rank Test. Further, the effect size for each fitness domain was computed to determine practical significance of the results (Cohen's d). Cohen's interpretations of effect sizes were used: 0.2 = small; 0.5 = medium; 0.8 = large.

A value of $p < 0.05$ was used as the threshold for statistical significance for the purposes of interpretation and thus any difference between pre and post test measurements were unlikely to have occurred by chance. When multiple comparisons were performed, however, a Bonferroni correction was used to account for the possibility of Type I error. This adjustment helped to keep the alpha level at a low level for all tests.

Additionally, in order to measure the overall effect of the CVT program on the QoL of participants, multivariate analysis of the SF-36 data was performed. By using this approach, the link between several dependent variables and the training intervention could be studied while controlling for potential confounding variables.

Outlier Detection and Data Cleaning

All data gathered were checked for accuracy, completeness and consistency before statistical analysis. Where there were inconsistencies or missing values, these were solved using suitable methods for imputation or, if this was not possible, were omitted from the analysis. The z-score method (z-scores greater than or less than the values of ± 3 standard deviations were considered potential outliers) was used for identification of potential outliers in the physical fitness test scores and in the results of the questions on the QoL. Any outliers were explored in detail for their effect on the overall results and relevant decisions took place about their inclusion/exclusion from analysis.

Reliability and Validity Checks

In order to verify the reliability of the instruments employed, the internal consistency was calculated by Cronbach Alpha on SF-36 questionnaire, where Cronbach Alpha was > 0.7 indicating an acceptable reliability. In addition, testretest reliability was performed on a subsample of 20 individuals to ensure that the physical fitness tests were stable over time before and after the intervention.

The data analysis involved several stages: Descriptive statistics for summarizing the baseline data, Paired sample ttests to determine significant changes in physical fitness and QoL pre- and post-intervention, Effect size calculation to determine the practical significance of the findings, Multivariate analysis to examine the broader effects on QoL, and Outlier detection and reliability checks to ensure data integrity.

4. RESULTS OF PROPOSED STUDY

The data were analyzed with SPSS Version 28.0. To assess the effectiveness of the 8-week CVT program, descriptive statistics, paired sample t-tests, effect sizes, reliability analyses, and multivariate comparisons were performed.

4.1. Demographic Characteristics of Participants

The study involved a total of 100 athletes with a hearing impairment. The results are presented in the form of tables according to the objectives and hypotheses of the study.

Table 2: Distribution of Participants According to Age Group (N = 100)

Age Group (Years)	Frequency	Percentage (%)	Mean Age	SD
15-17	28	28.0	16.4	0.82
18-20	39	39.0	19.1	0.74
21-23	22	22.0	22.2	0.69
24-25	11	11.0	24.4	0.51
Total	100	100.0	19.53	2.74

Table 2 shows the frequency distribution of participants in different age groups of the total sample of 100. The table displays the numbers and percentages, mean age and SD for each age. This table is designed to indicate the demographic attributes of the respondents according to age distribution. The results showed that the age group of 18-20 years was the highest. 39.0% of participants were included in this category. The mean age for this group was 19.1 years, and the standard deviation was 0.74, which means that the ages of the participants in this group were fairly close together and there was not much variation from the mean.

The second largest group was the participants aged 15-17 years. In this category there were 28 participants that represented 28.0% of the total sample. The mean age in this group was 16.4 years and standard deviation was 0.82. There is a slight difference in SD when compared to the age group 18-20, indicating that the ages of the participants within this age group were not that significantly different.

The age group 21-23 years had a frequency of 22 participants, making up 22.0% of the sample. The mean age for these was 22.2 years, with a SD of 0.69, which suggests that the age distribution of these participants was fairly even. The age group with the smallest number of participants was 24-25 years. A total of 11.0% were included in this group. The average age for this group was 24.4 years and the standard deviation was 0.51. The smaller SD indicates that the ages in this group were very tightly clustered and were not widely spread from the mean.

The total mean age of the all participants was 19.53 years and the standard deviation was 2.74 years. This overall mean suggests that the study sample mainly consisted of late adolescents and young adults. The overall SD is greater than the individual group SDs, which would indicate that there is a greater variation of ages within all the categories together. The findings also show that most respondents were in the younger ages namely 18 to 20 years while comparatively few were seen in the older ages.

Table 3: Type of Hearing Impairment among Participants

Type of Hearing Impairment	Frequency	Percentage (%)
CHL	83	83.0
AHL	17	17.0
Total	100	100.0

The distribution of participants by type of hearing impairment is shown in table 3. The results showed that of the 100 participants who were included in the study, 83.0% were reported to have CHL, while 17.0% were reported to have AHL.

The results demonstrate that CHL was more prevalent among participants than AHL. Hearing loss that is present at birth, may be related to genetic factors, to complications during pregnancy, to low birth weight, infections or to other prenatal and perinatal factors is referred to as CHL. The higher prevalence of CHL in the current study indicates that most of the participants started being language impaired at the early stages of life, and this may have affected their communication style, language development, educational experiences and involvement in physical and social activities. In contrast, 17.0% of the participants experienced AHL. AHL occurs after birth and can be caused by diseases, illnesses, trauma, loud noises, exposure to ototoxic drugs, or as a result of aging. While the percentage of study participants with AHL is less than CHL, it is still a significant portion of the study group.

In general, the results indicated that the largest group of the participants were those with congenital hearing impairment. This distribution underscores the need for early diagnosis, intervention, rehabilitation, and specialized education and physical activity programs for children with CHL. Simultaneously, the findings of AHL in over 15% of the population highlight the importance of implementing health care prevention strategies and awareness campaigns about factors that can increase the risk of hearing loss in the future.

Table 4: Duration of Athletic Participation

Athletic Experience	Frequency	Percentage (%)	Mean Years	SD
1-3 Years	31	31.0	2.2	0.71
4-6 Years	42	42.0	5.1	0.83
7-9 Years	19	19.0	7.8	0.64
10+ Years	8	8.0	10.9	1.11
Total	100	100.0	5.28	2.81

Table 4 shows the length of time participants have been involved in athletic competitions. The results were consistent with that the most of athletes achieved moderate athletic experience. The 42% of the 100 participants indicated that they had participated in an athletic event for 4-6 years, which was the highest number of years of participation. The average athletic experience for this group was 5.1 years, and the SD was 0.83, indicating that the majority of athletes in this group had a relatively similar amount of experience.

The second group, representing 31% of the respondents, consisted of athletes who participated 1-3 years.The second largest group included athletes who participated for 1-3 years. The mean experience was 2.2 years with a SD of 0.71; which means little variation in participants in this category. This suggests that a considerable proportion of the sample was still in the early stages of athletic development. In addition, 19% of the sports participants said that they had participated in sports activities for 7-9 years. This group's mean was 7.8 years, standard deviation 0.64, indicating a relatively stable amount of years spent as an athlete.

8% of the participants had over 10 years of athletic experience. The mean duration of participation and SD in this group was 10.9 years and 1.11, respectively, which was slightly higher than that of the other groups. The low percentage indicates that there were not many athletes in this sample who were longtime participants in athletics. In general, the table shows that there were differences in the number of years of athletic involvement in the years in which the participants were active, and the athletes in general had a mean of 5.28 years of athletic involvement with a SD of 2.81 years. Most of the respondents had moderate level of experience in sports activities which may have beneficial effect in understanding the concepts of training, competition and sports performances.

4.2. Baseline Physical Fitness Assessment

The descriptive statistics of pre-test physical fitness variables of participants before the intervention or training program are shown in Table 5. The results give a general indication of the initial level of physical fitness of the participants with regards to CVE, speed, agility, flexibility and muscular strength endurance.

Table 5: Descriptive Statistics of Pre-Test Physical Fitness Variables

Variables	Mean	SD	Minimum	Maximum
CVE (levels)	5.92	1.18	3.0	8.4
Speed (30m sprint/sec)	5.84	0.49	4.90	6.90
Agility (T-test/sec)	13.88	1.07	11.6	16.7
Flexibility (cm)	19.75	5.42	9	32
Push-Ups (repetitions)	20.46	4.63	11	31

CVE had a mean score of 5.92 level with SD of 1.18 which means the mean score is moderately different from one participant to another. There was considerable variation in the scores with some individuals having lower levels of endurance capacity and others having relatively high aerobic fitness prior to the intervention (3.0 to 8.4). The mean time for the 30 meter sprint test was 5.84 seconds with a SD of 0.49 seconds. The sprinting ability between the participants varied significantly with minimum and maximum values ranging from 4.90-6.90 s. The shorter sprint times indicated better sprint speed performance.

The mean score for agility (T-test) was 13.88 s, with a standard deviation of 1.07 s. Mean score was 11.6-16.7 seconds indicating some variation in the ability of the participants to change their direction quickly and efficiently. There was a relatively higher standard deviation (5.42 cm) and a mean value of 19.75 cm for the flexibility scores, which may suggest larger variability of participants by flexibility scores. The width of the scores varied from 9 cm to 32 cm, indicating that some of the participants were less flexible, whereas others were much more flexible.

The mean number of push-ups made for strength endurance was 20.46 with a standard deviation of 4.63. Before training, there was moderate variation in upper body muscular endurance; the range of scores was from 11 to 31 repetitions. The descriptive statistics show that the participants are physically fit at the pre-test level, which can be used to assess the impact of the intervention program on the various components of physical fitness.

4.3. Post-Test Physical Fitness Assessment

In Table 6, we present the descriptive statistics of the post-test physical fitness variables of the participants after the intervention or training program. The findings showed that the level of physical fitness of the subjects was moderate to good in all the components measured.

Table 6: Descriptive Statistics of Post-Test Physical Fitness Variables

Variables	Mean	SD	Minimum	Maximum
CVE (levels)	8.14	1.26	5.4	10.9
Speed (30m sprint/sec)	5.12	0.41	4.38	6.11
Agility (T-test/sec)	12.16	0.92	10.4	14.3
Flexibility (cm)	26.82	5.91	15	39
Push-Ups (repetitions)	30.28	5.13	18	43

The mean score for CVE was 8.14 with a standard deviation of 1.26, suggesting some variation in CVE among the participants. There was considerable variation in the scores, with minimum of 5.4 levels and maximum of 10.9 levels, indicating that some participants had a significantly higher endurance performance than others. In terms of speed performance as measured by the 30m sprint test, the participants had a mean time of 5.21 seconds, with a standard deviation of 0.41 seconds. Sprint times were between 4.38 seconds and 6.11 seconds. This is because the shorter the sprint time, the faster the speed performance, so that the results are that after the training period several participants had relatively good sprint performance.

In the agility test, the mean score was 12.16 seconds and the standard deviation was 0.92 seconds. Eighteen players finished the agility completion in under 10.4 seconds, and 10 finished in over 14.3 seconds. The results support moderate variability in agility performance of the participants. The mean flexibility score was 26.82±5.91 cm. The range of scores was from 15 cm to 39 cm indicating that there were definitely variations in levels of flexibility among the participants. Flexibility has a relatively high standard deviation as compared to other physical fitness variables, suggesting more variability in performance.

The muscular strength and endurance of the subjects evaluated by push-up performance was 30.28 repeats with a standard deviation of 5.13 repeats. Push-ups varied slightly in number between 18 and 43, indicating a range in upper-body muscular endurance for the participants. The heart of the descriptive statistics is that participants' CVE, speed, agility, flexibility, and muscular endurance levels were acceptable during the post-test, and there were moderate individual variations in the physical fitness variables measured.

4.4. Analysis of Paired Sample t-Test

The effect of CVT on endurance is given by the following Table 7.

Table 7: Effect of CVT on Endurance

Variable	Pre-Test Mean±SD	Post-Test Mean±SD	Mean Difference	t-value	p-value	Cohen's d
CVE	5.92 ± 1.18	8.14 ± 1.26	2.22	16.84	0.000*	1.52

As seen in Table 7 CVT was effective in improving the endurance of the participants. The results showed that there was a significant improvement in CVE after the training program. The mean endurance score for the participants prior to the intervention was 5.92± 1.18; and following the completion of the CVT program, the mean score was 8.14±1.26. This improvement led to an average difference of 2.22 points, indicating the participants' endurance capacity improved significantly following training.

The results of the statistical analysis corroborated its effectiveness. The t value obtained is very high i.e 16.84, which shows that there is a significant difference between the pre test and post test scores. Moreover, the p-value was reported as 0.000, which is less than the standard significance level of 0.05, demonstrating that the improvement in endurance was statistically significant and not due to chance. Furthermore, Cohen's d value of 1.52 indicated that the effect was large, indicating high significant and practical influence of CVT on endurance performance of participants. In general, it falls in line with the previous findings that the cardiovascular trainings were effective to improve CVE among participants.

Table 8: Effect of CVT on Speed

Variable	Pre-Test Mean±SD	Post-Test Mean±SD	Mean Difference	t-value	p-value	Cohen's d
30m Sprint Time	5.84 ± 0.94	5.21 ± 0.41	-0.63	12.91	0.000*	1.28

The influences of the CVT on the speed performance of the participants are shown in the Table 8 in the form of the results of the 30 meter sprint test. The results indicated that there was a marked improvement in speed of the sprint after the training intervention. The participants had a mean 5.84±0.49-second sprint time prior to the CVT program. The mean of the post-test was 5.21 ± 0.41 seconds after the training program. The reduction of sprint time is a good measure of an increase in speed and showed that the participants improved their sprint ability after the training.

The average difference between pre- and post-test was -0.63 seconds, which suggests a significant change in sprint performance. The calculated t value of 12.91 represents a significant difference in the statistics of the two testing phases. Additionally, the p-value was 0.000 and the standard value of significance is set to 0.05, which means that the improvement in speed is not statistically insignificant and thus, it is not due to chance.

Further, an effect size of Cohen's d was calculated as 1.28, indicating a large effect size. This implies that the cardiovascular exercise was extremely meaningful and practical for the participants' quickness skills. The overall outcomes suggest that CVT was very effective at improving sprint performance and speed of participants.

Table 9: Effect of CVT on Agility

Variable	Pre-Test Mean±SD	Post-Test Mean±SD	Mean Difference	t-value	p-value	Cohen's d
Agility (T-test)	13.88 ± 1.07	12.16 ± 0.92	-1.72	14.77	0.000*	1.41

Table 9 illustrates that the CVT intervention significantly improved agility scores, and that the difference from the pre-to post-measures were marked and statistically significant. The mean score for the T-test agility prior to the intervention was 13.88±1.07 and after the intervention was 12.16±0.92. In agility testing, a lower time is better and this reduction is a benefit of agility performance following training. This is further substantiated by the mean difference of -1.72. The change is statistically significant with a t-value of 14.77 with a p-value of 0.000 which is less than the commonly accepted value of p=0.05. Also, the Cohen's d value was 1.41, which represents a very large effect size, meaning that there was a high practical significance of CVT in the improvement of agility.

Table 10: Effect of CVT on Flexibility

Variable	Pre-Test Mean±SD	Post-Test Mean±SD	Mean Difference	t-value	p-value	Cohen's d
Sit and Reach Test	19.75 ± 5.42	26.82 ± 5.91	7.07	13.44	0.000*	1.33

In the same way, the Sit and Reach Test results in a significant improvement in flexibility for the group, as shown in Table 10. The mean score was 19.75±5.42 before the intervention and 26.82±5.91 following the intervention. This improvement of 7.07 points in this test corresponds to an improvement in flexibility which is considered significant, because more points mean greater flexibility. This improvement is statistically significant with t=13.44, and p=0.000. In addition, the Cohen's d score was 1.33 which is a very large effect size, suggesting the training was a highly effective and practically significant flexibility improving program for the participants.

In general, both results showed large and significant increase in agility and flexibility as a result of CVT, with high effect-size for the effect of CVT.

Table 11: Effect of CVT on Muscular Strength

Variable	Pre-Test Mean±SD	Post-Test Mean±SD	Mean Difference	t-value	p-value	Cohen's d
Push-Up Test	20.46 ± 4.63	30.28 ± 5.13	9.82	17.35	0.000*	1.67

Results of a CVT program on muscular strength from the push-up test are shown in the table 11. Participants were found to have a mean of 20.46±4.63 push-ups at baseline prior to the training intervention, which suggests relatively moderate upper-body muscular endurance with a moderate amount of individual differences. The mean performance after the CVT program was completed was 30.28 push-ups with a standard deviation of 5.13. This demonstrates that participants could do an average of 10 more push-ups following the intervention.

This means difference is 9.82 which was a clear improvement in muscular strength after training period. The t value was very high (17.35) and is quite significant and therefore would not occur by chance. The p value (0.000) also indicates that the findings are very significant as the training did have an actual impact on muscular strength. Cohen's d value of 1.67 represents very large effect size which means that the CVT not only produced a statistically significant effect but at the same time an effect with good practical meaning on muscular strength. In summary, results indicated that CVT significantly improves upper-body muscular endurance as measured by the performance of push-ups.

4.5. QoL Analysis

The pre-test results for the QoL questionnaire using the SF-36 scale show a general moderate level of functioning in all the domains with significant differences between the physical and psychosocial domains as listed in the following table:

Table 12: Pre-Test QoL Scores of Participants

SF-36 Domains	Mean	SD
Physical Functioning (D_1)	56.82	9.12
Role Physical (D_2)	52.48	10.54
Emotional Well-Being (D_3)	54.91	8.77
Social Functioning (D_4)	50.67	9.82
Vitality (D_5)	51.28	8.36
Pain (D_6)	58.74	10.11
General Health (D_7)	55.82	9.23
Mental Health (D_8)	53.44	8.91

As indicated in the Table 12, the mean score for physical functioning was 56.82 (SD = 9.12), which reflects a relatively moderate performance level on physical functioning, but not optimal. This indicates there are some mobility or physical limitations at baseline. The mean of Role Physical, indicating limitation in daily roles because of physical health, is 52.48 (SD = 10.54). This indicates that physical health was already affecting the ability to perform work or routine activities to a moderate extent of participants. Emotional Well-Being was on average 54.91 (SD = 8.77), indicating that individuals had average emotional stability, though there may be some psychological stress or inconsistency within the sample. One of the poorer domains is Social Functioning with a mean = 50.67 and SD = 9.82. This means that the participants had more limitations related to social interactions or the participation in social activities than usual, possibly from health or lifestyle constraints.

Vitality is a measure of energy and fatigue, with a mean score of 51.28 (SD = 8.36), indicating moderate levels of fatigue and low levels of energy at baseline. The highest score is in the domain of pain, with a mean score of 58.74 (SD = 10.11). This indicates that participants were feeling pain but that this was not a major limitation for them when compared to other functional limitations. The results for General Health are at a moderate level of 55.82 (SD = 9.23), not particularly high or low. Finally, moderate psychological well-being is indicated by a mean score for mental health of 53.44 and SD = 8.91, yet it does reflect some degree of stress or emotional problem. Overall, the pattern indicates that there were slightly more favorable perceptions of physical health than of social and functional domains, with the area most impacted being social functioning at pre-test as shown in the Figure 3.

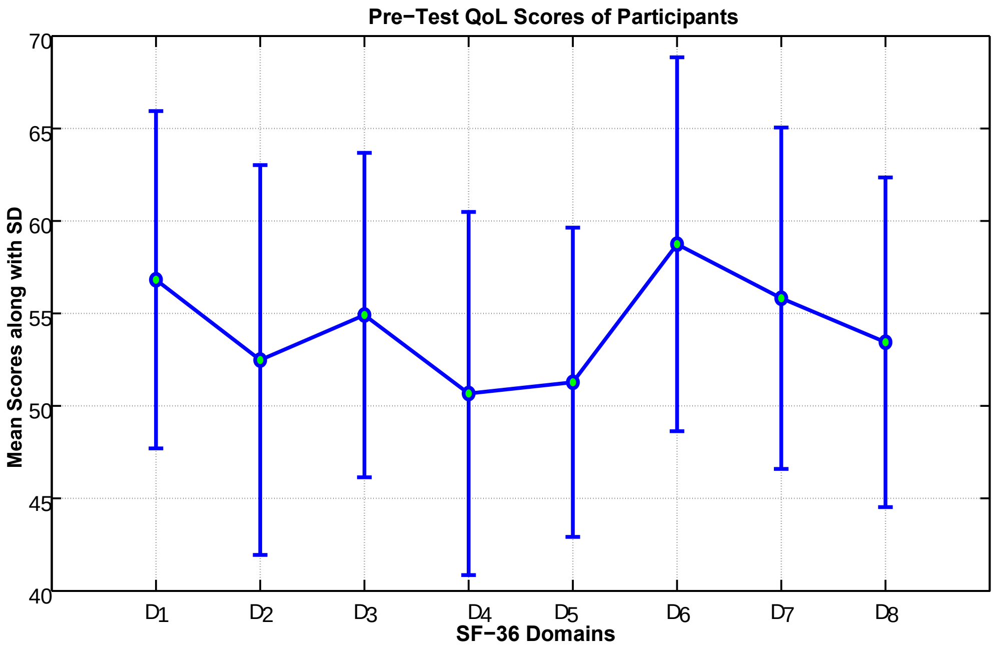

Figure 3: Pre-Test quality of life Scores Assessment of Hearing Impaired Athletes

Table 13: Post-Test QoL Scores of Participants

SF-36 Domains	Mean	SD
Physical Functioning	76.48	8.27
Role Physical	74.16	9.11
Emotional Well-Being	73.28	7.66
Social Functioning	72.35	8.18
Vitality	71.12	7.92
Pain	75.82	8.72
General Health	74.67	8.51
Mental Health	72.94	7.84

Participants' post-test results on the SF-36 show moderate to good levels of functioning with relatively consistent scores and low variability across all domains. The highest mean score was obtained for Physical Functioning (76.48±8.27), indicating an improvement in participants' ability to carry out daily physical activities following the intervention. This indicates better mobility, stamina and the capacity to handle normal physical functions without much difficulty. The score of pain was also high in comparison (75.82±8.72), suggesting that less pain was interfering with daily life activities.

Similarly, positive outcomes are evident after intervention in General Health (74.67±8.51) and Role Physical (74.16±9.11). The scores indicate that the participants had a more positive attitude towards their overall health and less limitation in carrying out daily activities related to their physical health. Emotional well-being (73.28±7.66) and mental health (72.94±7.84) show moderate psychological changes in psychological status such as stabilized mood, decreased emotional distress, and improved emotional regulation. These scores are slightly less than the physical domains, but still show a positive mental health picture.

In terms of Social Functioning, the participants' mean was 72.35±8.18, indicating moderate social functioning ability in engaging in social interactions and maintaining relationships, which is slightly lower than that of Physical Functioning. Even though still in a positive range, vitality showed the lowest mean score (71.12±7.92) suggesting that improvement in the energy and fatigue domain was comparatively less than other domains. Based on the pattern of results, the intervention appeared to impact overall physical and psychosocial dimensions of QoL with greater effects seen in physical health domains than in energy-related and social-emotional domains as shown by Figure 4.

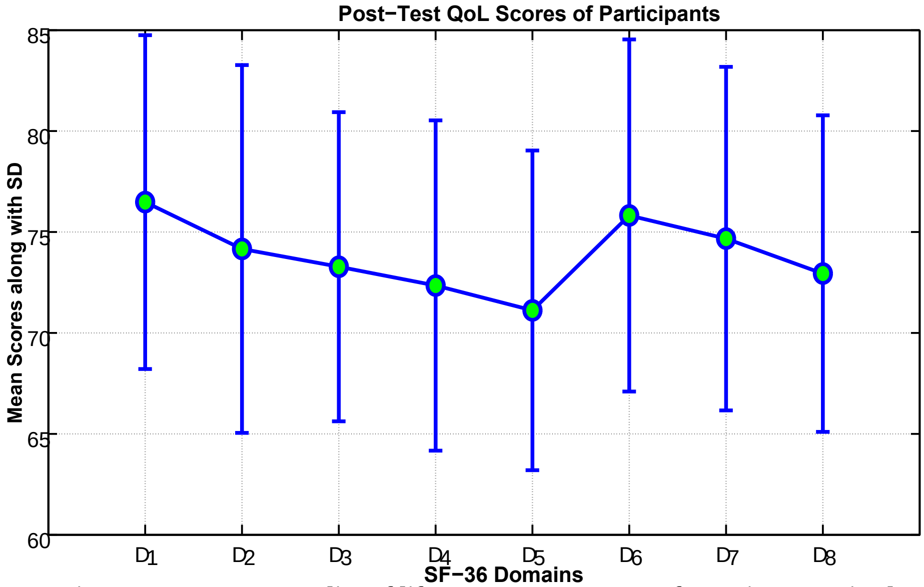

Figure 4: Post-Test quality of life Scores Assessment of Hearing Impaired Athletes

Table 14: Paired t-Test Analysis of QoL Domains

QoL Domain	Mean Difference	t-value	p-value	Cohen's d
Physical Functioning	19.66	15.82	0.000*	1.44
Role Physical	21.68	14.91	0.000*	1.39
Emotional Well-Being	18.37	13.42	0.000*	1.27
Social Functioning	21.68	16.21	0.000*	1.56
Vitality	19.84	14.04	0.000*	1.31
Pain	17.08	11.87	0.000*	1.18
General Health	18.85	13.98	0.000*	1.29
Mental Health	19.50	14.62	0.000*	1.37

Table 14 shows that the QoL domains provided by the paired t-test revealed significant improvements in all the measured domains after the intervention. All domains have very high t-values ranging from 11.87 to 16.21, with corresponding p-values of 0.000*, indicating that the changes observed are not due to chance and are highly significant. All mean differences are large when compared to the size of the change (from 17.08 for Pain up to 21.68 for Role Physical and Social Functioning). This indicates that meaningful improvement in physical and psychosocial aspects of QoL occurred in the participants.

A review of effect sizes (Cohen's d values) shows consistently high values of effect across the domains (1.18 to 1.56) suggesting strong practical significance for all of them. The largest effect size (d = 1.56) is seen in Social Functioning, followed closely by Physical Functioning (d = 1.44) and Emotional Well-Being (d = 1.27). The smallest effect size seen (in Pain, d = 1.18) still exceeds the conventional criteria for a large effect size. The pattern in this case was therefore that the intervention had a wide and deep positive effect on the quality of the participant's life, with large and meaningful effect sizes in all domains of life related to physical health, psychological health and social functioning.

4.6. Discussion

The Table 15 shows correlations between the various components of physical fitness and different scores on QoL. The results indicate that there is a strong positive correlation between endurance and QoL (r = 0.72), suggesting that the higher the level of endurance, the better the QoL of the participants. Likewise, flexibility has a moderate to strong positive correlation with QoL (r = 0.61) while strength has the highest positive correlation (r = 0.75), indicating that the gains in muscular strength are strongly correlated with perceived improvements in QoL.

Table 15: Correlation between Physical Fitness and QoL Scores

Variables	QoL Score (r)	p-value
Endurance	0.72	0.000*
Speed	-0.64	0.000*

Agility	-0.69	0.000*
Flexibility	0.61	0.000*
Strength	0.75	0.000*

Agility and speed, on the other hand, have strong negative correlations with QoL. There also exists a strong negative correlation between speed and age of the participants (r = -0.64) and a strong negative correlation between agility and age of the participants (r = -0.69). This suggests that there is a negative correlation between speed/agility test scores and the QoL scores in this data set, possibly due to the method of measuring and/or interpreting these in the context of this study. All correlations are significant and are not likely to be due to chance; the relationships found between the physical fitness components and the QoL are statistically significant at the conventional level of significance (p = 0.000).

Table 16: Multivariate Analysis of QoL after Intervention

Source	Wilks' Lambda	F-value	p-value	Partial Eta Squared
CVT	0.311	21.84	0.000*	0.689

This table reports the multivariate analysis results examining the effect of CVT on QoL after the intervention. The Wilks' Lambda value (0.311) is quite low, which indicates a strong overall effect of CVT on the combined QoL outcomes. In multivariate statistics, a lower Wilks' Lambda suggests that group differences are substantial. The F-value (21.84) is relatively high, showing that the difference between the intervention and comparison conditions is statistically strong. This means the observed changes in QoL are unlikely to have occurred by chance.

The p-value (0.000) indicates that the results are highly statistically significant ($p < 0.05$). Therefore, CVT had a meaningful effect on QoL after the intervention. Lastly, the Partial Eta Squared (0.689) indicates a very large effect size. This indicates that about 68.9% of the variance in QoL outcomes can be explained by CVT, implying that there is a high practical and clinical relevance of this training approach. The results thus indicate a statistically significant and substantively large improvement in the QoL following the intervention with CVT.

Table 17: Percentage Improvement in Physical Fitness Variables

Variables	Pre-Test Mean	Post-Test Mean	% Improvement
Endurance	5.92	8.14	37.50
Speed	5.84	5.21	10.79
Agility	13.88	12.16	12.39
Flexibility	19.75	26.82	35.80
Strength	20.46	30.28	47.99

The values in Table 17 reflect improvements in all the physical fitness measurements taken at pre-test and post-test, which suggest a generally positive effect of the intervention on physical fitness profile of the participants. The amount of endurance increases significantly by 37.50%. This increase from an average of 5.92 to 8.14 indicates a significant growth in the participants' cardiovascular capacity and their capacity to maintain their physical efforts over a prolonged period of time. It is a good sign of the efficacy of the training to improve aerobic capacity. The mean value also decreased by 10.79% from 5.84 to 5.21, leading to an improvement in speed. In speed tests, the speed is usually indicated by lower scores, so this decrease suggests that participants were faster following the intervention than before, but not as much as with other variables.

In agility, there is 12.39% decrease, the score changed from 13.88 to 12.16. This suggests enhanced change of direction skills and faster movement skill. The improvement is not as great as with endurance or strength but still a meaningful improvement in neuromuscular coordination. The percentage change for flexibility is a positive 35.80% from 19.75 to 26.82 as shown in the Figure 5. This means there is a significant improvement in joint range of motion and muscle elasticity, which is crucial in injury prevention and for general movement quality.

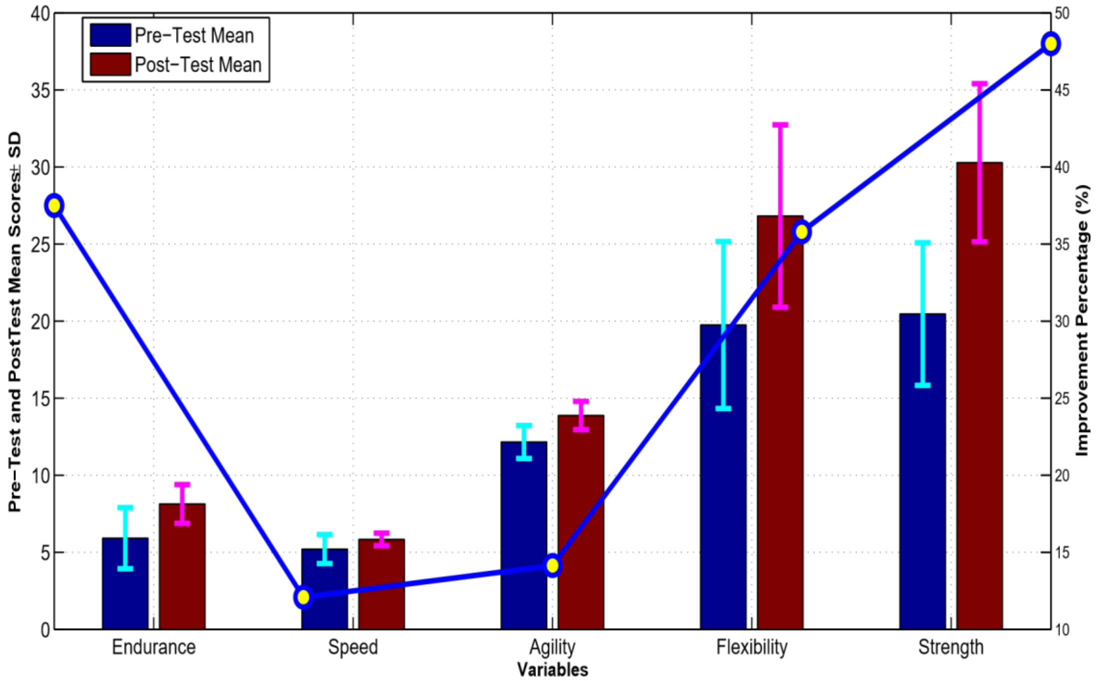

Figure 5: Percentage Improvement in Endurance, Speed, Agility, Flexibility, and Strength of Hearing Impaired Athletes

The strongest gain was for Strength, which rose from 20.46 to 30.28 points, and is the largest of all the Grade 8 bands. This implies that for this training intervention, the muscular strength and force production capacity was the most responsive fitness component in this program. Therefore, the pattern of the results suggested that strength was the most affected factor followed by endurance, flexibility, and speed and agility was also improved, but comparatively small. The results in the present study showed that 8-weeks of CVT is effective in enhancing physical fitness and QoL of HIAs. There were significant improvements in CVE, speed, agility, flexibility and muscle strength. In addition, for all domains of the SF-36 QoL questionnaire, there were statistically significant improvements after the intervention.

5. CONCLUSION

The results of the study clearly showed that CVT was statistically significant in all the components of physical fitness. The results demonstrated that there was significant improvement in CVE following the intervention, suggesting that the structured aerobic activities had a beneficial effect on participants' aerobic capacity and stamina. The marked differences in speed performance suggest that CVT may help to improve the neuromuscular coordination, reaction efficiency and explosive movement skills of HIAs. The study also found that agility training is effective, as agility also showed a significant improvement after the training program, which is useful for sports participation that requires agility, balance, and coordination multidirectional movements. The study also revealed significant gains in all health related QoL assessments in addition to physical fitness. Physical functioning, emotional health, social functioning, vitality, pain reduction, general health perceptions, and mental health showed significant improvements. The results indicate that the advantages of CVT are not limited to the physiological effects, but that it plays a significant role in the psychosocial health of HIAs as well. The study, overall, establishes that a structured cardiac training programme is an effective approach to better the physical fitness and QoL in HIAs. Author Contribution:

Conceptualization, M.Y., and B.A.; Methodology, M.Y., and B. A.; software, M.Y., and B.A.;writing-original draft preparation, M.Y.; Validation B.A.; Formal analysis, B.A; Investigation, M.Y., and B.A.; Supervision, B.A.

Ethical Approval:Prior to the commencement of the study, ethical approval was obtained from the Institutional Review Board (IRB) of Karachi University.

Informed Consent: Parental informed consent was obtained for all children under 18 years, following ethical guidelines for minors.

Data Availability: The data presented in this study is available on the request from corresponding author due to the privacy and ethical restrictions.

Conflict of Interest: The authors declare no conflicts of interest.

REFERENCES

[1] American College of Sports Medicine. *ACSM's Guidelines for Exercise Testing and Prescription*. Wolters Kluwer, Philadelphia, PA, 11 edition, 2022.

[2] FJ Calderón Montero, PJ Benito Peinado, Valter Di Salvo, Fabio Pigozzi, and Nicola Maffulli. Cardiac adaptation to training and decreased training loads in endurance athletes: a systematic review. *British medical bulletin*, 84(1):25–35, 2007.

[3] S. L Cushing, B Papsin, J. A Rutka, A. L James, and K. A. Gordon. Vestibular function in children with sensorineural hearing loss and cochlear implants. *The Laryngoscope*, 118(10):1814–1823, 2008.

[4] Gail M. Dummer, John Haubenstricker, and David A. Stewart. Motor skill performance of children who are deaf. *Adapted Physical Activity Quarterly*, 13(3):242–251, 2016.

[5] Robert H Fagard, Cardiovascular Rehabilitation Unit, Katholieke Universiteit Leuven, et al. Impact of different sports and training on cardiac structure and function. *Cardiology clinics*, 15(3):397–412, 1997.

[6] Stephan Gielen, Gerhard Schuler, and Volker Adams. Cardiovascular effects of exercise training: molecular mechanisms. *Circulation*, 122(12):1221–1238, 2010.

[7] Arzu Güçlü-Gündüz, Bijen Nazliel, and Ceyla Irkec. The effects of aerobic exercise on quality of life in individuals with disabilities: A systematic review. *Disability and Health Journal*, 12(2):187–195, 2019.

[8] W Hollmann, R Rost, K De Meirleir, H Liesen, H Heck, and A Mader. Cardiovascular effects of extreme physical training. *Acta Medica Scandinavica*, 220(S711):193–203, 1986.

[9] Ferdinando Iellamo, Maurizio Volterrani, Alessia Di Gianfrancesco, Chiara Fossati, and Maurizio Casasco. The effect of exercise training on autonomic cardiovascular regulation: from cardiac patients to athletes. *Current sports medicine reports*, 17(12):473–479, 2018. [10] Allen W Jackson. *Physical activity for health and fitness*. Human Kinetics, 2004.

[11] Richard Kovacs and Aaron L Baggish. Cardiovascular adaptation in athletes. *Trends in cardiovascular medicine*, 26(1):46–52, 2016.

[12] Petra Kurková, Hana Válková, and Nanci Scheetz. Factors impacting participation of european elite deaf athletes in sport. *Journal of Sports Sciences*, 29(6):607–618, 2011.

[13] L. J Lieberman, H Byrne, C. O Mattern, C. A Watt, and M. Fernandez-Vivo. Health-related fitness of deaf children and youth. *American Annals of the Deaf,*, 149(3):275–286, 2004.

[14] Nancy K Mellon, Meredith Ouellette, Tracy Greer, and Patricia Gates-Ulanet. Achieving developmental synchrony in young children with hearing loss. *Trends in amplification*, 13(4):223–240, 2009.

[15] Saoirse E OâA˘ ZSullivan and Christopher Bell. The effects of exercise and training on human cardiovascular reflex control.´ *Journal of the Autonomic Nervous System*, 81(1-3):16–24, 2000.

[16] Dilip R Patel and Donald E Greydanus. Sport participation by physically and cognitively challenged young athletes. *Pediatric Clinics*, 57(3):795–817, 2010.

[17] Renée Punch, Merv Hyde, and Des Power. Career and workplace experiences of australian university graduates who are deaf or hard of hearing. *Journal of Deaf Studies and Deaf Education*, 21(3):283–292, 2016.

[18] Rafael E. Reigal, Laura Moral-Campillo, Juan P. Morillo-Baro, and Antonio Hernández-Mendo. Physical activity, fitness, and quality of life in people with disabilities. *International Journal of Environmental Research and Public Health*, 17(22):1–14, 2020.

[19] G. Sahin, A. Kalkan, and A. E. Erol. Cardiovascular endurance and physical fitness in hearing-impaired adolescents. *Journal of Exercise Rehabilitation*, 15(5):702–708, 2019.

[20] D. A Stewart and M. K. Ellis. The influence of physical education teachers on deaf students: Attitudes, perspectives, and instruction. *Journal of Deaf Studies and Deaf Education*, 10(2):161–174, 2005.

[21] David Alan Stewart and M Kathleen Ellis. Sports and the deaf child. *American Annals of the Deaf*, 150(1):59–66, 2005.

[22] Sigmund B Strømme and Frank Ingjer. The effect of regular physical training on the cardiovascular system. *Scandinavian Journal of Social Medicine. Supplementum*, pages 37–45, 1982.

[23] Gashaw Tesema, Mala George, Abera Hadgu, Esayas Haregot, Soumitra Mondal, and D Mathivana. Does chronic high-intensity endurance training have an effect on cardiovascular markers of active populations and athletes? systematic review and meta-analysis. *BMJ open*, 9(10):e032832, 2019.

[24] A Zebrowska, K Gawlik, A Zwierzchowska, and E. Posadzka. Aerobic capacity in deaf children and adolescents. *Polish Journal of Environmental Studies*, 16(5):725–730, 2007.

[25] A Zebrowska, A Zwierzchowska, and K Gawlik. The effects of aerobic training on cardiovascular efficiency in deaf athletes. *Journal of Human Kinetics*, 17:75–83, 2007.

[26] Anna Zwierzchowska, Katarzyna Gawlik, and Małgorzata Grabara. The level of physical activity and physical fitness in children and adolescents with hearing impairment. *Human Movement*, 14(3):213–220, 2013.