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Contemporary Concepts in Pediatric Vestibular Assessment and Management

Guest Editors, Devin L. McCaslin, Ph.D. and Jennifer B. Christy, PT, Ph.D.

Vestibular Rehabilitation for Children

Rose Marie Rine, PT, Ph.D.[1]

[1]Specialty Therapy Source, LLC, Jacksonville, Florida

Address for correspondence Rose Marie Rine, PT, Ph.D. Specialty Therapy Source, LLC, 12948 Palmetto Glade Drive, Jacksonville, FL 32246, specialtytherapy@bellsouth.net

Abstract

This article focuses on vestibular rehabilitation (VR) for children. Reports of the presence of vestibular dysfunction in infants, young children, and adolescents have increased over the past decade. In addition to being a comorbidity of sensorineural hearing loss, vestibular dysfunction has been noted in children with cytomegalovirus, late prematurity, and concussion, to name a few. Despite ample evidence and reports of VR for adults, the selection and provision of exercises to be included in the VR protocol for children vary, depending on the nature of the lesion, impairments identified, age at the time of lesion, and developmental factors such as critical periods of development and intermodality interdependence. Unlike adults, children with loss of function or hypofunction of the vestibular apparatus since or shortly after birth present with a developmental delay that is progressive. Very young children may not be able to describe symptoms but rather only avoid activities or cry. This report provides a review of vestibular-related impairments in children, determinants of the symptoms and functional impairments of vestibular dysfunction, the mechanisms of recovery in children, the challenges of VR for children, and a summary of research on the efficacy for VR for children.

Keywords: Vestibular rehabilitation, children, vestibular-related impairments, pediatrics

Learning Outcomes: As a result of this activity, the participant will be able to (1) list and describe the mechanisms of vestibular compensation in children; (2) discuss the factors affecting the selection of vestibular rehabilitation exercises; (3) list and discuss the developmental considerations in vestibular rehabilitation; and (4) summarize the evidence of the efficacy of vestibular rehabilitation for children.

Despite increasing reports of vestibular dysfunction [1] and the symptoms and impairments associated with vestibular dysfunction in children, [2] [3] [4] there are few studies of the epidemiology of [5] [6] or rehabilitation for [7] [8] [9] [10] [11] [12] vestibular dysfunction in children. Vestibular dysfunction in children has long been accepted as a comorbidity in those with sensorineural hearing loss. [13] [14] [15] However, it is also evident in those with chronic otitis media, [16] mild concussion, [17] cytomegalovirus, [18] [19] [20] and late prematurity. [21] [22] The dysfunction may be due to pathology or a lesion involving peripheral (either bilateral or unilateral) or central vestibular structures. Peripheral dysfunction may be a loss (i.e., areflexia), hypofunction, or irritative in nature. Vestibular rehabilitation (VR) is focused on amelioration of impairments consequent to the vestibular dysfunction. However, specific rehabilitation varies dependent on the type and nature of the dysfunction as well as the determinants of the impairment of interest.

Vestibular-related impairments and symptoms in children include gaze instability, disequilibrium and deficits in postural control, motor development delay, and vertigo, depending on the nature of the dysfunction, the age of onset, [23] and the integrity of other factors that affect the impairment. Impairments consequent to a unilateral peripheral lesion include vertigo, whereas vertigo is not an impairment seen in those with a bilateral peripheral loss. An individual with pathology of the central vestibular system (e.g., cerebellum) does not typically report vertigo, but may report or present with difficulty reading or imbalance, or both. However, these vestibular-related impairments may be the result of pathology that does not involve the vestibular system. For example, balance ability is determined by the integrity of three sensory systems (i.e., vision, somatosensation, and vestibular), the integration of this sensory input by central mechanisms, and the integrity of the motor components of balance (e.g., muscle strength). Individuals with peripheral neuropathy of the lower extremities may have impaired balance ability despite normal vestibular function. Neither practice of balance nor VR will result in an improvement of balance for these persons. Therefore, assessment for VR must include tests of vestibular function, the behavioral and functional impairments, and at least a screening of other factors that contribute to the impairment of interest. Furthermore, for those with a vestibular deficit, rehabilitation will differ for those with peripheral versus central lesions.

Rehabilitation for a unilateral peripheral loss is focused on reduction of vertigo and improvement of gaze and balance abilities. [24] [25] [26] [27] [28] To improve balance, protocol will include training for use of remaining vestibular function. In contrast, rehabilitation to improve balance in an individual with bilateral loss must focus on training in use of other determinants of balance (i.e., visual and somatosensory cues, muscle strength, and response capability) and anticipatory mechanisms to enable substitution and compensation for the lost vestibular function. [25] Therefore, to develop appropriate rehabilitation interventions, the specialist must understand all factors that affect behaviors (i.e., gaze stabilization and balance) and symptoms (i.e., vertigo), and determine which factors are intact and functioning properly. Identification and selection of intervention is further complicated by developmental factors that affect assessment and intervention.

This report reviews the determinants of impairments evident in children with vestibular dysfunction, and the basis and efficacy of VR for children.

Vestibular-Related Impairments and Symptoms

Symptoms of vestibular dysfunction are well documented. [29] [30] [31] Rehabilitation to address these symptoms in children is based on the identification of the symptoms and impairments, an understanding of the determinants of the symptoms, and developmental status of the behaviors of interest. Furthermore, rehabilitation to ameliorate the symptoms and impairments varies based on the nature of the vestibular dysfunction.

Determinants of Vestibular-Related Symptoms and Impairments

The consensus document of the Committee for the Classification of Vestibular Disorders of the Bárány Society identifies categories for the classification of vestibular symptoms: vertigo, dizziness, vestibulovisual, and postural. [29] Although these classifications are readily used with children older than 10 years, the younger child may not be able to describe or report the symptom, and the behaviors (e.g., postural) are developing during childhood requiring age-referenced normed testing. This confounds identification of those for whom vestibular testing is warranted. To identify symptoms and impairments related to vestibular dysfunction and develop rehabilitation to address them, it is critical to appreciate factors affecting them. Vertigo (internal) is the sensation of self-motion when no such motion is occurring, and differs from the external visual sense of motion (external vertigo). Internal vertigo may be spontaneous or triggered (i.e., positional, head motion, visual, sound, and Valsalva induced). Vertigo may be due to a vestibular problem for which VR is appropriate, or a change in intracranial pressure (Valsalva-induced vertigo) for which vestibular rehabilitation is inappropriate. In contrast, dizziness is defined as the sensation of disturbed or altered spatial orientation without a sense of motion. Dizziness may be spontaneous or triggered by factors similar to those that trigger vertigo.

Vestibulovisual symptoms are typically the result of vestibular pathology or the interplay between visual and vestibular symptoms. Included in this category are false sensations of motion or tilt of the visual surround and visual distortions linked to vestibular, and not visual, pathology. This includes oscillopsia, movement-induced blur, and visual lag or tilt. Clinically, this is often referred to as impaired gaze stabilization. Visual illusions or hallucinations of objects moving, but not the surround, are not within this category. It must be acknowledged that the ability to keep an image stable on the retina requires not just vestibular information. Vestibular information is coordinated with visual and eye position information. Thus, the integrity of all three systems must be tested to determine which of the systems is problematic for gaze instability. If there is oculomotor pathology, VR alone will not address the impaired gaze stabilization. Importantly, of the three sensory systems, only vestibular information is able to correct for very rapid movements of the head (i.e., above 110 degree/second). Therefore, to test the integrity of vestibular function for gaze stability, visual acuity must be tested while the head is moving at or above this rate. Behavioral testing of this is done using the dynamic visual acuity (DVA) test (either computer-based or a clinical version). Measures of DVA have been shown to correlate with diagnostic measures of the vestibulo-ocular reflex (VOR), [32] [33] and to have good to excellent sensitivity and specificity for the identification of dysfunction of the VOR in adults and children. [24] [26] [27] [28] The test is readily completed on children as young as 3 years of age.

Postural symptoms refer to symptoms of balance (i.e., the ability to assume, maintain, and move) in upright postures (i.e., sitting, standing, and walking) which is mediated by the postural control system. The postural symptoms that are vestibular related include leaning or tilt, stumbling, holding onto an object or other person to walk or stand still, and loss of balance. However, the ability to assume, maintain, and move in these postures develops during childhood, and is dependent on three sensory systems (vision, vestibular, and somatosensory systems), integration of these sensory cues for interpretation of movement and alignment, and the integrity of central and peripheral neuromotor function. [34] [35] [36] Furthermore, there is a step-wise maturation of these abilities during childhood through adolescence, [37] [38] and vestibular information plays a role in the development of oculomotor and static and dynamic postural ability. Development of brain representations of body part positions and spatial orientation is essential for typical motor development abilities. Infants without otolith function acquire walking ability later than peers without vestibular dysfunction. [39] [40] Similarly, children with bilateral peripheral vestibular hypofunction (VH) at or shortly after birth have a progressive developmental motor delay which does not change without intervention. [13] Therefore, testing for identification of vestibular-related postural impairments and interventions to address them in children must include age-appropriate testing of balance ability and motor development.

Although research supports that in adults, bilateral or unilateral vestibular lesions result in spatial and nonspatial cognitive impairments, [41] there is a paucity of research on children. However, reports suggest that vestibular dysfunction during childhood would have a significant effect on cognitive development [4] and may provide a rationale for the poor school performance in children with vestibular deficits. [42]

Nature of Dysfunction

The symptoms experienced by patients with vestibular dysfunction vary by nature of the dysfunction. The dysfunction may be peripheral or central. [30] [31] Peripheral lesions may be unilateral or bilateral, and within each of these groups, the dysfunction may be a loss (i.e., areflexia), hypofunction, or irritative (e.g., benign paroxysmal positional vertigo [BPPV], Meniere's disease). Internal vestibular vertigo, as described earlier, occurs as a consequence of an asymmetry of information coming in to central centers from peripheral vestibular receptors or to misinterpretation by central centers. Thus, in the acute stage of a unilateral loss of peripheral vestibular function (e.g., vestibular neuritis), patients experience severe, persistent vertigo which will be reduced by passive adaptation of the system. In the case of BPPV, the vertigo is the result of asymmetrical firing of receptors due to the physiology of the diagnosis; the vertigo is positional and typically brief. [43] If the peripheral loss or damage is bilateral and symmetrical (e.g., ototoxicity, bilateral profound sensorineural hearing with concurrent vestibular loss), there will be no vertigo. It is possible that patients with central lesions experience vertigo that is episodic (e.g., migraine, mild traumatic brain injury), [44] [45] but not all with central lesions will experience vertigo. Benign paroxysmal vertigo of childhood, often considered a precursor to vestibular migraine, presents with episodic vertigo and or dizziness. [46]

The visual-vestibular symptom of oscillopsia is reported by patients with peripheral vestibular dysfunction (either uni- or bilateral) [26] [47] [48] and may be seen in those with central lesions. [17] [49] Results of numerous studies support that children with bilateral peripheral vestibular dysfunction since or shortly after birth score significantly below scores achieved by age-matched peers on tests of DVA and reading acuity. Pavlou et al [50] recently provided the first report of visually induced dizziness in children with peripheral vestibular dysfunction.

Most studies of vestibular-related impairments in children with vestibular dysfunction are focused on the impact of the dysfunction on balance, or postural control, and motor development. Several investigators have reported impairments of postural control in children with peripheral [13] [51] [52] as well as central vestibular dysfunction. [53] [54] However, the impairment is also dependent on the age at the time of lesion. Similar to adults, children with peripheral vestibular lesions experience a loss of balance on conditions 5 and 6 on dynamic posturography tests. However, they also experience diminished abilities on conditions 3 and 4 if the dysfunction occurs before the critical period of development of the sensory organization for postural control. [55] [56] These findings indicate that unlike adults with peripheral vestibular loss who readily use vision and somatosensation to substitute for the loss of vestibular function, the functional effectiveness of these two sensations for balance is not developed (relative to age-matched typically developing peers despite normal somatosensory and vision abilities). Therefore, rehabilitation for this group must first address development of the effectiveness of vision and somatosensation for balance before substitution can occur.

Vestibular Rehabilitation

VR for adults with vestibular dysfunction has been well documented, to include establishing the physiological mechanisms of recovery and function, and the efficacy of specific rehabilitation exercises. Research supports that the rehabilitation exercises and approach must be unique to individual patients because there are varied recovery mechanisms available depending on the nature of the dysfunction and the unique characteristics of the individual patient. Furthermore, research does support that there is a critical period in which the delivery of VR is optimal. [57] However, there is a paucity of research for children, and developmental implications for the VR. When selecting specific rehabilitation activities, rehabilitation specialists must consider several factors: (1) the type and nature of the vestibular lesion, (2) the mechanisms of recovery, and (3) the factors affecting behaviors of interest (i.e., gaze stabilization, balance ability, and vertigo). [57] [58] In addition, consideration must be given to the factors that affect the mechanisms of recovery, to include (1) the timing of the delivery of the rehabilitation relative to the onset of the condition, (2) the age of the patient and critical periods of development, (3) the effect of post-lesion experience that includes environmental enrichment, (4) dependency of vestibular function and behaviors on multisensory integration processes, (5) active participation and motivation on the part of the patient, and (6) requirements for motor learning. [57]

Mechanisms Underlying Vestibular Rehabilitation for Children

Rehabilitation for vestibular-related impairments is based on several mechanisms depending on the nature of the vestibular dysfunction and the integrity of the determinants of gaze stability, postural control, vertigo, and dizziness, as well as development of visuospatial ability, balance, and motor development. The mechanisms include (1) adaptation, (2) habituation, and (3) substitution. Definitions of these mechanisms specific to the vestibular literature are provided here. Adaptation refers to long-term changes in the neuronal response to head movements. The primary goals of adaptation exercises are to improve gaze stability and balance ability, and to diminish symptoms. Adaption exercises to improve gaze involve maintaining focus and clarity of a visual target while moving the head. Habituation refers to the reduction of a response by repeated exposure to a provocative stimulus. The primary goal would be reduction of vertigo and dizziness symptoms. Exercises to achieve habituation are selected on the basis of the specific movements or situations that cause the symptoms for the specific patient. Substitution refers to training in the use of alternative strategies for gaze stabilization and balance. This includes the use of other sensory cues (i.e., vision and somatosensation for gaze stabilization and balancing), central pre-programming and anticipatory responses. Reports support that covert saccades driven by the visual system are a prime contributor to the recovery of gaze stabilization. [59] [60] [61] For children, training must include strengthening determinants of a function (e.g., balancing, motor development) other than vestibular, and identifying if the development of these factors for the behavior in question has been affected by the loss of vestibular function. Rehabilitation for BPPV is unique in that in involves repositioning maneuvers so that otoconia are moved out of the involved semicircular canal. The vestibular receptors and neural tracts are intact. In addition to mechanisms of recovery, there are additional factors that must be considered in the selection of VR for children, to include critical periods of development, cooperation, and attention.

Developmentally, it is well known and accepted that development of individual factors that work together for a behavioral function can be hindered by the loss of one of the factors prior to the critical period of development for the behavior. For example, vision, vestibular, and somatosensory systems work together to enable balance. The critical period for the development of this intersensory organization has been determined to be between 4 and 6 years of age. [56] [62] Furthermore, it has been shown that the effectiveness of vision and somatosensation for balance is not developed in very young children with bilateral VH, despite having intact vision and somatosensory systems. [56] Thus, the intervention for these children must include training in the use of vision and somatosensation for balance, which will then enable substitution. Motor development and learning are dependent on exploration and practice. The young child with VH tends to avoid movements or environments that cause instability. The study by Rine et al [13] provides evidence that children with bilateral VH since or shortly after birth have a progressive motor development delay that is not improved without intervention. This provides support to the idea that the avoidance by the children due to vestibular dysfunction disrupts development of motor skills, not just balance ability.

Regardless of age, the success of rehabilitation is dependent on active participation and attention, enabling motor learning and development. This can be challenging when working with very young children or adolescents. The goals must be meaningful and relevant to the individual, and practice of activities or exercises in an enriched environment is required. Thus, although an adaptation exercise for an adult may be active turning of the head in yaw, with the instruction “move your head as fast as you can while keeping the letter clear," this concept is difficult for a young child to understand and the therapist cannot be sure that the "image is clear" just by asking. The adult is motivated by improvement of functional ability that was lost. However, the child may assume that the oscillopsia is typical, and that this uncomfortable and rather boring activity is not fun, discouraging active participation. An alternative could be to have the child sitting supported in a net swing that is moved in the yaw plane by the therapist. The child is asked to "point to the boat," "point to the flower," or to play a video game that requires visual attention and choice. This is less threatening, and the child may be motivated to be an active participant.

Efficacy of Vestibular Rehabilitation for Children

As discussed earlier, VR includes exercises to ameliorate the symptoms and impairments, which differ depending on the nature of the dysfunction, the impairment, and the age of the patient. Clinical practice guidelines for VR for peripheral VH have been established. [25] There are several investigations on the efficacy of VR for children. These will be grouped by the nature of the dysfunction (i.e., peripheral hypofunction, central dysfunction, and irritative).

Rine et al [11] and Braswell and Rine [8] completed work to examine the efficacy of VR to improve balance and/or motor development, and gaze stability, respectively. Rine and colleagues used a randomized, controlled, wait-listed design to examine if VR focused on adaptation, substitution, and motor learning resulted in improvement of motor development and postural control in young children with bilateral VH or areflexia. Participants were 24 children (4–7 years of age) with sensorineural hearing loss and vestibular dysfunction confirmed by rotary chair testing. Screening and review of charts were completed to assure that there were no other cognitive, orthopedic, or neurological deficits. Children were assigned to one of two groups matched for vestibular function (hypofunction vs. areflexia) and motor development level (standardized scores). Pre- and postintervention testing included tests of motor development (i.e., gross motor scale of the Peabody Developmental Motor Scales) and postural control (dynamic posturography testing to include sensory organization and dynamic testing with electromyography). Groups participated in 12 weeks of placebo and VR alternately, so that one received testing, and then VR in the first 12 weeks, testing, and then participated in placebo for 12 weeks and tested a third time (VR-P group). The sequence was reversed for the other group (P-VR group). Testers were blinded to group placement. Exercises (both placebo and VR) were provided three times weekly for 12 weeks by the same individual. Weekly review was performed so that exercises were progressed appropriately to assure increased demand of skill with successful participation. Activities were designed to enhance visual-motor and somatosensory abilities for substitution, training in the use of remaining vestibular function (as appropriate to the child), spatial awareness, and coordination. Four categories of activities included (1) balance training (e.g., standing on a 4-inch-wide line and walking along it; e.g., yellow brick road pathway), (2) visuomotor training (e.g., point to specific pictures while being moved in a net swing), (3) eye–hand coordination training (e.g., standing feet together and tossing a bean bag at progressively smaller targets), and (4) general motor planning (e.g., crawling and walking through obstacle courses of progressive difficulty). To encourage and maximize cooperation and motivation, specific targets and activities were modified for age. Step-wise progression of task difficulty was done at 80% criterion. At the end of the first intervention period, the VR-P group, and not the P-VR group, had a significant improvement in standard scores of the gross motor test ($p = 0.04$), and improved somatosensory ratio scores on posturography testing ($p = 0.01$). At the end of the second session of intervention, the P-VR had improved gross motor scores, performing similar to the VR-P group. Scores of each group were now merged for analysis of change due to VR. By the end of the study, the children with VH had gained in gross motor function, though still below age-matched peers. The visual and somatosensory effectiveness ratios from posturography testing, which initially were deficient compared with age-matched controls, were equivalent to typically developing peers, enabling substitution. Furthermore, on the dynamic test with EMG, only 4/24 (16%) had a loss of balance, compared with 21/24 (85%) preintervention. The children exhibited an alternative somatosensory-driven strategy (activation of hamstring muscles to pull the center of mass forward) to successfully complete this test.

Braswell and Rine [8] completed a controlled case study using a delayed treatment design to examine the efficacy of VR for the improvement of gaze stability in children with bilateral VH. Two children with VH confirmed by rotary chair testing (one 11-year-old with bilateral VH since birth; one 10-year-old with VH acquired at 17 months) participated. Gaze stability was measured three times using the DVA test and a test of reading acuity. The reading acuity test yields measures of critical print size (i.e., the smallest size that can be read at typical reading speed) and reading acuity (i.e., the smallest size that can be read regardless of speed). Tests were completed preintervention (test 1), after 4 weeks with no intervention (test 2), and after 4 weeks of intervention provided three times weekly for 4 weeks (test 3). Intervention was designed for each child, using exercises to facilitate adaptation, substitution, and learning. For adaptation, children had to identify letters as the head was moved in yaw and pitch, alternately. Progression included (1) increasing rate of head movement, (2) decreasing the size of letters (e.g., begin at 45 font, to 36 font, etc.), and (3) increasing complexity of the background that letter is presented on (i.e., plain, striped, busy children's wrapping paper). At test 3, clinical improvement was noted in DVA and critical print size scores. Parent and teachers reported improved reading. These results suggest that appropriately designed intervention can result in improved gaze stability in children, which may improve educational and community participation.

BPPV has been considered a diagnosis seen only in adults. However, there are two reports of identified BPPV in children with successful intervention. D'Agostino et al [63] reported horizontal canal BPPV in a 10-year-old. The child complained of vertigo and was successfully treated with a repositioning maneuver. Fay [9] provided a case report of two children (11 and 9 years of age) who were referred to physical therapy for vestibular assessment. The 11-year-old child had a history of migraine and complaints of vertigo with positional changes and head movements for the past 4 years. Audiogram and CT scan were unremarkable. Headaches were triggered by bright light and loud noise. Additional complaints were motion sickness on a school bus, difficulty concentrating in class, difficulty participating in physical education classes, and poor sleeping. He had vertigo when bending forward, but not turning in bed; experienced a falling sensation when lying flat and sitting up from supine; and reported a "spinning" sensation when rising to stand from sitting, or quick movement of the head. He also reported the sensation of rocking when getting out of the car. Oculomotor findings were negative. Left Dix-Hallpike (DH) was positive for brief (i.e., 40 seconds) up-beating left torsional nystagmus. He was seen for four treatments of canalith repositioning because, although reduced, symptoms continued. Patient and parent were trained to complete the repositioning at home. After 2 months, communication by phone indicated that the child was symptom free. The 9-year-old was referred to physical therapy for assessment and treatment for complaints of episodic vertigo (when moving from sit to stand, bending forward), intermittent tinnitus, and heavy-headed sensation. Symptoms lasted 5 to 10 minutes, occurring twice weekly for 1 year. Family history was negative for vertigo and migraine. A history of motion sickness was reported which was worsened in the year since the vertigo began. Patient reported that headaches began when the vertiginous episodes began, and lasted for 1 hour. Oculomotor exam was negative. Positive vestibular tests included positive head impulse test to the right, right beating torsional nystagmus observed on right DH, and up-beating left torsional nystagmus seen on left DH. Left repositioning maneuver was performed twice in a follow up session. At the third visit, patient reported no symptoms, and DH testing was negative bilaterally. He reported that motion sickness was improved and he was able to ride bumper cars at the amusement park.

There has been increased concern regarding concussion for young athletes, and there is increasing evidence of vestibular dysfunction, which may be central or peripheral in nature, in a percentage of these individuals. However, there is little research on whether the children and adolescents with sports-related concussion are referred for VR, and typically, vestibular function testing is not routine for this group. This is of concern due to reports that as many as 50% of those with sports-related concussion have vestibular–ocular dysfunction, which is predictive of prolonged recovery. [17] [64] Alsalaheen and colleagues [7] completed a retrospective study examining the efficacy of VR for individuals with concussion. Of the 114 patients, 67 (59%) were children (median age: 16 years, range: 8–18 years). VR was individually developed for each patient. For those with BPPV, repositioning was completed and successful in three of four. The fourth participated in additional VR. Outcome measures included (1) self-report of dizziness and completion of the Dizziness Handicap Inventory, (2) Dynamic Gait Index, (3) Functional Gait Assessment test, and (4) dynamic computerized posturography sensory conditions test (SCT). Of the 114, VR was warranted for 108, but only 84 participated. A significant treatment effect was seen for the group as a whole, but there was a significant interaction between treatment and age for dizziness and scores on conditions 1 and 2 of the SCT. Children improved more than adults. Interpretation of the results is guarded due to the retrospective nature, lack of control group, and vestibular test results were not reported.

Summary

There are increasing reports of vestibular dysfunction in children. The impairments consequent to this dysfunction include gaze instability, diminished balance ability, delayed development of motor skills, vertigo, and dizziness. The number of diagnoses that have been shown to include vestibular dysfunction as a comorbidity has grown, to include cytomegalovirus, late prematurity, and concussion. The relatively high incidence of "dizziness" in children in the United States, as reported by Li et al, [3] and the low percentage of who were seeing any health professional for it suggests that this is an overlooked entity. However, screening or testing of vestibular function is rarely, if ever, done for children in these groups. The Centers for Disease Control and Prevention reports that the age group with the highest incidence of concussion is children between 1 and 5 years of age, [65] and reportedly, this may include vestibular dysfunction in approximately 25%. The incidence of newborn infections of cytomegalovirus in the United States is 1 in 200 births (0.5%), [66] and reportedly, as many as 92% of those with sensorineural impairment have hearing loss and vestibular dysfunction. [20] Based on these reports, hundreds of thousands of infants and young children may be added to the number of children with vestibular dysfunction each year. Recent development of easy to administer questionnaires [50] [67] can assist in identifying children who should be referred for testing. However, it is rare that the children are screened for vestibular problems. As discussed within this report, vestibular dysfunction can have a serious life-long impact on the individual's performance and well-being. Furthermore, reports that VR is efficacious in minimizing vestibular-related impairments in children warrant that screening be done and VR provided as indicated.

Although there is a paucity of evidence for the efficacy of VR for children, the potential number of children affected and the life-long limits of function and performance consequent to vestibular dysfunction warrant that more work be done in this area. Research must begin to address several concerns: (1) What is optimal VR for peripheral versus central vestibular dysfunction in children? (2) What is the critical period for development of gaze stability and thus the provision of VR for children who attain vestibular dysfunction before birth or within the first few years of life? (3) What is optimal dosing? To move the development of VR for children forward, research must address these questions.

Footnotes

Conflict of Interest Author has no conflict of interest.

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