













Concussion Signs and Symptoms

- Physical: headache, balance problems, light/noise sensitivity, blurred vision, dizziness, fatigue, nausea, neck pain
- Cognitive: mentally foggy, difficulty concentrating, confusion, delayed processing
- Emotional: irritability, sadness, nervousness, anxiety, lability
- Sleep: drowsy, altered sleep patterns
- Duration of Symptoms is highly variable and may last from several minutes to months or even longer in some cases



Risk Factors

- Several risk factors contribute to an athlete's concussion recovery.
- Assessing the athlete's concussion history can provide valuable information; specifically, the number of concussions, the severity of each concussion, and how close in time the concussions occurred to each other.
- Additionally, assessing concussion symptoms (number, severity, and duration), the age of the athlete, and any preexisting conditions (e.g., history of migraines, headaches, ADD/ADHO, Learning Disability, Depression, Anxiety) before the season begins can help with managing a concussion if it ever occurs.



Special Communication November 5, 2018

ONLINE ONLY

Centers for Disease Control and Prevention Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children

> Author Affiliations

Concussion in 2019

1



Consensus Statement on Concussion in Sport

- There are 11 R's associated with SRC management:
- Recognize
- Remove
- Re-evaluate • Rest
- Rehabilitation
- Refer Recover
- Return to Sport
- Reconsider
- Residual Effects
- Risk Reduction

Pediatric Considerations

Based on a previous systematic review of the literature, this guideline includes 19 sets of recommendations on diagnosis, prognosis, and management/treatment of pediatric mTBI. Each recommendation was assigned a level of obligation (ie, must, should, or may) based on confidence in the evidence.

Supplemental Table via:

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NEW CONCUSSION RESEARCH DAILY!

ba	<u>d, J. Gan, Pract.</u> 2019. Aug. 40(8) 531-536.	PubMed
P	ersistent visual disturbances after concussion.	, aprilea
94	nasekaran.E ⁴ . Hodoe.G ² . Bose.E ³ . Eraser.GL ⁴ .	Alerts!
8	Author information	
1	BMedSc, MOrth, HDR candidate, Discipline of Orthoptics, Graduate School of Health, University of Technology Sydney,	NSW.
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3	DOBA, DipAppSci (Orth), GradDipNeurosci, PhD, Head of Discipline, Orthoptics, Discipline of Orthoptics, Graduate Sch University of Technology Sydney, NSW.	ool of Health,
4	MBBS, MMed, FRANZCO, Associate Professor in Neuro-ophthalmology, University of Sydney, Save Sight Institute, Disc Ophthalmology, Sydney Medical School, NSW.	ipline of

OBJECTIVE: The aim of this article is to inform general practitioners (GPs) about coular defects associated with concussion, identify test procedures and highlight the important role of GPs within the concussion paradigm.

processes and nginging the instrument one of one waterin the concession paragem. BioClusions: Occurs Antricentia that commonly course with concursal instructive advantualities of accommodation, convergence, saccade and smooth pursuits. This may cause burned values, double vision, could pain and difficulty with close work. Symptomic can severely affect daily work, school or play address. Palentes complaining of extended coular symptoms following concussion should be referred to an ophilamicipal for a complete coular assessment.

History and Future Directions of Vision Testing in Head Trauma.

Ashard O¹, Rizzo JR, Rucher JG, Hasanav L, Galetta SL, Balcer LJ Author Information

(ii) A during interfamiliation Attempting the interfamiliation of the inte

CONCLUSIONS: RAN tasks and VOG assessments provide objective measures of ocular motor function. Changes in obtain motor performance after concusion reflect generatized neurophycologic changes aftecting a variety of cognitive processes. Atthough these tests are increasingly used in head injury assessments, luttime study is needed to variable them as adjunctive diagnostic task and assessments of the second seco Nery

Visual and vestibular involvement in postural deficits following concussion.

Nowak MK¹

Author information

School of Public Health, Indiana University, Bloomington, Indiana.

Abstract Postural assessment is often recommended as a component of postcorocussion examination: Nowever, a reliable, objective approach to dentify and monitor the recovery of postural deficits is still needed. Degani et al. (Degani AM, Santos MM, Leonard CT, Rau TF, Patel SA, Mohayaha S, and Danna-Do-Santos A. Brain In (3): 14-59, 2017 suggest hat effects of corocusion on postural control can be defined by group level through apalotiompour. Indexno, and organic intraductivities of basis. In contrast, Winger et al. (Whigh WW, Temmer F and McDevit J. J. Vestb Res 27: 27-37. 2017) process addronal vesibular and coulorofic assessments to identify processing deficit manuscus basis. Name constraining in addroxim.

1 (c) 10113 Mar 16 (1997) 31 (20, 31 Aug 10) 10483 and 2013 (20 AUG 200)

Saccades and memory: baseline associations of the King-Devick and SCAT2 SAC tests in professional ice hockey players. Gainta MS¹ Gainta KM. McGrossin J. Wison JA. Moster S. Gainta SL. Baloar LJ. Dorshimer GW. Master CL-

Author information

A Method OAStock OA CONCLUSION: In this study of professional athletes, scores for the K-D test, a measure for which saccadic (last) eye movements are required for the task of rapid number naming, were associated with reductions in immediate Memory at a pre-season baseline. Both

neneroy fast saccade cyr rowneneta Dwe dewoly related aladorada thuches. Polating the dovalated prehostal coriex DDP-C1 X composite of brief rapid sideline tests, including SAC and K-D (and bulance testing for non-lice hockey sports), is likely to provide an effective clinical torio bases he altible with suspected concusation. Copyright © 2013 Elsevier B.V. All rights reserved.

VEP Testing





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Estavabi.D¹. Ledener.P. Con.L.S. Author information

*PhD †OD, FAAO \$MSEE Department of Psychology, University of Nor Heishts, Illinois (PL); and Discove, Inc. Pine Brock, New Jersey (UKC).

int) and parvo

METHODS: Sustained stimuli included 2-revis, 85% contrast cheo comprised 4-revis, 10% contrast vertical sinusoidal gratings with priori clinical model based on an assumption of at least a minimal n of 0.25 and 0.50 ts and a stat

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"These visual problems...can be remedied by a range of visual interventions: lenses, prisms, occluders, tints, and VISION THERAPY."

raumatic Brain Injury	
isual Consequences, Diagnosis, and eatment	
enneth J. Gauffreda, OD, PhD**, Diana P. Ludiam, BS, aveen K. Yadav, BS Optom, MS, PhD*, eethi Thiigarajan, BS Optom, MS, PhD*	COVT
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Aid teamstic brain injury (m184) represents a major public health problem in the Joined States and worldwide.	
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have one several activations are know analy of the visco sequelas in m28, actualing the search for closed and objection bearackers for m18, mand management and therapeutic intervention in the pediatric and severe brain injury.	

Vision Therapy for Post-Concussion Vision Disor

Dalasarch¹ Scheman II: Martel D. @ Author information

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ent. Evaluation of patients with

......... "CI and AI were the most common

diagnoses...VISION THERAPY had a successful outcome in the vast majority of cases that completed treatment protocol."

Post-therapy Functional Magnetic Resonance In Insufficiency. tic Co

National CE¹ Constaint, TS¹ London Ce², Kark MI, Tanix AJ¹, Kanton MR², Tool JJ

- 7. aged 18 to 30 years with symptomatic CI were tandom 00re 2.25 was posterior, inferior portion of the occipital labe placebo therapy. A significant decrease in ac two therapy and to a lesser extent after place after ver

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blood-oxygen level dependent response in the occipital areas following rehabilitative VISION THERAPY...suggests that both depth & vergence may be enhanced."

Cervicovestibular rehabilitation in sportrelated concussion: a randomised controlled trial w2. Lara Boyd5. Jian Kang1. Carolyn A Emery1.2.3

The first strength of the stre

- Results In the treatment group, 73% (11/15) of the participants were medically cleared within 8 weeks of initiation of treatment, compared with 7% (1/14) in the control group. Using an intention to treat analysis, individuals in the treatment group were 3.91 (95% CI 1.34 to 11.34) times more likely to be medically cleared by 8 weeks.
- Conclusions A combination of cervical and vestibular physiotherapy decreased time to medical clearance to return to sport in youth and young adults with persistent symptoms of dizziness, neck pain and/or headaches following a sport-related concussion.

Feasibility of Early PT for Dizziness After SRC: a

RCT Reneker JC¹, Hassen A², Phillips RS², Mo

- Scand J Med Sci Sports. 2017 Feb 17. doi: 10.1111/sms.12827. [Epub ahead of print Subjects aged 10-23 years old with acute concussion and dizziness were enrolled from sports medicine centers.
- Forty-one participants were randomized into treatment and were seen for physical therapy beginning at 10 days post-concussion.
- Subjects in the experimental group received individually tailored, pragmatically delivered progressive interventions.
- Subjects in the control received prescriptive sham to minimally progressive interventions.
- The two primary outcomes were medical clearance for return-to-play and symptomatic recovery.
 The median number of days to medical clearance for the experimental group was 15.5 and for the control was 26.
- The median number of days to symptomatic recovery was 13.5 for the experimental group and was 17 for the control.

Multidisciplinary Approach SRC

From withdrawal to return to play:

- Coach
- Athletic Trainer
- Sports Medicine Doctor
- Neuropsychologist
- Neurologist
- Vestibular Therapist (PT/OT)
- Vision Therapist
- Neuro-otologist Counselor
 - "It takes a village to treat a concussion...."Mickey Collins

Concussion

Management

The Team Pla

Multidisciplinary Approach

- Physician (PCM, SM, GP, Pediatrician)
- Neuropsychologist
- Neurologist
- Vestibular Therapist (PT/OT)
- Vision Therapist
- Neuro-otologist
- Audiologist (hearing/vestibular involvement)
- Counselor

The difficult concussion patient: what is the best approach to International Concession patient: what is the best approac investigation and management of persistent (>10 days) postconcussive symptoms? Michael Makifusis, Robert C Cantu, Karen M Johnston, Paul McCrory, Wille Meeuwisse

Cases of concussion in sport where clinical recovery falls outside the expected window (ie, 10 days) should be managed in a multidiscipary mamer by healthcare provides with experience in sports-related concussion. Important components of management, after the initial period of physical and cognitive rest, include associated therapies such as consideration country and a solution of the so



The Visual System Overview



Definition of Vision (Padula)

A <u>dynamic</u>, <u>interactive</u> process of <u>motor</u> and sensory function mediated by the eyes for the purpose of <u>simultaneous organization of</u> <u>posture</u>, <u>movement</u>, <u>spatial orientation</u>, <u>manipulation of the environment</u> and to its highest degree of perception and thought. How does vision relate to other sensorimotor systems?



Sight vs. Vision

- Sight is what allows us to read 20/20
 Normal Ocular Health
 Corrective Lenses?
- Vision is what the BRAIN does with the information taken in from the
 - eyes
 "Vision is first and foremost action, which makes perception impossible without movement."







Vision & Motor Link









Pathways of Ganglion Cells

- Parvocellular or P Pathway
- FOCAL
- WHAT?
- Magnocellular or M Pathway
- AMBIENT
- WHERE? HOW?



Parvocellular/Focal/Ventral Pathway

- Object Identification → WHAT?
- Reactive
- Slower
- Cortical/Higher Level Processing
- Guidance of fine motor · Secondary to ambient process in
- survival
- TEMPORAL LOBE



Magnocellular/Ambient/Dorsal Pathway

- Spatial Identification → WHERE??
 Proactive/Lightning fast/Subconscious
- Sensitive to Movement
- Spatial Localization
- Figure-Ground Segregation Larger impact on
- balance/posture/function
- Anticipates change in preconscious
 PARIETAL LOBE







Areas Responsible For Binocular Function



Task 1...Point and maintain eyes in the direction of the target.

- · Hold gaze steady on a target & image steady on the retina
 - Fixation: holds the image of a stationary object on the fovea when the head is immobile.
 - Vestibular (VOR): holds image steady on the retina during brief head movements.
 - Optokinetic: holds image steady on the retina when following object in motion.
- · Fixation is an active process, not merely an absence of visible eye movements



is 2014 06.003 E The correlation between the vestibulo-ocular reflex and multi-focal ocular correction: implications for vestibular compensation.

Michaelides E¹. Schutt CA² Author information

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CONCLUSIONS Pr d by Elsevier Inc

How do we direct the eyes to a target?

- <u>Saccades</u>: bring the image of an object of interest rapidly onto the fovea.
- <u>Smooth pursuit</u>: holds the image of a small moving target on the fovea.

 Vergence: moves the eyes in opposite direction (i.e., convergence or divergence) so that images of a single object are held simultaneously on both fovea.



Saccades

- Rapid simultaneous shifting of fixation
- 700 degrees/second
- The supplementary eye fields assist in initiating and controlling saccades made during motor movement (of head and body).
- <u>Voluntary Saccades</u>: the FEF unlock fixation and begin <u>deliberate</u> movement to visible targets or to the predicted location.
- <u>Reflexive Saccades</u>: the parietal eye fields (PEF) begin reflexive/stimulus generated movement based on the abrupt appearance of visual targets.

Saccades

- <u>Memory-guided saccades</u>: Volitional saccades generated to the remembered location when the target is no longer visible
- <u>Anti-saccades</u>: Volitional saccades generated in the direction opposite to target, require suppressing saccade to the visual target (SEE 8/15/18 ARTICLE)
- <u>Self-paced saccades</u>: Volitional saccades made b/n 2 continuous present targets w/o verbal commands







Saccadic eye movements are a highly coordinated & complex task



Smooth Pursuits

- Stabilizes the image of a small moving target on the fovea
- Cancels the VOR during combined eye-head tracking
- Limited in speed: 30 degrees/second



Task 2...<u>Coordinate the eyes</u> to send a single image to the brain.

- Simultaneous movement of eyes in opposite directions to maintain fusion.
 - <u>Convergence</u>: adduction of eyes to view an object at near
 <u>Divergence</u>: abduction of eyes to view an object at distance
- Maintaining fusion during vergences involves complex cerebro-brainstem-

cerebellar pathways.

Convergence Diregence

Vergence Pathway

- Stimulus for Vergence Response: double vision or different positions of image on the retina \rightarrow fusional vergence movement.
 - Tonic Convergence: resting state at a particular working distance.
 - Proximal Convergence: reaction target at near.
 - <u>Accommodative Convergence</u>: Accomm-Vergence relationship.
 - <u>Fusional</u>: prompted by double vision.
 - <u>Voluntary</u>: without a target, at will.

Task 3... Maintain a clear, steady image





Dizziness Post Concussion

Prevalence and Significance • Dizziness reported in 55-80% of concussed individuals • Dizziness associated with protracted recovery • Undiagnosed vestibular deficits may delay recovery



Causes of Vestibular Dysfunction in TBI

Type of TBI	Possible Manifestation	Comment
Labyrinthine Concussion	Ataxia, imbalance, BPPV may be present	Most common vestibular injury due to TBI
Skull Fracture	UVL or BVL (partial or complete) Conductive hearing loss May have mixed peripheral and central lesions	Common with blows to the occiput, temporal or parietal regions
Hemorrhage into Labyrinth	May create post traumatic hydrops (Meniere's type syndrome) Damage to labyrinth, may create acute vertigo and Unilateral hearing loss	Labyrinthine damage may present with signs and symptoms similar with acute peripheral vestibular damage
Hemorrhage into brainstem	Oculomotor signs, poor smooth pursuit, vertigo, perception of tilt	Damage to vestibular and oculomotor nuclei
Increased Intracranial Pressure	Fluctuating hearing loss, ataxia, imbalance	May cause peri-lymphatic fistula

Just How Important is the Vestibular System?







- Dizziness
- Blurry Vision
- NystagmusTinnitus
- Vertigo
- Hearing loss
- Loss of balance & possible falls
- Broad-based stance (to
- accommodate for imbalance) • Sweating, nausea, and vomiting (due to ANS involvement)

Vestibular Overview

Vestibular		Eye Movement
Vision	Vestibular Nuclei	Posture
Auditory	1 1	Spatial Orientation
	Cerebellum	

Ears and the Brain... Connection

- Head movements are detected by the cupula and transmitted via Vestibular Nerve to the Brain.
 Which then controls eye movement to stabilize the gaze
- The ratio of eye to head movement (GAIN) should be 1:1. Abnormal gain can cause symptoms of blurry vision or vertigo



Motor Outputs

- VOR (Vestibular Ocular Reflex): generates eye movements, which enables clear vision while head is in motion
- VSR (Vestibular Spinal Reflex): generates compensatory body movement in order to maintain head and postural stability, thereby preventing falls





Vestibulo-Spinal Reflex

- Stabilizes body
- Helps maintain desired orientation to environment





6 Degree of Freedom Problem

- Three axes of rotation
 Roll, pitch and yaw
- Three axes of translation
 AP, Lateral and Vertical



Navigation Problems

- Motion sensing is a "mission critical" task (need vestibular system to walk reasonably safely in the dark)
- Vestibular System incorporates considerable redundancy





The Peripheral Vestibular System





Inertial Navigation: Inner Ear

- Semicircular Canals are angular rate sensors
 Otoliths (utricle and saccule) are linear
- accelerometers
 Bilateral symmetry mean redundant design





Peripheral Vestibular System

Functions:

- Stabilization of visu
- novea of the retina during head movement to allow clear vision
- Maintain postural stability especial during movement of the head
- Provide information used for spatial orientation

Involves the vestibular apparatus in the inner ear:

- Semicircular ca
- Saccule
- CN VII: Vestibulocochlear ne

Orientation of the Semi-Circular Canal



Semicircular canals Þ Anterior Posterio Anterior Posterior Lateral (Cochlea) **Right side** Left side ()



- nd the
- dolymphatic to intracellul lia fluid)

Vestibular Hair Cells

- Relative movement of hair cells to head causes change in electrical potential
 During head acceleration hair cells bend proportionally to head acceleration and change the neuronal (CN VIII) firing rate
- Same general design for hearing

POSITION OF CILLA	NEUTRAL	TOWARD KINOCILIUM	AWAY FROM KINOCILIUM
KINOCILIUM			Z
(60-100)			
HAIR CELL VESTIBULAR AFFERENT NERVE ENDING ACTION POTENTIALS VESTIBULAR EFFERENT NERVE ENDING			
POLARIZATION OF HAIR CELL	NORMAL	DEPOLARIZED	HYPERPOLARIZED
FREQUENCY OF ACTION POTENTIALS	RESTING	HIGHER	LOWER





Cupular Deflection



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Vestibular Ocular Reflexes

Vestibular Reflex	Sensory Organ	Motor Output
Angular VOR	Semi-Circular Canals: Horizontal Anterior Posterior	Eyes more opposite to angular movement (rotation) of the head. Shaking the head up and down is termed pith and it is sensed by anterior and posterior canals. Shaking head side to side or horizontally is termed yaw and is sensed by horizontal canals.
Linear or Translational VOR	Otoliths Saccule Utricle	Eyes move opposite to linear movement of the head. Linear movement up and down (riding in elevator) is sensed by the saccule. Linear movement horizontally (riding on a train on a straight track) is sensed by the utricle
Ocular Tilt Reflex	Otolith Utricle	Eyes and head move opposite to the tilt of the head. Tilt left causes elevation of the left eye, depression of the right eye, torsion of both eyes to the right and the tilt of the head on the body to the right.



Central Processing

- 2 Targets for Vestibular Input:
 Vestibular Nuclear Complex
- The cerebellum
- Both locations processes vestibular sensory input in association with other sensory info (proprioceptive, visual, tactile and auditory)

Cerebellar Connections

Otolith Organ

 The otoliths (utricle and saccule) contain a local region of hair cells

region of hair cells Hair cells protrude their processes into a gelatinous matrix called macula which is covered by a surface of otoconia (calcium carbonate crystals)

- The cerebellum is the main adaptive
- Processor
 Monitors vestibular performance and readjusts central vestibular processing if necessary
- The cerebellum is the "back up system" for the adaptation of the gain of the VOR





Central Processing Proprioceptive Input



From: Armstrong B, McNair P, Taylor D. Head and neck position sense. Sports Med. 2008;38(2):101-117.





Dynamic Equilibrium



Components of Balance Control

- Gaze Stabilization System: maintains gaze direction of the eyes and visual acuity during activities involving active head and body movements. Gaze stabilization and the VOR system are often viewed as synonymous, even though the VOR is only 1 component of gaze stabilization
- · Postural Stabilization System: keeps the body in balance while an individual stands and actively moves in daily life



What Else Do We Need For Balance Control?
Musculoskeletal
components
Internal representations
Adaptive mechanisms
Anticipatory mechanisms
Sensory strategies
Individual sensory systems
Neuromuscular synergies



"It may be his inner ear."

Visual Dysfunction Following Concussion



Signs of Post Trauma Vision Syndrome (PTVS)

- Exotropia or High Exophoria
- Accommodative Dysfunctions
- Balance issues
- Unstable Ambient Vision (Magnocellular)

High Exophoria / Exotropia

Eye Teaming Problem!!!



Exotropia, as shown here, is a condition in which one eye deviates outward.

Misalignment Issues

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OCULAR MISALIGNMENT

Tropia – overt deviation of the eye • Exo – outward (laterally) • Eso – inward (medially) • Hyper – upward • Hypo - downward



- If Severe :
 - Diplopia
- · Head tilt (vertical misalignment)
- Noticeable eye turn

If Subtle:

- · Difficulty maintaining focus
- Cosmetically normal
 Ocular soreness
- Ocular soren
 Headaches
- Mental dullness

Vergence Issues

- Convergence: Ability of eyes to turn inward to focus on a near target
- Vergence Testing: Patient fixates on target brought in along the mid-sagittal plane toward the nose
 - Near Point of Convergence: when target becomes double
 - Normal NPC \leq 5 cm from tip of nose
 - RECENT RESEARCH



Eye Teaming/Vergence Issues

The consumption of soft drinks by American youth is increasing. National dietary surveys show that carbonated soft drink consumption more than doubled in youths aged 6 to 17 from about 5 onnces per day in 1977-78 to 12 ounces in 1994-98, the most recent years for which national data is available. Addescent boys' soft drink consumption more than tripled during those years.

There are at least two negative results to this soft drink explosion. First, the use of soft drink is likely related to the rise in childhood obesity. A variety of studies suggest that we don't eat fever calories from other sources when we increase calories from Deverages. If a child drinks 9 to 10 ounces of a soft drink, that's equivalent to almost 120 calories.

Vergence Dysfunction Symptoms

- General Symptoms
 - Asthenopia when reading
 - Frontal headaches
 - Intermittent/Constant double vision
 - Squints/closes one eye
 Letters appear to float/move on the page
 - · Letters appear to noat/move on the pa
- Common Vergence Diagnoses
 Convergence Insufficiency
 - Convergence Excess/Spasm

Double vision makes it difficult to read and comprehend.



Convergence Insufficiency



Convergence Excess (Spasm)



Oculomotor Issues

Pursuits:

- "Saccadic" pursuits
- "Saccadic Intrusions"
- Symptomatic with pursuits

Saccades:

- Hypometric Saccades
- Slowed Saccades
- Symptomatic with Saccades



Eye Tracking/Oculomotor Issues

Henry looked to the right. He looked to the left. He looked up, and he looked down. Where had Frog gone? Henry did not like being alone

Oculomotor Dysfunction Symptoms

General Symptoms

- Losing place while reading
- Skipping words/skipping lines when reading
- Visual fatigue
- Difficulty copying from chalkboard or switching fixation distance (i.e. computer monitor to reading material)
- Common Oculomotor Diagnoses
- Saccadic Dysfunction
- Pursuit Dysfunction
- Abnormal Oculomotor Studies

Abnormal Saccades



Abnormal Smooth Pursuits





Accommodative Issues

- Reduction in ability to focus at near
 May prematurely need reading glasses or bifocals be apparn
 Over focusing at near
 Over focusing at near
 Struggle to coordinate accommodation and vergence, leading to difficulty in spatial awareness Low blink rate

- Low blink rate
 COMPUTERS/PHONES/NEAR WORK



Eye Focusing/Accommodative Issues



Accommodative Dysfunction Symptoms

General Symptoms

- Blur (distance and/or near)
- Visual fatigue
- Headaches (frontal) → neck pain (suboccipital!) Difficulty copying from chalkboard or switching fixation distance
- (i.e. computer monitor→reading material) Common Oculomotor Diagnoses
 - Accommodative Excess (Spasm)
 - Accommodative Insufficiency



Spatial Orientation & Balance Issues

- · Approximately 20% of the nerve fibers from the eyes interact with the vestibular system.
- · Patient may misperceive their position in the environment.
- · Patient may show a tendency to lean to one side, forward and/or backward.



Unstable Ambient Vision (Magnocellular)

- Decoupling of the focal and ambient processes, which affects function
- and performance. Deficits in posture, balance, Denotes in postarce, building, movement, preconscious
 Loss in speed of ambient visual
 - processing
- · M-cells have larger diameter axons and are more susceptible to damage.



Why is the Magnocellular system so susceptible to a brain injury?



Unstable Ambient Vision leads to "Focal Binding"

- Causes inability to release detail.
 Environment becomes over-stimulating.
 Movement in the environment (busy, crowded) becomes chaos to the visual overtor.
- visual system. Print on page becomes mass of detail.







Vestibular Dysfunction Following Concussion



Current Evidence (Mucha, 2018)

The most common vestibi disturbances after SRC include;

- Benign paroxysmal positional vertigo
 Vestibulo-ocular reflex impairment
 Visual motion sensitivity
 Balance impairment

Balance impairment

Role of Pre-Existing Dynamic Balance Performance

contaction of Dynamic Balance With Sports-Related Co moved and the second seco

CONCLUSION: Rugby the Y belance test, have concusion. Three Fed.

Neuromuscular Control Deficits and the Risk of Subsequent Injury after a Concussion: A Scoping Review

David R. Howell, ^{1,2} Robert C. Lynall,³ Thomas A Buckley,^{4,5} and Daniel C. Herman⁶

- An emerging area of research has identified that an increased risk of musculoskeletal injury may
 exist upon returning to sports after a sport-related concussion.
 The mechanism sunderlying this recently discovered phenomenon, however, remain unknown.
 One theorized reason for this increased injury risk includes residual neuromuscular control
 defloits that remain impaired despite clinical recovery.
- A total of 32 studies were included in the two reviews (objective 1 n = 10, objective 2 n = 22).
- According to a variety of study designs, athletes appear to have an increased risk of sustaining a musculoskeletal injury following a concussion.
- Furthermore, dual-task neuromuscular control deficits may continue to exist after patients report
 resolution of concussion symptoms, or perform normally on other clinical concussion tests. Therefore, musculoskeletal injury risk appears to increase following a concussion and persistent motor system and attentional deficits also seem to exist after a concussion. While not yet experimentally tested, these motor system and attentional deficits may contribute to the risk of sustaining a musculoskeletal injury upon returning to full athletic participation.

Diagnostic Challenge



Headache Neck pain/stiffness

- Dizziness Dizziness · Headaches · Sensitivity to noise, light
- Balance problems Unsteadiness
- Fatigue 🛛 🖛
- Concentration and memory
 Concentration and memory problems
 Irritable, sad, anxious
 PTSD

How is This All Related?



JOSPT





King-Devick Test

- Frontal eye field (Frontal Cortex)
- Dorsolateral prefrontal cortex
 Brainstem structures
- Supplementary motor area
- Posterior parietal cortex
- Middle temporal Area
- Occipital Lobe, Striate cortex
- Thalamus Superior Colliculus





Oculomotor Range of Motion

- · Looking to see if the eyes move conjugately and smoothly.
- 18-24 inches from patient.
- NOTE:
 - · Smooth pursuit eye movements may be slightly saccadic in older people.
 - Small amount of end range nystagmus is normal.
 - Small jump in eye movement as the eyes cross midline is OK.



Pursuits

- · Holds images of a moving target on the retina.
- Simultaneously performed with ROM testing.
- Keep target between 2-3 feet from patient.
- 60 degree total arc to avoid end range nystagmus.
- Do not move finger too fast, if you see saccades then try again with slower movements.





- · Rapid conjugate movements of the eyes to pace the object of interest on the fovea.
- Have patient look between 2 targets approximately 15 degrees apart.
- Nose, pen, nose, pen in left/right and up/down.
- · Looking for number of eye movements it takes for patient's eyes to reach target.
- Normal is < or equal to 2 movements.
- · Overshoots are always an abnormal test.



Convergence

- Hold patient's head stable with finger/target 2 feet away.
- Ask patient to focus on your finger while you move it towards patient's nose.
- Eyes should converge and pupils should constrict.
- Ask when the patient sees 2 fingers/targets
- Convergence should be sustainable 5 cm from tip of nose.



Maddox Rod = Binocular Posture



Binocular Posture Norms



Stereo Testing

- Stereo glasses worn over regular near point correction.
- To see figures on the right, both maculae must be coordinating together in the brain.
- Left circles give us justnoticeable-difference (JND) for depth perception.
- >30 sec would be a FAIL.



Binasal Occlusion Screening



 Video on how to do binasal occlusion: https://www.youtube.com/watch?time_continue=39&v=JSFIkCWCwMc



Vestibular Ocular Motor Screening Tool (VOMs)

- Brief screening tool used in concussion management Track progress and symptom provocation
- Utilization by the non-vestibular practitioner to identify deficits for referral
- Looks at:
- ooks at: Smooth pursuits Saccades Near Point of Convergence VOR Visual Motion Sensitivity



Spontaneous Nystagmus

- · Holding patient's head still while they look straight ahead
- Observe for nystagmus



Fixed Gaze Nystagmus

- Hold patient's head stationary
- Use your finger or pen and take patient to 30 degrees left, right, up and down from center and hold gaze
- Observe for any nystagmus at 30 degrees
- DO NOT TAKE TO END RANGE!!!

What does Nystagmus Look Like?



VOR

- Tilt patient's head down 30 degrees
- · Start slowly moving head side to side while they focus on your nose, gradually increasing speed
- Repeat in vertical plane
- Assessing for integrity of VOR and for both fast and slow speeds



Head Thrust Test

- Grasp patient's head with your hands and patient focuses on examiners nose, with head tilted down 30 degrees
- · Head is rapidly thrust from midline to one side approximate 10 degrees only, repeat other side
- Observe for corrective saccade back to target after thrust
- · Repeat at target at a distance as well
- · Positive test indicates vestibular hypofunction on ipsilateral side

Head Shaking Nystagmus

- Tilt patient's head down approximately 30 degrees
- \bullet Have patient close eyes and you shake their head side to side 20x at 2Hz,
- Have patient open their eyes and fixate on target
- Watch for nystagmus!
- Optimal if performed with VNG goggles or Frenzel lenses!
- If nystagmus present + sign for unilateral vestibular hypofunction

Visual Acuity/Dynamic Visual Acuity

- Visual acuity (VA) is acuteness or clearness of vision, which is dependent on the sharpness of the retinal focus within the eye and the sensitivity of the interpretative faculty of the brain.
 Visual Acuity – Static
- Dynamic Visual Acuity DVA
- * This is your objective measurement of the VOR

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Dynamic Visual Acuity (VOR)



Computerized DVAT

• InVision

- The Dynamic Visual Acuity (DVA) Test Quantifies the impact of vestibular ocular reflex (VOR) system impairment on a patient's ability to perceive objects accurately while moving the head at a given velocity on a given axis.
- Gaze Stabilization Test (GST) Quantifies the range of head movement velocities on a given axis over which a patient is able to maintain an acceptable level of visual acuity.



VOR Cancellation

- Grasp patient's head and tilt forward 30 degrees (HC is in horizontal plane)
- Have patient hold thumbs in front of them, arms extended
- You move their head and hands in same direction back and forth observing for ability to keep eyes on moving target while head in motion
- Abnormal test would be saccadic eye movements



Optokinetic Nystagmus

- Normal response
- Eye movement elicited by the tracking of a moving field.
- It differs from smooth pursuit which is the eye movement elicited by tracking of a single distinct target.



What If Optokinetic Abnormal?



Modified CTSIB

• 4 Positions

- 1. Eyes open Solid Surface
- 2. Eyes closed solid surface
- 3. Eyes open compliant surface
- 4. Eyes closed Compliant surface Hold each position for 30 secs
- Rate Quality of Balance



High Technology Assessment



What About Dual Task Assessments?

Jackbedsatt, 2014 Nor 2, # 514-04441030004-4 MI 10040 (Jack Annual Long) Objective clinical tests of dual-task dynamic postural control in youth athletes with concussion. Ministra Till, Yano, A. & Mantan, A. & Mantan, M. & Mantan, W. 204 @ Author information

Abstract

Abstract ObJECTWBS: To prospectively evaluate single/dual-task timed-up-and-go (TUG) and tandem gait performance among children adsiescents with concussion and healthy controls.

DESIGN: Repeated measures.

METHODS: Participants with concussion (n=2); age=14.1s2.5years. 52% female; completed single/dail-task TUG, landem gail, and symptom assessments 0.7.8.8 and 32.3.64 data yout have, The control group (n=27; age=14.1s2.3years, 48% female) completed the mem protoxic initiality of 0.7.16 data yield and A participants completed single-task, (and/xeds attention) and dai-task (divided attention tests. The primary outcome variable was test completion time.

CONCLUSIONS: Sover dualiast TUG and lander gait times were effected arous both time points for the concession paper latifue the toro control grave. In concess, upgetabat tochong and redden approaches to the factors as synthesis. Suppeting formate and compressly from the addition of a cognitive task allows for the detection of persistent post-concussion detects that might take longer to reache.

Vision Referral/Optical Treatment

When To Refer For an OD Evaluation

- 4 weeks post-injury and still having visual symptoms (or 4 weeks after your treatment begins)
 Postconcussional syndrome
- Depending on patient's stamina/symptom level could be a 2 hour evaluation.



Optometry & Rehab

- Unfortunately the majority of eye care professionals focus on the central visual system (parvocellular).
- Vision is bi-modal!!!!!!
- Find an optometrist near you that performs neuro-visual rehab
 - Prism
 - Tints
 - Bi-nasal Occlusion
 - Therapy

www.covd.org www.noravisionrehab.org



Prescription Glasses

- Depending on age may need more than one pair of glasses.
- Often includes prism...
 Vertical deviations
 "First time I felt like myself
 - since the accident."

 Base IN prism to improve ambient processing.
- Gives us a surface to apply binasal occlusion or temporary prism.



Sunglasses/Tints/Overlays

- Patients often have a very immediate reaction to certain tint colors trialed during the exam.
- If positive response then consider tint in Rx.
- Often have patients who initially where
- sunglasses inside. • Particularly students in fluorescent lighting



Case Report

GM, 29 YOHF, involved in MVA on 2/24/18







You Have To Train All Systems!





- Alternative: use physiological diplopia

Convergence Exercises

- Pencil Push Ups (do not overtrain!)
- Brock String
- Arrow Chart/Dot Card







How Do You Make Convergence Functional?





What about Convergence and Reaction Time?





Convergence and Balance.....



Oculomotor Exercises

- 4 Corner Saccades
- Near Far Hart Chart
- Double Hart Chart Infinity Walk
- Complex Charts
- Marsden Ball
- Trails Scanning
- Double Hart Chart Ball Toss



Ambient Processing Exercises

- Central-Peripheral Saccades
- Dynamic Complex Charts
- Wall Ball
- Dynavision
- Peripheral Awareness
- Belgau
- Juggling
- Binasal Occlusion



Accommodation Exercises

- Near Far Hart Chart
- Brock String
- Look Hard/Look Soft
 with meditation

*LIKELY BENEFIT FROM READING GLASSES...REFERRAL



Functional Accommodative Training....











Vestibular Exercises







Vestibular Exercises

Vestibular Saliency





Balance and Reaction Time Training





- Substitution of other strategies to replace the lost or impaired function





Cheap Dynavision.....

Substitution





Oculomotor and Balance



Progression

- Adaptation (if there is something to adapt)
- Substitution (this includes oculomotor component)
- Habituation
- Add balance component into all of above or separately





Loading Activities

- Balance boards
- Walking Rails
- Bosu Ball
- Head Lamp
- Reaction Time
- Targets in Motion
- Infinity Walk
- Look Aways

- Cognitive Load Dynavision
- Trampoline • Catching/Throwing
- Different Fields of Gaze
- Yoked Prism
- Metronome
- Head Mvmt/Turning



Case 1: Collegiate Athlete



Are You Getting to Sport Specific Training?



Case 2: High Achieving Father of 6



Case 3: CEO that Plateaued









"The difference between an average healthcare professional & an excellent one is that the excellent one knows when to get others involved." --Eric Singman, MD, PhD--

Questions?



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