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ORIGINAL ARTICLE

Exercise effects on motor skills in hearing-impaired children

Zahra Soori[1] · Ali Heyrani[2] · Forouzan Rafie[3]

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Abstract

Purpose This study aimed to investigate the effect of 8 weeks of perceptual–motor training on bimanual coordination performance and static and dynamic balancing in students with hearing impairment aged 8–11 years in Kermanshah.

Methods 20 girls with hearing impairment with a mean age of 9.35 ± 1.42 were randomly selected and divided into control and experimental groups. The used tools in this study were continuous bimanual coordination test device, stork balance test, and Y dynamic balance test. First, all participants performed bimanual coordination task, and static and dynamic balance tests as pretest. Then, the experimental group performed the exercise training (such as static and dynamic balancing, throwing and catching a ball, running between obstacles) for 8 weeks, 3 sessions per week, and 60 min per session and finally posttest was applied for both groups. After ensuring the normal distribution of data using the Shapiro–Wilk test, *t* test was used to analyze intra-group and inter-group differences at a significance level of $P < 0.05$.

Results The results showed an increase in static ($P = 0.0011$), and dynamic ($P = 0.0206$) balancing, and bimanual coordination ($P = 0.0031$), improvement after 8 weeks of perceptual–motor training in the experimental group.

Conclusion According to the obtained results, it can be concluded that exercise training was effective in improving motor skills, as well as the use of these trainings is recommended to increase the level of motor performance.

Keywords Exercise · Motor skills · Hearing impaired · Children

Introduction

Hearing-impaired children show different abnormalities in motor and social behaviors. These disorders can be seen mostly in the form of ataxia, impairments of balancing, and postural disorders [1, 2]. Hearing loss is the most common sensory neural defects in human and one in thousand children comes into the world with severe to profound hearing loss [3]. According to the World Health Organization in 2005, 278 million people around the world is suffering from some form of hearing loss. Sotoudeh et al. [4] in Iran reported 4% prevalence rate of the disorder among 1999 primary school students. In the Baradaranfar study in 2009, 13.4% of the subjects were experiencing hearing loss [5]. These statistics indicate the presence of a large population with hearing disabilities in Iran and this emphasizes the need for planning and directing the appropriate interventions. In various studies, balance deficit has been reported among people with hearing disability compared to normal individuals [6, 7]. In addition, impairment of eye–hand coordination as well as coordination of body movements has been reported in hearing-impaired people [8].

Reineh et al. in 2000 reported that children with sensorineural hearing impairment (SNHI) and concurrent problem of vestibular apparatus have progressive motor skill developmental delays [9]. Balance, as basic need for daily activities and a complex and sophisticated mechanism, is responsible for the coordination of visual, vestibular, and somatosensory systems [10]. Damage to parts of the vestibulocochlear nerve not only causes sensorineural hearing loss, but also may be associated with the balance problems due to damage to the vestibular nerve branches. This may be one reason for the

✉ Forouzan Rafie
fr.rafie87@ut.ac.ir

Ali Heyrani
Ali.heyrani@gmail.com

1 Development and Motor Learning, Department of Physical Education, Razi University, Kermanshah, Iran

2 Department of Physical Education, Razi University, Kermanshah, Iran

3 Development and Motor Learning, Neuroscience Research Centre, Kerman University of Medical Sciences, Kerman, Iran

balance problems in hearing-impaired people [11]. Butterfield believes that the balance state is an integral part of most fundamental motor skills, so hearing-impaired children are facing delay in gross motor skills such as catching, kicking, jumping, and hopping compared to their healthy counterparts. The balance disorders may affect the learning of other motor skills as well as visual, perceptual, and motor developments and their sensory integration [12]. There are large differences among studies on the lack of balance in hearing-impaired people. Boyd [13] examined the static and dynamic balance in boys with hearing-impaired aged 8–10 years using Oseretsky scale, and showed that the dynamic balance in hearing-impaired children was significantly lower than in normal children [14]. On the other hand, some researchers have declared that hearing-impaired persons despite having defects in the vestibular data, when there is no abnormality in the visual and somatosensory systems, can do their balance activities without any problems similar to normal people [13, 15].

During childhood, that is the most important time to learn the skills, children with hearing impairment because of multiple motor, communication, and social disorders are experiencing various problems in the educational, developmental, and social fields. Therefore, many studies have emphasized the necessity and priority of intervention programs [16]. Given that most studies have been done on the effect of exercise on enhanced balance and motor coordination among healthy children and considering the high prevalence of hearing loss in children, this study aimed to investigate the effect of 8 weeks of perceptual–motor training on bimanual coordination performance, and static and dynamic balancing in girls with hearing impairment.

Methods

Research methodology was quasi-experimental pretest–posttest control group design. The statistical samples were 20 girls with hearing impairment (the mean age of 9.35 ± 1.42 years and the mean BMI of 19.8 ± 4.7 kg/m^2) who were selected randomly among girls in the school for the hearing-impaired children in Kermanshah, Iran. Before enrolling in the study, the medical records of participants were examined to ensure the absence of neurologic disease, hyperactivity, mental disability, physical or motor impairments, and visual problems. The severity of hearing loss was recorded in specialized audiology clinics. Accordingly, the subjects with deep and absolute hearing-impaired intensity over 61 dB were included to the study.

After obtaining informed consent, the participants were divided randomly into experimental ($n = 10$) and control ($n = 10$) groups; all participants were right handed. Due to lack of ability to speak and hear in deaf, a mediator who was an expert in sign language attended along with researchers at all stages of working with hearing-impaired people. In the beginning, summary of the research design was explained to all subjects and the pretest was done. Then training group performed perceptual–motor training for 8 weeks (24 sessions). During this period, the control group followed the daily routine works. The posttest was taken from each group at the end of 8 weeks.

The used tools in this study were continuous bimanual coordination test device, stork balance test, and Y dynamic balance test to assess, respectively, static and dynamic balancing. The subjects' score was calculated as the amount of distance that a person could achieve (in cm). To record the score, the subjects performed the test three times. The average achievement in any of three directions was measured and divided by the length of the leg (in cm) and multiplied by 100 to calculate the achievement distance in terms of percentage of the length of leg in any of three directions. The combined score was calculated as the sum of the values obtained and dividing it by three.

Measurement of bimanual coordination

Bimanual coordination test device (manufactured by Lafitte Co.) includes two handles that are taken with both hands. To perform every effort, the hands should move harmoniously with stylus on black star outline once in a clockwise direction and immediately in the opposite direction by reaching the tip of star.

The stylus moving on the screen is composed of two types of movements:

1. up and down, which is a symmetric movement and the same muscles of both hands are used at the same time (intrastate status);
2. left and right, which the hands move simultaneously on the left and right (interstate status), the purpose is stylus placing on the black part and moving in the direction of black star.

Before performing the task, subjects were given information on how to do the task and its purpose in the test chamber. This information includes way to do task and its objective. After that, they became familiar with way to do task a few times and performed three to five times tentatively the task. After making sure of understanding the way to do task, the subjects were ready to make major effort [17–19].

Measurement of static balance

The stork balance test has been designed as a common tool for measuring static balance. In this study, the modified test was used to evaluate static balance. For the test, the subject stands with one leg on a flat surface, free leg is lifted up to the ankle level, both hands are placed on the side of the body, and hand movements is free on the side of the body. Examiner measures the maximum time that the subject stands on its legs and stops time when the subject put his free leg on the ground. This test is carried out for both legs with three replications, and the best time was considered as a record [20].

Measurement of dynamic balance

Y dynamic balance test was used to measure dynamic balance in this research. To run the test, the subject was placed with one leg (premier leg) in the center so that the tip of shoe was behind the starting line. As far as they could, the participants tried to achieve the greatest distance in the anterior direction with the other leg and then returned to the normal position on two legs without losing balance, next did the posterior-internal and after that posterior-external directions. Each sample practiced the test four times to learn the methodology. The subjects with premier right leg performed the test in a counterclockwise direction, and the participants with premier left leg performed the test in a clockwise direction [20].

Training

Participants in the experimental group performed the perceptual–motor training for 60 min per day, 3 days per week for 8 weeks (24 sessions).

The perceptual–motor training was done as follows: 5 min' warm-up including walking slowly and correctly, walking on different parts of the foot, walking in different directions, walking with jumping movements, opposite arm and leg movements, butterfly movements, correct running, running between obstacles and running at different speeds. 10 min of exercise movements, (stretching exercises, and jerking movements included jumping rope, in place jumping on the right and left legs, hopping, zigzag jumping, and double feet forward and back jump). 40 min perceptual–motor training werewas included (static and dynamic balance exercises, basketball jump shot, rotating the ball around the waist while walking, throwing the ball onto target drawn on the wall, catching the ball, keeping the ball between the two knees, and walking upright, running between the obstacles, hitting the ping pong ball with the racket to control the ball). As children became more familiar with how to practice, the number of repetitions in each session was increased. 5 min of cooling down exercise included jogging, walking slowly and deep breathing, stretching exercises, and releasing the muscles.

Table 1 Descriptive statistics

Variables	Group	Pretest mean (SD)	Posttest mean (SD)
Coordination	Experimental	1.01 (9.60)	3.55 (2.06)
	Control	0.85 (9.54)	1.26 (0.49)
Static balance	Experimental	14.10 (7.63)	26.96 (7.83)
	Control	14.06 (7.37)	14.66 (6.30)
Dynamic balance	Experimental	9.45 (12.77)	13.94 (5.83)
	Control	9.07 (1.00)	9.22 (1.12)

Table 2 Paired *t* test comparing pre- and posttest in each group

Variables	Group	*t* test statistics	*DF*	*P* value
Coordination	Experimental	3.28	29	0.027
	Control	1.47	29	0.152
Static balance	Experimental	8.32	29	0.000
	Control	1.98	29	0.052
Dynamic balance	Experimental	3.21	29	0.003
	Control	1.2	29	0.239

Statistical analysis

Data were analyzed using SPSS 17 software at the significance level of $P < 0.05$, After ensuring the normal distribution of data using the Shapiro–Wilk Test. *T* test was used for analysis.

Results

The Shapiro–Wilk test was used to study the normal distribution of data. As the results showed the normal distribution ($P > 0.05$), parametric statistical methods were used to analyze the data.

Descriptive statistics of experimental and control groups is shown in Table 1. The pretest did not reveal any significant differences between the two groups ($P > 0.05$).

Paired *t* test was used to compare the variables in the studied groups in pre- and posttest. The differences between pre- and posttest were significant in experimental group (Table 2).

To compare the differences between the two groups in posttest, independent *t* test was used. As shown in Table 3, a significant difference was observed between two experimental and control groups in posttest coordination ($P = 0.0031$). Furthermore, significant differences were reported between two experimental and control groups in posttest static ($P = 0.0011$), and dynamic balance ($P = 0.0206$).

Table 3 Independent *t* test comparing two groups at posttest

Variables	*t* test statistics	*DF*	*P* value
Coordination	3.420	18	0.0031
Static balance	3.873	18	0.0011
Dynamic balance	2.538	18	0.0206

Discussion

In the present study, we evaluated the effect of 8 weeks exercise on motor performance (bimanual coordination, and static and dynamic balance) in hearing-impaired girls. The results showed that hearing-impaired children are suffering from balance and bimanual coordination disorders. This finding is consistent with a study by Kegel who showed disorders and defects of ball and manipulative skills in subjects with hearing impairment as well as other previous studies indicating balance, motor control, and motor coordination problems in hearing-impaired children [18–22].

On the other hand, 8 weeks of perceptual–motor training program demonstrated significant progress in coordination, and static and dynamic balance in the experimental group. The finding is in line with a research conducted by Rine et al. [23], and Majlesi et al. [24], who suggested that exercise interventions could cause strengthening of sensory system, balance, and motor development in hearing-impaired children [23, 24].

Rine et al. [25] examined the effect of compensatory training on motor development and posturography among children with sensorineural hearing loss and vestibular impairment. The aim of the study was to evaluate the effect of core stability training on static and dynamic balance in male students with hearing impairment using functional tests. The study population included 21 children with sensorineural hearing loss and vestibular impairment randomly assigned to two groups (exercise and placebo). The experimental group performed a compensatory training, emphasizing enhancement of visual and somatosensory function, and balance training for 12 weeks and 3 times per week. The results showed no significant difference in terms of posturography scores between experimental and control groups. However, the experimental group had better motor performance compared to the control group [25].

In a study by Shah et al. [26], 10 participants with hearing impairment aged 6–12 years performed balance training, hand–eye coordination, visual–motor coordination, and overall coordination for 10 min per day and 3 days per week for 12 weeks. The exercises could improve gross motor skills and postural control in these subjects [26].

The results of this study are in contradiction with the findings of Effgen [27] who reported a lack of effect of a 10-day exercise intervention on motor abilities of hearing-impaired children. Effgen [27] examined the effect of a daily exercise program on static balance in hearing-impaired children with an emphasis on balance training. In the study, 49 hearing-impaired children were tested on a force platform. There was no significant difference in static balance ability as measured by degree of sway between control and experimental groups. However, the length of time that children in the experimental group could stand on one leg increased significantly [27].

Some possible reasons for the differences obtained from the present research with other studies can be the nature of training employed (perceptual–motor training) and duration of training. To confirm the findings of this study, it can be said that activities related to perceptual–motor abilities have a very important role in development of motor skills in the early years of a child's life [28, 29]. Finally, it could be argued that the training activities used in the present study had a key role in strengthening the balance and its control systems as well as coordination of people with hearing impairment. One of the limitations of the current study is the use of only girl participants and thus no comparison between the two genders. It is recommended to use boys also in future research to investigate thoroughly the effect of gender. Due to the small number of participants, it is suggested to carry out similar research with a larger sample size and adding healthy subjects aiming to more accurate and comprehensive comparison.

Conclusion

According to the findings of the present study, it can be concluded that the perceptual–motor training may lead to improvements in coordination and balance of people with hearing impairment and this can result in better motor performance, daily activities, and thus the quality of life of people with hearing impairment. Hence, applying and paying attention to perceptual–motor training in daily programs of children with hearing impairment are recommended to their educators and parents.

Compliance with ethical standards

Conflict of interest The authors have declared no conflict of interest.

Ethical standards All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent All the subjects provided written consent to participate in the study, after the study procedure and methods were explained to them.

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