INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

PREVALENCE OF VESTIBULAR DISORDER AMONG DEAF CHILDREN

Original Research

Mahnoor Muzammil[1], Anbreena Rasool*[2], Rimsha Zaheer[1]
[1]The University of Faisalabad
[2]Assistant Professor, Department of Rehabilitation Sciences, The University of Faisalabad

Corresponding Author: Anbreena Rasool, Assistant Professor, Department of Rehabilitation Sciences, The University of Faisalabad, assistant.professor.rehab.419@tuf.edu.pk
Acknowledgement: The authors sincerely thank the participating schools and children for their cooperation.

Conflict of Interest: None | Grant Support & Financial Support: None | Publication Date: 01-04-2025

ABSTRACT

Background: Vestibular disorders involve dysfunction of the inner ear or central nervous system structures responsible for maintaining balance. In children with hearing impairment, particularly those with sensorineural hearing loss, the auditory and vestibular systems are closely interconnected embryologically and anatomically. Despite this association, the assessment of balance issues in deaf children is often overlooked. Understanding vestibular involvement in this population is essential to ensure timely interventions that support motor development and prevent secondary complications.

Objective: To determine the prevalence of vestibular disorders among deaf children and assess their balance performance using clinical and functional tools.

Methods: A descriptive cross-sectional study was conducted over four months after ethical approval. A total of 141 deaf children aged 5 to 18 years were recruited through non-probability convenience sampling from two special education institutions in Faisalabad. Both male and female participants were included. Standardized tools were used to assess balance and vestibular function, including the one-leg standing test (eyes open and closed), tandem walking test, head impulse test, Pediatric Balance Scale, and the Pediatric Vestibular Symptom Questionnaire (PVSQ). Tests were performed with assistance from tutors, and questionnaires were translated into Urdu for better comprehension. Data were analyzed using SPSS, and Pearson correlation was used to assess the relationship between test scores.

Results: Of the 141 participants, 48.9% were male and 51.1% were female, with a mean age of 13.71 ± 2.69 years. Balance impairment was observed in 61.0% of children with eyes closed during the one-leg standing test, while only 30.5% showed impairment with eyes open. Normal tandem walking was observed in 55.3%, and only 3.5% were identified as fall risk. VOR impairment was present in 14.2% of children. Significant correlations were found between vestibular and balance tests ($p < 0.001$).

Conclusion: While a subset of deaf children exhibited vestibular dysfunction, the overall prevalence of balance impairment was low. The findings support the importance of early vestibular screening in children with hearing impairment to detect and manage balance issues effectively.

Keywords: Balance, Deafness, Dizziness, Falling, Pediatric Vestibular Disorders, Sensorineural Hearing Loss, Vertigo.

INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH
AND REHABILITATION

INTRODUCTION

Hearing loss, whether congenital or acquired, is a significant sensory impairment that affects millions of individuals globally. Among the known causes of permanent hearing loss, approximately 27% are attributed to genetic factors, while fetal infections, neonatal complications, middle ear infections, and otosclerosis account for additional proportions (1). Sensorineural hearing loss (SNHL), the most common form of congenital hearing impairment, affects about 3 in every 1,000 live births and often coexists with vestibular dysfunction due to the close anatomical and embryological relationship between the cochlea and vestibular organs (2,3). The vestibular system plays a pivotal role in balance and spatial orientation, and its dysfunction can severely impact gross motor development, postural control, and visual stabilization. In fact, 20% to 70% of children with SNHL have been reported to exhibit vestibular terminal dysfunction, highlighting the need for clinical attention to vestibular performance in this population (4,5). Balance control is a sophisticated integration of sensory input and motor responses, involving the vestibular, visual, and somatosensory systems. In deaf children, compromised vestibular input can hinder the development of essential motor milestones, resulting in delays in crawling, standing, and walking. Moreover, the inability to properly stabilize gaze or maintain body posture can further affect a child's ability to engage in learning and social interaction (6,7). Studies have shown that children with vestibular deficits often display symptoms such as dizziness, vertigo, or a general sense of imbalance, though these symptoms may remain unreported due to their limited communication abilities or lack of awareness. Consequently, affected children may be misperceived as clumsy or developmentally delayed, when in fact they are struggling with an underlying vestibular disorder (8,9).

Vestibular dysfunction in deaf children is not merely a physical concern; it intersects with cognitive and emotional development. Language deprivation, reduced exposure to motor learning opportunities, and overprotection by caregivers are factors that can further compound motor deficiencies in this group. Some children experience limitations in verbal conceptualization or spatial understanding, which are often essential for planning and executing complex motor tasks. The impairment of vestibular function may also negatively influence the development of self-concept and environmental exploration, contributing to psychological effects and social withdrawal (10-12). Assessment tools such as the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) and center of pressure (COP) measurements using force plates have been employed to evaluate balance and stability in deaf children. These tools help differentiate between those with intact vestibular systems and those with dysfunction, facilitating timely intervention and rehabilitation. The presence of bilateral hearing loss during crucial developmental years can hinder language acquisition, academic performance, and emotional growth, further emphasizing the need for early screening and management of vestibular dysfunction in this population (13,14).

Given the established link between sensorineural hearing loss and vestibular impairment, it becomes imperative to explore this relationship in more depth. Despite emerging evidence, vestibular dysfunction remains an under-recognized issue in clinical practice, particularly in pediatric audiology and rehabilitation. This study aims to determine the prevalence of vestibular disorder among deaf children, to understand its impact on their static balance abilities, and to examine the association between vestibular dysfunction and motor performance. The findings may contribute to improved screening protocols and targeted interventions for enhancing the quality of life in children with hearing impairment (15,16).

METHODS

A cross-sectional study was conducted to assess the prevalence of vestibular disorders among deaf children in Faisalabad. The study was carried out over a period of four months following ethical approval from the relevant institutional review board at The University of Faisalabad. The study sites included two specialized educational institutions: Government Boys Higher Secondary School for Hearing Impaired and Tanzeem-Al-Lissan, both located in Faisalabad. Data collection and testing were performed within the premises of these institutions, ensuring a familiar and accessible environment for the participants (17). A total of 141 deaf children, aged between 5 and 18 years, were recruited through purposive sampling. Both male and female participants were included, provided they met the defined inclusion criteria: confirmed hearing impairment (either congenital or acquired), within the specified age range, and willingness to participate through assent or guardian/tutor consent. Children were excluded if they were younger than 5 or older than 18 years, had recent surgery or trauma, cerebral palsy (due to potential confounding motor impairments associated with brain injury), leg length discrepancy, or declined consent. The exclusion of cerebral palsy was particularly important to isolate vestibular dysfunction from broader neurological motor deficits, as supported by evidence in relevant literature (18).

Data collection involved a combination of objective clinical tests and subjective assessment tools designed to evaluate vestibular function and balance. The one-leg standing test (with eyes open and closed) and the tandem walking test were used to assess static and dynamic balance. The head impulse test was performed to detect peripheral vestibular dysfunction by evaluating the vestibulo-ocular reflex (VOR). Additionally, the Pediatric Balance Scale was employed to assess balance performance in a structured manner, while the Pediatric Vestibular Symptom Questionnaire (PVSQ) was utilized to capture subjective vestibular symptoms reported by children or

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

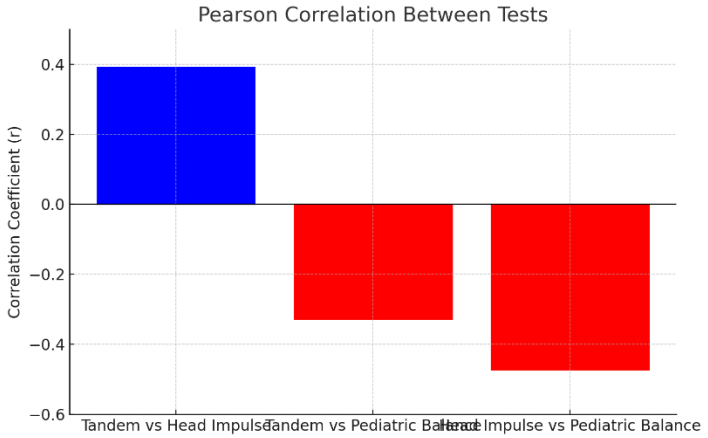
interpreted by guardians and tutors (19). All assessments were administered with the assistance of the children's tutors to ensure proper communication and understanding of the test procedures. For participants unable to comprehend English, the screening tools and questionnaires were translated into Urdu, maintaining semantic equivalence and clarity. Data collection was documented using structured data collection sheets, and information was gathered only after obtaining written informed consent from the child's guardian or tutor. For minors capable of understanding, verbal assent was also sought to promote ethical engagement in the research process (20). The data were systematically screened based on the inclusion and exclusion criteria prior to analysis. Statistical evaluation was planned to be conducted using appropriate software such as SPSS, with descriptive statistics to determine prevalence and inferential analysis to explore associations between variables where applicable (21).

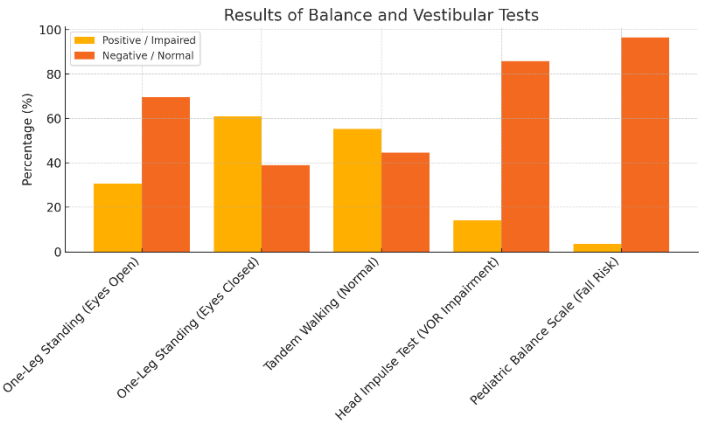
RESULTS

The study included a total of 141 deaf children, comprising 69 males (48.9%) and 72 females (51.1%), with a mean age of 13.71 ± 2.69 years and an age range of 6 to 19 years. Assessment of vestibular and balance function was conducted using multiple validated tools and clinical tests. The one-leg standing test revealed that 30.5% of participants exhibited balance difficulties with eyes open, while 61.0% showed impairment with eyes closed, indicating a significant reliance on visual input for postural stability. In the tandem walking test, 55.3% of children demonstrated normal gait and coordination, whereas 44.7% showed some level of instability. Evaluation of vestibulo-ocular reflex (VOR) through the head impulse test showed that 14.2% of participants had impaired VOR, while the majority, 85.8%, exhibited normal function. According to the Pediatric Balance Scale, only 3.5% of participants were categorized as being at risk of falling, suggesting overall functional balance in most children.

Pearson correlation analysis demonstrated a statistically significant weak positive correlation between the tandem walking test and the head impulse test ($r = 0.392$, $p = 0.000$), indicating that as vestibular function improved, tandem walking performance also improved. A weak negative correlation was observed between the tandem walking test and the Pediatric Balance Scale ($r = -0.328$, $p = 0.000$), and a similar negative relationship was noted between the head impulse test and the Pediatric Balance Scale ($r = -0.472$, $p = 0.000$), suggesting that impairments in vestibular function were associated with lower balance performance scores. These findings indicate that while a proportion of deaf children exhibited vestibular and balance impairments—particularly when visual compensation was removed—the majority maintained functional balance. However, the statistically significant correlations highlight the importance of screening for vestibular dysfunction, as even subclinical deficits may influence motor coordination and pose a risk to safety and development.

A subgroup analysis based on age and gender was conducted to explore potential differences in vestibular and balance function. When stratified by age, children aged 6–12 years demonstrated a higher prevalence of balance impairment on the one-leg standing test with eyes closed (68.2%) compared to those aged 13–19 years (54.1%), suggesting that younger children may rely more heavily on visual input for postural stability. Similarly, impaired tandem walking was more common in the younger age group (49.1%) versus older participants (40.5%). Gender-wise comparison revealed no significant difference in the prevalence of vestibular dysfunction, with males and females showing comparable rates of VOR impairment (14.5% vs 13.9%) and balance instability. The mean score on the Pediatric Balance Scale was 53.6 ± 3.4, indicating generally preserved functional balance across participants, while the mean duration for the one-leg standing test was 12.1 ± 4.6 seconds with eyes open and 6.3 ± 3.1 seconds with eyes closed. These findings support the role of age-related maturation in balance control and highlight the necessity for targeted early interventions in younger deaf children to mitigate developmental delays associated with vestibular dysfunction.





INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Table: Demographic Data of Participants

Variable	N	Mean ± SD / Percentage (%)	Range (Min–Max)
Age (years)	141	13.71 ± 2.69	6 – 19
Gender (Male)	69	48.9%	-
Gender (Female)	72	51.1%	-

Table: Summary of Testing Results

Test	Positive (%)	Negative (%)
One-Leg Standing (Eyes Open)	30.5%	69.5%
One-Leg Standing (Eyes Closed)	61.0%	39.0%
Tandem Walking (Grade 4 - Normal)	55.3%	44.7%
Head Impulse Test (VOR Impairment)	14.2%	85.8%
Pediatric Balance Scale (Fall Risk)	3.5%	96.5%

DISCUSSION

The present study evaluated vestibular dysfunction and balance impairment among deaf children and found that while certain participants exhibited mild to moderate challenges—particularly under conditions that removed visual input—most children maintained functional stability and a low risk of falls. These findings support the growing evidence that vestibular impairment may exist among children with hearing loss, especially bilateral sensorineural types, but do not necessarily translate into significant functional disability in all cases. A previously conducted study in 2012 reported a high prevalence of balance issues in deaf children, particularly in those with bilateral hearing loss; however, the current findings indicated a comparatively lower risk of functional balance impairment, suggesting that not all children with hearing loss are equally affected (22,23). The disparity may be attributed to differences in the sample composition, assessment tools, and inclusion of children with varying degrees and types of hearing loss in the present research. Corroborating findings from earlier research in 2011, this study also concluded that gender had no significant influence on balance performance, further reinforcing the idea that vestibular dysfunction in this population is more closely associated with developmental and sensory integration factors than sex-related differences (24). Additionally, consistent with prior literature, the current study observed age-related trends, with older children showing better balance capabilities than younger participants, which may reflect neuromotor maturation and compensatory adaptations over time (25).

Compared to another relevant study assessing vestibular characteristics using the single-leg standing test, the proportion of children exhibiting abnormal balance with eyes open was lower in the present research (30.5% vs. 44.1%). However, a notable contrast was observed with eyes closed, where the present study reported a substantially higher rate of impairment (61.0% vs. 35.3%) (26). This suggests a potential over-reliance on visual input for balance maintenance among deaf children, possibly due to underlying vestibular underperformance or sensory compensation. The discrepancy in findings across studies highlights the need for standardized protocols, consistent diagnostic thresholds, and stratification of participants based on the degree and onset of hearing loss to facilitate clearer comparisons (27). The present research offers several strengths, including the use of multiple validated tests such as the head impulse test, pediatric balance scale, and pediatric vestibular symptoms questionnaire, allowing for a comprehensive evaluation of vestibular and balance performance. The involvement of a relatively large sample size and inclusion of both genders across a broad age range enhances the generalizability of findings. However, limitations were also identified. This study primarily assessed static and functional balance but did not include dynamic gait analysis or instrumented vestibular testing, which could have offered more nuanced insights into vestibular system integrity. Additionally, logistical challenges such as time constraints, coordination issues with educational institutions, and the need for interpreters or supervisors for effective communication with deaf participants may have impacted the assessment process. Another limitation was the lack of follow-up to determine long-term balance outcomes or response to interventions (28).

Future research should aim to conduct multicenter studies across different cities to enhance external validity. It is recommended to incorporate vestibular function testing with advanced diagnostic tools such as videonystagmography or rotary chair testing and to examine the influence of variables such as the etiology of deafness, use of hearing aids or cochlear implants, and physical activity levels

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

on balance outcomes. Longitudinal studies would also be beneficial to track the progression or improvement of balance performance over time and assess the effectiveness of vestibular rehabilitation strategies tailored to the pediatric deaf population (29,30). Overall, the findings of this study underscore the importance of early screening and targeted management of vestibular disorders in deaf children, especially those exhibiting subtle balance difficulties. By addressing these impairments early, clinicians and educators can support optimal motor development, prevent secondary functional limitations, and improve the overall quality of life for affected children.

CONCLUSION

This study concluded that while vestibular impairments do exist among some deaf children, the majority demonstrate adequate balance and functional stability. The findings emphasize the importance of incorporating vestibular assessment into routine evaluations for children with hearing impairment, as early identification of balance-related challenges can guide timely interventions. Addressing vestibular dysfunction at an early stage may support better motor development, reduce the risk of functional limitations, and contribute to overall well-being and academic participation in this vulnerable population.

AUTHOR CONTRIBUTIONS

Author	Contribution
Mahnoor Muzammil	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Anbreena Rasool	Methodology, Investigation, Data Curation, Writing - Review & Editing
Rimsha Zaheer	Investigation, Data Curation, Formal Analysis, Software

REFERENCES

1. Pinninti S, Christy J, Almutairi A, Cochrane G, Fowler KB, Boppana S. Vestibular, Gaze, and Balance Disorders in Asymptomatic Congenital Cytomegalovirus Infection. Pediatrics. 2021;147(2).

2. Martens S, Maes L, Dhondt C, Vanaudenaerde S, Sucaet M, De Leenheer E, et al. Vestibular Infant Screening-Flanders: What is the Most Appropriate Vestibular Screening Tool in Hearing-Impaired Children? Ear Hear. 2023;44(2):385-98.

3. Wiener-Vacher SR, Campi M, Caldani S, Thai-Van H. Vestibular Impairment and Postural Development in Children With Bilateral Profound Hearing Loss. JAMA Netw Open. 2024;7(5):e2412846.

4. Li YH, Liu B, Yang Y, Chen M, Liu W, Shao JB, et al. Vestibular function of pediatric patients with sudden sensorineural hearing loss: based on vertigo symptom and vestibular function testing. World J Pediatr. 2021;17(6):637-42.

5. Karpeta N, Asp F, Edholm K, Bonnard Å, Wales J, Karltorp E, et al. Vestibular function in children with vestibulocochlear nerve aplasia/hypoplasia. Acta Otolaryngol. 2023;143(10):861-6.

6. Chisari D, Vitkovic J, Clark R, Rance G. Vestibular function and balance performance in children with sensorineural hearing loss. Int J Audiol. 2024;63(11):875-83.

7. Hazen M, Cushing SL. Vestibular Evaluation and Management of Children with Sensorineural Hearing Loss. Otolaryngol Clin North Am. 2021;54(6):1241-51.

8. Singh A, Raynor EM, Lee JW, Smith SL, Heet H, Garrison D, et al. Vestibular Dysfunction and Gross Motor Milestone Acquisition in Children With Hearing Loss: A Systematic Review. Otolaryngol Head Neck Surg. 2021;165(4):493-506.

9. Duarte DSB, Cabral AML, Britto D. Vestibular assessment in children aged zero to twelve years: an integrative review. Braz J Otorhinolaryngol. 2022;88 Suppl 3(Suppl 3):S212-s24.

10. Takahashi M, Sato G, Toda N, Azuma T, Nakamura K, Iwasaki H, et al. Vestibular and cochlear nerve enhancement on MRI and its correlation with vestibulocochlear functional deficits in patients with Ramsay Hunt syndrome. Auris Nasus Larynx. 2021;48(3):347-52.

11. Barozzi S, Soi D, Intieri E, Giani M, Aldè M, Tonon E, et al. Vestibular and audiological findings in the Alport syndrome. Am J Med Genet A. 2020;182(10):2345-58.

12. Stahl MC, Otteson T. Systematic Review on Vestibular Symptoms in Patients With Enlarged Vestibular Aqueducts. Laryngoscope. 2022;132(4):873-80.

13. Singh A, Heet H, Guggenheim DS, Lim M, Garg B, Bao M, et al. A Systematic Review on the Association Between Vestibular Dysfunction and Balance Performance in Children With Hearing Loss. Ear Hear. 2022;43(3):712-21.

14. Patterson JN, Chen S, Janky KL. Stability of Vestibular Testing in Children With Hearing Loss. Am J Audiol. 2022;31(4):1155-66.

15. Hope SJ, Govender S, Taylor RL, Kwok BYC, Pogson JM, Nham B, et al. The role of cochlear and vestibular afferents in long-latency cervical vestibular evoked myogenic potentials. Int J Audiol. 2025;64(3):201-8.

16. Melo RS, Lemos A, Raposo MCF, Monteiro MG, Lambertz D, Ferraz KM. Repercussions of the Degrees of Hearing Loss and Vestibular Dysfunction on the Static Balance of Children With Sensorineural Hearing Loss. Phys Ther. 2021;101(10).

17. Sumalde AAM, Scholes MA, Kalmanson OA, Terhune EA, Frejo L, Wethey CI, et al. Rare Coding Variants in Patients with Non-Syndromic Vestibular Dysfunction. Genes (Basel). 2023;14(4).

18. Kim SH. Posterior Cranial Fossa Meningioma Presenting With Hearing Impairment and Recurrent Vertigo. Ear Nose Throat J. 2020;99(6):353-5.

19. Kalinousky AJ, Luperchio TR, Schrode KM, Harris JR, Zhang L, DeLeon VB, et al. KMT2D Deficiency Causes Sensorineural Hearing Loss in Mice and Humans. Genes (Basel). 2023;15(1).

20. Alonso AV, Aguado RG, Camerano AM, Enseñat JF, de la Fuente EO, Angulo CM. Hearing and Vestibular Impairment Related to a Variant (c.263G>C) of the COCH Gene. Otolaryngol Head Neck Surg. 2025;172(3):982-92.

21. Obeidat FS, Bell SL, Julie E. An exploration of vestibular function pre and post unilateral cochlear implantation. Cochlear Implants Int. 2020;21(5):281-91.

22. Mohamed ST, Hazzaa N, Abdel Rahman T, Ezz Eldin DM, Elhusseiny AM. Efficacy of vestibular rehabilitation program in children with balance disorders and sensorineural hearing loss. Int J Pediatr Otorhinolaryngol. 2024;179:111931.

23. Kelly EA, Janky KL, Patterson JN. The Dizzy Child. Otolaryngol Clin North Am. 2021;54(5):973-87.

24. Park SM, Han JH, Lee JK, Choi BS, Bae YJ, Choi BY. Correlation between the etiology of severe hearing loss and endolymphatic hydrops. Eur Arch Otorhinolaryngol. 2025;282(2):781-7.

25. Hu CY, Lien KH, Chen SL, Zhang BY, Chan KC. Complications and prognosis associated with intra-tympanic steroid injection to treat sudden sensorineural hearing impairment. Am J Otolaryngol. 2022;43(1):103221.

26. Lim KH, Jeong YJ, Han MS, Rah YC, Cha J, Choi J. Comparisons among vestibular examinations and symptoms of vertigo in sudden sensorineural hearing loss patients. Am J Otolaryngol. 2020;41(4):102503.

27. Tsukada K, Nishio SY, Takumi Y, Usami SI. Comparison of vestibular function in hereditary hearing loss patients with GJB2, CDH23, and SLC26A4 variants. Sci Rep. 2024;14(1):10596.

28. Pinninti SG, Britt WJ, Boppana SB. Auditory and Vestibular Involvement in Congenital Cytomegalovirus Infection. Pathogens. 2024;13(11).

29. Aldè M, Di Berardino F, Ambrosetti U, Barozzi S, Piatti G, Zanetti D, et al. Audiological and vestibular symptoms following SARS-CoV-2 infection and COVID-19 vaccination in children aged 5-11 years. Am J Otolaryngol. 2023;44(1):103669.

30. Wu SS, Mahomva C, Sawaf T, Reinshagen KL, Karakasis C, Cohen MS, et al. Association of Ear Anomalies and Hearing Loss Among Children With 22q11.2 Deletion Syndrome. Otolaryngol Head Neck Surg. 2023;168(4):856-61.

