Research Paper

The Effects of 6 Weeks of Balance Training on Static and Dynamic Balance of Blind Students

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ABSTRACT

Background and Purpose: Visual disturbance causes problems in the orientation, balance, and movement of individuals. It is especially important in children because this is a golden age for adoring physical exercises and physical function in these people. Therefore, this study aimed to evaluate the effect of 6 weeks of balance training on the static and dynamic balance of blind students.

Materials and Methods: This is a quasi-experimental study, and the subjects included 45 blind students living in Ahwaz City, Iran. The participants were selected using convenience and purposive sampling methods. A sample of 20 girls and 20 boys, aged 7-14 years, was selected and randomly divided into two control and experiment groups consisting of 20 subjects each (10 females and 10 males). The experimental group received a six-week course of balance training intervention. They have received six-week balance training program, 2 sessions of 45 minutes a week. Static balance was measured by stork test and for dynamic balance star balance test was used. The Shapiro-Wilk test was used to control the normality of data. In order to study the effect of time and between groups, repeated measures ANOVA was used. For analyzing the data SPSS software, version 25, Excel 2019 software, and in all statistic test $\alpha=0.05$ was used. All analyses were done in SPSS software v. 25, Excel 2019 software. The significance level was considered at 0.05 for all tests.

Results: The two groups of blind student, each groups 20 subjects and mean age of 10.33 and 11.12 years in control and exercise group respectively. Comparing the groups showed that six weeks of balance training had a positive and significant effect on static balance and dynamic balance of exercise group ($P<0.001$). The results also showed that in the Post-test stage, the experimental group performed better in static and dynamic balance in all 8 directions compared to the control group ($P<0.001$). There was no significant difference between girls and boys in terms of balance.

Conclusion: Regarding the effect of these exercises on improving the balance of blind children, it is recommended that parents, physical education teachers, occupational therapists, physiotherapists, and all those who are in some way associated with these children, use balance training as a therapeutic plan.

Keywords: Blind, Static balance, Dynamic balance, Students

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1. Introduction

Blindness is a major concern of the World Health Organization, with around 39 million blind people and 285 million people with vision problems worldwide [1]. A person is blind when his or her vision, with correction, is less than 1.10 in the dominant eye or has a narrow field of vision of fewer than 20 degrees. The blind people obtain valuable information through other senses, but vision, the strongest source of outside-world perception, is responsible for transferring 80% to 90% of the brain's data. It leads to mild disorders in vision function and mental, physical, and movement problems in these individuals. The visual disturbance causes problems in the orientation, balance, and movement of individuals. Physical activities and sports, for example, sports camps, improve functions and elements of participation and quality of life in children with visual impairment [2]. This issue is particularly important in children because, at this period, they are becoming accustomed to the physical training and abilities of these individuals.

The sense of sight, with the momentary information from the surrounding environment to the nervous system, plays a direct and fundamental role in balancing. Any reduction or visual impairment changes the process of motor performance and human balance stability. A blind person has difficulty twice more as a healthy person in walking, three times in coming and going, twice in moving from a bed or chair, and twice as much in preparing food [1]. Fear of injury and parental support reduces activities such as running, jumping, and games in blind and visually impaired children, which can affect muscle growth and coordination and can ultimately lead to imbalance and weakness in stature control [3]. In contrast, when a person with visual impairment participates in sports activities, their understanding of the environment enhances, and they can overcome their fear of movement [4].

Balance is defined as the ability of the human body to maintain its center of mass and good stature in static and dynamic situations [5]. Balance is an indispensable factor for the blind, helping to create spatial integrity in blind people. Human balance control depends on the integrity of the afferent information of the atrial, visual, and somatosensory systems. When the activity of one of the systems involved in the control of the stature decreases or is lost completely, the loss of performance occurs in other mechanisms involved in controlling stature [6]. Schmidt and Lee declared that among the sensory input, vision is the most important source of many positions [7]. Therefore, the sensory input loss in the sense of sight also reduces the static balance and leads to a lack of dynamic balance. However, the review study by Danesshmandi et al. showed that blind people are comparable to normal people when sufficient data from the vestibular and proprioception systems are available [8]. This finding necessitates the sports exercises, especially balance exercises, and shows its possible effect on reducing the effect of visual feedback on the balance of the blind group. The research done on the topic of exercises to improve the balance of the blind is very limited. The research conducted by Jazi et al. on 19 blind students aged 9-14 showed that performing the selected balance exercises improved the dynamic balance in these subjects [9]. Mansoori et al. reported that using perturbation exercises improves balance and reduces the risk of falling in adult blind people [10]. A few studies have shown that core stability exercises affected the risk of falling and the quality of life in the studied blind individuals. They considered the importance of mobility, especially in children with visual impairments [11, 12].

Skowronski and Rutkowska compared the balance of blind children with respect to different age groups and genders. The results showed no significant difference between the postural parameters and the measured graphic of girls and boys in different age groups. They also found that as age rises, along with the biological evolution, such as increasing body height and body mass, body posture stability improves the static condition in children aged 6-11 [13]. Ahmadi et al. conducted a study on 30 blind students with an average age of 8.5 years, which included a combination of mental and physical exercises [14]. The study showed that they had no significant effect on the static balance of the subjects, but the combined practice method only allowed the dynamic balance to be developed [14]. Several research studies have shown that eliminating the visual factor in sighted people leads to weakness in balance control, so the blind have many problems in balance control, which is a key component of many activities [15]. It is necessary to assess the balance ability of these children to recognize their abilities or motor weakness in performing motor skills following their compensatory mechanisms; however, the results of the previous research have been contradictory. There have also been few studies within the country that were single-gender and limited to boys. The evaluation of motor disorders can detect primary and secondary deficiencies of abnormal growth because any form of motor reaction is related to the system and is directed by it [14]. Therefore, this research aimed to evaluate the effect of 6 weeks of balance exercises on the static and dynamic balance of blind and visually impaired school students.

2. Materials and Methods

Participants

This research was quasi-experimental and carried out on 20 female students and 20 male students aged 7-14 years. The research samples were selected using convenience and purposive sampling methods from the available population of the students of the exceptional school of Ahvaz (54 students) and randomly divided into two groups of 20 (10 girls and 10 boys) of control (Mean±SD age: 10.33±05.2 years) and the experimental group (Mean±SD age: 11.12±1.60 years). Concerning the limitation of the population, at first, 54 students participated in this study using the census method. Then, subjects with a history of fracture or surgery of the lower limb and subjects with more than 3 sessions of absence (14 subjects) were excluded from the analysis.

After signing the informed consent of the subjects' parents, the Stork standing test was used to measure the children's static balance. In this test, the subject stands on the dominant foot, then put the other fingertips on the knee of the reliance foot while putting his or her hands on his waist. With the command of the researcher, the subject lifts the heel of the reliance foot (dominant leg) and stands on the toe, and tries to hold his or her balance as far as possible without moving the hands' status from the waist and legs from their state (Figure 1). The best time taken from three tests (in second) is taken as the individual's record.

Figure 1. Stork test to measure static balance

To evaluate the Stork test (Johnson & Nelson), a retest method (test-retest) was used to determine the reliability coefficient, and the reported reliability coefficient (r) was 0.87. The star excursion balance test (SEBT) was used to estimate dynamic balance. This test has a network of 8 lines in different directions with an angle of 45°. Eight lines are named according to the position of the line relative to the foot in the ground, including the Anterior (A), Anteromedial (AM), internal (M), posteromedial (PM), Posterior (P), posterolateral (PL), external (L), and anterolateral (AL) (Figure 2).

The Star network was drawn using adhesive tape, a tape meter, and a conveyor directly on an unpolished surface. To determine the dominant leg, the subject was asked to shoot a ball in front of him or her on the ground. Given that the test group participants were blind, the tactile sense and the spatial orientation were used so that they could correctly find the 8 directions of the star test. For this purpose, without wearing shoes and socks, they stood at the center of the star, and the tester first moved at 2 to 3 steps of the subject's feet in the direction to be tested until he/she correctly performed and detected the direction, then the test starts. It should be

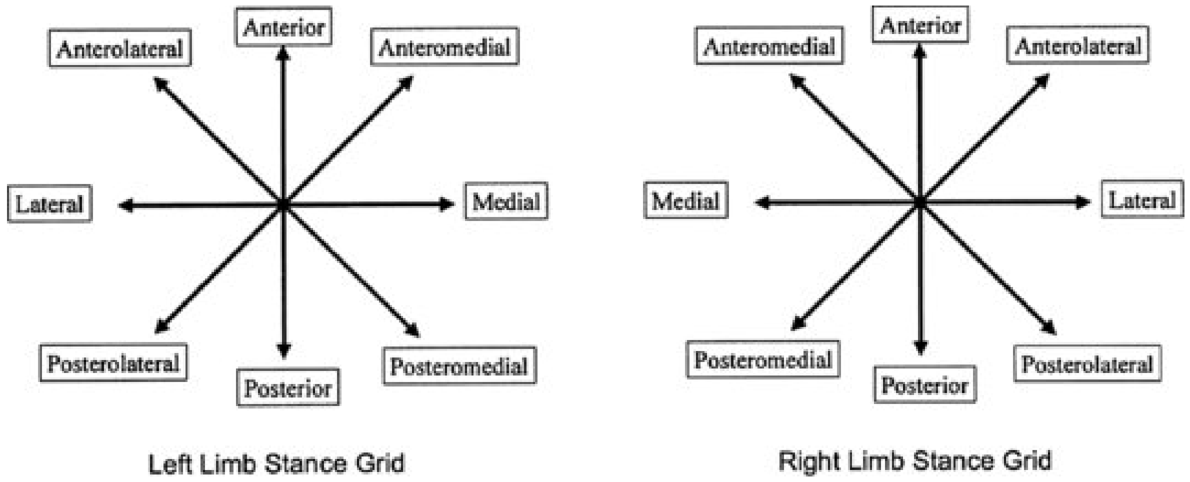

Figure 2. Star test for measuring dynamic balance

noted that the range of each direction is thicker than the plane surface so that the samples could correctly identify each direction with the tactile sense of the foot.

After 5 minutes of doing stretching exercises (quadriceps, hamstrings, gastrocnemius, and horseshoe) and warming up, the subject in the center of the network stood with one leg while his arms were on the waist, moved the end of the other leg in the direction of 8 lines as much as possible. The subject moved his or her leg 3 times in each direction and at any foot deviation with each move and held his or her leg for one second for recording. After each move, the subject returns to the position of standing on two legs and remains in that position for 3 seconds before the next move. All movements in one direction are completed before moving to the other direction, and between the movements in both directions, a 5-minute rest is considered [16].

The errors that resulted in the test being stopped are as follows: the subject removes the reliance foot from the middle of the star grid; the subject's balance is reduced during each access time; the subject cannot maintain the starting and returning state for one second, the subject's feet at any point, while bearing the weight on the reliance foot, contacts the line [16].

This training program was performed for 6 weeks and two sessions per week. Training intensity increased every 2 weeks from 4 to 6 sets (Table 1).

The length of the legs affects the distance between them. Therefore, the mean of the achievement distance was divided by the length of each subject's leg and multiplied by 100. The dependent variable is calculated, and the achievement distance is obtained as a percentage of the length size [16]. The leg length is measured from the anterior-superior iliac spine to the internal malleolus with the tape meter. Then, the subject rested on the back while the knees were in the extension position, and the ankles were distanced by 15 cm from each other.

For the training group, a 6-week balance training program is performed, two 45-min sessions per week. These balancing exercises include walking on the heel and paw; while walking, placing one heel in the front paw of the other leg in a way that touches the heel and the paw; standing on one leg and then alternating leg; sitting and getting up without using hands; bending the knee and raising the foot backward; bringing one leg by the side; bending of the hip joint and raising one leg, and opening hip joint. During this period, the control group did not participate in any activity.

To describe the individual characteristics of the subjects and the research variables, descriptive statistics of frequency, mean and standard deviation were used. The Shapiro-Wilk test was used to determine the normality of the data. Also, Levene's test was used to determine the homogeneity of variances. To study the effects of balance exercises before and after training within groups and between groups, repeated measures ANOVA was used. SPSS software, v. 25 was used to analyze the data, and Excel 2019 software was used to draw diagrams and tables. The significance level of all statistical tests was considered at 0.05 or less.

3. Results

The demographic characteristics of the samples are reported in Table 2. The Shapiro-Wilk test was used to

Table 1. Exercise protocol

Row	Type	Set	Frequency
1	Walking on the heel or toe	4-6 × 10 step	45 minutes twice per week
2	Tandem stance	4-6 set 10 s	
3	Scissors walking	4-6 × 10 step	
4	Standing on one leg and then switching legs	4-6 set 10 s	
5	Single leg raises	4-6 set 10 s	
6	Sitting and standing up without using hands	4-6 × 10	
7	Lunge and reverse lunge walking	4-6 × 10 step	

Table 2. Demographic characteristics of samples

Groups (Each 20 Subjects)		Mean±SD	Min	Max	P
Age (y)	Control	10.33±2.05	8.06	14	>0.05
	Exercise	11.12±1.60	8.00	14	
Height (cm)	Control	139.20±7.85	115	152	>0.05
	Exercise	141.45±9.38	124	162	
Weight (kg)	Control	40.80±11.89	24	68	>0.05
	Exercise	43.02±13.13	24	65	

check the normal distribution of data. The results of this test showed that the distribution of data was normal. The measured variables, including static and dynamic balance in the Pre-test and Post-test, in the control and exercise groups are presented in Table 3.

In the static balance with the dominant leg (P<0.001, $F_{1,38}$=19.10) and in the non-dominant leg (P<0.004, $F_{1,38}$ =9.66), there was a significant difference (Figure 3). Also, there was a significant difference between the groups in the static balance, and the times amounted from 4 to 11 seconds in the dominant leg (P=0.003) and the non-dominant leg from 4 to 12.6 (P<0.001) (Figure 4). ANOVA showed that the interaction between time and group is significant in the static balance of dominant leg (P=0.006, F1,38=8.56) and non-dominant leg (P=0.032, $F_{1,38}$=4.93). The covariance test showed that the Pre-test static balance positively affected the Post-test results (P=0.007, $F_{1,37=}$8.16). However, there was a significant difference between the groups after eliminating the Pre-test effect (P=0.006, $F_{1,37}$=8.58). There was no significant difference between the dominant leg and the non-precious leg in the Pre-test and Post-test.

By calculating the mean value of 8 directions of the dynamic balance, ANOVA showed a significant increase in the balance status from the Pre-test to the Post-test (P<0.001 and $F_{1,38}$=28.88); there was a significant difference between the two groups in the Post-test (P<0.001, $F_{1,38}$=28.88). The interaction between time and group in the dynamic balance was significant, too (P<0.001, $F_{1,38=}$62. 94) (Figure 5; Table 2). The eight directions were significantly different in time in the Post-test (P<0.001), the interaction between the groups was significant in all 8 directions, and the balance of the training group was more than that of the control group (P<0.001).

The covariance test showed that the dynamic balance of the Pre-test was effective in the Post-test results (P<0.014, $F_{1,36}$=6.19), but after the elimination of the Pre-test effect, the significant difference between the groups was relevant (P<0.001, $F_{1,36}$=78.52). Also, ANOVA results showed that the gender effect was not signifi-

Table 3. Static and dynamic balance scores in the Pre-test and the Post-test in the study groups

Groups	Variables		Mean±SD	
			Pre-test	Post-test
Control	Static balance (s)	Dominant leg	39.3±58.3	67.5±88.4
		Non-dominant leg	83.3±52.3	22.5±30.5
	Dynamic balance (cm)		77.42±38.85	51.72±64.37
Exercise	Static balance (s)	Dominant leg	20.6±78.5	34.16±39.13
		Non-dominant leg	15.8±46.7	68.17±72.15
	Dynamic balance (cm)		15.51±84.122	32.152±94.57

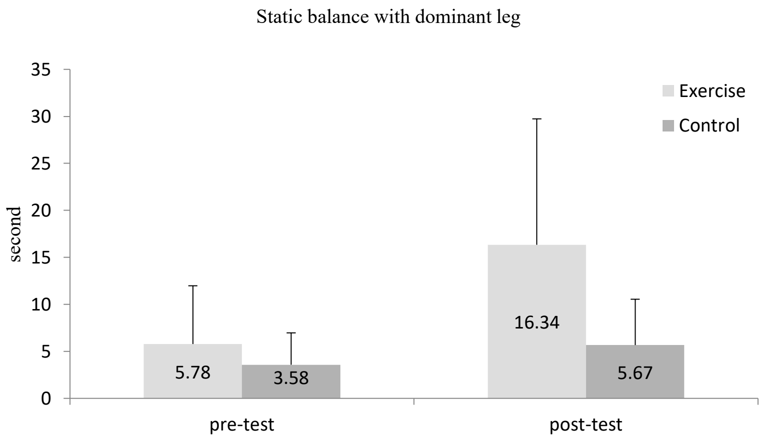

Figure 3. Mean±SD of static balance with the dominant leg at the Pre-test and Post-test in the two groups

cant between the groups and between two time points. Therefore, there was no significant difference between balance performance in boys and girls.

4. Discussion

This research showed that six weeks of balance training intervention significantly changed the static and dynamic balance between experimental and control groups. This difference indicates the improvement of static and dynamic balance due to the balance exercises and the better performance of children in the experimental group compared to that of the control group.

Regarding the results of this research, it should be noted that the balance in childhood greatly depends on visual input. Vision, especially in children, plays a more important role in maintaining postural stability. Because at this age, their balance depends on the inputs of the vision. The feedback from the senses to the central nervous system affects motor activity, and in the absence or weakness of these senses, motor efficiency decreases [17].

To justify these findings, the research of Schmid et al. [18] can be relevant. They stated that other sensory inputs could be a substitute for the long absence of visual information since vision plays a crucial role in the processing and integrating other sensory inputs to select the type of strategy to control the balance. In blind people, due to lack of vision, the total amount of storage of motion data and proper motor patterns in the central nervous system is reduced, and in general, this affects the balance performance of the individual. It also causes blind people to be weaker in their balance than others [19].

Mansoori et al. reported that perturbation exercises improve balance, increase movement function, and reduce the risk of falling in adult blind people.

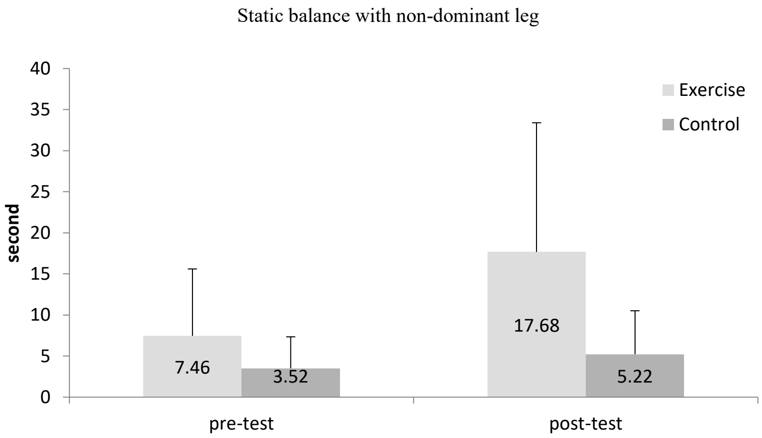

Figure 4. Mean±SD of static balance with non-dominant leg at the Pre-test and Post-test in the two groups

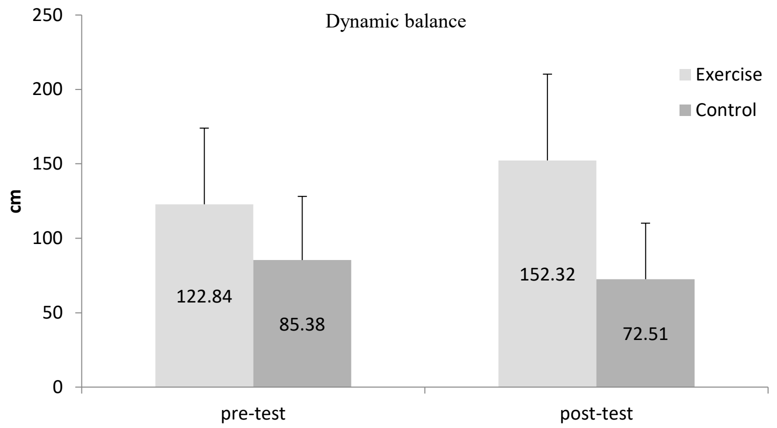

Figure 5. Mean±SD of dynamic balance at the Pre-test and Post-test in the two groups

Regarding the lack and the difference of balance performance of the girls in the study groups, it can be said that because the dynamic weight and strength are also some effective predictors of the estimation of children's balance score, the similarity of the body mass and the strength of the girls in the three groups can justify this conclusion [10].

Strange et al. investigated the effects of balance, vision, and reliance exercises on the duration of postural swings in healthy individuals. The results of this research showed that the difficult sensory conditions (closed eyes and soft surfaces) increase the length of the displacement path [20]. The results of this research section can be compared with the studies that examined the effects of balance exercises on static balance. These studies showed significant changes in the level of static balance in the dominant and non-dominant legs after balanced exercises in hearing-impaired students [21]. Also, computer games (based on balance exercises) slightly improve the performance and balance of children with autism, cerebral paralysis, and Down syndrome in postural control sensory systems in children with developmental disabilities [22].

Previous studies have shown that blind children have a weaker static balance than deaf and healthy children. Because blind people cannot compensate for the lack of visual input to maintain postural stability, the static postural stability is reduced. Therefore, the comprehensive identification of the factors affecting balance and the problems and the balanced weakness at the right time, paying attention to these factors in training programs and strengthening them in children with sensory disabilities, especially the blind, the use of specialist staff, and the special attention to the physical activity of these children in schools have been suggested [23]. Comparison of the athletic and non-athlete blind, in both static and dynamic balance tests, shows that the athletes had better performance than non-athletes [24]. Also, a comparison between the healthy and blind or visually impaired children showed a significant difference between the level of growth of balance abilities of these children, and the healthy children are in a better position [14]. This research shows the importance of the visual system in obtaining information about the environment and the role of compensatory and correction mechanisms among blind and visually impaired children using other senses to compensate for visual impairment.

Regarding the effect of balance training and improvement, Gipsman evaluated the dynamic balance between 48 innate blind, legally blind, and the sighted with closed eyes. To measure dynamic balance, the stabilometer showed the positive effect of the exercise on dynamic balance [25].

Study limitations

In this study, other physical activities of subjects were not controlled. The level of motivation and desire of the subjects to perform exercises and tests have not been investigated. Physiological features, stress and anxiety, fatigue, and distraction of the child were not controlled due to the wide range of test materials.

5. Conclusion

In the present study, we used simple and low-cost exercises such as the Star test and the Stork test that can be implemented at any school and do not require any special means. Therefore, it is recommended that parents, physical education teachers, instructors, occupational therapists, physiotherapists, and anyone who deals with these children apply for the balance training program as a treatment plan.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Yazd University (Code: IR.YAZD.REC.1398.014).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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