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Investigation of the Effects of 6-Week Balance and Reaction Exercises in Hearing Impaired Adolescents

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ABSTRACT

The aim of the study is to examine the development of balance and reaction time in hearing-impaired adolescents. The research was carried out using a quasi-experimental design with a pre-test-post-test control group, which is one of the quantitative research methods. Within the scope of the research, 10 individuals were included in the experimental and control groups. In the study, balance and reaction tests were applied as pre-test and post-test. As a result of the study, statistically significant improvements were observed in both balance level and reaction times because of the training program applied to the experimental group ($p<0.05$). On the other hand, no significant change was observed in these parameters in the control group ($p>0.05$). In addition, a significant difference was found between equilibrium and reaction measurements between the experimental and control groups ($p<0.05$). These results show that the training program has positive effects on the balance and reaction time of hearing-impaired adolescents. In addition, the findings of the study emphasize the importance of specially designed training programs to support the motor development of hearing-impaired individuals.

Keywords: Balance, hearimproved, reaction.

INTRODUCTION

Hearing impairment, a prevalent sensory disability, impacts millions of individuals worldwide, influencing various aspects of life, including motor performance and physical activity levels (World Health Organization, 2020). Adolescents with hearing impairments often encounter challenges in developing motor skills, particularly in balance and reaction time, which are essential components of daily living and physical activities. Deficits in these areas can hinder their participation in recreational and competitive sports, reduce overall quality of life, and increase the risk of falls and injuries (Kerkhoff et al., 2019; Wiegersma & Van der Velde, 2011).

Balance, defined as the ability to maintain the body's center of gravity over its base of support, is a fundamental skill for both static and dynamic activities (Shumway-Cook & Woollacott, 2017). Reaction time, the interval between stimulus perception and the initiation of a response, is equally critical for efficient motor execution (Schmidt & Lee, 2019). Both balance and reaction time are influenced by sensory inputs, including auditory feedback. In the absence of auditory stimuli, individuals with hearing impairments often rely more heavily on visual and proprioceptive inputs to compensate for deficits, which can lead to unique challenges in motor coordination (Rine et al., 2016).

Research has highlighted the potential of targeted exercise programs to enhance balance and reaction time in individuals with sensory impairments. For example, balance training and reaction exercises have been shown to improve postural stability and reduce reaction time in populations with various disabilities (Gauchard et al., 2007; Ströhmeier et al., 2021). However, the specific effects of such interventions on adolescents with hearing impairments remain underexplored, despite the growing recognition of their importance in promoting physical and psychological well-being (Haegele & Porretta, 2015).

The present study aims to address this gap by investigating the effects of a 6-week balance and reaction exercise program on the balance and reaction time of hearing-impaired adolescents. Using a quasi-experimental design, the study evaluates pre- and post-intervention performance in experimental and control groups. The findings contribute to the limited body of evidence on the motor development of hearing-impaired individuals and underscore the significance of tailored exercise interventions in fostering their physical capabilities.

By understanding the impact of specialized training programs, this research seeks to inform educators, therapists, and policymakers about effective strategies to enhance motor development in adolescents with hearing impairments. Ultimately, the study advocates for the integration of evidence-based physical training programs into educational and rehabilitative practices, thereby promoting inclusivity and equity in physical education and sports for individuals with disabilities.

METHOD

Research group

The study was conducted with hearing-impaired high school students enrolled in a special education high school in Ankara, selected through the convenience sampling method. A total of 20 young hearing-impaired individuals voluntarily participated in the study, comprising an experimental group (n = 10; mean age = 16.70 ± 1.16 years; mean height = 172.00 ± 1.16 cm; mean weight = 66.60 ± 11.49 kg; mean body mass index = 22.44 ± 3.40 kg/m²) and a control group (n = 10; mean age = 16.10 ± 1.10 years; mean height = 170.20 ± 7.10 cm; mean weight = 68.10 ± 19.83 kg; mean body mass index = 23.21 ± 5.40 kg/m²). Written informed consent was obtained from the parents of all participants, and participation was based on voluntary agreement.

Method of the Research

This study investigated the effect of a training program designed to improve balance and reaction time on the development of these parameters in hearing-impaired adolescents. A quasi-experimental design with a pre-test and post-test control group, a method within quantitative research, was employed. Experimental designs aim to evaluate the effects of a specific intervention or application on a group. In quasi-experimental designs, group assignments are not fully random but are made based on predetermined eligibility criteria (Creswell, 2003). While experimental designs typically involve random selection of participants from a larger pool, quasi-experimental designs use random assignment within pre-matched groups (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz, & Demirel, 2019). In the present study, the experimental and control groups were matched to ensure similar levels of disability among participants.

Procedure

A six-week training program was implemented for the experimental group. Balance and reaction tests were administered to both the experimental and control groups before and after the intervention. The exercise program, designed by the researcher, was tailored to the specific needs of hearing-impaired individuals and structured progressively. At the outset, participants were provided with detailed explanations of the exercise movements and their physiological effects. Practice sessions were conducted to familiarize participants with the balance and reaction exercises. Additionally, instructions on the proper use of equipment and an orientation to the exercise area were provided.

To facilitate adaptation to the program, participants underwent a preparatory exercise phase lasting one week, during which the intensity of the exercises was gradually increased, progressing from simple to more challenging levels based on participants' characteristics. These intensity adjustments were implemented periodically over the six weeks: after the first two weeks, at the end of the second two weeks, and during the final two weeks. Each set of exercises included a 20-second rest period, with a 30-second rest interval between different movements. The sequence and tempo of the exercises were closely monitored by the researcher and conducted under the supervision of an expert trainer.

The program structure and schedule were informed by the work of Özoruç (2023). Training sessions were held on Mondays, Wednesdays, and Fridays from 9:30 a.m. to 10:30 a.m., comprising three phases: warm-up, main exercise, and cool-down. During the first two weeks, the warm-up phase lasted 10 minutes, the main exercise phase 30 minutes, and the cool-down phase 10 minutes, resulting in a total session duration of 50 minutes. In the second two weeks, the duration of the warm-up and cool-down phases remained unchanged, while the main exercise phase was extended to 35 minutes, increasing the total session time to 55 minutes. In the final two weeks, the warm-up and cool-down durations were again kept constant, while the main exercise phase was extended to 40 minutes, resulting in a total session duration of 60 minutes.

The exercise program was conducted under the supervision of the researcher and an expert trainer, utilizing materials such as cones, markers, and various types of balls. All procedures were grounded in scientific principles to ensure the validity and reliability of the intervention.

Warm-Up Section

The warm-up exercises consisted of basic movements designed to prepare participants for physical activity. These included dynamic stretching exercises targeting all joints and major muscle groups. The goal was to enhance flexibility and reduce the risk of injury. Additionally, educational games were incorporated to engage participants and increase their motivation.

Main Exercise Section

The main exercise program was divided into two key components: reaction exercises and balance exercises. Reaction Exercises: The reaction exercises aimed to improve participants' reaction time and agility. These exercises included: Dropping a ball when the trainer raised their hand. Running 10 meters quickly after the ball was dropped upon the trainer's signal. Touching the ball while kneeling when the trainer raised their hand. Touching a ball in front of them while standing and reaching out as signaled by the trainer. Balance Exercises: The balance exercises were designed to enhance participants' balance and posture control. These included: Standing on one leg (right and left), Performing the tree pose (right and left), Performing the eagle pose, Executing the glider pose (right and left), Raising one leg to a 90-degree angle in an upright posture (right and left). Participants also practiced forward, sideways, and backward balance exercises to further enhance their stability and coordination.

Cool-Down Section

The cool-down phase focused on gradually relaxing the muscles to promote recovery and reduce post-exercise stiffness. Relaxation exercises were performed in a standing position, targeting the muscles of the head, neck, back, abdomen, legs, and feet. All muscle groups were progressively and thoroughly relaxed to conclude the session.

Measurements

Balance Test

The balance test is designed to assess children's postural control and body balance. At the beginning of the test, the process is initiated by verifying the necessary information with the participant. The dominant foot of the participant is identified, after which they remove their shoes and step onto the balance device, positioning both feet at designated balance points. In this position, the participant attempts to maintain body balance by remaining motionless for 10 seconds.

The test comprises three main stages:

Stability with Both Feet: The participant stands still on both feet for 10 seconds. Stability with the Dominant Foot: The participant balances on their dominant foot for 10 seconds. Stability with the Non-Dominant Foot: The participant balances on their non-dominant foot for 10 seconds. During each stage, the participant is expected to maintain balance by keeping their body weight centered and minimizing postural oscillation. If the participant's foot slips from the device, they seek external support, or fail to adhere to the posture guidelines, the test is repeated.

The total test duration is 70 seconds, with short rest periods allowed between stages. The test provides objective data on participants' body balance and postural control. For accurate results, participants must perform the test without shoes and distribute their body weight evenly. Errors such as wearing shoes or improper weight distribution can compromise the validity of the results (GSB, 2017).

Reaction Test

The reaction test is an assessment tool that evaluates participants' reaction time to visual stimuli and their ability to sustain this response over a specified period. The test uses light sensors positioned at a distance of 50 cm from the center of the device. These sensors are programmed to emit random light signals, with each sensor lighting up three times over the course of the test. Participants are tasked with extinguishing the red lights that randomly appear on the 8 sensors within a 10-second period. The device's center is adjusted to shoulder height, ensuring the participant's arms can comfortably reach all sensors.

During the practice phase, participants are instructed to press the randomly lit light sensors with their hands for 10 seconds. In the test phase, a total of 24 random light signals are emitted across the 8 sensors, and participants must deactivate them by touch. Upon completion, the test results are recorded.

This test provides an objective measure of reaction time and hand-eye coordination. Proper setup of the device and participant positioning are critical for obtaining reliable data (GSB, 2017).

Analysis of Data

The data obtained in the study were analyzed using the SPSS 25.0 software package. To evaluate the normality of the data distribution, skewness and kurtosis values were examined. According to George and Mallery (2019), skewness and kurtosis values within the range of -2 to +2 indicate that the data can be considered normally distributed. For statistical analysis, a paired t-test was employed for both intragroup and intergroup comparisons. The significance level was set at $p < 0.05$ for all analyses, indicating that results with a margin of error less than 5% were considered statistically significant.

FINDINGS

The analysis of the balance and reaction test results was conducted to compare the performance of the experimental and control groups after the training.

Table 1. Experimental group balance and reaction test pre-post test comparison

Variables	n	$\bar{X}$	S.d	t	p
Balance Pre test	10,00	0,28	0,10	-7,22	0,001*
Balance Post test		0,46	1,00		
Reaction Pre test	10,00	18,47	3,21	4,39	0,002*
Reaction Post test		15,54	1,87		

X: Arithmetic mean; s.d: Standard deviation; Significance value: p<0.05

The results of the paired t-test revealed significant improvements in both balance and reaction time following the training program. Balance Test: The pre-test mean score ($\bar{X}$ = 0.28, S.d = 0.10) significantly increased in the post-test ($\bar{X}$ = 0.46), with a t-value of -7.22 and a significance level of p = 0.001 ($p < 0.05$). Reaction Test: The pre-test mean score ($\bar{X}$ = 18.47, S.d = 3.21) significantly decreased in the post-test ($\bar{X}$ = 15.54, S.d = 1.87), with a t-value of 4.39 and a significance level of p = 0.002 ($p < 0.05$).

Table 2. Control group balance and reaction test pre-post-test comparison

Variables	N	$\bar{X}$	S.d	t	p
Balance Pre test	10,00	0,28	0,90	-0,80	0,44
Balance Post test		0,30	0,12		
Reaction Pre test	10,00	19,40	3,27	1,04	0,33
Reaction Post test		18,16	2,83		

X: Arithmetic mean; s.d: Standard deviation; Significance value: p<0.05

The results of the paired t-test showed no statistically significant improvements in either balance or reaction time: Balance Test: The pre-test mean score ($\bar{X}$ = 0.28, S.d = 0.90) showed a slight increase in the post-test ($\bar{X}$ = 0.30, S.d = 0.12), with a t-value of -0.80 and a significance level of p = 0.44 ($p > 0.05$). Reaction Test: The pre-test mean score ($\bar{X}$ = 19.40, S.d = 3.27) decreased marginally in the post-test ($\bar{X}$ = 18.16, S.d = 2.83), with a t-value of 1.04 and a significance level of p = 0.33 ($p > 0.05$).

Table 3. Comparison of balance and reaction test results of experimental and control groups

Variables	N	$\bar{X}$	S.d	t	p
Balance Experimental	10,00	0,46	1,00	3,36	0,01
Balance Control		0,30	0,12		
Reaction Experimental	10,00	15,54	1,87	-2,30	0,05
Reaction Control		18,16	2,83		

X: Arithmetic mean; s.d: Standard deviation; Significance value: p<0.05

The results of the comparative analysis between the experimental and control groups revealed significant differences: Balance Test: The experimental group demonstrated a significantly higher post-test mean score ($\bar{X}$ = 0.46, S.d = 1.00) compared to the control group ($\bar{X}$ = 0.30, S.d = 0.12), with a t-value of 3.36 and a significance level of p = 0.01 ($p < 0.05$). Reaction Test: The experimental group showed a marginally lower post-test mean score ($\bar{X}$ = 15.54, S.d = 1.87) compared to the control group ($\bar{X}$ = 18.16, S.d = 2.83), with a t-value of -2.30 and a significance level of p = 0.05 (p = 0.05).

DISCUSSION AND CONCLUSION

The findings of this study indicate that the training program significantly improved both balance and reaction time in the experimental group compared to the control group. These results align with previous research and provide further evidence supporting the efficacy of structured training interventions in enhancing physical performance metrics.

The significant improvement in balance observed in the experimental group (t = -7.22, p = 0.001) highlights the effectiveness of the training program. This result is consistent with previous studies, such as Smith et al. (2020) and Lee et al. (2018), which demonstrated that targeted balance training enhances proprioceptive awareness and postural stability. The lack of significant improvement in the control group (t = -0.80, p = 0.44) underscores the necessity of specific interventions for meaningful gains in balance. Regularly engaging in balance-oriented exercises may optimize neuromuscular coordination and improve equilibrium, as noted by Hoffman et al. (2015).

The reaction time improvements in the experimental group (t = 4.39, p = 0.002) suggest that the training program successfully enhanced participants' motor response efficiency. Previous research, such as studies by Johnson et al. (2017) and Taylor and White (2016), reported similar findings, linking reaction time improvements to repetitive neuromuscular stimulus-response training. In contrast, the marginal decrease in reaction time observed in the control group (t = 1.04, p = 0.33) suggests that reaction time adaptations are unlikely without structured interventions. These findings corroborate the importance of incorporating reaction-focused exercises, as suggested by Miller et al. (2018).

The comparative analysis between the experimental and control groups further reinforces the benefits of the training program. The experimental group demonstrated significantly better balance performance (t = 3.36, p = 0.01) and reaction time (t = -2.30, p = 0.05) in the post-test evaluations. These findings align with the conclusions of Garcia et al. (2019), who highlighted the importance of specific, goal-oriented training regimens in enhancing physical and cognitive performance.

The results of this study have practical implications for designing training programs in sports and rehabilitation contexts. Interventions that target balance and reaction time improvements can contribute to better athletic performance and injury prevention, as suggested by the works of Nguyen et al. (2020).

The findings of this study underscore the efficacy of structured training programs in enhancing balance and reaction time, both of which are critical components of physical performance and injury prevention. The significant improvements observed in the experimental group, coupled with the negligible changes in the control group, highlight the necessity of targeted interventions for achieving measurable progress. These results reinforce the idea that balance and reaction time are trainable attributes that can be improved with systematic and focused exercises.

From a practical perspective, incorporating balance and reaction time training into athletic programs or rehabilitation plans could lead to better overall performance and reduced injury risk. Specifically, balance training can improve postural stability, while reaction time exercises can enhance neuromuscular response efficiency. Such improvements have far-reaching implications for athletes, older adults, and individuals undergoing physical rehabilitation.

Recommendations

Future studies should explore the long-term sustainability of balance and reaction time improvements across diverse populations. Additionally, integrating these training programs with other fitness components could enhance their overall effectiveness and practical applicability.

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