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## DISORDERS

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### PEDIATRIC VESTIBULAR DISORDERS

More than 1 in 20 (nearly 3.3 million) children between the ages of 3 and 17 have a dizziness or balance problem.

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## ARTICLE

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# Part I: Pediatric Vestibular Disorders

**Vestibular impairments in children:** incidence, diagnoses, assessment and intervention

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## ABSTRACT

### INTRODUCTION

Until recently, most medical professionals assumed that problems with vestibular function primarily affect adults, with only a small number of children being affected. However, there is growing evidence of vestibular system dysfunction in children, with consequent problems with gaze stability (seeing clearly with head movement), balance ability and/or the development of balance abilities, and dizziness.

### PURPOSE

The purpose of this three part series for parents, patients and professionals is to provide a brief review of the diagnoses known to affect vestibular function in children, the incidence of these diagnoses, and appropriate evaluation of and intervention strategies for vestibular problems in children. Specifically, we will discuss common symptoms and impairments experienced by children with vestibular dysfunction as well as valid and reliable clinical and diagnostic tests to quantify the extent of these impairments. Finally, we will discuss evidence based treatments known to improve vestibular related impairments in children.

### SUMMARY

Parents and pediatric health care professionals should be aware of the signs and symptoms of vestibular impairments so that referrals to appropriate professionals can be sought, enabling appropriate diagnosis and provision of appropriate interventions.



## COMMON SYMPTOMS

- **Vertigo**
- **Dizziness**
- **Imbalance**
- **Delayed motor development**
- **Impaired visual acuity during head movement**

### INCIDENCE OF VESTIBULAR DYSFUNCTION IN CHILDREN

The vestibular system enables balance abilities and stabilization of visual images when an individual is moving his/her head. When the function of the vestibular system is disrupted, adult patients experience dizziness or vertigo (a moving or spinning sensation), clumsiness or problems with balance, and difficulty with reading.<sup>1-3</sup>

The majority of studies and advancements in the evaluation and treatment for vestibular dysfunction have focused on adults. There are increasing reports of vestibular deficits and related functional impairments in children, and a recent report by Li et al.<sup>4</sup> suggests that as many as 1 in 5 children in the United States have problems with dizziness or balance. Interestingly, only 36 percent of the children in whom these problems were noted had seen a health professional for the problem. This is of concern since problems with balance, motor development, gaze stability and reading acuity have been reported consequences of vestibular deficits in children.<sup>5-11</sup>

It is evident that vestibular deficits do occur in children, and most are not receiving the medical and rehabilitation services that are warranted. To address this issue, it is important to identify the incidence of the problem, the diagnoses, presentation and symptoms.

Deficits of the vestibular system can be due to problems with the peripheral nervous system (i.e. the inner ear and/or the nerve that travels to the brainstem) or in the central nervous system (i.e. neural pathways that travel throughout the brain and spinal cord). The signs and symptoms differ based on the location of the problem (i.e. peripheral or central) and can change from the

acute (within days of onset) to chronic (weeks post onset) stage of the condition. The differences and changes in signs and symptoms can complicate the identification of children for whom comprehensive testing is warranted. It is, therefore, important to screen children at risk for disruption of vestibular function. Children at risk are those with **vestibular symptoms** (e.g. dizziness, balance problems, visual instability), and those with diagnoses known to have the potential for vestibular dysfunction.

### SYMPTOMS AND FUNCTIONAL LIMITATIONS RELATED TO VESTIBULAR DEFICITS IN CHILDREN

The most common symptoms of vestibular dysfunction in children are:

- Vertigo
- Dizziness
- Imbalance
- Delayed motor development
- Impaired visual acuity during head movement

**Vertigo** is typical of one sided damage to the peripheral vestibular system in the acute stage (within days of disruption), but can be evident in central lesions as well. It is a perceptual distortion of movement that can be due to a dysfunction of one or several sensory systems that contribute to the ability to balance (i.e. vestibular, vision, somatosensation), or of central nervous system structures involved in balance abilities.

A problem with the vestibular system can result in sensations of intense spinning, falling, or rolling, which can be brief or last several hours or days. In the acute stage of damage to one side of the peripheral vestibular system, this sensation is often accompanied by eye movements called **nystagmus** (i.e. a rhythmic moving of the eyes left to right or up-down).

Vertigo can also be a result of vision problems, particularly with asymmetric vision, or convergence problems (i.e. the person is unable to move both eyes inward to have them clearly focused on a near or far target).

**Visual vertigo** is often associated with visual overload (e.g. long sessions with video games, television or reading). However, a visual deficit should NOT result in rotary vertigo (spinning sensation) lasting hours.



Adults can readily report and clarify vertigo symptoms, but this is not the case for young children. For very young children who cannot describe what they are feeling, vertigo may be demonstrated by clinging to parent or caregiver, refusing to stand up, or falling asleep. The older child may say that “the house is moving” or “I am falling.” It is also important to note when the sensation occurs and for how long. Intense, constant spinning suggests recent damage to one side of the peripheral system, which is never seen with vertigo due to problems in the visual system.



Vertigo that may be described by a child or adolescent as “in my head” and the room or surroundings are not moving may be due to **migraine equivalent, oculomotor problems, or orthostatic hypotension** (i.e. drop in blood pressure when getting up to stand), and is often associated with a headache. In some cases, the sensation of vertigo can be associated with nausea, loss of appetite, vomiting, abdominal pain (e.g. child states that ‘my tummy hurts’), and/or headaches. However, if damage to the peripheral vestibular system is **bilateral** (both sides) or central, there may be no vertigo. However, the child will experience constant instability or loss of balance.

### **BALANCE AND MOTOR DEVELOPMENT**

Problems with the development of balance ability or a change in balance ability may be associated with disruption of vestibular function that is unilateral or bilateral and peripheral, or of central vestibular system disruption.

Rine and colleagues<sup>8-12</sup> noted that children with **bilateral peripheral vestibular hypofunction** since or shortly after birth have significant delays in the development of balance and other motor abilities. Similar findings were reported by Christy et al,<sup>6</sup> Janky and Givens,<sup>7</sup> and Cushing et al.<sup>13</sup> Cassel

Brandt et al<sup>5</sup> reported that children with **disruption of vestibular function secondary to chronic otitis media** also have problems with balance abilities. This problem was persistent in children who had multiple surgeries for the otitis media with **effusion** (an infection of the air-filled space behind the eardrum).

It is interesting to note that Wiener-Vacher et al<sup>14</sup> reported that in children with no impairment of vestibular function, maturation of the **otolith vestibular organs** (utricle and saccule) correlated with the onset of walking. The importance of otolith vestibular function to walking and balance ability is further supported by Shall<sup>15</sup>, who reported impaired motor development abilities in children with loss of vestibular function, particularly the otolith organs, at or shortly after birth.

### **GAZE STABILITY ISSUES OR OSCILLOPSIA**

Gaze stability problems due to disruption of vestibular function is called **oscillopsia**, or **perceived oscillating movement** or ‘jumping’ of objects that are not moving. Oscillopsia is a reported symptom in children with dysfunction of the vestibular system.<sup>7,16,17</sup>

Braswell and colleagues<sup>17,18</sup> noted that in children, **vestibular hypofunction** correlated with impaired visual acuity during head movement and diminished reading acuity. This could impede the child’s school performance (e.g. reading). Franco and Panboca<sup>19</sup> found that of children underperforming in school, 68% had vestibular deficits confirmed by diagnostic testing.

In summary, it is well established that as a consequence of disruption of vestibular function, children may present with all, some, or one of the following: **vertigo, dizziness, balance problems, motor development delay, and visual acuity concerns**. Although it may be recommended that all children with these symptoms be screened for potential disruption of vestibular system function, it is also important to note the diagnoses that have a significant incidence of disruption of vestibular function.

### **DIAGNOSES AND COMMON ETIOLOGY OF VESTIBULAR DYSFUNCTION IN CHILDREN**

Several investigators have examined the type, etiology and incidence of vestibular dysfunction in children. Anoh-Tanon et al<sup>20</sup> reported that of 523 children with complaints of vertigo and



imbalance, 95% had some form of vestibulopathy. Wiener-Vacher<sup>21</sup> reviewed the records of children seen in otolaryngology clinics over a 14 year period and found that the most prevalent causes of vertigo were **migrainous equivalent** (25%), **benign paroxysmal vertigo of childhood** (20%), **head injury with fracture of temporal bone** (10%), **congenital malformations** (10%), **ophthalmological problems** (10%), and **vestibular neuritis** or **labyrinthitis** (presenting as ear infection or otitis media with effusion) (8%). Similar findings were reported by Riina et al<sup>22</sup> and Salami et al<sup>23</sup> although the ordering or sequencing of the first four conditions was varied. Other pediatric diagnoses associated with peripheral vestibular dysfunction include **severe to profound sensorineural hearing loss**, **congenital cytomegalovirus**, **late-preterm birth**, and **global developmental delay**.<sup>24</sup> **Ototoxic medications** used to treat disorders such as childhood cancer, cystic fibrosis and meningitis might also damage the peripheral vestibular system.<sup>25,26</sup> A review by McCaslin et al<sup>27</sup> concurred with these findings and also describe vestibular related impairments in children with **traumatic head injury and concussion**.

## VESTIBULAR MIGRAINE

**Vestibular migraine** is characterized by vertigo and/or imbalance that can last for seconds to days. Typically, these symptoms are independent of, or not temporally correlated with, headache.

This diagnosis has been investigated and reported by several groups.<sup>28-30</sup> Vestibular function testing is usually unremarkable, and the cause of vestibular migraine is unclear. It is recommended that if symptoms are severe or acute, medication can be helpful.<sup>28,29</sup>

Brodsky et al<sup>29</sup> based diagnosis on the International Classification of Headache Disorders (ICHD), which requires that the patient meet the criteria for **migraine**: has at least 5 episodes with moderate to severe symptoms lasting 5 minutes to 72 hours, has concurrent migraine with or without aura, and migraine features (headache, photophobia, phonophobia or visual aura) that occur in at least half the episodes of vertigo. Of the patients that met this criteria, all had true **rotary vertigo**, 75% also had sensations of swaying or rocking.

A diagnosis of probable vestibular migraine is given if there are at least 5 episodes as described above, and either a concurrent migraine with or without

aura or the child has one or more of the migraine features listed above.



## BENIGN PAROXYSMAL VERTIGO OF CHILDHOOD

**Benign paroxysmal vertigo of childhood (BPVC)** is, as the name implies, unique to very young children under 6 years of age.<sup>21,31,32</sup> In this condition, the vertigo is not position or movement related. BPVC is characterized by acute, episodic vertigo with normal hearing, and no **nystagmus** or **tinnitus** (ringing in the ear), though the child may experience nausea and vomiting. Because this condition occurs in the very young, it may often be missed since the child presents with temporary flu-like symptoms. However, for this diagnosis, episodes recur.

## CONCUSSION OR MILD HEAD TRAUMA

Reports of vestibular symptoms and deficits with mild traumatic brain injury, or concussion, are increasing.

Ellis et al<sup>33</sup> reported on a cohort of 101 children (mean age 14.2 years). Of this group, 77 (76%) had a sports related concussion, and 24 (24%) had post-concussion syndrome. Of those with sports related concussion, 29% had vestibular dysfunction confirmed with diagnostic tests, compared to 63% of those with post-concussion syndrome. Most recently, Zhou et al<sup>34</sup> found that 90% of children with persistent dizziness or imbalance



following a sports-related concussion had some form of vestibular dysfunction. Unfortunately, neither screening nor comprehensive evaluation for vestibular dysfunction is typically done in these children. Consequently, treatments known to improve the symptoms and function are not provided.

## VESTIBULAR NEURITIS AND LABYRINTHITIS

The presentation of **vestibular neuritis** or **labyrinthitis** is similar to that of **otitis media with effusion**. The child will have nausea and/or vomiting and possibly imbalance. The very young child does not indicate that he/she is dizzy, they just do not feel well. However, if the inner ear is affected on one side, nystagmus (rhythmic beating of eyes) may be observed by the parent.

Reports on this condition in children are scarce,<sup>35,36</sup> but it is of concern since the most common reason that medical attention is sought for young children is ear infection. Several investigators have reported that children with **chronic otitis media** (affecting approximately 10% of children under the age of 1 year in the United States) may have persistent deficits of vestibular function, with consequential delays in motor development and poor gaze stability.<sup>5,37</sup>

Screening of vestibular function is warranted in all children with chronic otitis media, particularly those with repeat surgeries for drainage tube insertion.

## OTOTOXICITY

**Ototoxicity** refers to exposure to drugs or chemicals that damages structures of the inner ear or the vestibulocochlear nerve. Because this is typically a systemic exposure, the damage is usually bilateral. Therefore, dizziness is not a symptom, but imbalance and problems with gaze stability during head movement are evident. Hearing may also be disrupted, or the individual may experience tinnitus.

**Substances known to be ototoxic include:** aminoglycoside antibiotics,<sup>26</sup> anti-neoplastic medications (e.g. anti-cancer; cisplatin, carboplatin<sup>25,26</sup>), aspirin, quinine, and environmental chemicals (e.g. lead, carbon monoxide, mercury, carbon disulfide).<sup>25,26,38,39</sup>

## OTHER DIAGNOSES

Several conditions have some form of vestibulopathy as a secondary disorder, with

consequent functional impairments of balance and/or gaze stabilization. A majority of children with severe or profound sensorineural hearing loss have vestibular hypofunction.<sup>8,17,40-42</sup> Cochlear implantation, although providing excellent treatment for hearing loss, has also been shown to disrupt previously normal vestibular function in 5%-60% of implanted ears.<sup>7,43-46</sup>

Other diagnoses include: late prematurity,<sup>47,48</sup> congenital cytomegalovirus,<sup>49,50</sup> and global developmental delay.<sup>24</sup>

## SUMMARY

Pediatric vestibular dysfunction is common and causes impairments in motor development, balance and visual stability. Children complaining of vestibular related symptoms, or children with diagnoses related to vestibular dysfunction should be tested so that the proper interventions can be initiated.

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