Vestibular Rehabilitation in Children

Jessica Pidgeon, PT, DPT
Heather Molind, PT, DPT, PCS, ATC

Department of Physical and Occupational Therapy Services
Boston Children's Hospital
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Where the world comes for answers

Boston Children's Hospital
Department of Education

Disclosures

Both presenters have nothing to disclose

Objectives

1. Review the developmental considerations for somatosensory organization
2. Review the impact on gross motor development
3. Discuss evaluation and treatment techniques with the pediatric population
4. Discuss considerations for vestibular rehabilitation in children with a variety of diagnoses

Sensory Organization

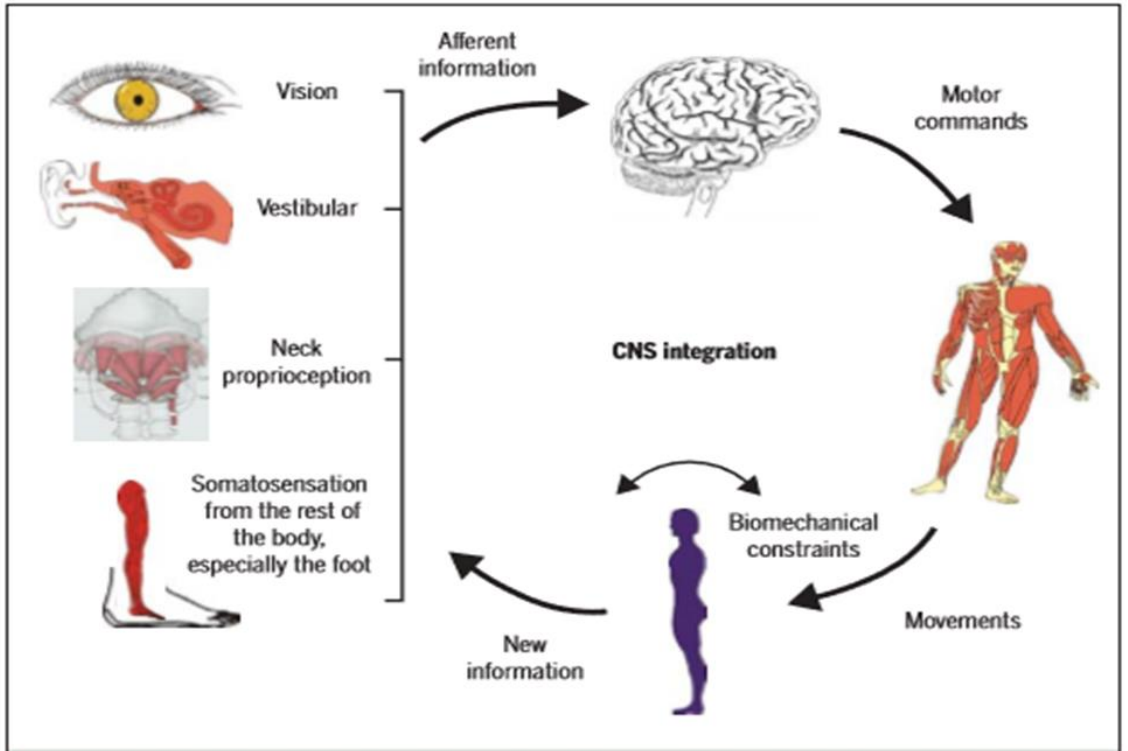


FIGURE 1. Input from the rest of the body is also an important source of information for the postural control system. The feet are peculiar in this respect as they aid in determining body sway relative to the ground. Abbreviation: CNS, central nervous system.

Kristjansson & Treleaven, 2009

Postural Control Development

- The ability to achieve and maintain balance during activity

- Static
- Anticipatory
- Reactive

Development of Sensorimotor Control

- Cervical movement sense
- Cervical position sense
- Gaze stability
- Visual motor control
- Eye-head coordination
- Postural control
- Balance

Development of Sensorimotor Control

- Head control in midline
- Neck strength in all positions
- Fix and follow
- Visual tracking with head movement
- Progression with postural control

Vestibular System

VOR - vestibulo-ocular reflex

VSR - vestibulo-spinal reflex

- Visual stabilization during movement
- Postural stability during movement
- Spatial orientation

Sensory Weighting

Sensory Weighting and Development

Reweighting of strategies evolves with development - influenced by:

- Maturation
- Musculoskeletal development
- Age
- Gender
- Weight
- Height
- BMI

Based on experience!

Pediatric Considerations

- Nature of diagnosis
- Timing of onset
- Ability to describe or report symptoms
- Impact on overall development/gross motor activity

Causes of Pediatric Vestibular Dysfunction

- Sensorineural hearing loss (SNHL)
- Chronic otitis media
- Benign paroxysmal torticollis of infancy (BPTI)
- Benign paroxysmal vertigo of childhood (BPVC)
- Vestibular migraine
- Concussion/head trauma
- Benign paroxysmal positional vertigo (BPPV)
- Inner ear malformation
- Infection/inflammation
- Tumors

Presentation of Symptoms

- Dizziness
- Vertigo
- Headache
- Nausea/vomiting
- Visual complaints
- Motion sensitivity
- Poor balance

- Head holding
- Avoiding head movement
- Avoiding motion
- Seeking motion
- Frequent falling
- Delayed gross motor milestones

Vestibular PT Evaluation

- Past medical history
- Primary report/complaint
- Diagnostic testing
- Specialist evaluations

- Symptom report or pattern
- Functional impact
- Patient/family goals

Vestibular Testing

- Vestibular Evoked Myogenic Potential (VEMP)
  - Assesses saccule and utricle function
- Video Head Impulse Test (vHIT)
  - Assesses VOR function
- Computerized Dynamic Posturography (CDP)
  - Assesses balance/postural control

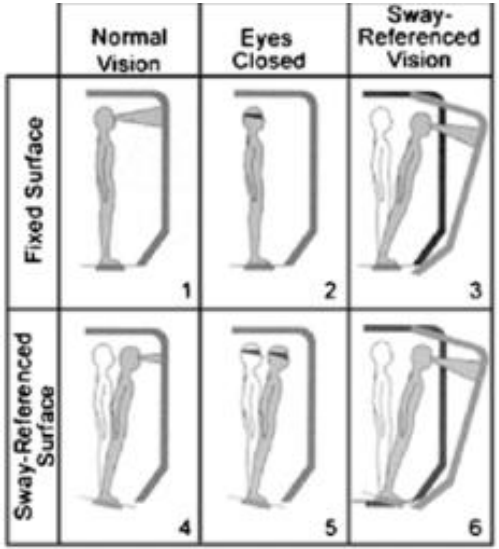
What do these results mean?

Abnormal VEMP
- Otolith organ stimulation

Abnormal vHIT
- VOR training

Abnormal CDP
- Balance training

CDP



SOT subscale	Definition	Sensory System (s) available for balance
1	Eyes open, support and visual surround stationary	*Somatosensory, visual, and vestibular*
2	Eyes closed, support and visual surround stationary	*Somatosensory and vestibular*
3	Eyes open, support stationary and visual surround moves	*Somatosensory and vestibular*
4	Eyes open, support surface moves, visual surround stationary	*Vision and vestibular*
5	Eyes closed, support surface moves, visual surround stationary	*Vestibular*
6	Visual surround moves, support surface moves	*Vestibular*

O'Keefe et al, 2015

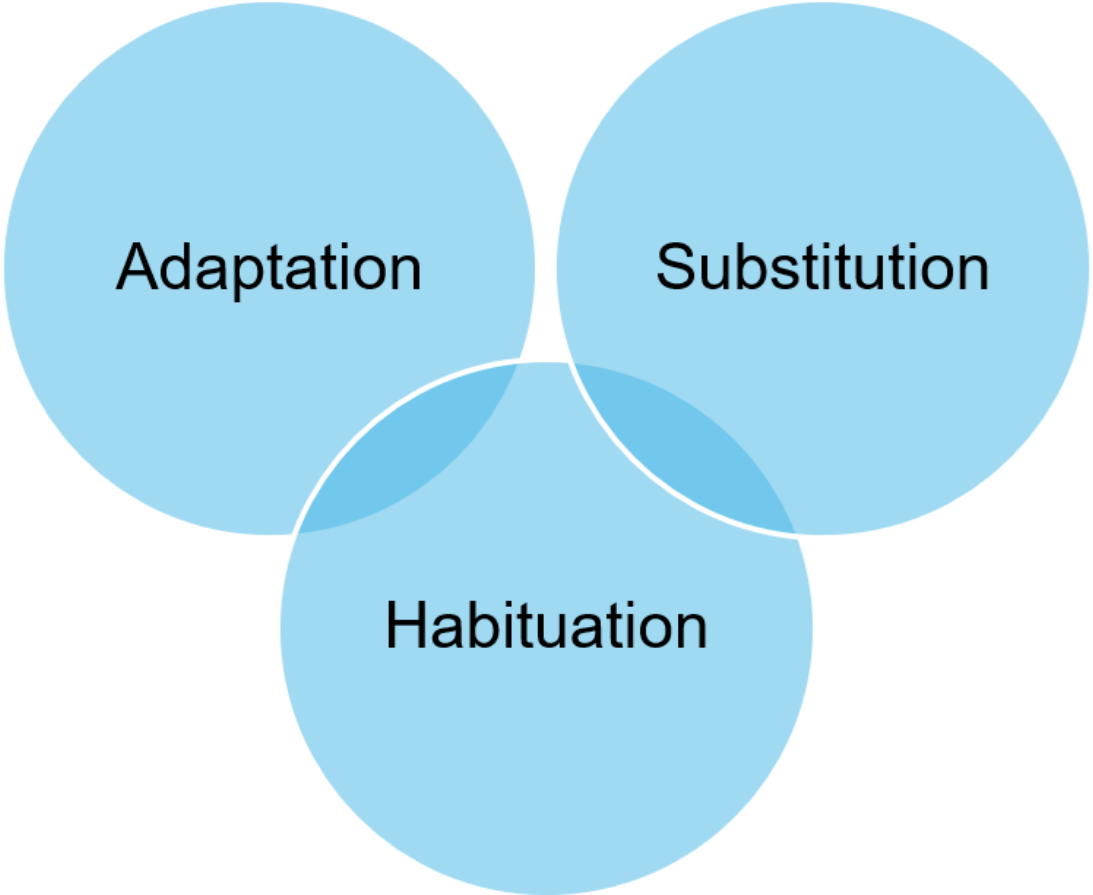
Vestibular PT Evaluation

- Oculomotor
- Vestibular
- Balance/postural control
- Gross motor activity

- Patient Specific Functional Scale
- Patient reported outcome measures

Vestibular Rehabilitation/Treatment

- Vestibular Hypofunction
  - Unilateral
  - Bilateral
- Vestibular Migraine Variants
- BPPV
- Concussion
- Persistent Postural Perceptual Dizziness (PPPD)
- Sensory Processing Disorder


Adaptation
Substitution
Habituation

Adaptation

- Improve gaze stability and balance
- Pediatric Considerations:
  - Static visual target with head movement
  - Ongoing development of sensory systems

Substitution

- Use alternative strategies for loss of function
- Coordination of sensory systems to maintain balance

Habituation

- Repetition of symptom provoking movements
  - Exercises are patient specific
  - Play based to increase participation
  - Gradual progression

Unilateral Vestibular Hypofunction

- Most often due to infection
  - Resume normal function of VOR
  - Uptrain remaining sensory inputs
  - Improve response to provocative movements

Bilateral Vestibular Hypofunction

- Congenital or Acquired
  - Effectiveness of visual and somatosensory cues
  - Address gross motor delay with principles of motor learning

Vestibular Migraine Variants

- **BPTI** or **BPVC**
  - Gross motor delay or balance impairment
- **Vestibular Migraine**
  - Peripheral vestibular impairments
  - Gross motor delay
  - Motion sensitivity as a migraine trigger

BPPV

Canal	Maneuver
Posterior	• Epley • Semont Liberatory
Horizontal	• BBQ Roll • Gufoni
Anterior	• Neck Extension

Concussion

PPPD

- Habituation
- Balance
- Visual Desensitization
- Aerobic Exercise
- Coping Strategies

Sensory Processing Disorder

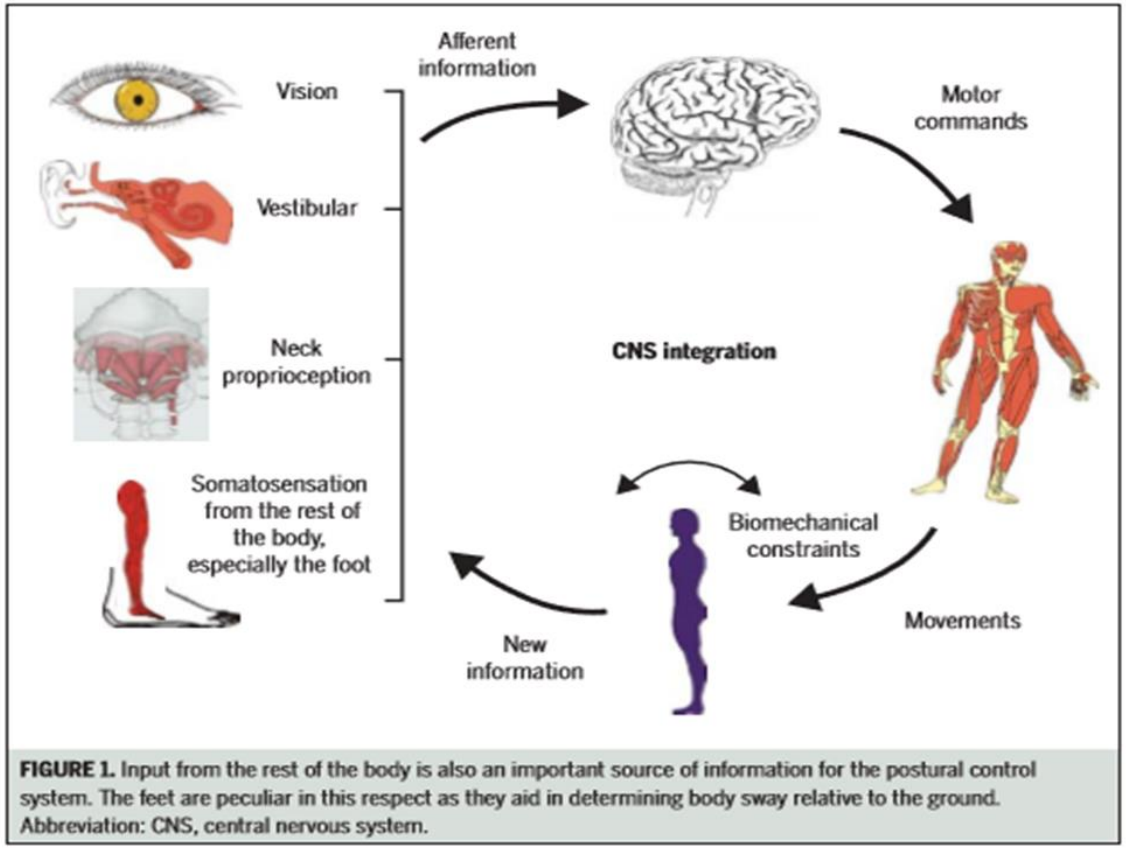
- Overarousal of vestibular system:
  - Movement seeking
    - Proprioception to promote regulation
- Underarousal of vestibular system:
  - Gravitational insecurity
    - Gradual progression of activity to increase comfort

Functional Goals

- Gross motor skill development
- Tolerance to transitional movements
- Decrease falls or loss of balance
- Participation in age appropriate play
  - Playground
  - Sports
  - Physical education

Sensory Organization

And Re-organization!



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THANK YOU!

Contact Us:

Jessica Pidgeon jessica.pidgeon@childrens.harvard.edu

Heather Molind heather.molind@childrens.harvard.edu

References

- Braswell J, Rine RM. Preliminary evidence of improved gaze stability following exercise in two children with vestibular hypofunction. *International Journal of Pediatric Otorhinolaryngology.* 2006;70(11):1967-1973. doi:https://doi.org/10.1016/j.ijporl.2006.06.010
- Brodsky JR, Shoshany TN, Lipson S, Zhou G. Peripheral vestibular disorders in children and adolescents with concussion. *Otolaryngol Head Neck Surg.* 2018; 159(2):365-370. doi: 10.1177/0194599818770618.
- Christy JB. Considerations for Testing and Treating Children with Central Vestibular Impairments.*Semin Hear.* 2018 Aug;39(3):321-333. doi: 10.1055/s-0038-1666821. Epub 2018 Jul 20. PMID: 30038458; PMCID: PMC6054582.
- Duarte JA, Leao EM, Fragano DS, et al. Vestibular syndromes in childhood and adolescence. *Int Arch Otorhinolaryngol.* 202; 24(4):e477-e481.
- Han BI, Song HS, Kim JS. Vestibular rehabilitation therapy: review of indications, mechanisms, and key exercises. JClin Neurol. 2011 Dec;7(4):184-96. doi: 10.3988/jcn.2011.7.4.184. Epub 2011 Dec 29. PMID: 22259614; PMCID: PMC3259492.
- Hirabayashi S, Iwasaki Y. Developmental perspective of sensory organization on postural control. *Brain and Development*. 1995;17(2):111-113. doi:https://doi.org/10.1016/0387-7604(95)00009-z
- Kapadia M, Scheid A, Fine E, Zoffness R. Review of the Management of Pediatric Post-Concussion Syndrome-a Multi-Disciplinary, Individualized Approach. *Curr Rev Musculoskelet Med*. 2019 Mar;12(1):57-66. doi: 10.1007/s12178-019-09533-x. PMID: 30758705; PMCID: PMC6388574.
- O'Keefe JA, Robertson-Dick E, Dunn EJ, Li Y, Deng Y, Fiutko AN, Berry-Kravis E, Hall DA. Characterization and Early Detection of Balance Deficits in Fragile X Premutation Carriers With and Without Fragile X-Associated Tremor/Ataxia Syndrome (FXTAS). Cerebellum. 2015 Dec;14(6):650-62. doi: 10.1007/s12311-015-0659-7. PMID: 25763861.

References

- O'Reilly R, Thierry M, Brodsky JR, Cushing SL. *Manual of Pediatric Balance Disorders*. Plural Publishing, Inc; 2020.
- Rine R. Vestibular Rehabilitation for Children. *Seminars in Hearing*. 2018;39(03):334-344. doi:https://doi.org/10.1055/s-0038-1666822
- Rine RM, Braswell J, Fisher D, Joyce K, Kalar K, Shaffer M. Improvement of motor development and postural control following intervention in children with sensorineural hearing loss and vestibular impairment. *International Journal of Pediatric Otorhinolaryngology*. 2004;68(9):1141-1148. doi:https://doi.org/10.1016/j.ijporl.2004.04.007
- Rine RM, Wiener-Vacher S. Evaluation and treatment of vestibular dysfunction in children. NeuroRehabilitation. 2013;32(3):507-18. doi: 10.3233/NRE-130873. PMID: 23648605.
- Sinno S, Dumas G, Mallison A, et al. Changes in the sensory weighting strategies in balance control throughout maturation in children. *J Am Acad Audiol*. 12021; 32:122-136. doi: 10.1055/s-0040-1718706.
- *What Is Unilateral Vestibular Hypofunction? A Special Interest Group of Fact Sheet*.; 2015. Accessed March 19, 2023. https://www.neuropt.org/docs/default-source/vsig-english-pt-fact-sheets/unilateral-vestibular-hypofunction54a135a5390366a68a96ff00001fc240.pdf?sfvrsn=88a25343_0&sfvrsn=88a25343_0