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ASSESSMENT

It is important for pediatric health care professionals to recognize the signs and symptoms of vestibular dysfunction and to screen accordingly.

ARTICLE

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Part II: Pediatric Vestibular Disorders

Vestibular assessment for children

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REVIEW OF IMPAIRMENTS

Recent studies show that 5.3% of U.S. children, ages 3-17 years, complain of vestibular related impairments. Of these only 29.9% received treatment. [1]

Vestibular related impairments include one or more of the following:

- dizziness
- poor balance
- delay in motor development
- difficulty with stability of vision

This can affect a child's participation in sports and academia. [2-5]

Common diagnoses that are known to be related to vestibular dysfunction include:

- severe to profound sensorineural hearing loss
- pediatric migraine
- chronic otitis media (ear infection)
- congenital cytomegalovirus
- meningitis
- enlarged vestibular aqueduct syndrome. [6-8]

In addition, traumatic brain injury, even mild (i.e. concussion), may affect the central vestibular, peripheral vestibular, and visual pathways, causing symptoms. [9] Vestibular and balance therapy has been shown to be efficacious to improve developmental delay [10] and instability of vision. [11] It is important for pediatric health care professionals to recognize the signs and symptoms of vestibular dysfunction and to screen accordingly so that interventions can be initiated.

QUESTIONNAIRES

Children with vestibular related impairments present with varying

subjective complaints, depending on the part of the system that is damaged. Therefore it is important that the clinician complete a thorough history to include the onset, timing and severity of symptoms in addition to main developmental milestones (e.g. age of independent sitting, walking and riding a bicycle). The clinician should also ask about how well the child is doing in school, since poor visual stability is associated with reading deficits. [12]

Children born with bilateral or unilateral peripheral vestibular hypofunction have delayed motor development (e.g. independent walking after age 15 months), poor balance in challenging situations (e.g. in the dark on uneven surfaces), and visual instability that might not be appreciated since the child has never had a normally functioning gaze stabilization system. [10,13-16] However, children with migraine or BPVC might complain of episodic vertigo and feelings of disequilibrium. [6]

Clinicians can quantify severity and impact of vestibular related impairments using the **Dizziness Handicap Inventory for parents and caregivers (DHI-pc)**. [17]

The Canadian Occupational Performance Measure (COPM) can be used with children and their parents to determine the magnitude of perceived performance and satisfaction with self-identified problems. [18]

The **Convergence Insufficiency Symptom Scale (CISS)** is a questionnaire sensitive to visual impairments often experienced by athletes with concussion. [19]

The symptom scale of the **Sport Concussion Assessment Tool, 3rd Edition (SCAT-III)** is also helpful to discern the impact of symptoms from concussion in children aged 5 years and older. [20]

RELIABLE AND VALID CLINICAL SCREENING TESTS

VISION

The clinician should quickly screen for vision problems since they can contribute to symptoms of dizziness and difficulty reading. The following screening tests can be completed in 5-10 minutes:

1. **Smooth pursuit:** the child follows a small toy with the eyes as the toy is slowly moved to the right, left, up and down.
2. **Saccades:** the child looks quickly from one target to another and the clinician watches the eyes for quickness and accuracy.
3. **Alignment:** the child looks straight ahead as the clinician completes the cover/cross-cover test to determine the presence of skew deviation.
4. **Convergence:** the child follows a target as it is slowly moved toward the bridge of the nose. The eyes should converge to at least 6cm.
5. **Visual acuity:** use an LEA Symbols chart or print a chart from i-see.org. If abnormal results are obtained, the clinician should refer to the appropriate professional (e.g. pediatric optometrist or neurologist) depending on the nature of the abnormal results.

CLINICIANS CAN USE EASY AND INEXPENSIVE SCREENING TESTS TO DETERMINE IF A CHILD SHOULD BE REFERRED TO A SPECIALIST FOR SPECIFIC TESTING.

VESTIBULAR HYPOFUNCTION

The clinician can quickly screen for vestibular dysfunction completing the following tests: [3]

1. **Head Impulse Test (HIT):** the child maintains focus on the examiner's nose as the examiner rapidly moves the head right or left a short amplitude. The inability to keep the eyes focused on the nose indicates a poorly functioning vestibule-ocular reflex (VOR) to that side.
2. **Emory Clinical Vestibular Chair Test (mECVCT):** The child sits in a rotating office chair and closes the eyes as the examiner rotates the chair to the right for 30-seconds at 0.5 Hz (i.e. cycle per second using a metronome). The examiner stops the chair and immediately puts the goggles on the child, then times the nystagmus until it stops. After 1-minute complete the test to the other side and add the right and left seconds. A score of < 29.2

seconds (right + left) was sensitive (63%) and specific (100%) for hypofunction in children aged 6-12 years with sensorineural hearing loss.

3. To examine functional use of the vestibular ocular reflex (VOR) the clinician can complete the **Clinical Dynamic Visual Acuity Test (DVA)** using LEA Symbols or EDTRS charts. [3,14] A decrement in visual acuity between head still and head moving conditions that is greater than 2 lines is sensitive (88%) and specific (69%) for hypofunction, and can be completed in children as young as 4 years of age. The best reliability was obtained with 2 trials of DVA.
4. An impairment that might be appreciated by children with central vestibular dysfunction (e.g. concussion, cerebral palsy, myelodysplasia) is poor perception of vertical (i.e. subjective visual vertical or SVV). The **Bucket Test** shows promise to measure this with good test-retest reliability (ICC=0.74), although sensitivity and specificity has not been determined for children. This test requires an opaque bucket with no seams or visual cues, a computer generated straight line placed on the bottom of the bucket and an angle finder on the outside of the bucket. The examiner holds a bucket over the child's face. The child closes the eyes and the examiner turns the bucket so that the line is off center. The examiner then slowly turns the bucket and the child says "now" when they perceive that the line is straight up and down. Perform 5 trials to each side. Children as young as 6 years should be within 2.5 degrees of true vertical.

BALANCE

A clinical test of static balance, sensitive and specific for children with hypofunction is the **modified Clinical Test of Sensory Interaction on Balance (mCTSIB).** [3] The child is asked to stand still with the arms across the chest and feet together during four conditions:

1. Eyes opened on a stable surface;
2. Eyes closed on a stable surface;
3. Eyes opened on a compliant surface (i.e Airex or NeuroCom foam);
4. Eyes closed on a compliant surface.

The mean of 3 trials (in seconds) for each condition are added for a total possible score of 120. A score less than 111 seconds was sensitive (88%) and specific (85%) for hypofunction.

The Sensory Organization Test (SOT, Natus Medical, Inc.) vestibular ratio (i.e. swayed surface eyes closed stability score/stable surface eyes opened stability score) is sensitive (75%) and specific (92%) for vestibular hypofunction (VH) using a cutoff score of 0.20.3 Pediatric normative data can be obtained from Natus, Inc.

If time is a factor, clinicians can time the child during single legged stance, hands on hips, with eyes opened and closed. Considering that the standard deviation of typically developing children is large for each age group, children should generally be able to stand on one foot with eyes opened for 10 seconds by age 5 years, 15 seconds by age 7 years and 30 seconds by age 9 years. Children should be able to stand on one foot with eyes closed for 5 seconds by age 7 years, 15 seconds by age 9 years and 30 seconds by age 11 years. [21]

MOTOR DEVELOPMENT

Motor development is delayed in children with peripheral vestibular hypofunction. [10] Therefore, clinicians should complete a standardized test of motor development such as the **Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) for older children** or the **Peabody Developmental Motor Scales (PDMS-2) for children under 6 years of age**. [22,23] The BOT-2 has subscales (e.g. balance, bilateral coordination, strength) that can be completed without doing the entire battery of tests. Clinicians who do not own the BOT-2 or PDMS can complete the Functional Gait Assessment, keeping in mind that it has only been validated in high school athletes and exhibited a ceiling effect in this group. [24]

LABORATORY DIAGNOSTIC FUNCTION TESTS

The gold standard laboratory tests for vestibular

hypofunction continue to be the **caloric test (for unilateral weakness)** and **rotary chair test (for bilateral weakness of the vestibular canals)**.

Although normative data are published for children, each laboratory typically collects its own normative data. Young children can complete both tests, but must be cooperative. For example, the caloric test requires that children wear video goggles with vision occluded, be in the dark and allow the clinician to put warm and cold water or air into the ear canal. The rotary chair test requires that the child sit quietly in the dark with video goggles on their face and the head restrained as the chair moves and spins. Very young children can sit in the lap of a parent or examiner, and can also use electrodes instead of goggles, but they must still be cooperative. [25]

A promising test to study the VOR (vestibulo-ocular reflex) is the **video High Impulse Test (vHIT)**, which can test the horizontal, anterior and posterior canals. [26] Versions of this test are available with goggles or using a high speed camera without goggles.

Functional integrity of vestibular otolith function can be completed using the **cervical vestibular evoked myogenic test (cVEMP) for the saccule** and **Ocular VEMP (oVEMP) for the utricle**. The tests can be easily done with young children. This test requires electrodes on the neck (cVEMP) or face (oVEMP) as the examiner delivers sound to the ear or vibration to the mastoid. [27,28]

CONCLUSION

In summary, clinicians can use easy and inexpensive screening tests to determine whether a child should be referred to an otolaryngologist or audiologist for specific laboratory testing to determine whether or not the child has vestibular hypofunction. Early detection will enable identification of vestibular related impairments, and early intervention so that progressive delays can be halted. The next article will outline interventions that are shown to be efficacious to treat gaze instability, motor and balance impairments in children with vestibular hypofunction.

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