


Vestibular and Oculomotor Dysfunction: Signs and Symptoms in Pediatric Concussion

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Caryn Keller PT, DPT, NCS

Children's Hospital Colorado Department of Physical Therapy

SPORTS MEDICINE
CENTER

 Children's Hospital Colorado

Introduction

Caryn Keller, PT, DPT, NCS

caryn.keller@childrenscolorado.org

Therapy Care on Telstar-Colorado Springs

2375 Telstar Drive, Suite 160

Vestibular Screening- Colorado Springs

719-305-8014

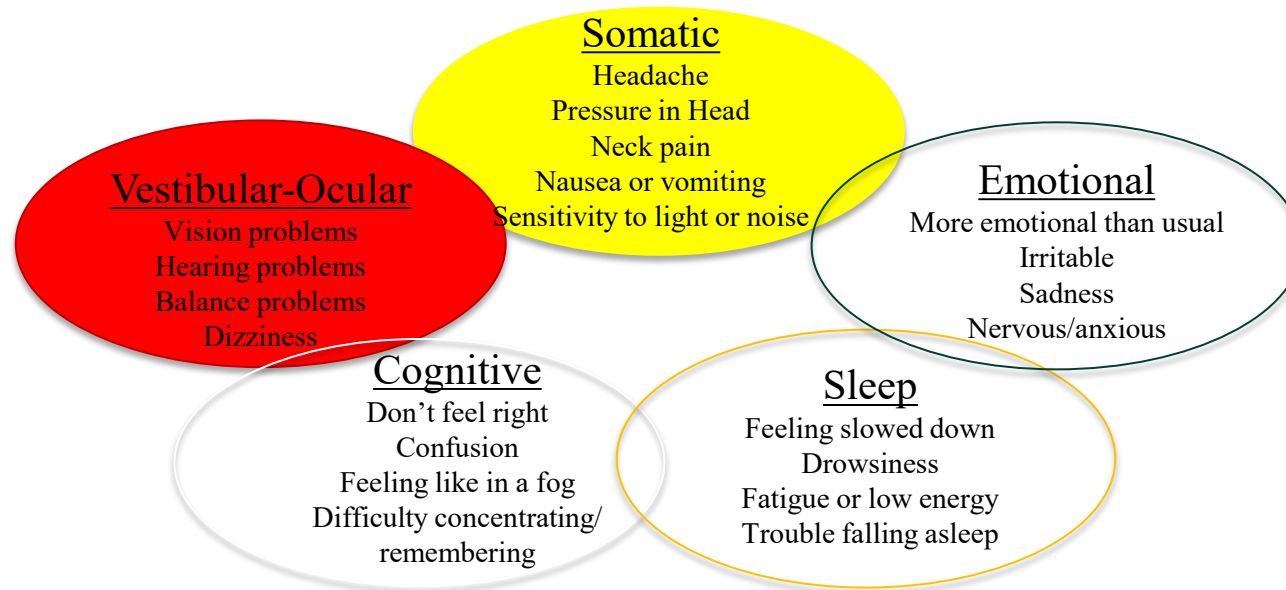


No Disclosures

Objectives

- 1 Vestibular & oculomotor dysfunction in concussion, what do we know now?
- 2 Recognizing pediatric BPPV following concussion and making timely referrals
- 3 Vestibular rehabilitation principles
- 4 Questions & Answers

Not all concussions are the same



Howell et al., Acta Ped, 2016

Vestibular-Ocular
Vision problems
Hearing problems
Balance problems
Dizziness

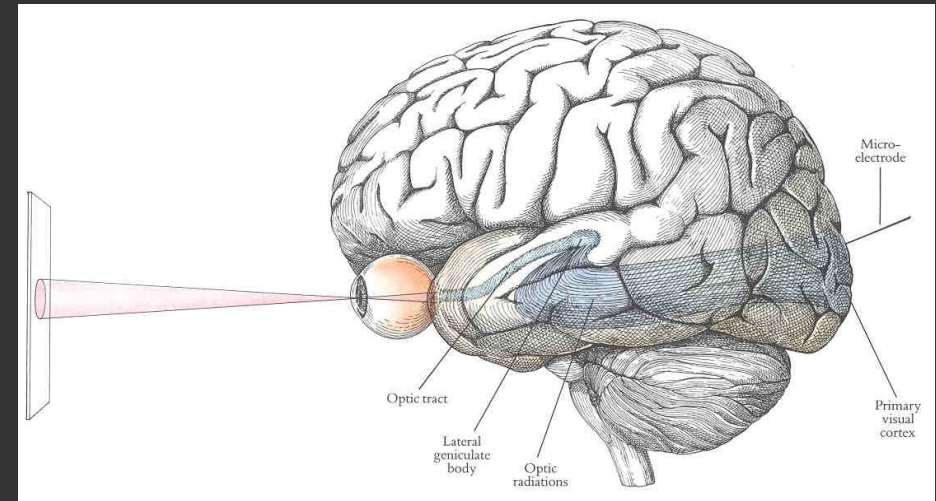
Margot Gray, PT, DPT

Oculomotor System

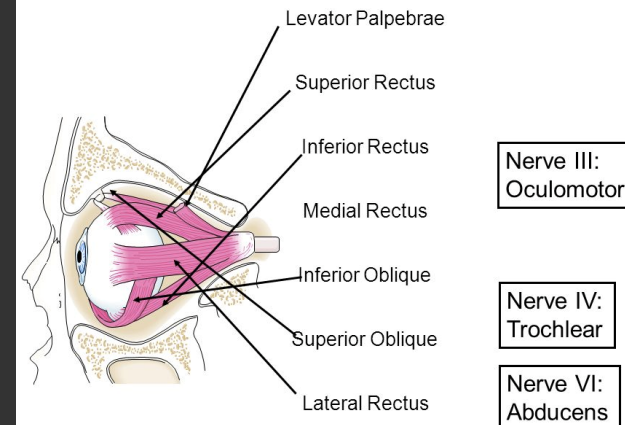
Neurologic pathways associated with the visual system, including oculomotor function, are widely distributed throughout the brain

- Sensitive to sub-concussive head impacts

Diffuse shear injury with concussion often can produce a broad dysfunction throughout the afferent and efferent visual systems.



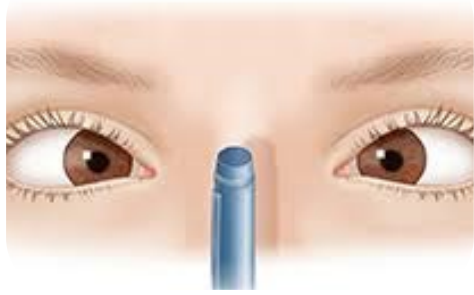
3 Cranial Nerves Control the Eye



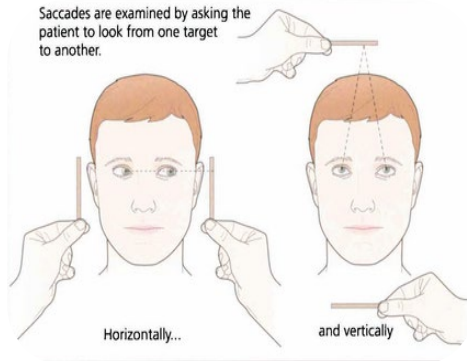
Visual Symptoms

1. Light sensitivity
2. Blurry Vision
3. Double Vision
4. Eye Strain
5. Appearance of words moving on the page
6. Place loss while reading

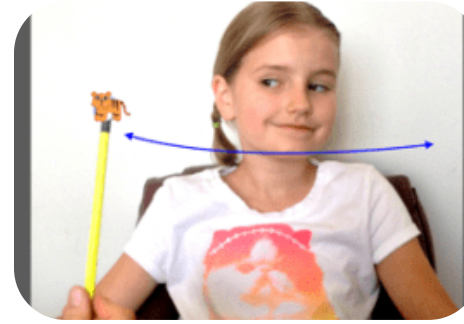




Convergency
Insufficiency



Saccadic eye
movements



Smooth pursuits



Accommodative
Dysfunction

Visuo-oculomotor Function and Reaction Times in Athletes with and without Concussion

[Graham D. Cochrane](#), [Jennifer B. Christy](#), PT, PhD, [Anwar Almutairi](#), PT, MS, [Claudio Busetini](#), PhD, [Mark W. Swanson](#), OD, MSPH, FAAO, and [Katherine K. Weise](#), OD, MBA, FAAO

- Compared collegiate athletes with and without concussion
- Ages 18-24
- Rotary chair and SOT
- 87 patients with 28 having had a concussion

RESULTS

Concussed athletes had longer saccadic, visual and dual task reaction times and reduced saccadic accuracy



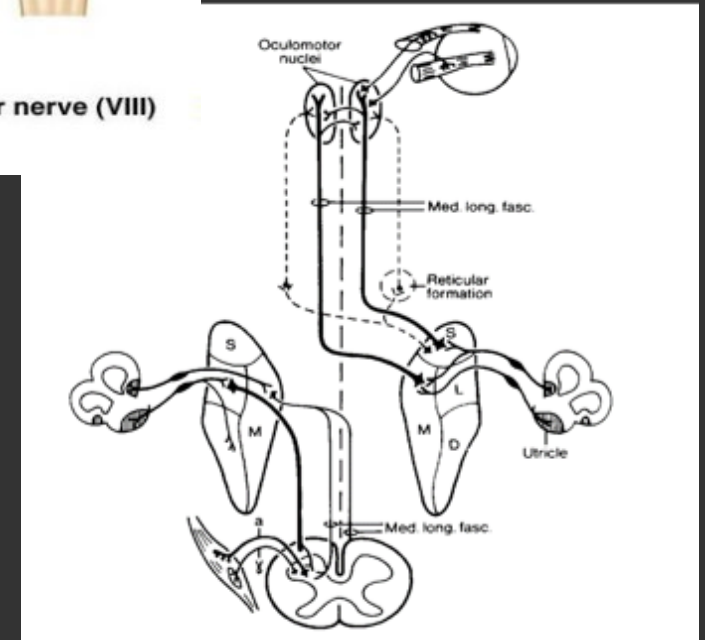
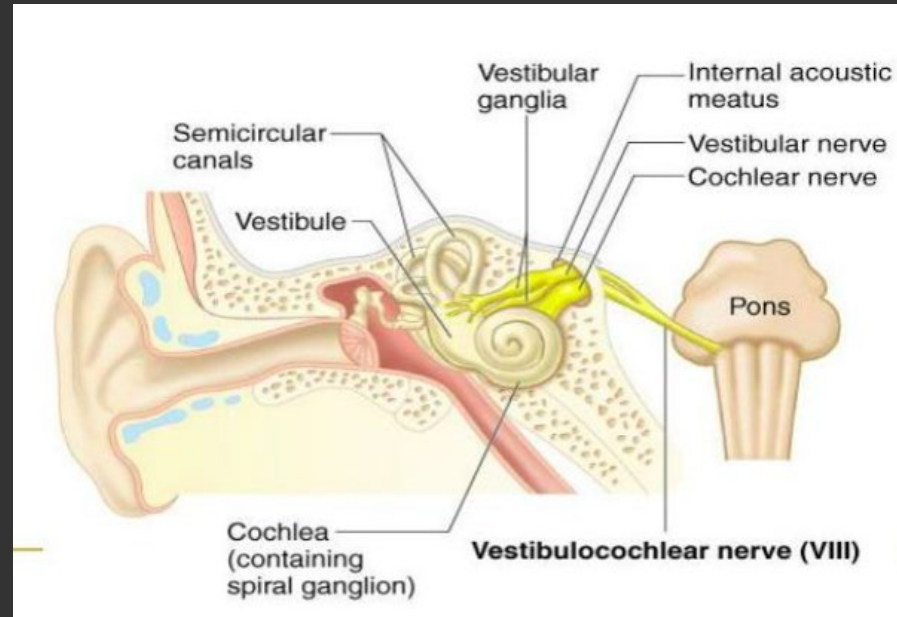
Vestibular System

Peripheral System

- Semicircular canals
- Otolith organs
- Connects to the central system through CN8

Central System

- Vestibular nuclei brainstem (Medulla/Pons)
- Cerebellum
- Reticular activating system
- Cortex -spatial orientation and self-motion perception
- Spinal cord



Vestibular Reflexes

The projections from the vestibular nuclei mediate two main classes of reflexes:

- 1) Vestibulo-ocular reflexes
- 2) Vestibulospinal reflexes



Vestibular Reflexes

1) Vestibulo-ocular Reflex (VOR)

- Uses information sourced from the organs of the inner ear to generate eye movements that stabilize gaze during head movements
- This is accomplished by the generation of eye movements that are equal and opposite to head movements

Gaze stabilization



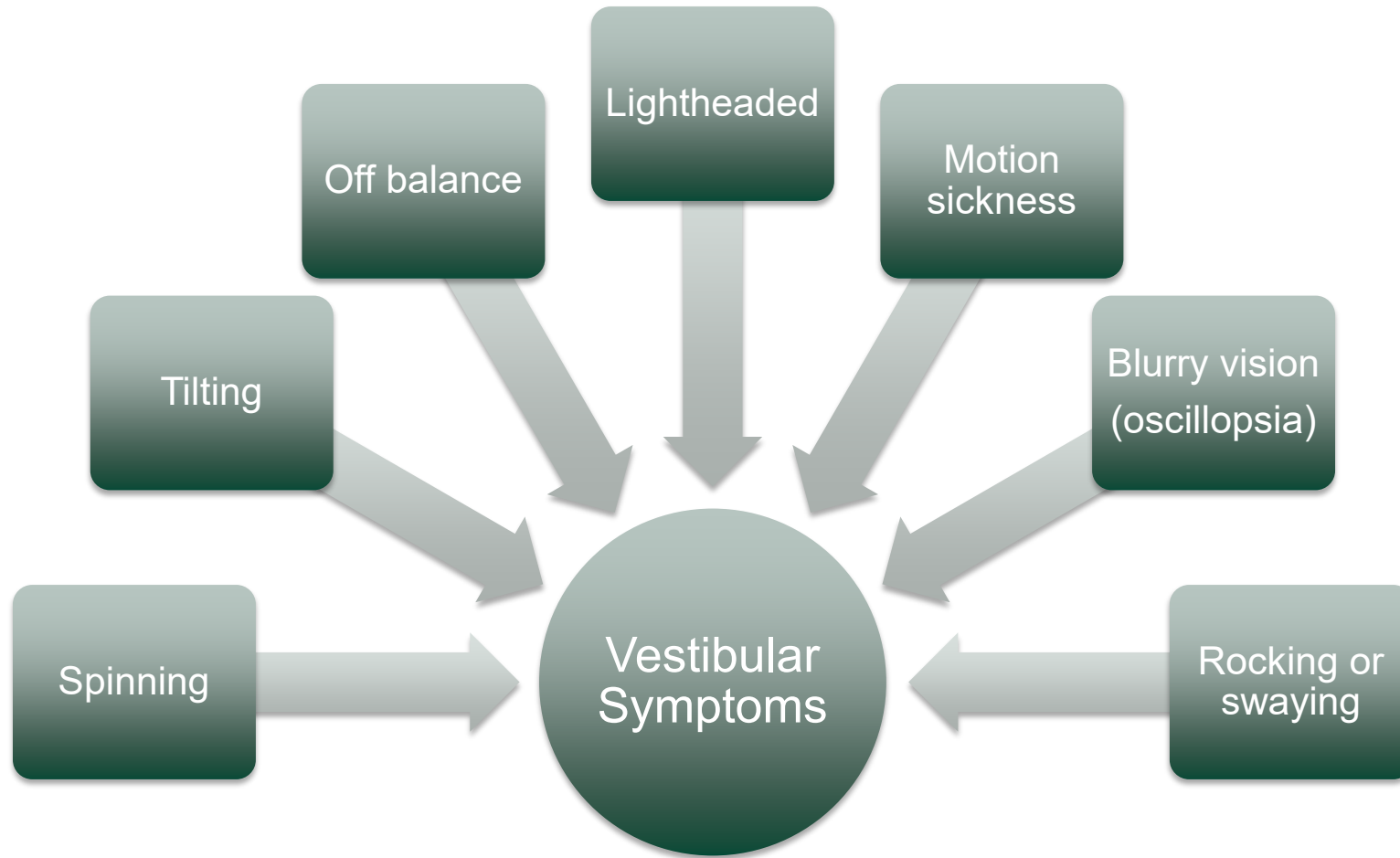
Vestibular Reflexes

2) Vestibulo-spinal Reflex (VSR)

- Activation of spinal motor neurons that innervate neck, trunk, and limb muscles
- Maintain balance and body orientation in the face of ongoing perturbations
- Reflexes are fast, providing compensatory movements that counteract and protect against the potentially injurious results of tripping or falling

Postural orientation





Margot Gray, PT, DPT

Peripheral Vestibular And Balance Function In Athletes With And Without Concussion

Jennifer B. Christy, PT, PhD^a, Graham D. Cochrane^a, Anwar Almutairi, PT, MS, PhD^a, Claudio Busetini, PhD^{b,c}, Mark W. Swanson, OD, MSPH, FAAO^b, and Katherine K. Weise, OD, MBA FAAO^b

Healthy athletes (n = 87) and athletes with sports related concussion (SRC) (n = 28)

- Rotary chair (RC), cervical vestibular-evoked myogenic potential (c-VEMP), Sensory Organization Test (SOT)

RESULTS:

- No significant difference for tests of peripheral vestibular function (RC and c-VEMP)
- Athletes with SRC had significantly worse scores on VOR cancellation gain, subjective visual vertical and horizontal variance, and all conditions of the SOT
- Concussion may alter central processing of vestibular and visual information while not affecting the peripheral vestibular organs and associated brainstem- and cerebellar-level processes

Peripheral Vestibular Disorders in Children and Adolescents with Concussion

Jacob R. Brodsky, MD^{1,2}, Talia N. Shoshany^{1,2},
Sophie Lipson^{1,2}, and Guangwei Zhou, ScD^{1,2}



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SAGE

- 109 patients ages 7-20
- 28 patients (25.7%) + PVD
- Study includes non-sports related concussions

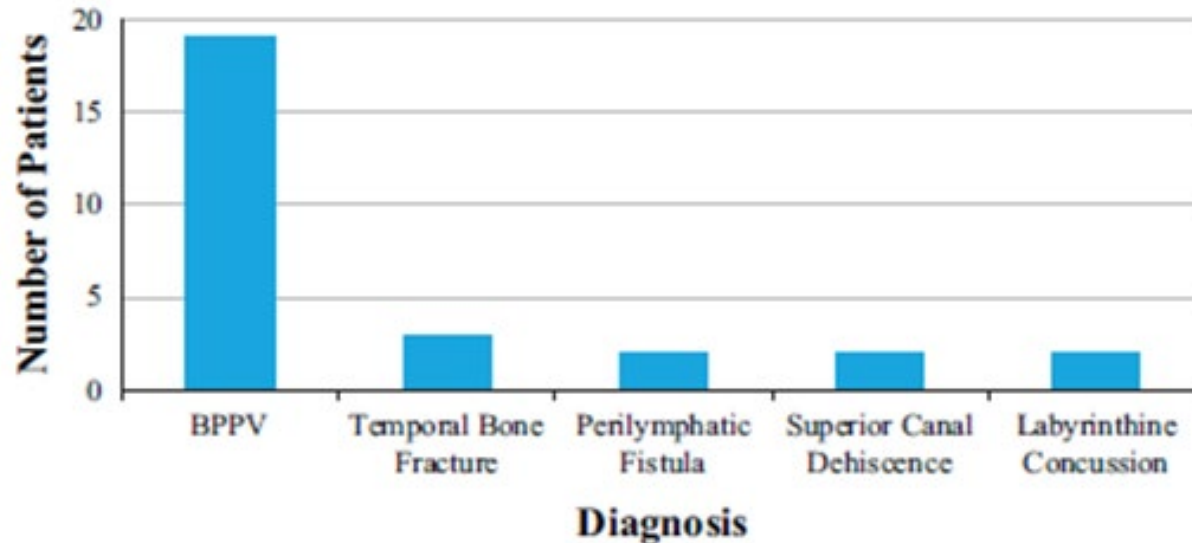


Figure 1. Peripheral vestibular disorders diagnosed in 28 patients in the setting of postconcussion syndrome in patients aged 7 to 20 years. BPPV, benign paroxysmal positional vertigo.

Vestibular Testing at CHCO

- Comprehensive Vestibular Evaluation

- cVEMP and oVEMP
- vHIT
- Rotary Chair
- Headshake
- VNG (oculomotor, positional, and caloric testing)
- Subjective Visual Vertical test

- Limited Vestibular Evaluation

- cVEMP and oVEMP
- vHIT
- Rotary Chair

- Vestibular Screening

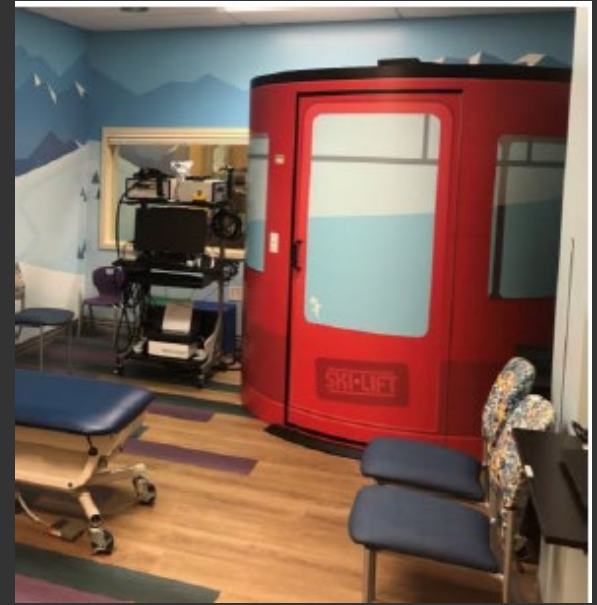
- cVEMP and oVEMP
- vHIT
- Physical Therapy Vestibular Evaluation

**Anschutz
Campus**



**Telstar, Colorado
Springs**

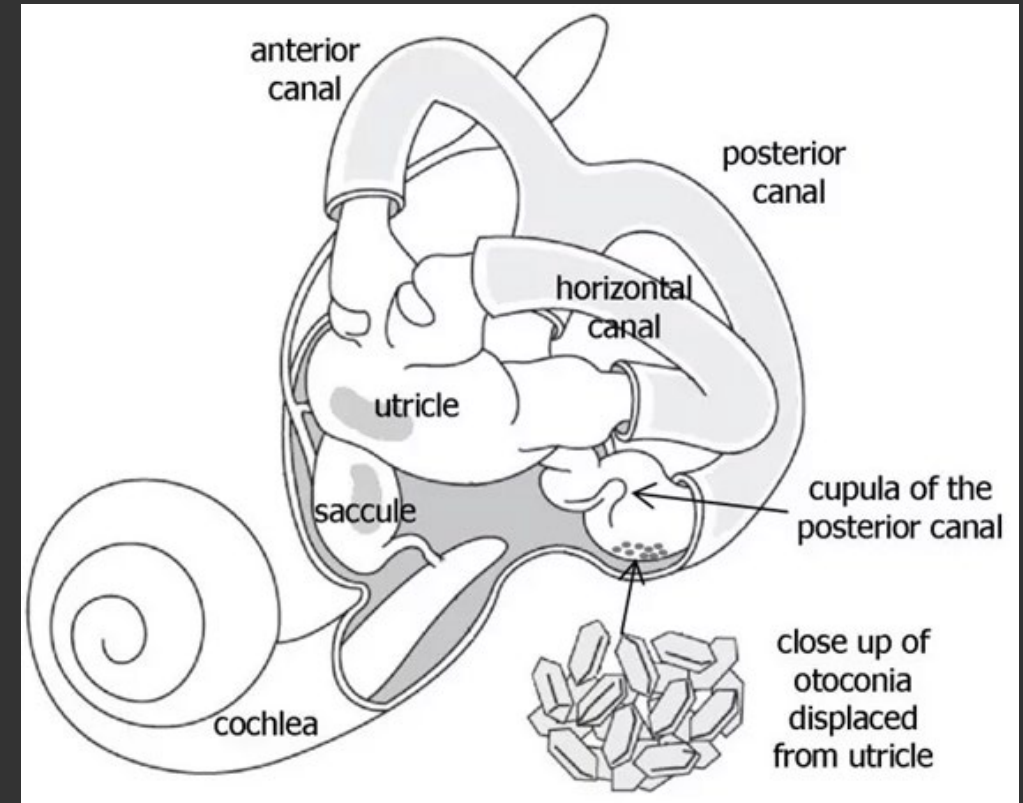




Benign Paroxysmal Positional Vertigo (BPPV)

Biomechanical disorder

A displacement of otoconia (calcium carbonate crystals) from the utricle (otolith organ) to the semicircular canals in the inner ear causing vertigo or dizziness with head movements



www.vestibular.org

Prevalence of BPPV in Pediatric Concussion

Most common peripheral vestibular disorder in pediatric concussion

- Prevalence between **10%-30%**

Similar rates regardless of gender or age group

- Children vs adolescents

Delayed diagnosis and management- Average of **19 weeks** after injury

- Increased awareness of BPPV among concussion providers could have a major positive impact on accelerating recovery

Benign Paroxysmal Positional Vertigo After Pediatric Sports-Related Concussion

Karen Reimer, MSc, BMR(PT),*†‡§ Vanessa Ellis, BMR(PT),* Dean M. Cordingley, MSc,*§ Kelly Russell, PhD,§¶|| and Michael J. Ellis, MD, FRCSC*§¶||**

- 115 patients with SRC
- Age <19 years BPPV assessment
- **10.4% were diagnosed with BPPV**
- All successfully treated with repositioning maneuvers

TABLE 2. Summary of the Clinical Findings and Outcomes of Pediatric SRC Patients Evaluated and Treated for BPPV

Age/ Sex	Sport	Duration of Symptoms Before Initial Assessment	Initial PCSS Score	BPPV Diagnosis/ SCC Involvement	PR Maneuver	No. of Treatments	Successful Treatment of BPPV (Yes/No)	Coexisting Condition (Treatment)	Overall Clinical Outcome (Length of Recovery)
14 M	Hockey	2 d	32	Right PSCC BPPV	Semont	1	Yes	Cervical spine dysfunction (cervical spine physiotherapy)	Clinically recovered (38 d)
15 F	Diving	9 mo	8	Right ASCC BPPV	Half somersault	2	Yes	None	Clinically recovered (11 mo)
15 F	Bike riding	8 d	57	Left PSCC BPPV	Epley	4	Yes	Vestibulo-ocular dysfunction (vestibular physiotherapy)	Lost to follow-up
16 F	Ringette	4 d	59	Left PSCC BPPV	Epley	2	Yes	Vestibulo-ocular dysfunction (vestibular physiotherapy)	Clinically recovered (55 d)
14 F	Volleyball	2 mo	22	Right ASCC BPPV	Half somersault	2	Yes	Cervical spine dysfunction (cervical spine physiotherapy) Autonomic/ physiological PCD (submaximal aerobic exercise prescription)	Lost to follow-up
15 M	Football	6 d	63	Right PSCC BPPV	Epley	1	Yes	None	Clinically recovered (35 d)
14 M	Hockey	7 d	28	Left ASCC BPPV	Half somersault	1	Yes	None	Clinically recovered (25 d)
14 F	Football	5 d	37	Right PSCC BPPV	Epley	2	Yes	Autonomic/ physiological PCD (submaximal aerobic exercise prescription)	Clinically recovered (61 d)
7 F	Bike riding	5 mo	19	Right PSCC BPPV	Epley	1	Yes	None	Clinically recovered (6 mo)
12 F	Hockey	3 d	60	Right PSCC BPPV	Epley	1	Yes	None	Clinically recovered (37 d)
16 F	Soccer	76 d	37	Left ASCC BPPV	Half somersault	1	Yes	Vestibulo-ocular dysfunction (vestibular physiotherapy)	Clinically recovered (185 d)
14 F	Horseback riding	28 d	12	Left PSCC BPPV	Epley	1	Yes	None	Clinically recovered (57 d)

Subjective Questioning

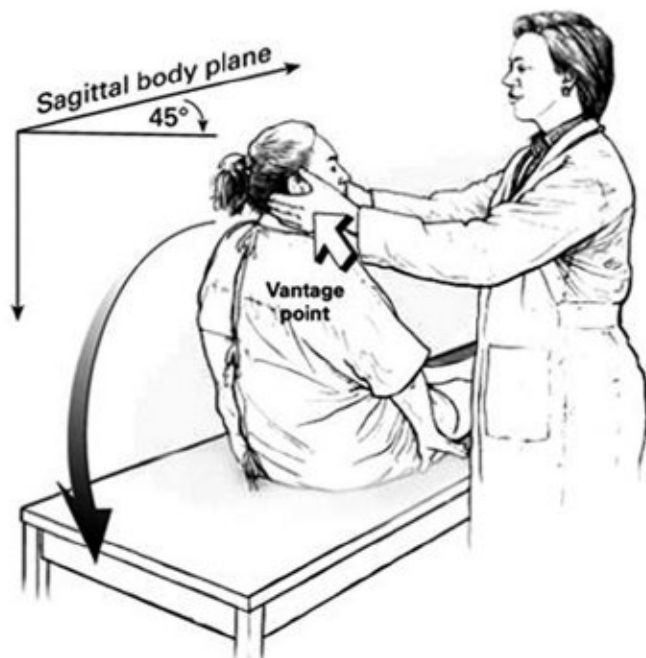
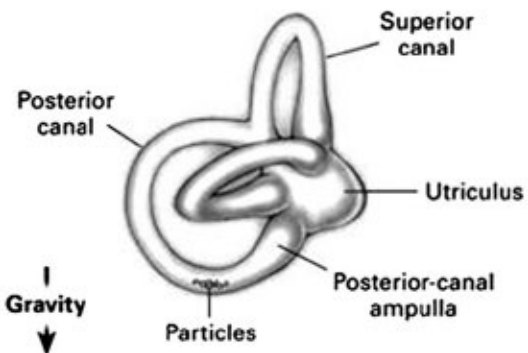
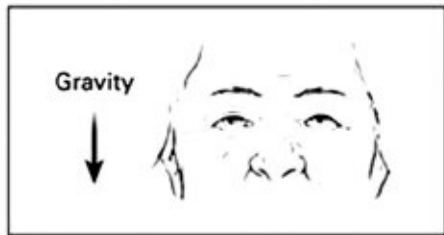
Dizziness is the second most common symptom in pediatric patients with concussion

Use thorough history taking as a guide for referral for suspected BPPV

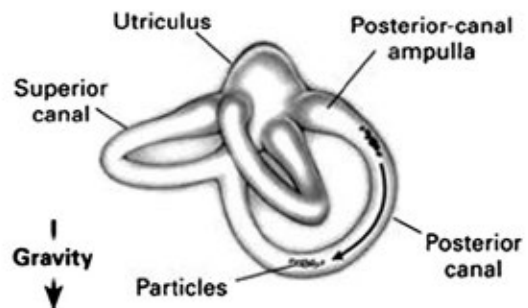
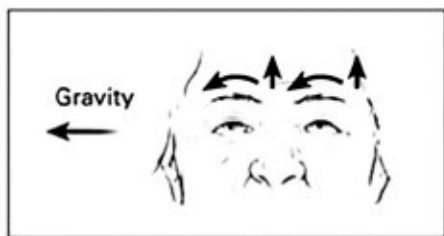
- 1) **Rotary spells** "room is spinning," or "I am spinning"
- 2) Duration < **30 seconds**
- 3) Associated with a head **position change** in relationship to gravity
 - Rolling in bed (waking up/getting up), putting on shoes, wash hair
- 4) Dizziness severity NOT reliable
 - Patients with BPPV did not report more severe dizziness than patients not diagnosed with BPPV



A



B



Dix-Hallpike




Refer to Vestibular Physical Therapy

If you suspect BPPV

Refer right away-do not delay!

- Accelerate recovery
- Reduce risk of development of functional vestibular disorders



Vestibular Rehabilitation and Pediatric Concussion

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Vestibular Rehab is MORE than just balance training...



**Repositioning
Maneuvers**
BPPV

Adaptation
Gaze stabilization
(peripheral
dysfunction/VOR
recalibration)

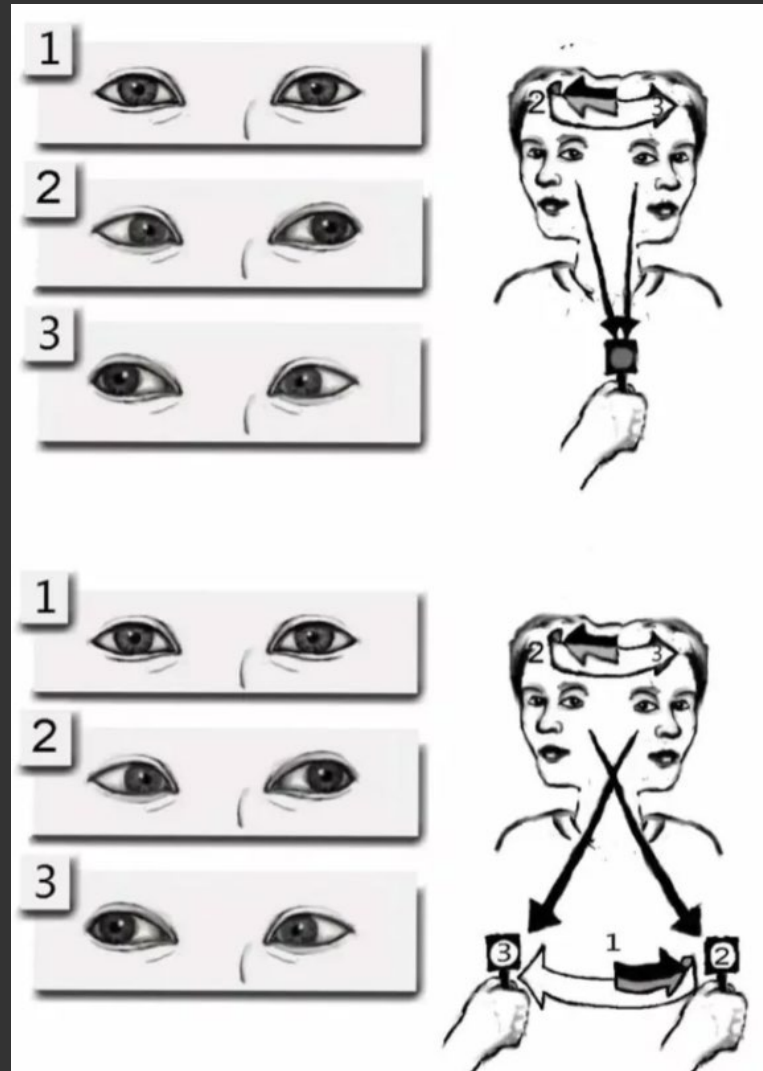
Habituation
For dizziness that is produced
because of self-motion and/or
visual stimuli

Adaptation

Gaze Stabilization exercises are used to recalibrate the VOR back to gain of 1

Test/Retest:

Dynamic Visual Acuity Test

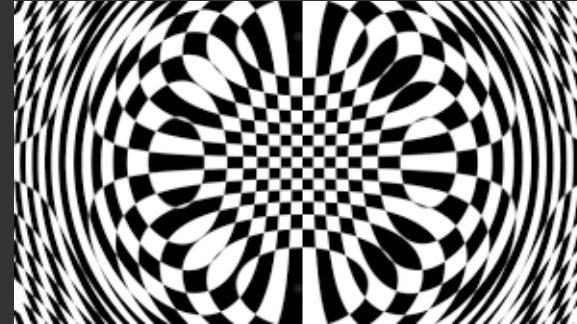


<https://vestibular.org/article/diagnosis-treatment/treatments/vestibular-rehabilitation-therapy-vrt/>

Habituation

Reduction in a behavioral response to repeated exposure to a provoking stimulus with the goal of reducing symptoms

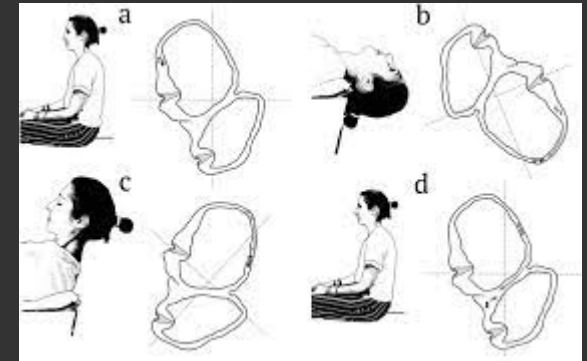
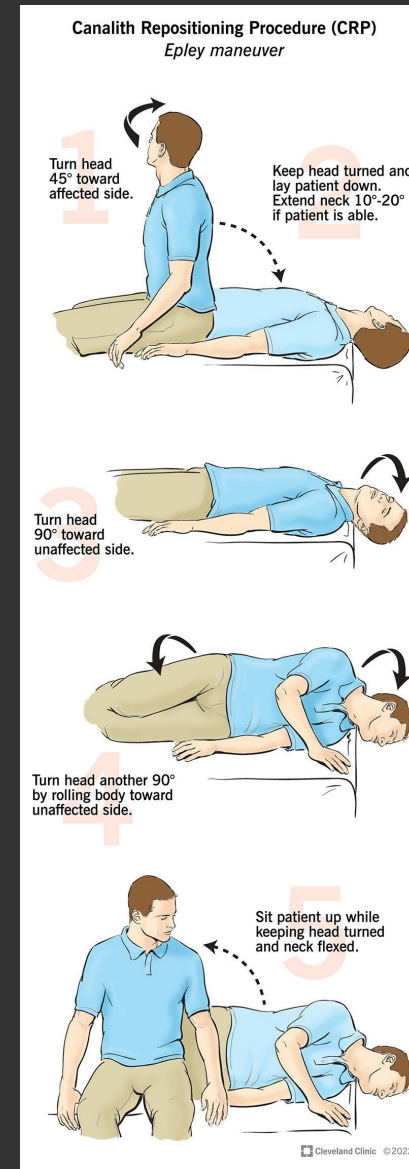
Must replicate what provokes the symptoms!



Repositioning Maneuvers

BPPV

- Goal is to mechanically remove otoconia from the semicircular canal
- Selection of maneuver is determined by the location of the otoconia
- Maneuvers are designed to clear otoconia from specific semicircular canals based on the canal orientation to gravity



Oculomotor Exercises

Pursuits: tracking targets with stationary head ex: X pattern, figure 8, Trackit, tracking ball toss with stationary head

Saccades: eye movements between 2 targets with stationary head, pen and paper tasks (ex: Michigan tracking, circle the Ps)

Convergence: brock string, pencil push-ups

Habituation



Questions?



Thank You!

Vestibular testing or screening questions?

Contact us:

Vestibular@childrenscolorado.org



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