CONCUSSION

In the United States, every 15 seconds a child suffers a head injury and roughly 90% are a (mTBI) mild traumatic brain injury (concussion), and in general within the U.S. the cost is nearly 77 billion dollars. Kids also incur most of the mild traumatic brain injuries in the United States and it is difficult to determine if the head injury has caused a concussion because they don't have the ability to explain things as well as adults.

Common Post Concussion Symptoms List

- Aching eyes
- Amnesia (retrograde, anterograde)
- Appearing dazed
- Audiophobia
- Balance problems or dizziness
- Bothered by light or noise
- Brain Fog, feeling dazed
- Confusion, or concentration or
- Depression
- Difficulties with eye movements, such as: ocular pursuits (eye tracking ability) saccades (shifting gaze quickly from one point to the other) accommodative inability (focusing)
- Double vision or blurry vision
- Headache or "pressure" in head. always happen, <10%)
- Fatigue, feeling sluggish, hazy, foggy, or groggy
- Forgetfulness
- Inability to maintain visual contact or focus
- Irritability
- Just not "feeling right," or "feeling down"
- Memory problems
- Nausea or vomiting
- Reading difficulties: words appear to move
- Reduction or loss of visual field
- Ringing in the ears
- Sensitivity to light, glare sensitivity
- Sleep disturbance
- Slowed mental processing
- Temporary loss of consciousness (does not
- Vertigo/Dizziness
- Visual motion sensitivity

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The Key to Successful Diagnosis and Management

The key to a successful diagnosis is determining whether someone does or does not have a concussion and there are only 3 accepted criteria for assessment of concussion which include: Neurological, Vestibular and Oculomotor. The oculomotor is the more complex of all 3 assessments.

The neurological exam is pretty self-explanatory and will include cranial nerve assessment. The vestibular examination involves both a (VOG) Vestibular Oculography examination with infrared goggles as well as a Dynamic Posturography or Computerized Axial Posturography examination. Until recently the diagnostic criteria have relied heavily on subjective complaints by utilizing such things on the playing field as the SCAT assessment. However, current research suggests that the Best biomarker for objective concussion assessment is the Oculomotor System such that there is a specific pathological eye movement response to mild traumatic brain injury. And, it has also now been determined that eye movements in children who have a concussion are different than eye movements in an adult who sustains a concussion. Therefore, the eye movement biomarkers may be missed unless someone is trained to look at them.

Let us understand that various areas of the brain are responsible for different patterns of eye movements. So, with eye movements we like to look at the ability to maintain gaze fixation, we look at saccades which are fast eye movements, we observe and record slow pursuit eye movements called smooth pursuits, the latency of eye movements meaning reaction Time metrics, and dysautonomia.

For example; when we look at fast or slow eye movements we have to look at them as being Voluntary and Involuntary, or what can be called reflexive eye movements similar to what occurs in the body with ticks or when stepping on a tack. As a clinician we want to quantify the movement as to its speed. Is it fast or is it slow? Are the movements accurate?

If the eye movements are fast, it is necessary to know whether they are they jerky? or is there a combination of fast and slow eye movements such as in nystagmus? When a patient is following a target and the pursuit is inappropriate, meaning that the eyes come off the target, particularly during upward pursuits, this could imply that there is something is broken within the central nervous system that is compromising the activity. There are also autonomic movements in the eye as to whether the pupil is smaller or larger.

3-Pronged Approach

With our 3-pronged approach, utilizing the *accepted* criteria for concussion evaluation; Neurological, Vestibular and Oculomotor, we are capable of determining the injured area(s) of the nervous system resulting in greater specificity in our therapeutics and thus better outcomes.

In concussion, it is necessary to find a practitioner who is skilled in Neurological, Vestibular and Oculomotor assessment for both evaluation and management of mild traumatic brain injuries. I hope you find this short video informative and if I or my team may be of assistance please feel free to call us at **(530) 342-6441.**

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Concussion Articles:

1. "Persistence of tandem gait impairment was particularly common, suggesting that patients with severe mTBI should receive postural stability assessment before returning to certain complex physical activities." Motor impairment after severe traumatic brain injury: A longitudinal multicenter study. Journal off rehabilitation research and development, vol. 44, November 2007.
2. "Visual and verbal memory exhibited stronger correlations to balance and gait measures compared with reaction time." Relationship between cognitive assessment and balance measures in adolescence referred for vestibular physical therapy after concussion. Clinical Journal of sports medicine 2015
3. "Gait analysis and balance and vestibular testing can document subtle changes in gait and balance among those with TBI. " An assessment of gait and balance deficits after traumatic brain injury. Archives of physical medicine and rehabilitation 2003.
4. "Dual task related changes for gait speed and medial lateral sway during walking can distinguish concussed and non-concussed individuals." The use of the dual task paradigm in detecting gait performance deficits following a sport related concussion. A systematic review and meta-analysis. Journal of science and medicine, sports, 2013.
5. "Measurement of visual tracking performance is promising as a past and practical screening tool for mild traumatic brain injury." Visual tracking synchronization as a metric for concussion screening. The Journal of head trauma rehabilitation 2010.
6. "Our results indicate that eye-movement function is impaired in post-concussion syndrome, the deficits being unrelated to the influence of depression or estimated intellectual ability." Impaired eye movements in post-concussion syndrome indicate suboptimal brain function beyond the influence of depression, malingering or intellectual ability. Brain 2009.
7. "Deficits seen during predictive visual tracking correlate with diffusion tensor imaging findings and with observed damage to neural pathways known to carry out cognitive and affective functions that are vulnerable to mild traumatic brain injury." Occurrence of ocular motor dysfunctions in acquired brain injury: a head respective analysis. Optometry 2007.
8. "Deficits observed during predictive visual tracking correlate with DTI findings that show lesions localized in neural pathways subserving the cognitive functions often disrupted in mild traumatic brain injury." A united science of concussion: Annals of the New York Academy of sciences, 2010.
9. "In the concussion group, fMRI signals from the ocular motor AI and abducens nuclei showed about a 50% reduction relative to controls." Deficits in the activation of human ocular motor nuclei in chronic traumatic brain injury. Frontiers in neurology 2015.
10. "Persistent prolonged psychotic reaction times in mild traumatic brain injury patients may separate patients with persistent mTBI from those with recovering mTBI." Saccadic eye movements in mild traumatic brain injury: a pilot study: Canadian Journal of neurological sciences, 2014.
11. "Even every mild traumatic brain injury. There are obvious alterations in saccadic latency distributions with increased mean latency." Saccadometry: the possible application of latency distribution measurements for monitoring concussion. British Journal of sports medicine 2007.
12. "Being sedentary after an injury or illness is 1 of the most consistent risk factors for chronic disability." Is rest after concussion, the best medicine? Journal of head trauma rehabilitation 2013.
13. Delineating function and connectivity of optokinetic hubs in the cerebellum and the brainstem. Ria Maxine Ruehl, Carolin Hinkel, Thomas Bauermann & Peter zu Eulenburg
Brain Structure and Function **volume 222**, pages 4163–4185(2017) Original Article Published: 23 June 2017

Abstract

Optokinetic eye movements are crucial for keeping a stable image on the retina during movements of the head. These eye movements can be differentiated into a cortically generated response (optokinetic look nystagmus) and the highly reflexive optokinetic stare nystagmus, which is controlled by circuits in the brainstem and cerebellum. The contributions of these infratentorial networks and their functional connectivity with the cortical eye fields are still poorly understood in humans. To map ocular motor centers in the cerebellum and brainstem, we studied stare nystagmus using small-field optokinetic stimuli in the horizontal and vertical directions in 22 healthy subjects. We were able to differentiate ocular motor areas of the pontine brainstem and midbrain in vivo for the first time. Direction and velocity-dependent activations were found in the pontine brainstem (nucleus reticularis, tegmentum pontis, and paramedian pontine reticular formation), the uvula, flocculus, and cerebellar tonsils. The ocular motor vermis, on the other hand, responded to constant and accelerating velocity stimulation. Moreover, deactivation patterns depict a governing role for the cerebellar tonsils in ocular motor control. Functional connectivity results of these hubs reveal the close integration of cortico-cerebellar ocular motor and vestibular networks in humans.

Adding to the cortical concept of a right-hemispheric predominance for visual-spatial processing, we found a complementary left-sided cerebellar dominance for our ocular motor task. A deeper understanding of the role of the cerebellum and especially the cerebellar tonsils for eye movement control in a clinical context seems vitally important and is now feasible with functional neuroimaging.

14. Horizontal or vertical optokinetic stimulation activates visual motion-sensitive, ocular motor and vestibular cortex areas with right hemispheric dominance. An fMRI study.
Brain 1998 Aug;121 (Pt 8):1479-95. doi: 10.1093/brain/121.8.1479. M Dieterich[1], S F Bucher, K C Seelos, T Brandt
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Abstract
The differential effects of optokinetic stimulation with and without fixation suppression were analyzed in an fMRI study in 10 right-handed healthy subjects. Horizontal and vertical small-field optokinetic stimulation activated the same multiple visual, ocular motor and vestibular cortical and subcortical areas in both hemispheres. The extent of activation in each hemisphere was independent of the stimulus direction. All activated areas representing cortical (occipitotemporal cortex, posterior parietal cortex, precentral and posterior median frontal gyrus, prefrontal cortex, medial part of the superior frontal gyrus) and subcortical (caudate nucleus, putamen, globus pallidus and paramedian thalamus) ocular motor structures were activated during optokinetic stimulation as well as during fixation suppression of optokinetic nystagmus. However, the activation was significantly stronger with optokinetic nystagmus compared with fixation suppression. The only relatively increased activity during fixation suppression was seen in the medial part of the superior frontal gyrus (supplementary eye field) and the anterior cingulate gyrus. The anterior insula and the posterior insula (human homologue of the parieto-insular vestibular cortex) were activated during optokinetic nystagmus but not during fixation suppression. A significant right hemispheric predominance (regardless of stimulus direction) was found under both conditions in the visual motion-sensitive and ocular motor areas of the cortex, except the supplementary eye field and anterior cingulate gyrus. This was most prominent in the occipitotemporal cortex but did not occur in the primary visual cortex and in subcortical ocular motor structures (putamen, globus pallidus and caudate nucleus). Thus, cortical and subcortical activation patterns did not differ for horizontal and vertical optokinetic stimulation, and there was distinct right-hemisphere dominance for visual motion-sensitive and cortical ocular motor areas and the thalamus. Fixation suppression of optokinetic nystagmus yielded four different results: (i) increased activation in the supplementary eye field and anterior cingulate gyrus; (ii) unchanged activation in the visual cortex; (iii) decreased activation in most of the ocular motor areas; and (iv) suppressed activation in the anterior and posterior insula and the thalamus. Activation of the parieto-insular vestibular cortex may be related to ocular motor function rather than self-motion perception.

When to Rehabilitate Concussion?

1. "One-month post injury has been proposed." Updated clinical practice guidelines for concussion: mild traumatic brain injury and persistent symptoms. Brain injury 2015.
2. "Premature voluntary exercise within the 1st week after concussion impairs recovery, while aerobic exercise performed 14 to 21 days after concussion improves cognitive performance." Rehabilitation of concussion and post concussive syndrome. Orthopedic surgery 2012.
3. "Persistent signs and symptoms for weeks after injury benefit from active rehabilitation." Rehabilitation strategies for prolonged recovery in pediatric and adolescent concussion. Pediatric archives 2012.
4. "Late exercise, initiation, beginning at 5 weeks after trauma, but not early initiation of exercise at one week, significantly reduce working and retention memory impairment at 3 months, and decrease lesion volume compared to non-exercise injury controls." Late exercise reduces neuro- inflammation and cognitive dysfunction after traumatic brain injury. Neurobiology of disease 2013.
5. "It was found that intensive multidisciplinary rehabilitation has a positive effect on functional recovery after TBI." The sooner patients begin neural rehabilitation, the better their functional outcome. Brain injury 2013.
6. "After 8 weekly physical therapy sessions insisting of vestibular and cervical spine rehabilitation, subjects in the treatment group were nearly 4 times more likely to be medically cleared when compared with the control group." Current and emerging revalidation for concussion. Clinical sports medicine 2015.
7. "Significantly higher proportion of individuals who were treated cervical spine physiotherapy and vestibular rehabilitation were medically cleared to return to sport within 8 weeks of initiating treatment." Cervical vestibular rehabilitation in sport related concussion: a randomized controlled trial. British Journal of sports medicine 2014.
8. "People who had, persistent dizziness and gait and balance dysfunction after having concussion seem to have improved after vestibular rehabilitation." Vestibular rehabilitation for dizziness and balance disorders after concussion." This to Peter revalidation for dizziness and balance disorders after concussion. Journal of neurologic physical therapy 2010.
9. "Exercise influences multiple neurotransmitter systems and promotes neural plasticity, neurogenesis, and angiogenesis." Is rest after concussion. The best medicine? Journal of head trauma. We habilitation 2013.
10. "Changing synaptic strengths and synaptogenesis involves complex physical change processes resulting from changes in genetic expression of several thousand well described molecular processes." Brain plasticity-based therapeutics. Frontiers in human neuroscience, 2014.
11. "Most gains are won by patients who practice and extrinsically drive fundamental experience dependent mechanisms." Recovery after brain injury: mechanisms and principles. Frontiers in human neuroscience, 2013. (Meaning that brain ischemia can lead to long-term intrinsic neural plastic changes. It is more important to create plasticity from an experience dependent plasticity. Giving exercise and activities is more beneficial than rest).