Concussion = mild acquired brain injury (mABI)

Steve Leslie

B Optom FACBO FCOVD Dip Cert Oc Ther Spec Cert MNOD

Concussion is a complex and not well understood condition

- This is a very complex and intensive area of optometric care, which 3 of us have been teaching in Australia and New Zealand for 4 years, comprised of over 12 months of lectures, workshops, case studies and exams.

- In just 30 minutes we will explore some of the:
- current issues of concussion causation and management
- signs, symptoms and visual conditions optometrists may encounter with patients who have suffered one or more concussions.

WHAT IS AN ACQUIRED BRAIN INJURY?

Diagnostic descriptors:

- ABI = Acquired Brain Injury
- TBI = Traumatic Brain Injury
- mABI = mild Acquired Brain Injury.

Traumatic Brain Injury Continuum

All concussions are an mTBI, but not all mTBI's are a concussion

"The terms mTBI and concussion are often used interchangeably in the trauma literature and the clinical vernacular."

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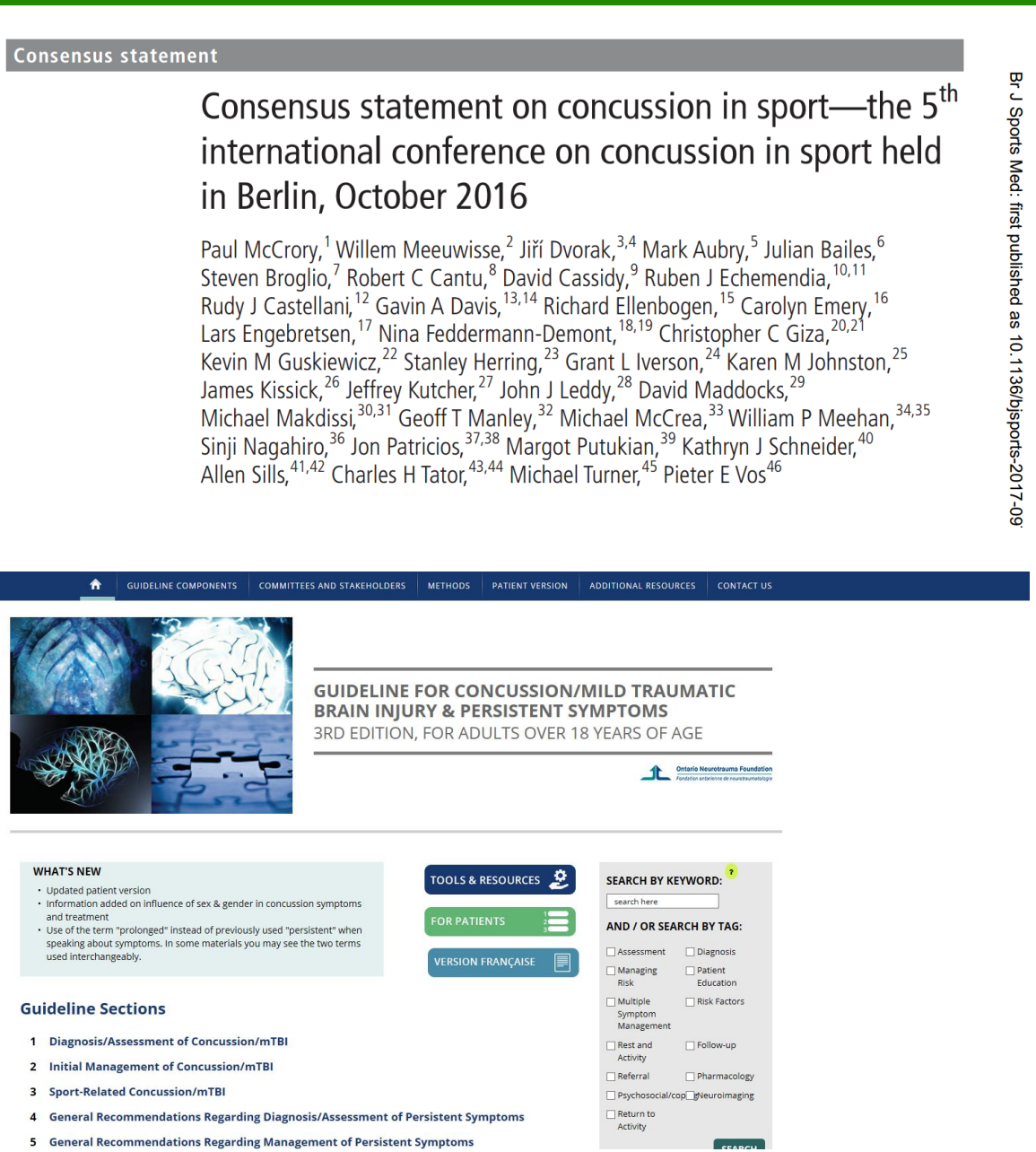
ABI FUNDAMENTALS

- Neuroscience research has proliferated in the last fifteen years

- Awareness of the ramifications of concussion on **ability to learn, work, drive and be safe** have become better understood in the last ten years



Consensus statement

Consensus statement on concussion in sport—the 5th international conference on concussion in sport held in Berlin, October 2016

Paul McCrory,[1] Willem Meeuwisse,[2] Jiří Dvorak,[3,4] Mark Aubry,[5] Julian Bailes,[6] Steven Broglio,[7] Robert C Cantu,[8] David Cassidy,[9] Ruben J Echemendia,[10,11] Rudy J Castellani,[12] Gavin A Davis,[13,14] Richard Ellenbogen,[15] Carolyn Emery,[16] Lars Engebretsen,[17] Nina Feddermann-Demont,[18,19] Christopher C Giza,[20,21] Kevin M Guskiewicz,[22] Stanley Herring,[23] Grant L Iverson,[24] Karen M Johnston,[25] James Kissick,[26] Jeffrey Kutcher,[27] John J Leddy,[28] David Maddocks,[29] Michael Makdissi,[30,31] Geoff T Manley,[32] Michael McCrea,[33] William P Meehan,[34,35] Sinji Nagahiro,[36] Jon Patricios,[37,38] Margot Putukian,[39] Kathryn J Schneider,[40] Allen Sills,[41,42] Charles H Tator,[43,44] Michael Turner,[45] Pieter E Vos[46]

Br J Sports Med: first published as 10.1136/bjsports-2017-09

GUIDELINE COMPONENTS | COMMITTEES AND STAKEHOLDERS | METHODS | PATIENT VERSION | ADDITIONAL RESOURCES | CONTACT US

GUIDELINE FOR CONCUSSION/MILD TRAUMATIC BRAIN INJURY & PERSISTENT SYMPTOMS

3RD EDITION, FOR ADULTS OVER 18 YEARS OF AGE

Ontario Neurotrauma Foundation

WHAT'S NEW

- Updated patient version
- Information added on influence of sex & gender in concussion symptoms and treatment
- Use of the term "prolonged" instead of previously used "persistent" when speaking about symptoms. In some materials you may see the two terms used interchangeably.

TOOLS & RESOURCES

FOR PATIENTS

VERSION FRANÇAISE

SEARCH BY KEYWORD:

search here

AND / OR SEARCH BY TAG:

- Assessment
- Diagnosis
- Managing Risk
- Patient Education
- Multiple Symptom Management
- Risk Factors
- Rest and Activity
- Follow-up
- Referral
- Pharmacology
- Psychosocial/cop
- Neuroimaging
- Return to Activity

Guideline Sections

1 Diagnosis/Assessment of Concussion/mTBI
2 Initial Management of Concussion/mTBI
3 Sport-Related Concussion/mTBI
4 General Recommendations Regarding Diagnosis/Assessment of Persistent Symptoms
5 General Recommendations Regarding Management of Persistent Symptoms

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Recent Fremantle Dockers player concussion history

- *West Australian 25.2.2026*
- Player sustained his third concussion in 3 years
- History of multiple concussions as a junior, now struggling to recover from head knocks
- Reports **delayed concussion onset** after a head knock

- “The positive for X… is his concussions have not been cases where he has been knocked out instantly on the field” ***
- “He has passed concussion tests and then reported symptoms later”***
- Wrong!

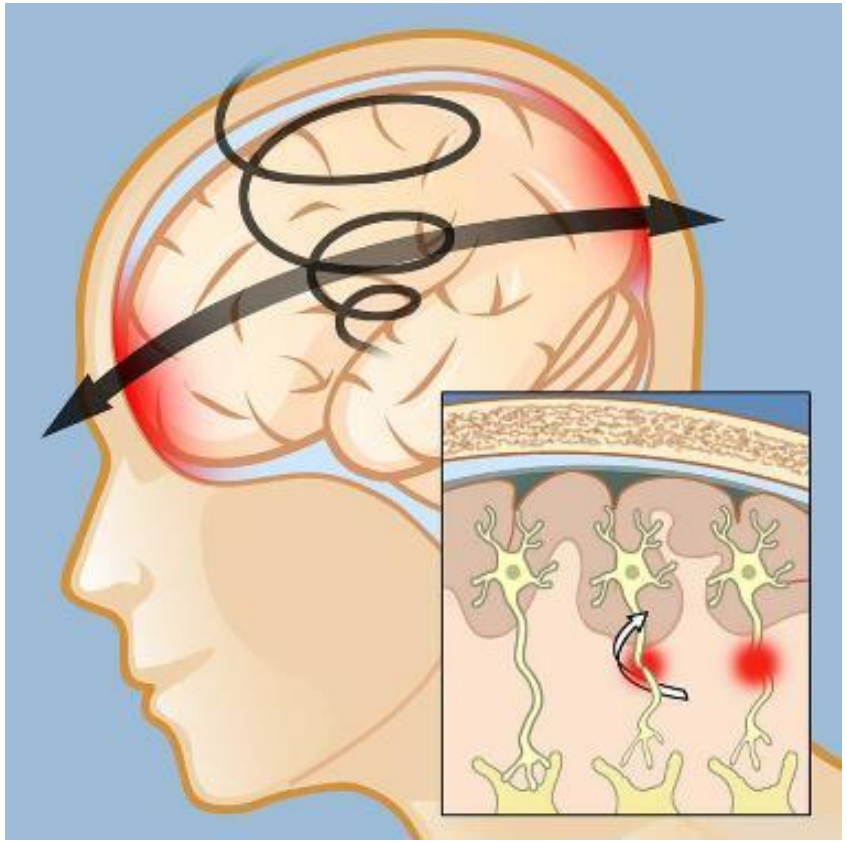
Neurometabolic cascade of concussion

What is our understanding of the neurometabolic dysfunction?

- "*Force delivered to the brain causing disruptive stretching of neuronal cell membranes and axons resulting in a* ***complex cascade of ionic, metabolic and pathophysiological events***"
- Phases to mTBI
  - Excitatory Phase, followed by:
  - Spreading Brain Function Depression

Barkhoudarian, Hovda & Giza. The molecular Pathophysiology of concussive brain injury. Clin Sports Med 2011;30(1):33-48

TYPES OF INJURY in mABI



Concussion is more likely to result when the force is directed **laterally**

- Coup – acceleration
- Contrecoup – deceleration
- Shearing force
- Diffuse axonal injury
  - Mechanical
    - ✓ Shearing of axons
    - ✓ Rupture of cell walls
    - ✓ Glia Injury
    - ✓ Synapse disruption
  - Vascular
    - ✓ Micro-vessel ischemia
    - ✓ Micro-vessel hemorrhage
  - Bio-mechanical
    - ✓ Cell and axonal leakage
    - ✓ Inflammation

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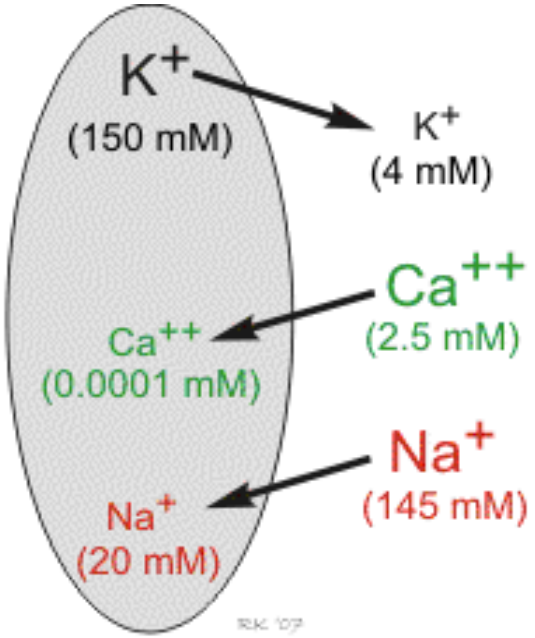
MILD ABI - CONCUSSION

The Neurometabolic Cascade

* **Acceleration and Deceleration Injury**
  - **Mechanical Stretching/Shearing at the white/gray matter junction**



- Excitatory Phase then Depressive Phase
  - Ion influx causes imbalance and neuronal dysfunction
  - Need ↑ activation of the Na+/K+ pump
  - Depletes ATP
  - ↑ Ca^{++} impacts mitochondria function rendering oxidative metabolism dysfunctional
  - Switch to anaerobic glycolysis for ATP production 9x less efficient
  - Production of ATP ↓↓ vs Demand for ATP ↑

BRAIN ENERGY CRISIS !!!

MILD ABI - CONCUSSION

The Neurometabolic Cascade

- **Outcome:**
  - Persistent low-grade headache, often exacerbated by exercise
  - Poor concentration / attention
  - Memory dysfunction
  - Easy fatigability
  - Irritability
  - Intolerance to light and sound
  - Anxiety / depression / mood issues
  - Sleep disturbance

mTBI

Common reasons for mTBI include:

- Falls or injuries
  - If at work compensation issues!
- Blunt trauma
  - ✓Sports related injuries
  - ✓Vehicle related injuries
- Assaults
- Blasts or explosions

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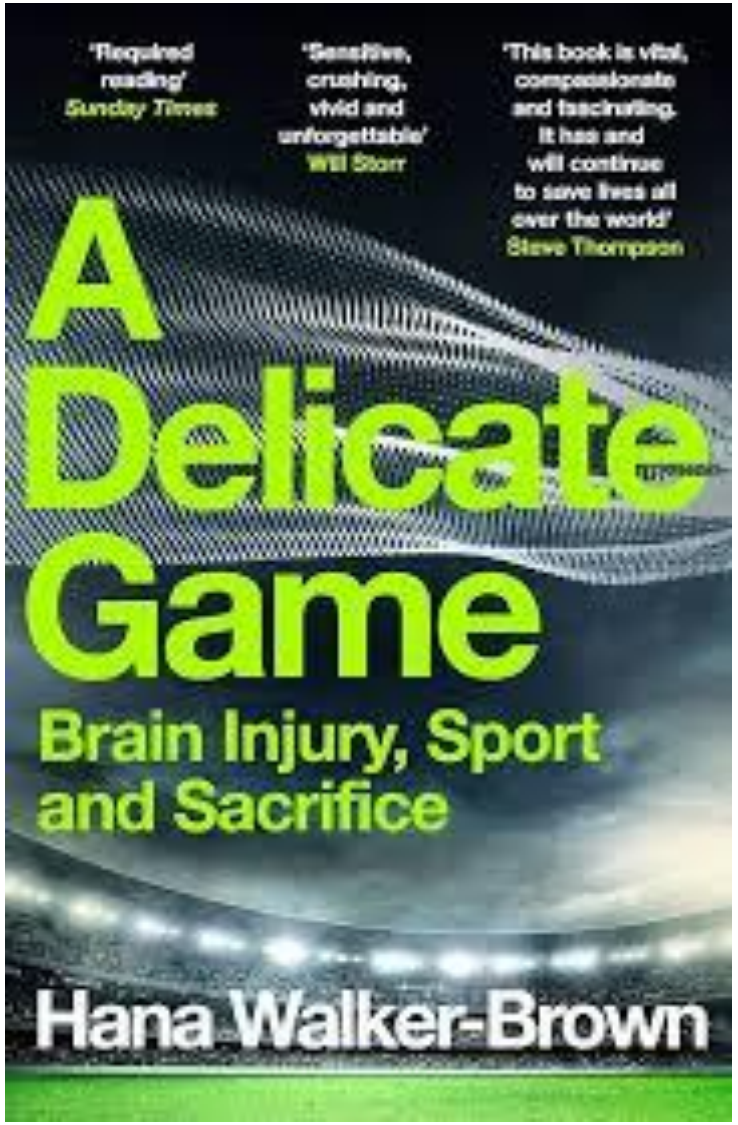
Females suffer more concussions & longer lasting symptoms in the same sport than men

- Thinner skulls
- Less neck strength
- In sports, fewer years of experience in avoiding and taking contact
- Hormonal differences
- Domestic violence
  - Effects on attention, memory and emotional lability with police and courts
  - *Pinkconcussions.com*
  - *Wunderle, K.et al. 2014. Menstrual Phase as Predictor of Outcome After Mild Traumatic Brain Injury in Women. J of Head Trauma Rehabilitation 29, E1.*



EPIDEMIOLOGY OF mABI IN POST-CONCUSSION SYNDROME

The Natural Course of recovery in Concussion

- 80-90% of people who experience an mTBI will recover spontaneously
- Time frame according to the Berlin Guidelines is
  - ✓Adult 2 weeks
  - ✓Peds 4 weeks
- Remaining 10-20% have post-concussion syndrome

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INCIDENCE OF VISION DYSFUNCTION IN mABI

Let's consider this in relative terms:

- **Convergence Insufficiency**
  - ✓Incidence in general population 4%
  - ✓Incidence in ADHD population 15.9%
  - ✓Incidence in concussed population 9-56%
- **Accommodation Dysfunction**
  - ✓Incidence in general population 6%
  - ✓Incidence in learning disabled pop 55%
  - ✓Incidence in concussed population 51-76%

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INCIDENCE OF VISION DYSFUNCTION IN mABI

Type of Visual Impairment	%mTBI	%controls	p
Convergence Insufficiency	55%	5%	0.0012
Saccadic Impairment	30%	0%	0.0202
Pursuit Impairment	60%	0%	0.0001
Ocular Misalignments (vertical phoria)	55%	5%	0.0012
Ocular Misalignments (horizontal phoria)	45%	5%	0.0084
Accommodative Dysfunction	65%	15%	0.0031

Ocular Motor Dysfunction following mTBI - Capo'-Aponte et al. Military Medicine 2012

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INCIDENCE OF VISION DYSFUNCTION IN mABI

Diagnosis	Occurrence
Convergence Insufficiency Defined as: Near point of convergence of ≥6 cm break and - Reduced positive fusional convergence at near (<20 pd or fails Sheard's criterion) or - Vergence facility (distance or near) ≤9 cpm with more difficulty with base-out	56%
Convergence Excess Defined as: ≥3 pd esophoria at near and - Reduced negative fusional convergence at near (<8 pd or fails Sheard's criterion) or - Vergence facility at near ≤9 cpm with difficulty with base-in	8%
Accommodative Insufficiency Defined as: Amplitude of accommodation ≥2 diopters below mean for age (15-1/4 age) or Monocular accommodative facility ≤6 cpm (difficulty with minus lenses)	76%
* * Reduced Reading Rate	82%
Reduced Reading Efficiency	68%

Tannen, B, etal. 2015. Vision and Reading Deficits in Post-Concussion patients: a Retrospective Analysis. Vis Dev Rehab 1, 206–13.

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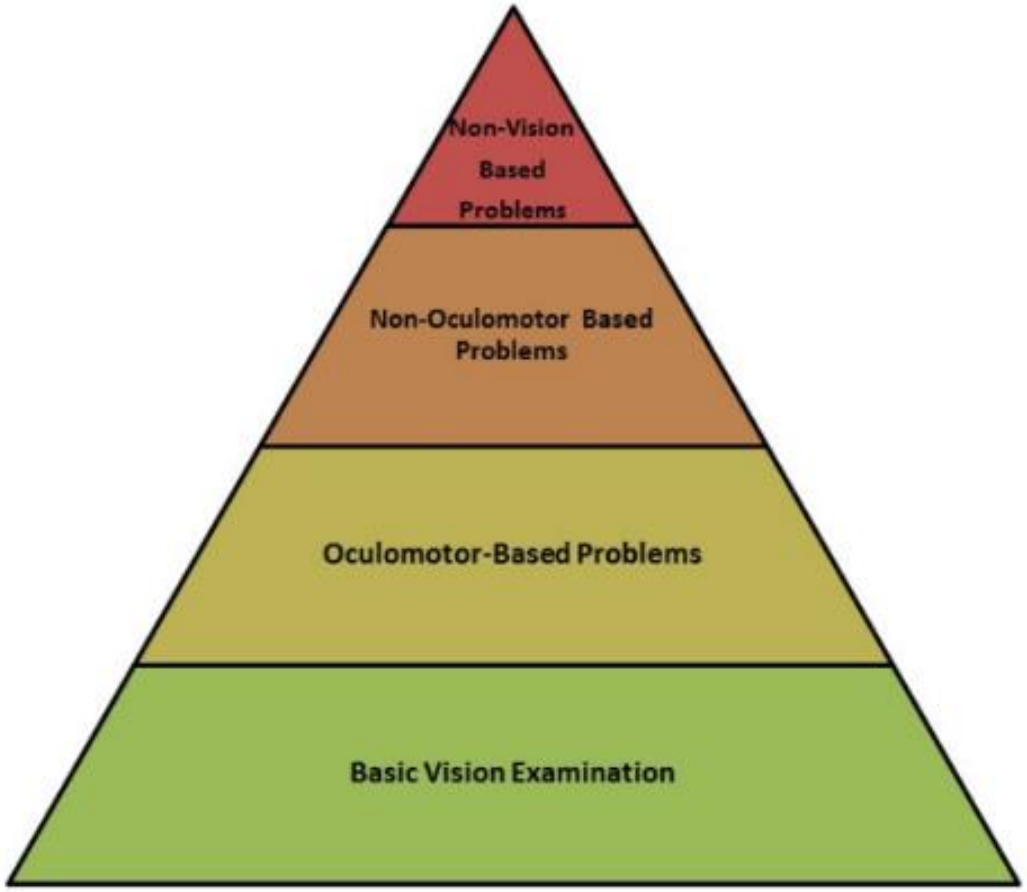
Conceptual model of optometric assessment*

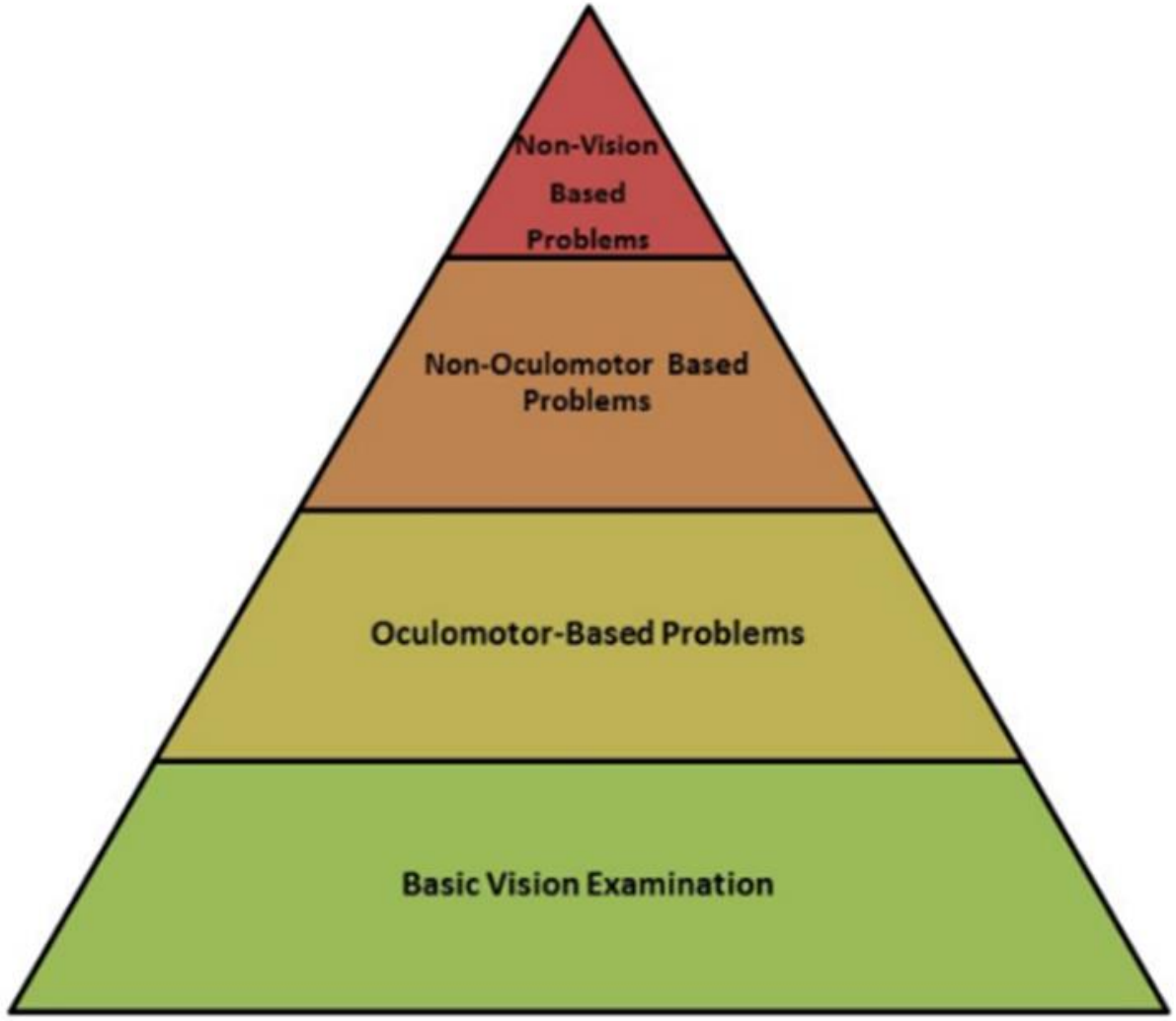
- 1 Standard assessment
  - Refraction, basic accommodation, ocular motility
- 2 Oculomotor
  - Comprehensive assessment of binocularity, accommodation and oculomotor function, including effects on vestibular and motion processing
    - Palinopsia

Ciuffreda, K.J., et al. 2016. Traumatic Brain Injury: Visual Consequences, Diagnosis and Treatment, in: Advances in Ophthalmology and Optometry. Elsevier, Philadelphia PA, pp. 307–333.



Conceptual model of optometric assessment*

- 3 Non-ocular motor
  - Photosensitivity/pattern glare
  - Vestibular dysfunction
  - Visual motion hypersensitivity
- 4 Non-ocular issues
  - Anxiety and depression
  - Cognitive impairment
  - Migraine headaches
  - Reporting requirements



Early optometric assessment is important to recovery and management of symptoms

- defini
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ARTICLE

Optometric Intervention in Ocular, Vestibular and Cervical Subtypes of Concussion and Mild Traumatic Brain Injury

Curtis Baxstrom, MA, OD, FAAO, FCOVD, FNORA
Owner and Director at Northwest Vision and Learning Center

ABSTRACT

sensorimotor vision function and its interaction with the somatosensory system, as well as the central and peripheral vestibular apparati, incorporating optometrists onto the inter-professional health care team may result in more timely and favorable outcomes for concussed patients with visual and vestibular symptoms.

INTRODUCTION

Mild traumatic brain injury (mTBI), under which category concussion lies, is a growing concern nationwide and worldwide. Examples

TBI[1], c

sensorimotor vision function and its interaction with the somatosensory system, as well as the central and peripheral vestibular apparati, incorporating optometrists onto the inter-professional health care team may result in more timely and favorable outcomes for concussed patients with visual and vestibular symptoms.

ARTICLE

Neuro-Optometric Rehabilitation of Visual and Visual-Vestibular Symptoms Following Acquired Brain Injury

visual deficits and symptoms of disequilibrium affecting their activities of daily living and quality of life. Dizziness, vertigo and gait disturbance, and their effect on balance, are among the most common complaints in this population. The visual system is a major component of balance and although often overlooked, it contributes

Conclusion: The visual system plays a crucial role in the overall sense of balance. Even minor oculomotor deficits and binocular vision dysfunction can have a negative effect on the vestibulo-ocular reflex (VOR) by creating mismatches between the visual and vestibular systems. This mismatch may exacerbate the sensation of disequilibrium, especially when patients are in multi-visually stimulating environments with motion, such as shopping in a grocery store, or without motion, such as watching TV or working on a computer monitor. As awareness of visual and visual-vestibular dysfunctions following ABI increases, the demand for optometrists who offer neuro-optometric rehabilitation will increase as well. Understanding the visual sequalae following ABI and coupling it with the current research on neuro-plasticity, optometrists who specialize in neuro-optometric rehabilitation can better aid in the rehabilitation of these individuals.

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DIAGNOSIS OF mABI / CONCUSSION

Early Dx is important

- Secondary/repeat concussion
    - 5-6x ↑ Risk within 12 months

- ↑Risk of **cumulative** brain and vision issues

- Sport – remove from play for significant time span, controversial!

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Imaging: MRI and CT vs fMRI

- "My doctor said the MRI/CT scan is clear, so there is nothing wrong with my brain. But I still have all of these terrible symptoms!??"

- Almost always standard brain MRI and CT scans in patients with concussion **do not show physical damage**

- But: "…. observations provide evidence for neural networks of interactions involving the control of eye movement for visual processing, reading comprehension, spatial localization and navigation, and spatial working memory

- *1.*
- *Rockswold SB, et al.* ***Functional*** *Magnetic Resonance Imaging and Oculomotor Dysfunction in Mild Traumatic Brain Injury. J Neurotrauma. 2019 Apr 1;36(7):1099–105.*

And….

- In a study of 28 **chronic mTBI** patients with **normal BCVA & fundi**, 64% reported vision problems, 68% were light sensitive, and **some** had:
- Decreased contrast sensitivity (should be assessed)
- Reduced peripapillary RNFL thickness (temporary swelling?, so OCT)
- Increased optic nerve /sheath size (glial scarring?, so OCT)
- Machine learning identified:
  - Subtle differences across the primary visual pathway, including the optic radiations and occipital lobe regions
- *Rasdall, M.A., et al. Primary Visual Pathway Changes in Individuals With Chronic Mild Traumatic Brain Injury. JAMA Ophthalmol 2025 143, 33–42.*

Acuity and refraction considerations

- 1 Slow cognitive skills and responses
- 2 Expressive dysphasia
- 3 Importance of low previously uncorrected, now decompensated refraction
  - Especially uncorrected low hyperopia
  - Trial low plus to see results

- **Many ABI patients c/o blurred vision despite multiple pairs of glasses and seeing 6/6 R&L!**
- Wave hands beside their head and vision worsens.
- Visual acuity (central vision) depends on stable peripheral vision function and processing!

Assessment: OKN, hand waving (grades)

Photophobia vs Pattern Glare

- Patients with concussion will often complain of increased light sensitivity outside, but if they are comfortable with inside lighting, and patterns, they have **photophobia**.

- **Pattern glare** is significantly increased sensitivity to outside AND inside light, accompanied by blurred vision, headaches, pain and nausea from :
  - Flickering light
  - Patterns of light such as in carpets or clothing, and even reading small lines of print (black and white “stripes”)

Flickering light patterns

- Fluorescent lights
  - Varies depending on installation, age and colour temperature
  - Often bright in offices and shopping centres, plus crowds, noise and movement- so avoided by sufferers due to sensory overload
- Driving with light flickering through trees
- Freeway lights
- Music concerts

- Warnings!!

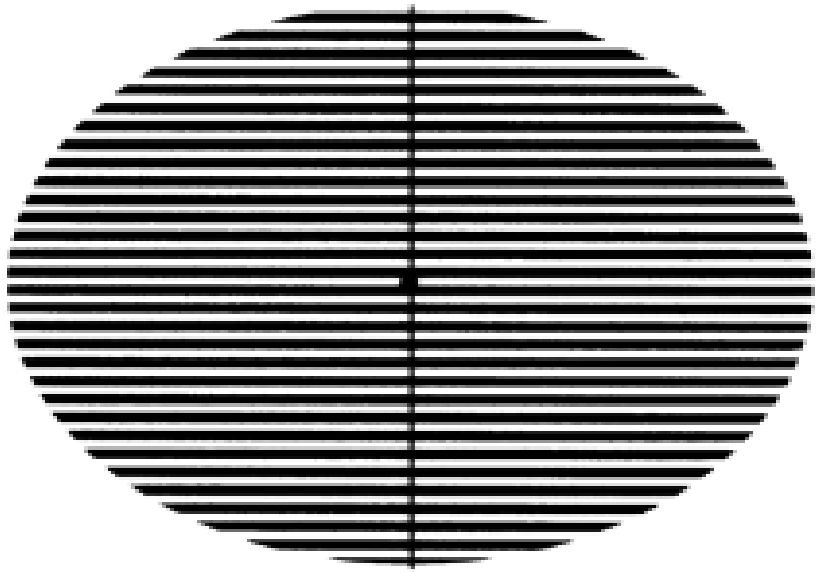
Patterns of light

- Striped shirts
- Patterns in carpets, clothing, décor:
  - hotels, restaurants, sports arenas
- Venetian blinds, escalators
- Much worse if moving eg scrolling on screens or “busy” print on screens, XL sheets

- Issues watching TV or movies
  - Fast moving movie, quick jumping images eg music videos

Lines of print are light and dark stripes

- Lines of reading print at about 12-14 point font, often blur, move, jump, swirl and very uncomfortable



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Final version: http://www.emeraldinsight.com/journals.htm?issn=0307-4803&volume=114&issue=7/8&articleid=17092908&show=html

Reading and learning from screens versus print: a study in changing habits

Part 1 – Reading long information rich texts

Judith Stoop, Paulien Kreutzer and Joost Kircz

CREATE-IT Applied Research, University of Applied Sciences, Amsterdam, The Netherlands

Abstract
Purpose – The purpose of this paper is to research the difference in reading and learning from print versus electronic media in a professional and educational setting. To what extent does the materiality of the medium influence the efficiency and effectively of the reader? What is needed to create "digital born" information rich texts? In Part 1, sustained reading of information and knowledge rich texts is addressed.
Design/methodology/approach – In-depth comparative tests with a great number of subjects between print-on-paper, e-ink screens and LCD screens. In Part 1 the results of tests with sustained reading of information and knowledge rich texts are reported.
Findings – All tests show that print-on-paper is still a superior medium for learning and digesting complicated and elaborate texts, whilst electronic screens are appreciated for quick information gathering, communication and navigation. Electronic representations of information and knowledge demand that the structure of the writing has to change.
Research limitations/implications – Given the rapid development in electronic displays, many issues – in particular ergonomical – become a "moving target". An important limitation – which is one of the quests of this research – is the lack of sufficient genuine digital born texts.
Practical implications – The need to start and review the writing process; the appearance but also the structure of information and knowledge rich texts. A second issue is the need to develop easy capabilities to make an electronic text as easy a "tool" as the print text, with underlining, comments and notes.
Social implications – The development of novel ways of publishing educational texts.
Originality/value – Deep qualitative research in comparison with quantitative tests. Comparison between professional information acquisition and learning.
Keywords- Electronic publishing, Reading, Print media, Learning processes, e-books, Digital ibraries,
Information dense texts
Paper type- Research paper

Associations and impact on severity of photophobia

- Photosensitivity severity in mild – ABI is significantly impacted by:
    - Repetitive mild traumatic brain injury
    - Anxiety
    - Sleep disturbances
    - **Time lapse since event**
    - Dry eye/medications

Jotie JM, et al. Association of mild traumatic brain injury, post-traumatic stress disorder, and other comorbidities on photosensitivity. Optometry and Vision Science. 2024 Feb;101(2):90.

Patient adaptations

- Turn screen brightness down as much as possible
- Change to white print on black or coloured screen background
- Enlarge print on screen to increase space between “stripes” of print
- Print material out rather than reading on screens

- (* Optometrist: reading lines of letters on a VA chart especially if backlit will often be a problem: if so use single letters)

Optometric prescribed chromatic filter

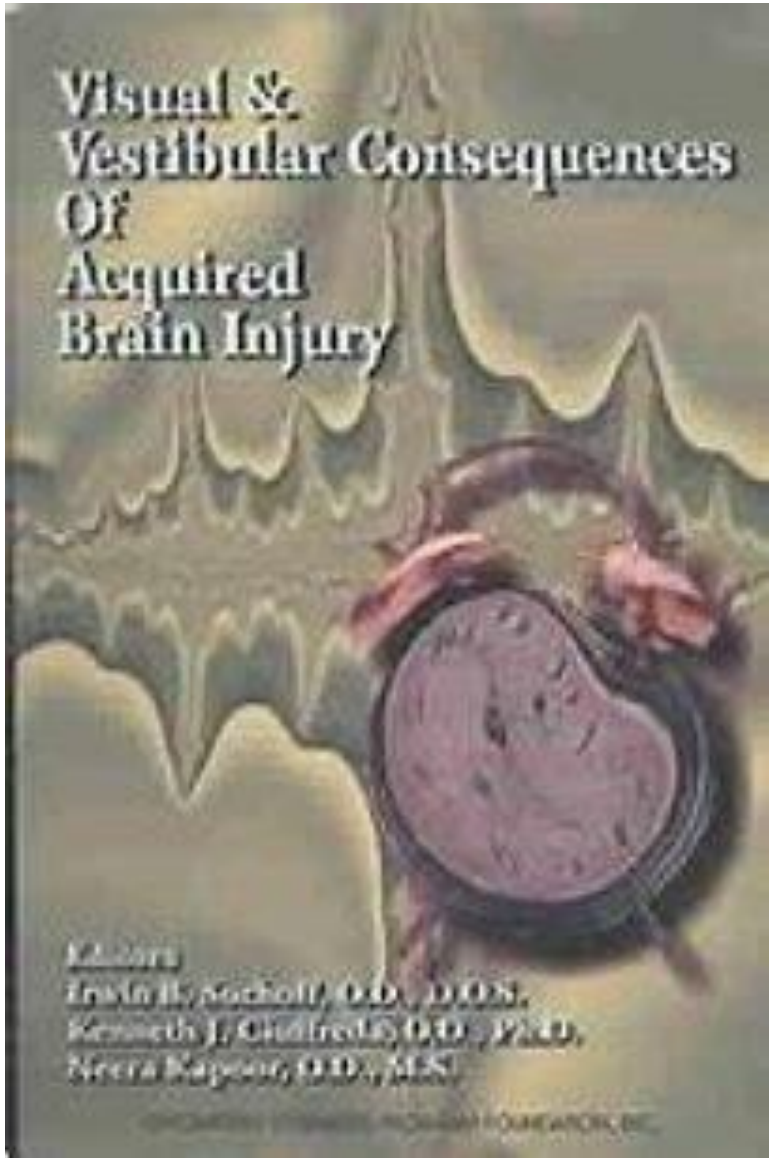
- **Every patient is different. The optimal colour hue and saturation varies from patient to patient**
- Some benefit significantly, others minimally or not at all, especially if it is chronic.
- The Intuitive Colorimeter was scientifically designed to present sequentially the colours in colour space, thereby allowing a patient to swiftly identify the precision colour that may help alleviate their symptoms.”
- Wrap around sunglasses can help to minimise peripheral flicker and movement.

PalinopsiaPalinopsia

- The persistent recurrence of a visual image either moving or after the stimulus has been removed
- Illusory palinopsia
- Thought to be related to disturbance of eye movement visual input processing

Strong evidence:

- The most common effects of acquired brain injury (ABI) are **accommodative dysfunctions**
- Rarely recognised by other professionals
- Has significant effects on quality of life, working, reading…
- Can impede rehabilitative progress



Normal assessment of accommodation

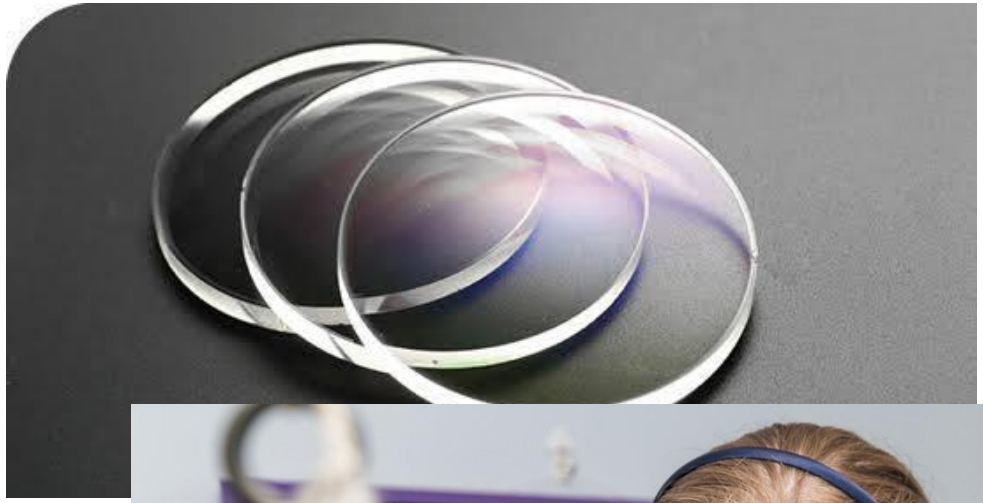
- ***Amplitude***-monocular by pushup
  - **Scientific evidence shows this test is not very accurate**, I prefer using near retinoscopy to measure amplitude with pushup
  - But it is commonly used by many practitioners, so test and record
- ***Accuracy***- near retinoscopy to assess lag or lead
- ***Flexibility***- flippers (subjective and near retinoscopy
- ***PRA/NRA***

Accommodative Syndromes

- Accommodation reduced amplitude
- Accommodative insufficiency
- Accommodative fatigue
- Accommodative infacility
- Accommodative inertia
- Paralysis of accommodation
- Accommodative spasm (not uncommon after severe ABI)

Management is effective

- Accommodation and convergence dysfunctions even in significant and/or chronic mABI can relatively easily be “normalised” with lenses, prisms, and Vision Therapy
- Treatment makes a big difference to reading, rehabilitation progress and quality of life.
- Minor refractive errors are important
- Check for medication effects.



Vision therapy works for concussion-related accommodation and vergence dysfunctions

- **In-office sequential vision therapy*** for post-concussion CI is effective
- Watchful waiting does not help
- fMRI showed significant changes in brain networks that support vergence function
- * **CITT studies prove pencil/finger pushups are no better than placebo.**

- *Alvarez, T.L., Scheiman,et al. The CONCUSS Randomized Clinical Trial of Vergence/Accommodative Therapy for Concussion-Related Symptomatic Convergence Insufficiency.* ***2025. Br J Sports Med 60****, 340–354.*
- *Sangoi, A., et al* ***2025****. Functional activity changes after vergence and accommodative rehabilitation of concussion-related convergence insufficiency: CONCUSS clinical trial fMRI results.* ***Front. Neurosci****. 19:1303781.*

Visual Motion Hypersensitivity (VMH)

- If egocentric visual space is unstable, movement in peripheral vision will not be computed automatically or accurately
- This can result in visual motion sensitivity
- Driving:
  - Better as driver, worse as passenger
  - Cars feels as though still moving when stopped at lights
  - Supermarket syndrome – rows of shelves “moving” opposite when walking in aisles (optic flow)

Visual Motion Hypersensitivity

“Nausea and dizziness associated with motion-related tasks”

“Objects on walls jump out at me”

Shopping centres

Scrolling print is nauseating

Car /train passenger, especially:

Reading or phone in car

Crowds

Fast moving TV images

Balance issues can result

Reading difficulty

Escalators / lifts with view

WARNING!!

Visual Motion Hypersensitivity

- Also known as visual vertigo and/or motion sickness

- Leading theory is a "*mismatch in the information received by the brain between the*
- *visual*
- *vestibular and*
- *somatosensory systems*"

- Symptoms of VMH include:
  - Dizziness
  - Nausea
  - Vomiting
  - Vertigo
  - Imbalance
  - Diplopia
  - Headache
  - Disorientation

Petrosyan, T., 2019. What is visual motion hypersensitivity. Vis Dev Rehab 5, 8–13.

Visual Motion Sensitivity

Clinical issues to note:

- **Eye movement testing creates nausea and headaches etc**
- **Binocular vision testing creates nausea and dizziness**
- **Avoid using your hands when talking to patients with concussion!**

- Often “migraine” diagnosis without pre-trauma Hx

Visual Motion Sensitivity - management

-Often associated with light sensitivity – Pattern Glare

Using an individualized chromatic filter often reduces VMS

Wrap around glasses to minimize peripheral visual movement

Advanced level:

Correct ametropia: **SV lenses often, multifocals often cause symptoms**

Vision Therapy (individualised protocols)

“More relaxed, less tension in my head and eyes. I can breathe, my chest is not as tight… I can look at my phone..”

Recommended Optometry initial workup

- In all cases of mild acquired brain injury, assess and record:
- History
- Vision
- Pupils
- Ocular health, front to back (+ images)
- Visual fields
- OCT
- **Refer to an experienced colleague if significant/prolonged symptoms beyond one month; earlier is even better.**

Refer to an experienced colleague

- 90 accredited optometrists in Australia and New Zealand
- Extensive online lecture series with MCQ's
- 5 days of workshops
- > 150 hours of education and experience
- Case studies, logbooks and exams
- Significant pre-requisite courses for entry *(accommodation, eye movements, VMS, pattern glare, vision therapy)*
- *https://www.acbo.org.au/for-patients/about-vision/336-neuro-optometric-care*

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A few references: Questions?

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