

REMOVE-FROM-PLAY: A PROPOSED INVESTIGATION OF RINKSIDE CONCUSSION TESTS

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Introduction

"No single test has been shown to quickly and reliably assess concussion in all cases. In addition, most of the current concussion tests have not been fully validated by scientific investigation."¹



The King-Devick Test (K-D)

"One of the most promising rinkside assessment tools is the King-Devick Test (K-D), a rapid number-naming test that is sensitive to impaired coordination of purposeful saccadic eye movements, attention, and language."²

"In order to aid the coach, trainer or sports medicine professional with remove-from-play decision making, a rapid rinkside adjunct to the K-D is desirable. This poster will review several potential rinkside concussion tests which do not require baseline testing.

"The aim of the proposed study is to invite scientists, trainers and other investigators to administer the baseline K-D to their respective teams and to perform one or more of the five potential tests, in addition to the K-D, on athletes who are suspected of having sustained a concussion. Failure on the K-D will result in an athlete's removal-from-play and subsequent medical evaluation for concussion. The results will be collected over the next three years and the sensitivity and specificity of each new test will be analyzed and compared against the K-D.

Methods



Repeated Nearpoint of Convergence Test (nNPC)

nNPC: It has been observed that the act of repeated convergence of the eyes to an incoming target by individuals who have suffered a traumatic brain injury may elicit a dramatic onset of severe nausea and/or vomiting.³ The mechanism behind this phenomenon is not well understood, but recent studies have found that an autonomic nervous system (ANS) impairment of primarily adrenergic function will frequently occur in concussed individuals.⁴ The ANS may be hypersensitive so that repeated convergence, a parasympathetic activity, may suddenly overwhelm the entire autonomic system creating a sudden onset of nausea symptoms and/or gastric distress. It is also possible that repeated convergence may excite the proprioceptive/stretch receptors of the medial rectus and trigger an oculocardiac reflex, which would result in an oculi-tingimus-vago-abdominal (oculobulbomediastinal) reflex and create symptoms such as nausea and vomiting.⁵

We propose to add a Repeated Nearpoint of Convergence Test (nNPC) as a quick rinkside test to screen for this phenomenon. The nNPC involves having an athlete fixate the tip of a pencil, pen or penlight target placed at eye level in front of the subject's eyes and having the athlete converge the eyes on the tip while the target is slowly advanced (1-cm/s) toward the athlete's nose. This activity is repeated 4-5 times while monitoring the athlete for a sudden onset of symptoms.

OKN+: Sensitivity to motion is a frequent symptom found in concussed individuals, causing a dizziness and nausea.⁶ It is suggested that this may be provoked dramatically by reversing Gibsonian Optic Flow upon the retina with the use of an OKN (optokinetic nystagmus) drum.^{7, 12, 13, 14} According to one theory, the hypersensitivity observed in visual vertigo is due to a sensory conflict between the vestibular and somatosensory systems caused by the concussion.^{14, 15} Another theory suggests that as a result of a vestibular disturbance from the concussion, there is a sudden dependence for balance on the visual system as one must rely on visual cues more than vestibulo-proprioceptive inputs.¹⁶ In any case, a repetitive moving stimuli in the visual field of a concussed individual may result in the sudden onset of visual vertigo.^{17, 18}

We propose to download the OKN+ app (Touch Diagnostics) onto an iPad and to hold it 25 cm in front of the athlete's face. With the vertical moving stripes held first in direct gaze and then 20 degrees to either side of the athlete's direct gaze, the administrator records the presence or absence of sudden symptoms of visual vertigo.



Methods continued

NeuroOptics PLR-200™ Pupilometer



Pupillometry: Recent studies of mTBI individuals have demonstrated slower pupillary dynamics for both constriction and dilation.¹⁹ Both the afferent and efferent pupillary light reflex involve the midbrain, as does the oculomotor near triad.²⁰ The functional pupil abnormalities from a concussion might serve as a useful way to detect a concussion.

We propose to objectively assess the pupillary dynamics of athletes suspected of a concussion using a NeuroOptics PLR-200 handheld, monocular pupilometer. Athletes will fixate a target at 3m distance with the non-tested eye while the tested eye is fixated and a response is recorded for 5 seconds thereafter. This will be repeated three times for each eye, separated by one minute for light adaptation recovery, and the results from the pupilometer will be recorded.

FixTrain Anti-Saccades: Recent studies have found that anti-saccades (the suppression of a reflex saccade and the movement of the eyes in the opposite direction of a distracting stimulus) were able to differentiate mTBI from non-TBI subjects.^{21, 22} The anti-saccade task requires that the individual first inhibit a reflexive saccade toward a briefly appearing peripheral target and then generate a saccade to an equivalent point in the opposite hemifield. The antisaccade is felt to be a function of the prefrontal cortex.²³

We propose to use the FixTrain Device (Freiburg, Germany) as a way to measure anti-saccadic performance in athletes suspected as having sustained a concussion. The FixTrain is a small hand held device for testing/training of saccadic eye movement control and/or stabilization of fixation including visual attention and general concentration.²⁴ It has some similarity with computer games but with controlled effects on eye movement. Holding the device at a comfortable position, the fixation point in the center of the screen is shown to the athlete and after one second it is extinguished. 200 ms later, another stimulus (a star symbol) is presented randomly 4 deg to the right or left of center as a distractor. The athlete is instructed to look to the opposite side of the screen of the distractor stimulus where a small test stimulus is briefly presented in one of 4 possible orientations. The task of the athlete is to identify the orientation of the test stimulus. The best strategy to identify the orientation requires an antisaccade with respect to the distracting stimulus to identify the orientation by foveal vision. The athlete performs 100 trials of the task on the device (4-6 min), which then records the percentage of correct antisaccade responses.

Nearpoint of Fixation Disparity Test (NFPD): The dynamics of accommodation and vergence have been found to be disrupted in persons with mTBI.^{25, 26} The midbrain is felt to be intimately involved in both of these functions. The NFPD (Visual Assessment Corp.) is a new test that was developed as a dichoptically vergence disparity cross utilizing monius lines and verrier acuity to determine when binocular fixation disparity occurs during gradually increased nearpoint accommodation and vergence demands. According to its developer, the NFPD provides one of the most sensitive measures of the disruption of binocular vision due to accommodative-vergence dysfunction.²⁷ A recent study has found that the NFPD break point is a sensitive predictor of past history of concussion, suggesting that this may be an important tool for rinkside diagnosis of concussion.²⁸

We propose to use the NFPD as a measure of the disruption of the accommodative-vergence system in athletes suspected of having sustained a concussion. Wearing polaroid glasses, the athlete views an E target at the center of a "plus" sign formed by two vertical and two horizontal arrows on the NFPD target. Although both eyes are able to see the E target, only the right eye will be able to see the top vertical arrow while only the left eye will be able to see the bottom arrow. Slowly (1-2cm/s) the NFPD target is moved inward toward the athlete's nose, stressing both accommodation and convergence. The athlete indicates when the vertical arrows begin to slide or slip so that they no longer appear to be aligned with each other or the central E target. The distance at which the vertical lines on the target appear to become misaligned indicates the NFPD breakpoint and is recorded. Slowly the NFPD target is pulled away from the athlete's face and the athlete is asked to indicate when the misaligned vertical arrows again become perfectly aligned. This distance of realignment is then recorded as the recovery point. The task is repeated three times.



The FixTrain Device



Nearpoint of Fixation Disparity Test (NFPD)

Expected Results

	NeuroPathway	Significant Outcomes	Sensitivity	Specificity	Repeatability	Reference	Baseline	Objectivity	Test Duration	Ease of Admin.	Cost	Equipment	Other Uses
K-D	Multiple	Decreased visual-verbal responses	0.76	0.99	Hi	Positive	Yes	++	2 min.	+++	\$45.00 +	K-D cards	Reading Disabilities
	Brainstem, Cerebellum	from baseline										Stowatch	
nNPC	Cerebral Cortex	Oculocardiac Reflex	TBD	TBD	TBD	Criterion	No	+	1 min.	+++	\$0.00	Pencil, pen,	Binocular function
	ANS	Nausea/Vomiting										Penlight	
OKN+	Visual-Vestibular-Sensomotor	Visual Vertigo/ Nausea/Vomiting	TBD	TBD	TBD	Criterion	No	+	1 min.	+++	\$2.99	iPAD	Vestibular function, Optokinetic Nystagmus function
											\$325.00		
Pupillometry	Midbrain	Slowed constriction/dilation dynamics	TBD	TBD	Hi	Norms	No	+++	7 min.	+++	\$8,000.00	NeuroOptics	Autonomic function, anesthesia, migraine, alcohol consumption, pharmacodynamics, optic neuropathies, retinal function
												PLR-200	
FixTrain	Prefrontal Cortex	Reduced anti-saccade accuracy	TBD	TBD	Hi	Norms	Optional	++	4-6 min.	++	\$2,000.00	FixTrain	Parkinson's, Alzheimer's, Dystonia, ADHD, Schizophrenia, ALS, Huntington's
Anti-Sacc.	Midbrain	Revised NFPD break/recovery	TBD	TBD	TBD	TBD	Optional	+	3 min.	+	\$60.00	Nearpoint Rule	Binocular function
											\$89.00	NFPD	

Over the next three years, athletes who are suspected of having sustained an on-ice concussion and/or have failed the K-D will be followed medically to assess assessment of the sensitivity and specificity of each test and to compare these results to the K-D.

Concluding Remarks

• One or more of the adjunct rinkside tests may prove to be an aid in remove-from-play decision making for concussed athletes.

• One of more of the adjunct rinkside tests may prove to be an aid in return-to-study decision making for concussed student-athletes.

• One or more of the adjunct rinkside tests may prove to be an aid in return-to-play decision making for concussed athletes.

• One or more of the adjunct rinkside tests may prove to be an aid in rehabilitation therapy management for concussed athletes.

• All interested investigators, scientists, trainers and organizations are invited to adopt the K-D along with any or all of the proposed rinkside tests for investigation within their respective communities over the next three years and to FAX the results to Dr. David Biberdorf at 701 772-8161. Protocols and score sheets are available by emailing dribberdorf@valleyvision.net

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