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ORIGINAL ARTICLE

The Effect of a Selected Aerobic Training Program on Cardiovascular Indices, Anxiety, and Aggression in Male Students with Hearing Impairment

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Abstract: The purpose of the present study was to determine the effect of a selected aerobic step training program on cardiovascular indices, maximal oxygen uptake (VO_2max), subcutaneous fat, anxiety, and aggression in deaf male students. Thirty males with hearing impairment with a mean age of 19–25 years, height ranging from 167 to 186.5 cm, and weight between 51 and 105 kg were randomly divided into experimental (n = 15) and control (n = 15) groups. The training program for the experimental group lasted for six weeks, consisting of three sessions per week, each session lasting 45 minutes with an intensity of 80–85% of maximum heart rate (HRmax). Pre- and post-tests were administered to measure aerobic capacity, anxiety, and aggression using the aerobic step test, Spielberger's Anxiety Inventory, and the Buss–Perry Aggression Questionnaire, respectively. Subcutaneous fat was measured using a

skinfold caliper. Data were analyzed using independent t-tests and covariance analysis. The results revealed a significant increase in aerobic capacity as well as a significant decrease in anxiety, aggression, and subcutaneous fat percentage following the aerobic training intervention. Overall, the findings indicate that aerobic exercise has a positive effect on aerobic capacity adaptation, body composition, anxiety reduction, and aggression control in deaf individuals.

Keywords: Aerobic exercise, Maximal oxygen uptake (VO_2max), Anxiety, Aggression, Body fat percentage.

Highlights

- Aerobic training improved the cardiovascular capacity of adolescents with hearing impairment.
- A significant reduction in anxiety and aggression was observed following the exercise intervention.
- Aerobic exercise serves as an effective tool for promoting both physical and psychological health in individuals with hearing impairments.

Introduction

Hearing impairment, as one of the major global public health challenges, affects not only biological functioning but also various dimensions of quality of life, social interactions, and educational opportunities (Sabato et al., 2023). According to the World Health Organization (2021), more than 1.5 billion people worldwide suffer from some degree of hearing loss, of whom approximately 430 million experience disabling hearing impairment; a figure projected to exceed 700 million by 2050 (Chilton, 2025). Although the prevalence of hearing loss is generally higher among the elderly, an alarming increase has also been observed among young people and adolescents. Prolonged exposure to loud sounds, including the use of headphones and staying in noisy environments, has placed nearly 1.1 billion individuals aged 12 to 35 at risk of noise-induced hearing loss (Sabato et al., 2023). This indicates that hearing impairment is not limited to old age but has become an intergenerational issue. In Iran, similar statistics have been reported. According to data from the Ministry of Health, Treatment, and Medical Education (2024), more than 5.5 million people in the country experience some degree of hearing loss. Among children and adolescents, about 3 to 5 percent are affected, a significant portion of which results from environmental factors and modern lifestyle habits. Among the elderly, this rate is considerably higher, with approximately 48 percent of individuals over the age of 65 and almost all people over 80 experiencing some level of hearing loss (Jalilvand, 2021).

Aggression is defined as any behavior that is deliberately performed with the intention of causing harm to another individual. In order to control such behaviors, the perpetrator must believe that their action was aimed at harming another person, which consequently evokes avoidance behaviors in the target. Aggression may manifest in various forms. Its verbal and physical expressions represent the instrumental or behavioral components, anger reflects the emotional dimension, and hostility represents the cognitive aspect of aggression (Hafezian et al., 2020). Anxiety can also be defined as a feeling of worry accompanied by physiological arousal, which may arise from one or more of the following: threat to self-esteem caused by failure, physical danger (injury), ambiguity (unpredictability and fear of the unknown), or disruption of

daily life balance (Roos et al., 2021). In this regard, adolescents with hearing impairment—who are in a critical stage of developing social and emotional behaviors—show greater vulnerability to various forms of maltreatment and abuse compared to their hearing peers. Evidence indicates that this group is two to three times more likely to experience violence and abuse, which can lead to the emergence or exacerbation of disorders such as anxiety, depression, and aggressive behaviors (Karic et al., 2023). These findings clearly demonstrate that hearing impairment is a multidimensional phenomenon that not only affects an individual's health but also directly influences social participation, equitable access to educational opportunities, and the realization of health equity at the societal level. Therefore, addressing this issue and designing specialized interventions tailored to the unique characteristics of the hearing impairment community are of vital importance from two perspectives: first, from a human rights standpoint, emphasizing the provision of equal conditions for achieving an adequate quality of life; and second, from a clinical effectiveness perspective, highlighting the necessity of developing practical and evidence-based solutions.

From an epidemiological and behavioral perspective, lifestyle changes in recent decades—particularly the reduction of physical activity—have imposed an additional burden on the biological and psychological systems of younger generations. Physical inactivity is associated with an increased risk of obesity, metabolic disorders, and cardiovascular diseases, and it also shows a significant relationship with the onset and exacerbation of mental disorders such as anxiety and depression (Fulton et al., 2022). In this regard, aerobic exercise, as a low-cost, safe, and scientifically well-supported intervention, has considerable potential for simultaneously promoting physical and mental health. Classical studies and numerous meta-analyses have demonstrated that regular aerobic activity leads to increased maximal aerobic capacity (VO_2max), improved body composition (reduced body fat percentage), and decreased symptoms of anxiety and aggression (Ouyang & Liu, 2023). From a physiological perspective, the increase in VO_2max resulting from aerobic training is the outcome of a series of adaptations, including increased stroke volume and cardiac output, greater capillary density in active tissues, enhanced mitochondrial efficiency, and higher oxidative capacity in skeletal muscles. These adaptations ultimately result in more efficient oxygen utilization and improved ATP production (Li, 2022). Such physiological changes not only enhance physical performance and endurance but are also psychologically associated with reduced fatigue and increased self-efficacy. From a metabolic standpoint, elevated energy expenditure during and after exercise leads to a reduction in fat stores and improved body composition over the long term (Van Baak et al., 2021).

In explaining the psychological effects of aerobic exercise, several mechanisms can be proposed. First, the regulation of neuroendocrine systems: regular aerobic activity is associated with modulation of the hypothalamic–pituitary–adrenal (HPA) axis, increased secretion of endorphins, and changes in neurotransmitter levels such as serotonin and dopamine, all of which play essential roles in mood regulation and anxiety reduction (Fulton et al., 2022). Second, from a psychosocial perspective, participation in physical activities—especially in group settings—can strengthen social support networks, enhance self-efficacy, and improve emotion regulation and impulse control skills, all of which are linked to reduced aggression and anxiety (Peng et al., 2025; Tamminen et al., 2025). Despite existing evidence on the general

benefits of physical activity, limited studies have examined the simultaneous effects of structured exercise interventions on both physiological and psychological indices in adolescents with hearing impairment (Liu et al., 2022; Jones & Smith, 2021). Previous research has commonly suffered from methodological limitations such as non-random sampling, lack of appropriate control groups, incompatibility of measurement tools with the characteristics of people with hearing impirment, and short follow-up durations. Accordingly, the present study was designed to fill this research gap by focusing on the fundamental question: Can a selected aerobic training program simultaneously improve aerobic capacity (VO_2max) and body composition while reducing symptoms of anxiety and aggression in adolescents with hearing impairment? Therefore, this study employed a quasi-experimental pretest–posttest design with a control group, grounded in a theoretical framework emphasizing the influence of exercise on neurohormonal physiology and metabolic health (Wilson & Brown, 2020). This integrative approach not only contributes to a better understanding of the multidimensional effects of exercise but also provides a scientific framework for developing evidence-based rehabilitation and educational programs in relevant institutions, ultimately enhancing quality of life and promoting social participation among adolescents with hearing impairment.

Materials and Methods

Participants: The statistical population included all male students with hearing impairment, aged 18 to 25 years enrolled in exceptional secondary schools in Rasht during the 2024–2025 academic year, totaling 50 individuals. From this population, 30 participants were purposefully selected based on inclusion and exclusion criteria and randomly assigned to two groups: experimental (n=15) and control (n=15). Inclusion criteria consisted of confirmed hearing impairment (verified by educational and medical records), the ability to participate in aerobic physical activities, absence of cardiovascular or musculoskeletal disorders limiting activity, and obtaining informed parental consent. Exclusion criteria included absence from more than two training sessions, injury or illness during the intervention period, and noncompliance in completing questionnaires.

Instruments: Anxiety and aggression indices were assessed using the Spielberger State–Trait Anxiety Inventory (STAI-Y) and the Buss–Perry Aggression Questionnaire (AQ), respectively. Maximal aerobic capacity (VO_2max) was measured using the Forestry Step Test. Anthropometric indices—including height, weight, and body fat percentage—were measured using a stadiometer, scale, and skinfold caliper, respectively. The intervention for the experimental group consisted of a six-week aerobic training program, three sessions per week, each lasting 45 minutes, while the control group did not receive any intervention.

Spielberger State–Trait Anxiety Inventory (STAI-Y): This questionnaire, first introduced by Spielberger et al. (1970), measures state and trait anxiety (both overt and covert) and was revised in 2025 (Valente et al., 2025). It consists of two 20-item forms: the state anxiety form assesses the individual's level of anxiety "at this moment," whereas the trait anxiety form evaluates general attitudes and experiences of anxiety. This instrument has demonstrated high reliability and validity in both international and domestic studies; Cronbach's alpha coefficients for the various scales have been reported above 0.9, and its reliability has been calculated at 87% (Illardi et al., 2021). Criterion and concurrent validity of the questionnaire have

also been confirmed in Iranian samples using the means of state, trait, and total anxiety scores (Rouhzadeh et al., 2021).

Buss–Perry Aggression Questionnaire (AQ): Developed in 1992 by Arnold H. Buss and Mark Perry, this questionnaire consists of 29 items with four subscales: physical aggression, verbal aggression, hostility, and anger. This self-report instrument has been validated internationally and domestically for reliability and validity. The overall Cronbach's alpha coefficient is 0.89, with subscale alphas ranging from 0.72 to 0.85 (Loja Secua et al., 2021). Studies in Iran have also confirmed its reliability and validity (Afshari et al., 2025). Its use in the present study allowed precise assessment of aggressive behaviors and analysis of the effects of aerobic exercise on its various dimensions.

Data Collection: The present study was quasi-experimental research with a pretest–posttest design and a control group. Necessary permissions were first obtained from the Department of Education of District 2 in Rasht and subsequently from the Organization for Exceptional Education. A list of secondary schools for male students with hearing impairment in Rasht was then acquired. On the first day, after participants arrived at the testing site, comprehensive explanations regarding the study objectives, procedures, and importance of each stage were provided. The explanations were delivered with the assistance of the school physical education teacher proficient in sign language, ensuring that all participants fully understood the research process and could provide informed consent. Following this, written consent forms and questionnaires were distributed, and anthropometric measurements including height and weight were taken. Height was measured using a wall-mounted stadiometer with standardized posture, and weight was measured with a precise scale without shoes. All data were recorded individually and systematically.

On the second day, body fat percentage was measured using a Lafayette caliper following Jackson–Pollock's three-site method (chest, abdomen, and thigh) for males. Measurements were conducted with high precision and the assistance of the physical education teacher. Participants were then prepared for the Forestry Step Test, which was demonstrated both practically and visually. They stepped up and down the platform for five minutes at a pace of 22.5 steps per minute. A visual metronome was used to maintain rhythm, ensuring correct performance. Heart rate was recorded immediately after the test to calculate VO_2max. This test is based on the Harvard Step Test and the Strand–Ryming test and has demonstrated validity and reliability in multiple domestic (Shadab et al., 2023) and international studies (Jensen et al., 2023). Following the pretests, the experimental group began the six-week aerobic training program, three sessions per week, 45 minutes per session. Each session included 10 minutes of warm-up with stretching, 30 minutes of main training including running and team games, and 5 minutes of cool-down. Exercise intensity was set at 80–85% of maximum heart rate. The first week involved running 1,500 meters in 8 minutes, 4 minutes of slow jogging, followed by 2,200 meters in 13 minutes with 5 minutes of slow jogging. In the second week, the running protocol was similar, with the addition of team games such as basketball. The program was adapted from published aerobic training protocols (Ge et al., 2023). The control group did not receive any intervention.

At the end of the six-week period, posttests—including repetition of the step test, measurement of body fat percentage, and completion of anxiety and aggression questionnaires—were conducted for both groups.

Data Analysis: Data were collected and entered into SPSS version 24 for descriptive and inferential analyses, including means, standard deviations, independent t-tests, and analysis of covariance (ANCOVA) to examine the effects of aerobic exercise on the variables. A significance level of $p \leq 0.05$ was considered.

Results

The findings of the present study include descriptive and inferential results regarding the effects of a selected aerobic training program on maximal aerobic capacity (VO_2max), anxiety, aggression, and body fat percentage in male adolescents with hearing impairment. Prior to conducting inferential analyses, the data were presented descriptively, and the distribution of the study variables—including VO_2max, anxiety, aggression, and body fat percentage—was examined in both the experimental and control groups.

Results of the Shapiro–Wilk and Kolmogorov–Smirnov tests indicated that all p-values were greater than 0.05, suggesting that the data distribution was approximately normal. Additionally, inspection of Q–Q plots and histograms confirmed that the use of parametric tests, such as independent t-tests and ANCOVA, was appropriate. The significance level for all tests in this study was set at $p \leq 0.05$.

Table 1 provides an overview of the descriptive indices, including the means and standard deviations of the main study variables—maximal aerobic capacity (VO_2max), anxiety, aggression, and body fat percentage—in both the experimental and control groups at pretest and posttest stages.

Table 1. Descriptive indices (mean ± standard deviation) of the study variables in the two groups

Variable	Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)
VO_2max (ml/kg/min)	Experimental	42.86±3.85	48.46±3.62
	Control	42.53±4.62	42.13±4.61
Anxiety	Experimental	42.86±3.14	40.13±2.29
	Control	42.53±2.23	41.20±1.78
Aggression	Experimental	71.20±3.99	66.73±2.94
	Control	71.60±3.12	70.93±2.61
Body fat percentage (%)	Experimental	23.40±3.85	17.93±3.62
	Control	22.93±2.29	22.60±2.19

Based on the descriptive results (Table 1), the mean VO_2max in the experimental group increased from 42.86 mL/kg/min at pretest to 48.46 mL/kg/min at posttest. In contrast, the control group showed no substantial change (42.53 at pretest to 42.13 at posttest). These findings indicate that a selected aerobic training program had a significant effect on improving the aerobic capacity of male adolescents with hearing impairment.

Regarding anxiety, a notable reduction was observed in the experimental group (from 42.86 at pretest to 40.13 at posttest), whereas the control group experienced only a slight decrease (from 42.53 to 41.20). This suggests that the training intervention had a clear effect on reducing participants' anxiety levels.

Similarly, aggression scores in the experimental group decreased from 71.20 at pretest to 66.73 at posttest, while the control group showed only a minor reduction from 71.60 to 70.93. This difference reflects the effective role of aerobic exercise in controlling and reducing aggressive behaviors in adolescents with hearing impairment.

Finally, body fat percentage in the experimental group decreased from 23.40% at pretest to 17.93% at posttest, whereas changes in the control group were negligible (from 22.93% to 22.60%). Thus, as observed, the experimental group showed significant improvements across all variables compared to the control group. While the control group demonstrated minimal changes in most indices, the substantial increase in VO_2max and meaningful reductions in anxiety, aggression, and body fat percentage in the experimental group highlight the positive impact of the exercise intervention.

The results of the independent t-test for posttest comparisons between the experimental and control groups are reported in Table 2. The findings indicate that the observed changes in the experimental group compared to the control group were significant and reliable across all variables. The significance level was set at $p \leq 0.05$.

Table 2. Results of Independent t-test in the Post-test for Comparison Between the Two Groups

Variable	t	df	Sig (2-tailed)
VO_2max	-3.35	28	0.002
Anxiety	7.13	28	0.001
Aggression	5.89	28	0.001
Body fat percentage (%)	2.70	28	0.01

The t-values and significance levels reported in Table 2 indicate that the posttest mean differences between the two groups were significant for all indices. Notably, the substantial differences in anxiety and aggression ($p < 0.001$) suggest that aerobic exercise had a highly positive effect in reducing negative psychological factors among adolescents with hearing impairment. Additionally, the significant increase in VO_2max ($p = 0.002$) and reduction in body fat percentage ($p = 0.01$) demonstrate the notable impact of aerobic training

on improving physiological indices. These results indicate that the observed changes in the experimental group were attributable to the exercise intervention rather than natural or random variations.

Table 3 presents the results of the analysis of covariance (ANCOVA) for the study variables at posttest. This table reports F-values, significance levels, and effect sizes (η^2). The ANCOVA was conducted to control for potential pretest effects and to more precisely examine the impact of the aerobic exercise intervention on the dependent variables. In this study, the groups were randomly assigned, and the pretest statistical analysis indicated no significant differences between the groups at baseline. Therefore, the randomization was successful and valid, minimizing the likelihood of selection bias.

Table 3. Results of ANCOVA in the Post-Test for the Study Variables

Variable	F	Sig	η^2
VO_2max	27.16	0.01	0.53
Anxiety	44.79	0.001	0.65
Aggression	45.05	0.001	0.67
Body Fat Percentage (%)	8.94	0.01	0.27

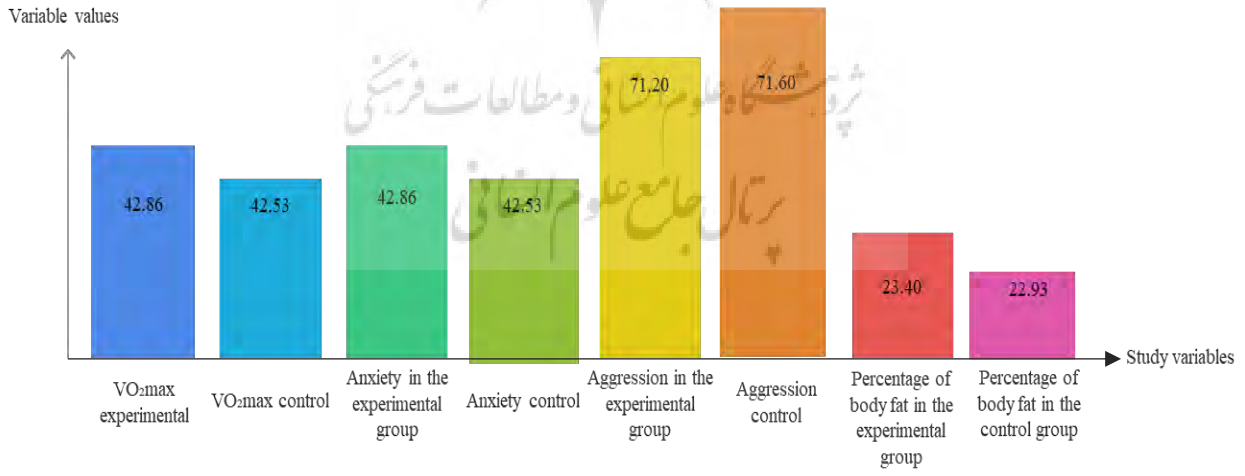

Figure 1 . Comparison of study variables between experimental and control groups

Table 4. Effects of Aerobic Exercise Intervention on Study Variables

Variable	Group	Pre-test	Post-test	t	p	f	p	η^2
VO_2max	Experimental	42.86±3.85	48.46±3.62	-3.35	0.002	27.16	0.001	0.53
	Control	42.53±4.62	42.13±4.61					
Anxiety	Experimental	42.86±3.14	40.13±2.29	7.13	< 0.001	44.79	< 0.001	0.65
	Control	42.53±2.23	41.20±1.78					
Aggression	Experimental	71.20±3.99	66.73±2.94	5.89	< 0.001	45.05	< 0.001	0.67
	Control	71.60±3.12	70.93±2.61					
Body fat %	Experimental	23.40±3.85	17.93±3.62	2.70	0.01	8.94	0.01	0.27
	Control	22.93±2.29	22.60±2.19					

Discussion

The present study aimed to examine the effects of a selected aerobic exercise program on cardiovascular indices, body fat percentage, and psychological variables of anxiety and aggression in male adolescents with hearing impairement. The findings indicated that regular and targeted implementation of this type of exercise led to significant improvements in maximal aerobic capacity (VO_2max), reductions in body fat percentage, and decreases in anxiety and aggression symptoms. Accordingly, the results of the present study are consistent with those of Eghbalian et al. (2025), Karic et al. (2023), Shave et al. (2021), and Vali & Hossein (2021), which reported positive effects of aerobic exercise and physical activity on cardiovascular health and psychological well-being, including reductions in anxiety and aggression. These findings are particularly significant given the multifaceted impact of hearing impairments on the physical and mental health of individuals with hearing impairment, highlighting the importance of exercise for both physiological and psychological dimensions in this population. Moreover, in the context of the limited research conducted in this area, these results provide a valuable contribution to the scientific community, especially within the Iranian context. The evidence from the present study indicates that aerobic activities can significantly contribute to improving the psychological well-being of individuals with hearing

impairment, particularly in reducing anxiety and aggressive behaviors. These effects are not only clinically significant but can also be scientifically explained through models related to neuroendocrine mechanisms. According to theories associated with the hypothalamic–pituitary–adrenal (HPA) axis, regular aerobic exercise modulates the body's stress responses, enhances endorphin secretion, and activates neurotransmitters related to mood regulation (Fulton et al., 2022). Consequently, these processes lead to a reduction in negative emotions such as anxiety and aggression, providing a foundation for psychological stability and improvement. Additionally, physiological changes, such as increased tolerance to environmental stressors and enhanced autonomic nervous system functioning, play a supportive role in this process (Peng et al., 2025).

Aggression is, in fact, a major behavioral challenge during adolescence and young adulthood, which becomes more pronounced in individuals with sensory impairments such as deafness due to their unique social and psychological circumstances (Bard et al., 2025). From a physiological perspective, exercise reduces stress and balances hormonal activity, thereby creating conditions for decreased aggressive reactions (Ouyang & Liu, 2023). Moreover, from a psychosocial standpoint, group physical activities and the training of communication and emotional skills provide greater opportunities for positive interaction, which, by strengthening social support networks and enhancing the sense of belonging, play a crucial role in moderating aggression (Peng et al., 2025). Furthermore, research shows that beyond physiological effects, sports activities can foster positive social contexts and create meaningful participation opportunities for adolescents with hearing impairment. Engagement in sports groups enhances psychosocial skills such as emotion regulation, impulse control, and communication abilities—skills that contribute to reducing aggressive behaviors and promoting psychological cohesion (Cho & Yang, 2020). Since adolescents with hearing impairments are at a sensitive stage of psychological and social development, targeted exercise interventions can induce substantial positive changes in both their clinical and social trajectories (Khalid et al., 2025).

Moreover, the analysis of the results indicates that the design and implementation of training programs for this population require adaptation to their specific characteristics and limitations, including the use of visual instructions, the presence of a sign language interpreter, and the employment of non-auditory control tools. This approach not only ensures compliance with scientific and ethical standards but also facilitates the development of culturally adapted and locally relevant interventions, thereby paving the way for future research in populations with specialized needs (Werfel & Lund, 2024).

From a physiological perspective, the increase in VO_2max reflects an enhanced capacity of the body to utilize and transport oxygen to active tissues, resulting from multiple physiological adaptations, including increased stroke volume, improved cardiac output, and greater capillary density in skeletal muscles (Kayam et al., 2021). This finding is particularly important for adolescents with hearing impairment, as they are at higher risk for cardiovascular disorders and reduced physical fitness due to communication limitations, lower physical activity levels, and social challenges (Norkadri et al., 2021). The present study also demonstrates that targeted exercise interventions can elicit favorable physiological adaptations, thereby improving functional capacity and cardiovascular health in this population. This underscores the importance

of designing training programs that are tailored to the specific characteristics and needs of adolescents with hearing impairement.

A significant reduction in body fat percentage in the intervention group represents another important finding of this study, with well-established positive effects on general health, decreased risk of chronic diseases, and improved body composition (Khan & Joz, 2021). Aerobic exercise, by increasing energy expenditure and enhancing fat metabolism, directly contributes to the reduction of subcutaneous fat stores, which can serve as a preventive and therapeutic strategy for metabolic issues in this population (Bernot et al., 2023).

Individuals with hearing impairement face substantial limitations in verbal and nonverbal communication, which can lead to social isolation, loneliness, and the emergence of psychological problems such as anxiety and aggression (Uma et al., 2024). Participation in group-based physical activities and regular aerobic training provides a valuable opportunity to foster positive social interactions, strengthen cooperation and civic skills, and enhance self-concept. Recent research has shown that building strong support networks through sports and recreational activities significantly contributes to reducing psychological stress and improving social awareness among individuals with hearing impairement (Karampidis et al., 2021).

Finally, the present study, by providing robust empirical evidence, highlights the importance of aerobic exercise in improving both the physical and psychological health of male adolescents with hearing impairement and underscores the necessity of policy-making and development of sports programs focused on special-needs populations. This not only represents a scientific and clinical imperative but also an ethical and social commitment to ensure equal rights and enhance the quality of life for individuals with hearing impairement.

Conclusion

The present study, by providing robust empirical evidence, underscores the importance of aerobic exercise in enhancing both the physical and psychological health of boys with hearing impairment and highlights the necessity of policymaking and the development of targeted exercise programs for populations with special needs. This emphasis represents not only a scientific and clinical imperative but also an ethical and social responsibility to ensure equal rights and to improve the quality of life of individuals with hearing impairement.

Limitations and Future Directions

The limitations of the present study include the short duration of the intervention (six weeks), a relatively small sample size, the gender-specific nature of the sample (only male adolescents with hearing impairement from a single geographic area), and the use of self-report questionnaires, which may be subject to response biases. Additionally, although participants were randomly assigned to groups, a thorough statistical verification of randomization was not conducted, which may affect the internal validity of the study. Therefore, it is recommended that future research be conducted with larger samples, including female participants and individuals from diverse geographic regions, and employ multi-dimensional assessments and biological markers to enhance generalizability and strengthen internal validity.

Given the positive effects of aerobic exercise on the physical and psychological health of adolescents with hearing impairement, it is essential to integrate specialized and targeted sports programs into their

educational framework. The Ministry of Education and the Organization for Exceptional Education can facilitate active participation of this population in physical and psychological activities by developing comprehensive plans, providing trained instructors capable of effective communication with hearing impaired individuals, and equipping necessary facilities. Furthermore, future research with larger samples, including hearing impaired girls and other special-needs populations across different regions of the country and over longer intervention periods, can consolidate scientific knowledge in this field and reliably assess the long-term effects of sports interventions.

Improving assessment tools, including the design of psychological and physiological instruments tailored to the characteristics of hearing impaired individuals and combining self-reported and objective measures, is also crucial for increasing the accuracy and validity of study outcomes. Education and support for families and caregivers regarding the importance of physical activity and active participation in sports are vital for enhancing the effectiveness and sustainability of interventions. Interagency coordination between the Ministry of Health, Ministry of Education, and organizations related to individuals with disabilities is necessary for designing, implementing, and evaluating comprehensive therapeutic-rehabilitation sports programs effectively. Adopting these coordinated and evidence-based approaches can contribute to social inclusion, sustainable health, and improved quality of life for hearing impaired adolescents, representing a significant step toward fulfilling social responsibilities and human rights.

Declarations

Ethical Considerations

This study was conducted as a research project in full compliance with ethical guidelines concerning participants. All principles, including obtaining voluntary informed consent, respecting the right to withdraw from the study at any time, and ensuring the confidentiality of participants' information, were strictly adhered to.

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Authors' Contributions

All authors contributed equally to every stage of the project, including study design, implementation, and manuscript preparation.

Conflict of Interest

According to the authors, the results of this study do not present any conflict of interest with any organization or entity.

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