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Balance of Children with Visual Impairment: Effectiveness of Game-Like Exercises at Home Protocol

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ABSTRACT

Aims Balance is one of the key components of most physical activities. To control balance and choose a balanced strategy, vision plays a crucial role in processing visual inputs. The present study aimed to design and implement a game-like exercise protocol and determine its effectiveness on the static and dynamic balance of children with visual impairment.

Materials & Methods This quasi-experimental study consisted of all 6-11-year-old children with visual impairment referring to the counseling centers Yazd province and done in the summer 2020. A total of 35 visually impaired children were selected using the purposeful convenience sampling method. After matching, the samples were assigned into an experimental group (n=18) and a control group (n=17). The experimental group received 24 sessions in 60min training. The required data was gathered using the Stork Balance Stand and Timed Up and Go tests for visually impaired children. The collected data were analyzed using ANCOVA by SPSS 20.

Findings The obtained results showed a significant difference in the means of the static balance test ($p<0.01$) and the dynamic balance test ($p<0.01$) between subjects of the experimental and control groups.

Conclusion Considering the effectiveness of the game-like exercises on improving children's balance with visual impairment, these games are suggested to be implemented daily at home.

Keywords Visual impairment; Education; Play Therapy; Postural Balance; Psychomotor Performance

CITATION LINKS

[1] Blindness and visual ... [2] Does blindness influence trust? a comparative ... [3] Impact of cerebral visual impairments ... [4] A fundamental study on health anxiety in ... [5] Blindness enhances auditory obstacle circumvention ... [6] Effect of transient perturbations of short-term memory ... [7] protocol for a controlled, randomized, blind, clinical ... [8] Relationship between motor skills, balance, and physical ... [9] Relationships between types of balance ... [10] The impact of balance specific physiotherapy, intensity ... [11] Virtual navigation for blind people: Transferring ... [12] Assessment of motor skills in children with ... [13] Visual impairment and objectively measured ... [14] Physical activities of people with visual impairment ... [15] Impact of visual impairment on static and ... [16] The assessment of static balance in children with ... [17] Audio motor training improves mobility ... [18] Improved balance performance accompanied by ... [19] The effect of static and dynamic balance training ... [20] Latin aerobics: An exercise work-out for static ... [21] Measurement of fine-motor skills in young children ... [22] Effect of front crawl swimming trainings ... [23] Static balance of persons with intellectual ... [24] Timed up & go test in children and ... [25] Impact of visual impairment on balance and visual ... [26] Including children with visual impairment in mainstream ... [27] Essential elements in early intervention: Visual ... [28] Unknown City: Audio Games ... [29] Unknown City: Better World ... [30] San Francisco: Pinterest; 2018 ... [31] Cronbach's alpha ... [32] Evaluation of sensory skills among ... [33] Expansion of the tonotopic area in the ... [34] The effects of Tai Chi on the balance ... [35] Physical activity, physical fitness, and body composition ...

Introduction

People with a visual impairment include people with blindness and low vision. Legally, a blind person is said to a person whose vision, even with a visual aid, such as glasses, is 20/200 or less in the best-seeing eye. Additionally, people whose vision is around 20.70 to 20/200 are called low vision [1]. Estimations indicated that 217 million people worldwide have moderate to severe visual impairment, and about 36 million are blind [2].

Visual impairment affects the sense of vision and all aspects of the child's development [3]. In the experts' view, 80% of learning and one-third of the processing of the human brain are done with the aid of the visual sense [3, 4]. Research studies have shown that a person's body sway increase by 20 to 70% when standing with eyes closed compared to when standing with eyes open. Vision, which provides rich information for a person to move in the environment, is paramount in motor control and balance [3]. Visual impairment disrupts spatial orientation, balance, motor skills implementation [5], cognitive abilities, and learning [6].

Balance control is an integral part of any motor system. As one of the controversial issues of the sensorimotor system, balance examines the complex relationship between sensory inputs of the required motor responses to maintain or change posture, which is a key and integral component of daily activities [7, 8]. Balance is in two forms: static and dynamic; static balance refers to maintaining a base of support with minimal movement, and dynamic balance refers to the ability to perform an activity or task while maintaining a stable posture [9, 10]. All activities of daily living require the control of balance in a state of stillness and movement. Accordingly, impaired sense of vision causes problems in orientation, balance, and movement of people [11, 12]. Children with visual impairment have similar needs to other children, but there is the fact that they are unable to see naturally, which restricts their activities in games in many cases to the extent that their physical development is significantly affected and delayed. Fear of injury instilled in them by their parents reduces children's natural interest in large muscle activities such as running, climbing, and jumping; however, these activities are kid games in which muscle growth plays an important role in creating coordination [13, 14]. In maintaining upright body posture, we use a combination of sensory resources, including the vestibular system, somatosensory, and visual system. The central nervous system activates the programmed limb-muscle patterns by receiving and processing information from the visual, vestibular, and proprioceptive systems. These movement patterns create movement strategies following which the individual can maintain his balance. People with visual impairment have difficulty maintaining and controlling their balance [15]. They need more somatosensory and vestibular information for balance maintaining. The most common strategy used by these individuals is employing other senses to maintain stability and coordinate movements to adjust the body's posture in space [16]. People with visual impairment can bring their balance to that of healthy people through exercise [17].

Moreover, Rogge *et al*. concluded that training could significantly affect the balance and plasticity in blind people [18]. In this vein, Başakcı Çalık *et al*. concluded that cognitive training improves the static and dynamic balance in blind children [19]. In a study, Ignacio stated that visually impaired people could increase their balance by training [20]. Thus, paying attention to movement, motor development, and daily motor skills can help with the independence of visually impaired people, especially children younger than five years with visual impairment [21].

One of the most effective and accessible ways to acquire motor skills in children with visual impairment is to engage in physical activity. The question that arises in this regard is whether it is possible to pave the way for the normal development of these children by providing purposeful game-like activities and sensory-motor experiences and engaging the vestibular system and proprioception in these children? The present research aims to modulate the balance problems in children with visual impairment by designing a purposeful training protocol so that using it; the disabled can take steps to empower themselves in society and feel the positive effect of this training protocol. The practical importance of this research is in the use of various games at home to help children improve to enhance the balance performance, fertilize balance-specific programs, and improve the lifestyle of visually impaired children. Therefore, this study aimed to evaluate the effectiveness of home exercise protocol on balance in children with visual impairment. This study is designed to answer whether selected game-like exercises at home can improve the static and dynamic skills of children with visual impairments.

Materials and Methods

This quasi-experimental study consisted of all 6-11-year-old children with visual impairment referring to the counseling centers Yazd province and done in the summer 2020. Thirty-six children with low vision and complete blindness were selected using the purposeful convenience sampling method. Samples were first matched for age, gender, and the degree of visual impairment and then assigned into an experimental group (n=18) and a control group (n=18). Using G*Power statistical software based on the repeated measures ANOVA, the significance level of 1% (α=0.01), test power of 80% (β=0.2), medium effect size (d=0.3), and the number of repetitions of

2 would result in a total sample size of n=30 (n=15 for each group). To compensate for the dropout of the subjects, 36 subjects were included in the study. Inclusion criteria: Children with low vision or blindness based on the approval of an ophthalmologist; and not taking medication that causes an imbalance in the child, including to the study. Moreover, the exclusion criteria included the absence of the subject on the days of testing, absence for more than three training sessions, and child or family withdrawal from research.

To measure the static balance, the stork balance test with a validity of 0.79 and reliability of 0.93 was used [22]. During this test, the subject first places the hands on either side of the pelvis, stands on the supporting foot, and places the sole of the non-supporting foot against the inside knee of the supporting foot. The individual's balance score is equal to the total time (in seconds) the person keeps this position. The longer this time, the higher the static balance. As soon as the heel of the non-supporting foot was raised from the floor, the duration of standing on one foot was recorded using a stopwatch until the non-supporting foot lost contact with the knee. Each subject took the test three times, and the best attempt was recorded as the subject's score. The stopwatch was stopped if the subject's supporting foot swiveled, hands came off the pelvis, and non-supporting leg hooked around the other leg or moved backward or in any direction to maintain balance [23]. Timed Up and Go (TUG) test was used to measure the dynamic balance in visually impaired children. TUG test includes getting up from a chair, walking up to 3 meters, returning, and sitting on the chair again. The total time taken by the person to perform this maneuver is measured using a stopwatch. The shorter this time, the higher the dynamic balance. This test is used to measure the dynamic balance and show the basic mobility in children (r=0.77; ICC=0.95) [24]. In the present study, the path between the chair and the opposite wall was surrounded by partitions such that a path 3m long and 0.5m wide was created [25].

In designing the perceptual-motor training package to improve the static and dynamic balance of visually impaired children, first library studies were performed. By referring to books [26, 27], relevant papers [16-19], educational websites [28-30], and specialists who worked professionally in this field, different types of exercises, games, solutions, and instructions were extracted. Additionally, the words, practical training activities, and different activities suggested increasing the balance functions of visually impaired children in designing and developing this training package, and the age and cognitive status of children were considered. In addition, attempts were made to maintain the necessary diversity to keep the children motivated and exciting training programs. Finally, 14 educational games were designed to develop this package. Due to the desire and tendency of children and families to perform exercises and continuity in performance, exercises were designed in the form of games. To examine the content validity, the training package was reviewed by 12 experts in fields of exceptional children psychology, children counseling, occupational therapy for exceptional children, play therapy, and educational psychology. Their suggestions were implemented, and drawbacks were removed. Then, the training package was experimentally implemented on two children with low vision and three children with complete blindness. The purpose of this step was to modify the training package, adapt it to visually impaired children's characteristics, and become aware of possible unforeseen problems to determine whether the content of the designed package is suitable for this purpose? At this stage, using the estimation formula for numerical face validity of each item and substituting CV=0.59, two contents of the training protocol were removed, and some changes were made in three other items. Furthermore, the reliability of the training package was calculated to be 0.79 using Cronbach's alpha measurement method, indicating the good reliability of this package [31].

The research ethics committee of Khorasgan University granted ethical approval of the present study. The selected training program began with simple movement programs and was completed with specialized movement programs. It was worth mentioning that all tools and toys used were made of soft and safe material. The content of this training package was demonstrated in Table 1.

To determine the effectiveness of the training package in improving the balance of visually impaired children, a pre-test was taken before the onset of intervention. Then, children were assigned into an experimental group and a control group. The intervention program was implemented in the Ziaee Counseling Center of Meybod city, Golshan-e Raz Counseling Center of Meybod city, Yazd Counseling and Psychological Services Center, and Mehregan Counseling Center Ardakan city in Yazd province. The experimental group was trained for eight weeks, three days a week (24 sessions) [17]. At the end of the intervention program, the experimental and control groups took part in a post-test under conditions similar to the pre-test.

The obtained data were analyzed using descriptive and inferential statistics in SPSS 22 software. Analysis of covariance (ANCOVA) was used to analyze and compare scores gained in pre-test and post-test. The significance level was considered at 0.01.

Table 1) Perceptual-motor training for visually impaired children

Exercises	Implementation description
Coordinate	Including games such as hopscotch, jumping forward, jumping up, turning around, stroke movement, angel, etc.
Stand up, sit down	Doing a sit-up and vice versa.
Ground coordination ladder	Doing pair jumping, hopscotch, etc., without touching ladder fences.
Stretching exercises	Doing cat, bridge, grasshopper movements, etc.
"Freeze" and become a statue	Dancing with music, when the music stops, children must freeze and hold that position like a statue for 5s.
Toys and tools pool	Playing sorting games, finding the same shapes, etc., inside a pool, there are small and various tools and toys.
Straight- and curved-path walking	Walking a tactile paving path and performing various body postures such as placing hands on the waist, placing the book on the head, etc.
Reminding objects	Touching different objects and telling the names of objects, moving objects of the same family by walking and placing them on the palms, heads, etc.
Playing with beads	Placing the beads between the fingers and carrying them.
Where does the sound come from?	Performing balance movements (hopscotch, jumping, …) evoked by the sound (ringing ball, rattler, …) played in different directions of the training environment.
Orientation with sound and music	Including hopscotch toward the north direction, performing pair jump toward the south direction, etc., by order of the family.
Playing with a bell	Performing vertical jump movement and touching the bell at height, and ringing the bell.
Jigsaw puzzle	Touching geometric objects and performing the corresponding balance movement (e.g., performing the circle movement by touching the circle).
Basic and secondary directions	Moving in the basic directions (cross-shaped path) and then in the secondary directions (cross path).

Findings

One of the subjects in the control group was not present on the day of testing (n=17).

The mean pre-test and post-test scores of static and dynamic balance in children with visual impairment showed in Table 2.

Table 2) Mean pre-test and post-test scores of subjects in experimental and control groups

Group	Pre-test	Post-test	p.
Experimental (N=18)			
Static balance	2.220±0.943	4.610±0.916	0.0001
Dynamic balance	7.500±1.249	4.280±0.699	0.0001
Control (N=17)			
Static balance	2.12±0.928	2.180±1.131	0.04
Dynamic balance	5.88±1.16	6.350±1.412	0.021

The results of variance in populations were not significant ($p>0.01$). Therefore, the data were distributed normally in the experimental and control groups.

The adjustment of the pre-test scores revealed the significant effect of the between-subjects factor of the static balance variable ($p<0.01$, $f_{(1.32)}=52.57$) and dynamic balance variable ($p<0.01$, $f_{(32.1)}=40.01$). In other words, this package could effectively improve the static and dynamic balance in children with visual impairment (Table 3).

Table 3) Results of ANCOVA analysis for the between-groups training effect with the elimination of the pre-test effect

Variable	SS	df	MS	F	p
Static balance					
Pre-test	4.346	1	4.346	4.575	0.04
Group	49.945	1	94.945	52.57	0.0001
Error	30.402	32	0.95	-	-
Dynamic balance					
Pre-test	6.134	1	6.134	5.884	0.021
Group	41.711	1	41.711	40.01	0.0001
Error	33.36	32	1.042	-	-

Discussion

The present study aimed to design and implement a game-like exercise protocol and determine its effectiveness on the static and dynamic balance of children with visual impairment. The obtained results showed that after implementing the designed protocol, the static and dynamic balance of children improved significantly in the experimental group compared to the control. The results of this research are in agreement with previous studies by Çalık *et al.* [19] and Ignacio. [20] To maintain their stability, people need input information from vestibular, somatosensory, and visual systems. Lack of information from a system may affect the body's spontaneous sways and result in the loss of body balance while walking in a straight line. The present study results showed a significant increase in the static and dynamic balance of the blind. Though vision plays a fundamental role in postural control, people's motor function is dependent on other sensory inputs, especially the sense of touch, proprioception, and sense of hearing, indicating the continuous use of these senses [32, 33]. It means that both muscle activity and motor coordination can be improved through training exercises and motor learning to maintain stability, and the body sway is controlled through the vestibular and somatosensory system [32, 33]. Performing exercises improves and facilitates the transmission of the above-mentioned sensory inputs by challenging the systems involved in maintaining balance and applying extra load on the senses involved in balance and proprioception [34]. It can be concluded that performing training protocol in the experimental group strengthens proprioception and vestibular sense of visually impaired children and compensates for the lack of visual system in postural control to an acceptable level. Therefore, it can be found that purposeful motor activities play an effective role in strengthening balance and its control systems, especially the somatosensory system. As a result, active people do not depend much on specific systems and work more independently [34, 35]. According to the results, the static and dynamic balance of children with visual impairment in the control group showed no significant change after eight weeks. As the balance control system in the control group was not exposed to overload, and none of the components of this system were exposed to training, change, improvement, and overload, it seems reasonable not to observe a significant change in balance [35].

One of the limitations of the present study is that this research has been conducted in Yazd province, and its generalizability should be done with caution. This research may also be due to changes in time, limitations in the pattern of daily activities and rest, diversity, and differences in people's social, economic, cultural, and health status in society. It is suggested that in future research, the effect of these games should be measured in other regions of the country with climatic, social, and cultural differences. Also, the effect of this type of training is investigated on other perceptual-motor characteristics of children, such as orientation and motor coordination. It is also suggested that the effect of this training protocol be investigated on various aspects of the lives of children with visual impairment, such as quality of life, psychological well-being, and independence of action so that it can be provided to educators and families of these children as a complete training program.

Conclusion

The designed training protocol has a significant positive effect on children's static and dynamic balance with visual impairment. Game-like exercises improved the nervous system is planning to perform physical movements and activities. Overall, all these changes and positive effects caused a reduction in the imbalance symptoms in children with visual impairment. The main cause of these changes can be attributed to proper exercise planning. Therefore, considering the effectiveness, safety, cost-effectiveness, and applicability of this training protocol, the rehabilitation centers, occupational therapy centers, Special Education Organization, and parents of visually impaired children are recommended to encourage children to play these games daily at home.

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Ethical Permissions: The research ethics committee of Khorasgan University granted ethical approval of the present study (Code No: IR.IAU.KHUISF.REC.1398.137).

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