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# Growing evidence for balance and vestibular problems in children

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# Growing evidence for balance and vestibular problems in children

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**Abstract**
Reports of vestibular deficits and related impairments in children are increasing in number. However, vestibular dysfunction in childhood appears to be an under-reported and overlooked entity. This report provides an overview of current literature regarding the incidence of vestibular deficits in children, the related impairments of gaze stability and balance and intervention for vestibular related impairments in children.

**Key words:** *vestibular, balance, gaze stability, children, vestibular rehabilitation*



## Introduction

Vestibular deficits, related impairments and the efficacy of therapy intervention for related impairments are well documented in adults (1–3). Adults with vestibular deficits present with gaze stability deficits that disrupt reading, balance deficits, and often complain of disequilibrium, vertigo and/or a feeling of disorientation to position in space. However, only recently have these problems been documented in children (4–10). Investigators have reported a high incidence of vestibular hypofunction in children with sensorineural hearing loss (8,11). Additionally, there are increasing reports of vestibular problems in children, to include vertigo attacks (6), benign positional vertigo (12), vestibular neuritis (13), familial early-onset progressive vestibulopathy (14), and otitis media (10,15). Despite reports that, as a consequence of vestibular deficits, children have poor gaze stability that affects reading (7), and impairments of motor development and balance (8,9,16), children are typically not screened or evaluated for vestibular deficits. Consequently, vestibular dysfunction in childhood is an overlooked entity (17) and intervention to ameliorate these impairments is not provided. The purpose of this article is to provide a review of vestibular deficits and related impairments in children, and the efficacy of intervention.

The peripheral vestibular system includes the semicircular canals and otoliths, which mediate the vestibular ocular reflex and vestibulo-spinal responses. Thus, the vestibular system is critical for gaze stabilization and postural control or balance. Damage to this system results in functional impairments of gaze and balance abilities. Comprehensive testing of vestibular function should include tests of canal and otolith function for diagnostic purposes, and functional evaluation to identify impairments warranting therapeutic intervention. When adults present to their healthcare provider with complaints of oscillopsia, imbalance, and dizziness, appropriate referral for vestibular testing is usually implemented. However, young children will not complain of visual disturbances since they are not really aware that there is a problem. Furthermore, since most children with vestibular deficits do develop walking ability, problems are not noted, even though they may avoid play on items off the ground outdoors (i.e. swinging) or appear clumsy. Consequently, vestibular testing is not performed, despite the documentation of significant impairments that impede school progress and negatively impact the child's ability to play with other children.

## Hearing loss

Results of investigations (7,8,18–23) have shown that children with hearing loss have a balance and/or motor deficit that may be progressive. More recently, a deficit in dynamic visual acuity has also been documented in this group (7,23). In children with sensorineural hearing loss (SNHL), concomitant damage to vestibular structures is reportedly common (11,20,24,25). Since damage to vestibular structures is known to affect motor and balance ability (26,27), it has been postulated as a primary

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cause of these deficits in this population (8,28). In a cross-sectional study by Rine et al. (21), children with SNHL and vestibular hypofunction (VH) scored significantly lower than the normative sample on the Gross Motor Scale of the Peabody Developmental Motor Scales (29), and the delay was less in the older children. However, longitudinal examination (8) revealed that the developmental delay was progressive (i.e. standard scores were lower one year later) in those with canal VH. Interestingly, several children without canal VH also had a progressive delay. Thus, identification of deficits may be confounded by cross-sectional versus longitudinal testing and testing of canal and otolith vestibular function. Similarly, Horak et al. (20), Crowe and Horak (25), and Rine (9) examined vestibular, motor and balance function in children with VH and reported that, like adults, children with canal vestibular deficit had abnormally increased sway only on posturography test conditions relying on vestibular information. Using dynamic balance testing, Rine et al. (9,30) found that in children with SNHL, the response of tibialis was later and larger, and the relative latency of soleus and tibialis anterior was larger in children with vestibular loss compared to peers without vestibular loss. Most experienced a complete loss of balance even with eyes open (9). More recently, impairments of gaze stability have also been reported in this group.

The ability to maintain a stable visual image with head movement, as in walking, is dependent upon an intact vestibular ocular reflex. Recently, the DVA test was found to be a valid assay of individual semicircular canal function when the head was passively moved in the plane of the each of the canals, compared with scleral search coil data (31). Finally, DVA score has been shown to be inversely related to VOR gain (eye velocity/head velocity) (32). Rine and Braswell (33) developed a reliable and valid clinical DVA test for use with children 3–12 years of age and reported a DVA deficit in young children with SNHL and canal VH (33). Furthermore, a relationship between deficits of DVA and reading acuity was found (7,34). Children with canal VH had a significant increase in critical print size and reading acuity, indicating that they require larger print to read comfortably. These preliminary data enhance the argument of the importance of the identification of VH in young children. Clearly, to adequately examine the consequent impairments due to VH in children, tests of gaze stability must be included. It is also important to note that children with severe to profound sensorineural hearing loss are candidates for cochlear implant surgery, as are adults with severe loss of hearing. This surgery may disrupt any remaining vestibular function (35,36). Reportedly, patients with cochlear implants have symptoms of dizziness and imbalance (35,36). Vibert et al. (36) reported disruption of canal vestibular function in 43% of cases after implantation.

## Otitis media

Otitis media with effusion (OME) is the most common reason that medical care is sought for young children. Several investigators have reported vestibular impairment in children as a consequence of OME. Cohen et al. (10) reported a significant impairment of balance, based on standardized testing, in young children with bilateral OME, despite parent report of no problem. Casselbrant et al. (37) evaluated postural control using dynamic posturography pre- and post-tympanostomy tube insertion in children with OME. These investigators reported significantly impaired balance in conditions requiring vestibular control (e.g. sway platform and/or visual surround). Golz et al. (38) evaluated vestibular function using ENG, and development using the Bruininks-Oseretsky Test of Motor Proficiency, of children with OME. These investigators found aberrant ENG and motor development results in a majority of the children, with resolution of the impairments in most following tube insertion. Furthermore, Casselbrandt et al. (39) reported persistence of these impairments even when children with chronic OME were free of effusion. However, in none of the studies was the effect of VH on gaze stabilization examined. Despite this limitation, these reports support that chronic OME has a significant effect on development. However, vestibular testing is rarely performed on this group of children, and the children are not typically referred for rehabilitation. Thus the developmental consequences of VH are not resolved.

## Vestibular deficits in children – increasing reports

In a recent report, Weiss and Phillips (17) reported on five children with unique clinical presentations (e.g. fluctuating visual acuity and intermittent nystagmus, congenital hearing loss, neurotropic keratitis, ataxia following mild traumatic brain injury and episodic vertigo). In all cases, vestibular deficits were confirmed by rotary testing. Balatsouras et al. (40) reported that the most common causes of vertigo in children were viral infections, benign paroxysmal vertigo of childhood and migraine. Otitis media, head trauma, benign paroxysmal positional vertigo, Ménière's disease and brain tumor were less common causes. Brantberg (14) reported a case of familial early-onset progressive

vestibulopathy without hearing loss in two young sons (eight and 10 years of age). The father had a previously undiagnosed VH evident by diminished VEMP responses and low gain on rotary testing. Both boys had delayed motor development and vertiginous episodes. Monobe and Murofushi (13) provided a case report of a three-year-old with vestibular neuritis who presented with rapid onset nausea, vomiting, ataxia and parent notation of nystagmus. The child was otherwise healthy and had achieved normal developmental milestones. On examination, the following was noted: left beating resting nystagmus, left beat nystagmus in the dark on ENG testing, no response to ice water on caloric testing, and absent VEMP response on the right side. Clearly, with increased awareness, there is an increase in the acknowledgement of vestibular deficits in young children. However, as noted above, vestibular dysfunction in children is most likely an overlooked entity. Consequently, intervention, known to be efficacious for the amelioration of balance and visual impairments, is not provided.



## Intervention for balance gaze stability impairments

There is ample support for the efficacy of vestibular rehabilitation for the amelioration of disequilibrium, vertigo and balance in adults with VH. Rehabilitation programs (41–44) have focused on the reduction of vertigo and disorientation, re-establishment of symmetry within the VOR and vestibulospinal pathways, and improved postural control abilities. However, investigation of intervention for the balance deficits in children has been minimal. Lewis et al. (45) reported that participation in a balance and body awareness program resulted in significant improvement in balance skills in 6–8-year-old children with hearing impairment. The program by Lewis et al. (45) included activities requiring multiple sensory use (e.g. standing balance on foam), and thus substitution. It is possible that most subjects had VH, but neither vestibular function nor the nature of the hearing loss was measured. In a controlled study using a wait-listed design, Rine et al. (46) found that participation in exercise intervention resulted in an arrest of the progressive developmental delay, and improvement in postural control measures. The children participating in placebo intervention achieved motor development standard scores that were lower than at initial testing.

Using a wait-listed double-blind design, Rine et al. (46) tested motor development and postural control pre- and post-intervention. Intervention focused on substitution, with enhancement of the use of vision and somatosensation for balance. Somatosensory and vision effectiveness for postural control was improved and the progressive motor delay was arrested following participation in exercise intervention. These investigators also found that improvement of results on dynamic balance testing was due to an earlier activation of hamstring muscles, to compensate for the delayed tibialis anterior. Subjects who stepped or experienced a loss of balance pre-intervention completed the test without stepping or falling (9).

Improvement of gaze stability following exercise has also been reported in adults with VH (23,47). Herdman et al. (47) reported improved DVA following exercise intervention in adults with unilateral VH. They attributed improvement to centrally programmed eye movements that substitute for the deficient VOR. Herdman et al. (48) also reported improved DVA in adults with bilateral VH following exercise, not placebo intervention. Braswell and Rine (23) reported that DVA and reading acuity improved in a child with SNHL and bilateral VH since the age of one year. Although reading acuity improvement was significant in a second child with SNHL and VH since birth, DVA improvement was not significant. Although limited, this report provides preliminary evidence of improved gaze stability in children with VH following exercise intervention that may impact success in the educational setting.

## Summary and conclusion

In summary, there is a growing body of evidence that children do have vestibular deficits. Furthermore, this vestibular deficit has a significant effect on the development of balance and other gross motor abilities and impacts visual acuity. However, current practice does not include referral for vestibular testing for children with diagnoses known to have a high incidence of vestibular deficit (e.g. OME, sensorineural hearing loss). Unless acute symptoms (e.g. vomiting, nausea, vertigo) are present, parents do not notice or report problems. Furthermore, preliminary reports suggest that functional improvement can be achieved via participation in vestibular rehabilitation focused on substitution and adaptation exercises. However, additional work is needed to examine the long-term effects of intervention and whether rehabilitation of longer duration can yield similar positive results as those seen in adults with VH. Clearly, children do have vestibular deficits. Vestibular testing is warranted in all children with SNHL, and vestibular screening should be performed on all children with OME. Furthermore, once vestibular symptoms or deficits are identified, the children should be referred for testing of balance,

motor development and gaze stability, with intervention provided as warranted.

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