Original Article

# Balance Training Exercises and Mobility in Children with Visual Impairments: A Randomized Controlled Trial

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## ABSTRACT

**Purpose:** To evaluate the effects of Balance Training Exercises on mobility in open and closed environments in children with Visual Impairments.

**Study Design:** A Randomized controlled trial.

**Place and Duration:** Rising Sun Special School from December 2022 to May 2023.

**Methods:** A total of 24 children with visual impairments were randomly assigned to experimental and control groups. Pretest assessments using the Timed Up and Go (TUG) test and the Gross Motor Function Measure (GMFM-88) were conducted after an initial instructional session. The experimental group received both static and dynamic balance training exercises, while the control group received static balance exercises and walking training twice a week for eight weeks. Post test assessments were conducted after 16 training sessions.

**Results:** Significant improvements were observed in GMFM-88 scores for both the experimental and control groups in open and closed environments (p = 0.002 and 0.003, respectively). Similarly, TUG scores showed significant improvement (p = 0.000 and 0.001, respectively). The Mann-Whitney test showed no statistically significant difference between groups for GMFM-88 in open and closed environments (p = 0.154). Similarly, no significant difference was found for TUG scores (p = 0.154).

**Conclusion:** Balance training led to significant improvements in mobility within both groups in open and closed environments. However, between-group analysis showed no statistically significant differences. Despite this, clinical improvements in mobility were observed.

**Keywords:** Balance training exercise, Open and Close environment, Visual impairment, visually impaired children.

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## INTRODUCTION

The World Health Organization (WHO) defines visual impairment as a significant loss of vision that cannot be fully corrected with glasses, contact lenses, medication, or surgery. It includes both low vision and blindness.[1] WHO classifies visual impairment based on visual acuity and visual field loss. Visual acuity worse than 6/18 but equal to or better than 3/60 is moderate visual impairment and Visual acuity worse than 3/60 but better than light perception is Severe visual impairment. Engaging children with visual impairments in rhythmic exercises and physical activities is essential for promoting overall health and enhancing self-confidence. Regular participation in structured physical activities improves balance, coordination, and cardiovascular fitness while also fostering spatial awareness, motor skills, and social interaction. Additionally, rhythmic exercises contribute to better posture, mobility, and psychological well-being, ultimately supporting the child's independence and quality of life.[2] Visually impaired individuals often find it challenging to understand body movements and emotional expressions conveyed through gestures.[2] The intervention should be tailored to the individual needs of visually impaired individuals, focusing on balance and navigation. This includes exploring the home environment and developing a structured movement plan for training.[3] Motor development and training play a crucial role in this process, encompassing both fine and gross motor skills. Gross motor skills involve large skeletal muscles and are essential for activities such as crawling, walking, and maintaining posture while fine motor skills require the coordination of small skeletal muscles and are necessary for precise movements, such as typing or picking up small objects.[4] A well-structured intervention can enhance mobility, independence, and overall motor function, improving the individual's ability to navigate their surroundings effectively.

For visually impaired children, mobility is a big challenge, use of training and assistive tools help them to move easily in open and closed places. Recommendation for mobility include; orientation and mobility, white canes, environmental modifications, auditory assistance, guide and assistance dogs, peer support and socialization.[5] Children with visual impairments often experience balance difficulties and gait abnormalities, leading to postural deficits. Implementing both dynamic and static balance training can significantly enhance their mobility, stability, and overall postural control.[6] Balance board exercises along with small squats and knee bends can be helpful.[7] Each impaired youngster needs personalized direction and support in view of his or her capacities and requirements.

A 2022 study on physical activity in special education institutions examined the barriers faced by visually impaired children (VIC). Teachers identified key challenges, including limited peer support, inadequate access to appropriate spaces, and a lack of specialized equipment for physical activities and play.[8] Awareness among parents about the necessary interventions, lack of resources and financial constraints to provide them physical activities platforms were also reported. They recommended to add fun activities with motor activities for VIC.[9]

Most research on exercise and injury-related barriers has focused on older adults. To the best of the researchers' knowledge, there is limited literature addressing balance training in children with visual impairments. Additionally, previous studies have included sighted individuals in the control group, whereas this study aims to address this gap by including visually impaired children in both the experimental and control groups. Furthermore, there is a scarcity of research investigating the impact of balance training exercises on mobility in open and closed environments for children with visual impairments. Therefore, the aim of this study is to evaluate the effects of balance training exercises on mobility in these environments for visually impaired children.

## METHODS

This RCT was conducted after the approval from the ethical committee of Riphah International University, Lahore (**REC/RCR & AHS/23/0705).** The design was randomized controlled trial. Epitools software was used to calculate the sample size. Randomized Sampling technique was used to collect data. The clinical trial was registered prospectively at American register of Clinical Trials wide Trial identifier: **NCT05 787223. (https://classic.clinicaltrials.gov/ct2/show/record/NCT05787223**)

After getting permission from a special education school and written informed consent from parents' or guardians, a total of 24 patients were enrolled in this study and randomly divided into two groups with 12 patients in each group. Children aged 7 to 14 years, of both genders, with a visual acuity of 20/70 or worse (with correction), were included in the study. All participants were diagnosed as legally blind by an ophthalmologist.[10] The children included in the study were able to see at least one word, walk independently for short distances with or without assistive devices, and follow simple verbal instructions. Children who were unable to complete follow-up tests, had serious medical conditions such as uncontrolled seizures, cardiac diseases, or diabetes, or could not maintain age-appropriate behavior, were excluded from the trial. Additionally, children with orthopedic or neurological conditions that could affect balance, as well as those unable to follow commands during exercise performance, were also excluded.

In physical therapy unit of the study Centre,

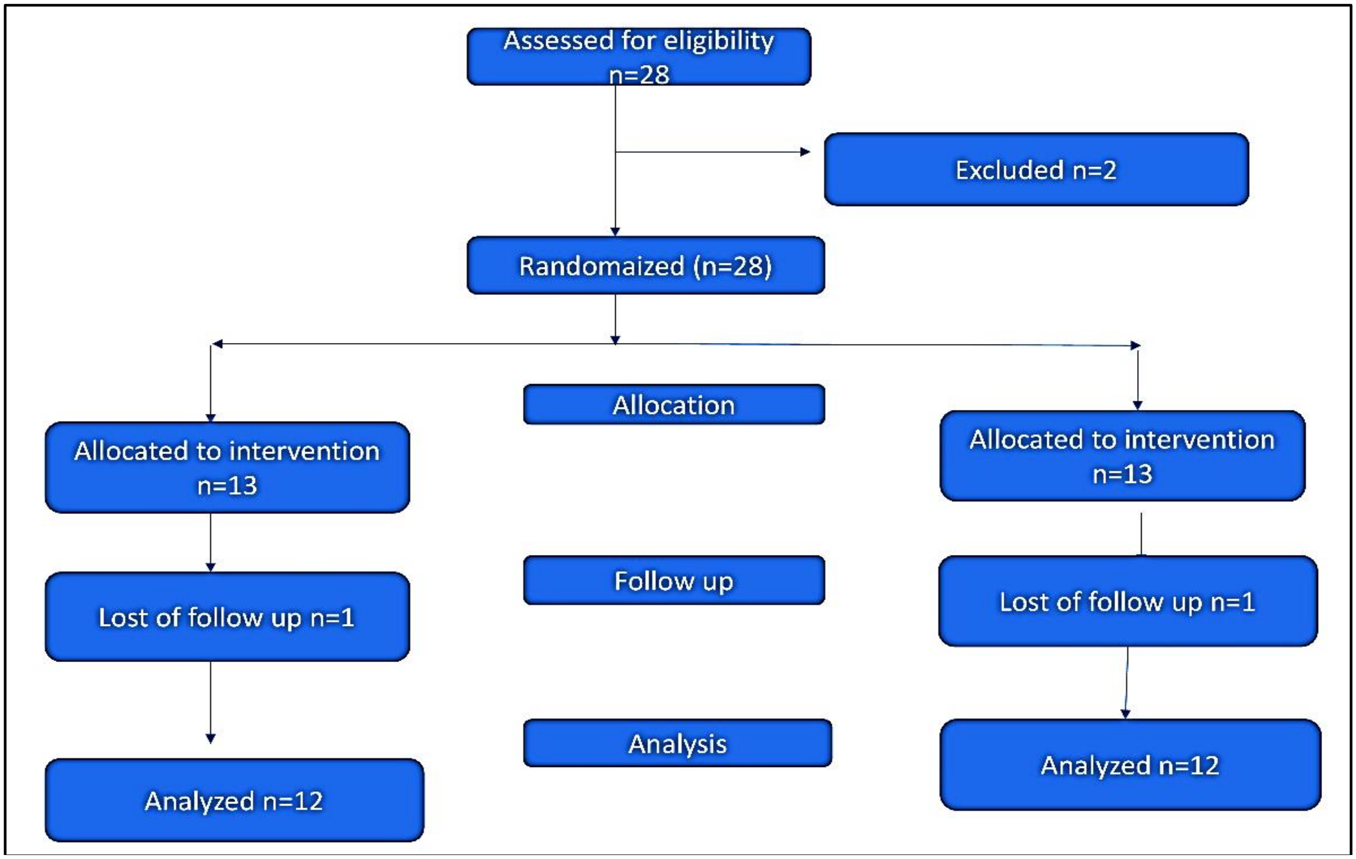


**Figure 1:** *CONSORT flow diagram.*

randomization was conducted using the sealed envelopes. Children were assigned randomly to the control and treatment groups in an equal ratio (Figure-1).

Pretests were conducted following the initial instructional session, with both the Timed Up and Go (TUG) test and the Gross Motor Function Measure (GMFM-88) assessed in both Group A (experimental) and Group B (control). Group A received both static and dynamic balance training exercises, while Group B received only static balance exercises and walking training twice a week for eight weeks. Post-test assessments were conducted after completing the 16 training sessions.

The Shapiro-Wilk test was used to assess the normality of the data. Qualitative data were presented as percentages and frequencies, while quantitative data were summarized as mean ± standard deviation.

## RESULTS

Pre- and post-treatment values for the GMFM-88 and TUG tests were evaluated, and the appropriate statistical tests were applied after assessing normality using the Shapiro-Wilk test. **Table 1** presents descriptive statistics, including age, gender, family history, BMI, and cousin marriage. **Table 2** shows the results of the Wilcoxon rank-sum test for group analysis in open and closed environments.

For the balance training treatment group in the open environment, the pre-treatment and post-treatment medians were 85.50 and 95.00, respectively, with mean ranks of 6.50 and 0.000, a Z-score of -3.066, and a p-value of 0.002 (significant). For the conventional treatment group in the open environment, the pre-treatment and post-treatment medians were 88.00 and 92.00, with mean ranks of 6.00 and 0.000, a.

In the closed environment, the balance training treatment group showed pre-treatment and post-treatment medians of 89.00 and 97.00, with mean ranks of 6.50 and 0.00, a Z-score of -3.063, and a p-value of 0.002. For the conventional treatment group in the closed environment, the pre-treatment and post-treatment medians were 90.00 and 94.00, with mean ranks of 6.50 and 0.00, a Z-score of -3.068, and a p-value of 0.002. These findings suggest significant improvements in both groups for balance training and conventional treatments, in both open and closed environments.

Table 3 shows pre and post treatment means and Standard deviation in both the experimental and control groups with p values of 0.000 and 0.001, respectively (Table 4(A)) shows Mann Whitney test between group analysis for GMFM-88-E-Open environment, p=0.154 (non-significant) and for close environment p=0.026 (Significant) respectively. Table 4(B) shows between group analysis for TUG for open and close environment. P-value 0.306 and 1.00 respectively which are non-significant for both.

**Table1:** *Baseline characteristics and Demographic Features (n=24).*

| Variables | n | Experimental Group (A) | Control Group (B) |
|---|---|---|---|
| **Age** | | | |
| • Mean±standard deviation (Years) | 24 | 10.75±2.41 | 11.33±1.96 |
| • Min-Max (years) | | 7-14 | 8-14 |
| **Gender** | | | |
| • Male | 13 | 6 | 7 |
| • Female | 11 | 6 | 5 |
| **Height** | 24 | 130.5cm | 140.2 cm |
| **Weight** | 24 | 30.16 kg | 34.41 kg |
| **BMI** | | | |
| • Underweight | 24 | 6 | 6 |
| • Normal | | 4 | 6 |
| • overweight | | 2 | 0 |
| **Cousin marriage** | | | |
| • Yes | 24 | 8 | 6 |
| • No | | 4 | 6 |
| **Family History** | | | |
| • Yes | 24 | 4 | 6 |
| • No | | 8 | 6 |

**Table 2:** *Intra-group comparisons using Wilcoxon sign rank test for GMFM for both open and closed environments.*

| **GMFM-OPEN-88** Groups | Treatment | Median | Mean rank | Z score | P value |
|---|---|---|---|---|---|
| Experimental | Before-Treatment | 85.50 | 6.50 | -3.063 | .002 |
| | After-Treatment | 95 | 0 | | |
| Control | Before--Treatment | 88 | 6 | -2.974 | .003 |
| | After-Treatment | 92 | 0 | | |
| **GMFM-CLOSE-88** | | | | | |
| Experimental | Before--Treatment | 89 | 6.50 | -3.063 | .002 |
| | After-Treatment | 97 | 0 | | |
| Control | Before--Treatment | 90 | 6.50 | -3.068 | .002 |
| | After-Treatment | 94 | 0 | | |

**Table 3:** *Inter group comparison for Balance using Paired Sample T-Test.*

| **Open Environment Time Up and Go Test** Group | Treatment | Mean | Std. Deviation | P-value |
|---|---|---|---|---|
| Experimental | Before-treatment | 14.33 | 3.65 | 0.000 |
| | After-Treatment | 11.58 | 3.42 | |
| Control | Before-Treatment | 11.83 | 2.88 | 0.001 |
| | After-treatment | 10.33 | 2.30 | |
| **Close environment Time Up Go and Test** | | | | |
| Experimental | Before-treatment | 11.83 | 2.65 | 0.001 |
| | After-Treatment | 9.58 | 1.26 | |
| Control | Before-Treatment | 11.16 | 2.96 | 0.000 |
| | After-treatment | 9.58 | 2.06 | |

**Table 4:** *Between Group comparisons using Mann-Whitney U Test.*

***A) GMFM-88 Total Scores.***

| Treatment | Group | Mean Rank | Median | Z score | P value |
|---|---|---|---|---|---|
| GMFM-E Open | Experimental Group | 14.54 | 95.00 | -1.42 | 0.154 |
| | Control Group | 10.46 | 92.00 | | |
| GMFM-E Close | Experimental Group | 15.67 | 97.00 | -2.219 | 0.026* |
| | Control Group | 9.33 | 94.00 | | |

***B) Independent Sample T-test For TUG in Open and Close environment in both groups.***

| Treatment | Group | Mean | Std. Deviation | P value |
|---|---|---|---|---|
| TUG-Open | Experimental Group | 10.33 | 2.30 | 0.306 |
| | Control Group | 11.58 | 3.42 | |
| TUG-Close | Experimental Group | 9.58 | 2.06 | 1.00 |
| | Control Group | 9.58 | 1.26 | |

## DISCUSSION

The research was conducted to determine the effects of balanced training exercise on mobility with visually impaired children. In this study, the terms “open environment” and “closed environment” refer to the types of settings where the balance training exercises were conducted, with distinct characteristics: Open Environment refers to a setting where external factors or obstacles (such as uneven surfaces, distractions, dynamic conditions) are present.[11] It mimics real-world situations where individuals need to balance and move in unpredictable environments. Closed Environment refers to a controlled setting where conditions are stable and predictable. The space is typically free from obstacles, and the environment is more structured, with less external interference. This allows for exercises that focus on improving balance without the added complexity of unpredictable or moving elements. The distinction helps assess how well children with visual impairments can improve their mobility and balance in both real-world and controlled settings.

The previous researchers compared the visually impaired children with normal sighted children, but current research studies only the visually impaired children so that effects of exercises on both groups can be studied and explored. The current research also provides treatment for both groups with difference of exercises. The TUG studies the level of mobility while GMFM test checks the improvement in the gross motor skill.

In Nepal, an eight-day dance therapy program for 24 visually impaired children significantly improved their balance.[12] Similarly, an eight-week balance training program incorporating both movement-based and non-movement exercises in children with congenital blindness demonstrated notable improvements in motor ability and overall movement skills.[13]

A 2021 study compared children with visual impairments (VIC) to sighted children in terms of balance, gait, navigation, physical movement, and body position control in various environments. Fourteen VIC children, aged 8 to 18 years, were assessed for single-leg stance time, postural sway, gait variability and stability, navigation performance, and self-reported physical activity. The results indicated that physical activity significantly improved gait, navigation, and balance in the VIC group.[14]

The games-based improve both dynamic and static balance in VIC. A systematic review determined the effective interventions for VIC within age range of eighteen and above eighteen years old. Dance, Yoga and Tai chi, can have positive results, particularly in balance and mobility. The reviewers recommended the need for large sample and longitudinal intervention base studies.[15]

Mansori et al, studied the effects of a 4-week vestibular exercise program on risk of falling, postural control, and quality of life in visually impaired individuals.[16] They focused upon improvement of gross motor skills using (TUG) Test, Biodex Balance System, and the quality of life questionnaire of 36-Item Short-Form Health Survey (SF-36)to assess the risk of falls, postural control, and quality of life respectively before and after the intervention. After four weeks of training, reassessment showed that exercise plays a significant role in enhancing balance but has no major impact on strength. The current research used an Eight-week training program and used same test (like TUG) to check the gross motor function. Between group results showed that physical activity-based exercise was highly effective for balanced training and within group comparison in open and close environments both groups showed significant results. The finding of current research are in line with previous research that in the experimental group gross motor skills improved with balanced training exercise.[17]

Surakka et al, (2018) investigated the effects of motivating visually impaired and deaf-blind individuals to engage in regular physical exercises. The study aimed to reduce challenges faced by visually impaired children in balance control, body posture, coordination, muscle tension, spinal alignment, and arm movement. Of the twenty-four children, half led an active lifestyle. After the training, physical activity, posture, and balance improved significantly in the previously inactive participants.[18]

Another study explored the effects of dynamic and static exercises on congenital blindness, using TUG test. The experimental group was given proper balance training which showed significant improvement in their balance. In the current study where TUG test had little improvement in closed environment, in open environment with TUG, performance of control group was better as compared to balanced training group.[13] The previous literature did not support the findings of TUG test assessment in open and close environment showing unique contribution in new literature.

A study conducted by Rutkowska in 2015 assessed balance function in individuals with visual impairment using the Bruininks-Oseretsky Test. Participants were divided into two groups based on WHO classification: partially sighted (61 participants) and blind (66 participants). The study found no significant differences between gender, age, and the degree of visual impairment. However, individuals who were partially sighted demonstrated better balance than those who were blind, with a decrease in visual acuity correlating with a reduction in balance skills. In contrast, the current study observed significant improvements in functional assessment, mobility, and balance in visually impaired children, particularly across different environments and through several types of balance training during the sessions.[19]

In a randomized controlled trial to study the effects of core stability training on postural control, risk of falling and function of the blind persons significant improvement was noted in function, postural control, and risk of falling in experimental group as compared to the control group ($p<0.05$).[20]

Limitations of the study include a small sample size, short duration, lack of long-term follow-up, and reliance on subjective assessments, which may affect the generalizability and sustainability of the findings.

However, it is important that clinicians address the concern of mobility and overall function in visually impaired children via different forms of dynamic training like walking, cross walk, and hopping. Balance training may be performed in regular routine in distinct types of environments. More studies should be conducted to explore strategies to reduce mobility issues and improve gross motor function in open and closed environments.

## CONCLUSION

Balance training within group analysis of both groups in an open and close environment shows improvement in mobility. The between group analysis is not statistically significant different on mobility in both groups but clinical improvement in mobility was observed.

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**Patient's Consent:**
Researchers followed the guidelines set forth in the Declaration of Helsinki.

**Conflict of Interest:** The authors declared no conflict of interest.

**Ethical Approval:** The study was approved by the Institutional review board/Ethical review board **(REC/RCR & AHS/23/0705)**.

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**Disclaimer:** The manuscript is based on post graduate research project.

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## Authors Designation and Contribution

Mubashra Tariq; Senior Physiotherapist: *Concepts, Design, Literature search, Data acquisition, Data analysis, Manuscript preparation.*

Fareeha Kausar; Lecturer: *Concepts, Design, Literature search, Statistical analysis, Manuscript review.*

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Sana Umar; Lecturer: *Literature search, Data analysis, Manuscript editing.*