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Case Report: A Novel Ocular Screening Aid for Detection of Sport-related Concussion in High School Athletes

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CASE REPORT:

A NOVEL OCULAR SCREENING AID FOR DETECTION OF SPORT-RELATED CONCUSSION IN HIGH SCHOOL ATHLETES

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science degree in Sport and Recreation Studies and is acceptable for meeting the thesis requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

CASE REPORT:

A NOVEL OCULAR SCREENING AID FOR DETECTION OF SPORT-RELATED CONCUSSION IN HIGH SCHOOL ATHLETES

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Objective: The purpose of this study was to develop, implement and determine the general effectiveness of a novel battery of ocular tests referred to as the *Rapid Ocular Screening Test (ROST)* that can be performed efficiently on the sideline and is based on our current understanding of the physiological effects of blunt head trauma on ocular functioning.

Background: Assessment of ocular function following a suspected head-injury has been recognized as an important adjunct to a concussion evaluation protocol; however, sideline-screening recommendations currently do not include a comprehensive set of ocular functioning tests. Three high school student athletes who suffered a traumatic brain injury during sport participation were evaluated using a standard accepted sideline assessment and a novel ocular screening tool (ROST). The participants were removed from activity, given instructions for rest and recovery, and reported for a follow-up post-concussion screening by a licensed athletic trainer within 72 hours of the injury.

Differential Diagnosis: Sport-related concussion

Diagnostic Test and Results: All 3 participants had equal pupil reactions and vertical eye tracking with no vertical nystagmus. Two participants had significant symptomology while 1 participant reported only headache and dizziness; all participants

reported headache and dizziness. All participants reported increased symptomology following saccades. The ROST demonstrated positive findings in number of symptoms, symptom severity and an increase in symptoms during horizontal saccades for all participants. All 3 participants reported headache and dizziness as the primary symptoms. Two participants also demonstrated increased symptoms following vertical saccades and 1 participant demonstrated impairment with smooth pursuit. Two individuals had at least 1 near point convergence (NPC) measure greater than 5 centimeters; however, on average 1 person had a mean over 5 centimeters. Additionally, all participants that were sideline tested also tested "positive" for a SRC at 24-72 hours using the combination of the immediate post-concussion assessment and cognitive test (ImPACT®), balance error scoring system (BESS), and King- Devick (KD).

Uniqueness: Healthcare providers who assess student-athletes following blunt head trauma during an athletic event have a responsibility to keep student-athletes safe from further harm; however, they also do not want to keep a student-athlete out of participation if no injury exists. Being able to assess a SRC within the first 15-30 minutes, without the benefit of a biomarker, can be very challenging. The findings of this study demonstrate the addition of an ocular screening may improve a clinician's ability to accurately determine if a SRC exists when assessing an injured player on the sideline in order to make a better decision on behalf of the safety and well being of the participant.

Conclusions: Our findings suggest the addition symptom evaluation with saccades and near point convergence (NPC) may aid in the recognition of a sport-related concussion during a sideline assessment. Our findings also reiterate the importance of a thorough symptom examination. It is recommended that clinicians use a combination of

these tools to accurately diagnose a SRC on the sideline within 15-30 minutes following the trauma event. **Key Words**: VOMS, SCAT5©, Sideline Assessment, Near Point Convergence, Sport-Related Concussion

INTRODUCTION

In the last decade, epidemiologists have documented the substantial prevalence of sport-related concussions (SRCs) amongst youth sport participants. Discussions surrounding the detection, management and long term consequences of SRCs have also become more prevalent in the media and research in the past decade.[1] Approximately 1.6 to 3.8 million SRCs occur annually, most of which occur in youth ages ten to 19 years old.[2] More specifically, incident rates of SRC for youth have been calculated to range from 0.17 to 0.25 per 1000 athlete exposures across all sports.[1] According to the 5th International Consensus statement from the concussion in sport group (CISG), SRC is defined as a complex, pathophysiological process affecting the brain, induced by biomechanical forces.[3] These mechanical forces change the chemical balance in the brain, and subsequently the brain immediately tries to restore this change.

The first step in managing individuals who suffer sport-related concussion is to recognize or diagnose the condition. In order to best diagnose a SRC, one must understand the pathophysiology. Since 2000, the scientific community has been trying to better define the pathophysiology of SRC. Following a biomechanical brain injury there is an abrupt change in cellular homeostasis. Stretching of mechanoreceptors in the brain causes an efflux of intracellular potassium. This, in turn, causes a rapid influx of extracellular calcium. In order to restore homeostasis, the sodium potassium pump works in overdrive, which consequently consumes a large amount of adenosine triphosphate (ATP).[4-6] These cellular changes manifest in a physical nature over time with common symptoms including headache, nausea, difficulty concentrating, and visual problems.[7-9] Currently, athletic trainers are unable to capture these events on the sideline with a

"biomarker". Therefore, the approach to date has been to develop a multimodal assessment process that helps capture functional impairments. The challenge for clinicians who work with concussed individuals is to identify an evaluation strategy that identifies impairments post-injury and accurately detects the condition.

After an individual sustains a SRC, or is under suspicion of having a SRC, they should be removed from play until evaluated by a medical professional.[5, 6,10] Sport-related concussions are difficult to diagnose, due to the fact that physical symptoms do not always appear immediately and the physical presentation is different for each individual.[3] Student-athletes will also sometimes try to hide their symptoms to remain in the game, which adds to the difficulty of diagnosing a SRC within the first 30 minutes of the traumatic event. Researchers predict that up to 50% of SRCs sustained by youth athletes go unreported.[11,12] There are however ways to increase the likelihood of correctly recognizing a SRC.

When a student-athlete receives a "hit" on the field, it is important to recognize whether or not a SRC exists. Sending a student-athlete back on the field when they are concussed is potentially life threatening, as receiving another blow to the head, or even a whiplash-like mechanism could cause second impact syndrome and possibly produce a catastrophic result. Perhaps just as important as determining if a SRC exists is determining whether the student-athlete can return to participation if, after delivering a sideline protocol, the student-athlete is not demonstrating signs of a SRC.[13]

In an effort to standardize SRC assessment on the sideline, experts with the CIS group developed a multifaceted tool known at the Sport-Concussion Assessment Tool (SCAT) to help combat the elusiveness of subtle SRC impairments.[14] This tool has been

revised 3 times since its inception in 2004 and updates have been based on both expert consensus and best available evidence. The current tool is the SCAT5[3] and includes 2 sections: (1) Immediate/On-Field Assessment and (2) Office or Off-Field Assessment. Within these two sections, the following domains are captured: (1) Observable Signs, (2) Maddock's Questions (on-field orientation/mental status), (3) Glasgow Coma Scale, (4) Cervical Spine Assessment, (5) Symptom Evaluation, (6) Cognitive Screening (Standardized Assessment of SRC or SAC), (7) Neurological Screen (including balance), and (8) Delayed Recall. Although the SCAT5© includes multiple brain function assessments, including cognition and balance testing, it only includes on short measure of ocular function (without moving their head or neck, can the patient looked side to side and up and down without double vision). Evidence within the last 5 years however, suggests that ocular assessments may be beneficial to the detection of a SRC.[7,8,15-17]

As previously mentioned, the neurometabolic cascade of a SRC presents physically with symptoms including dizziness and nausea. These symptoms are believed to be effects of dysfunction to the vestibular/oculomotor systems.[18] Though research involving screening for ocular deficits following SRCs is relatively new in the past decade, these tests have shown to be a promising addition to a multi-modal assessment strategy. Near point convergence (NPC), smooth pursuit, and saccades have been proven to increase the likelihood of recognizing a SRC. These tests have also demonstrated increased sensitivity in differing between concussed and healthy subjects.[18]

Statement of the Problem

Although more objective tools are available for clinicians today as compared to 10 years ago, researchers and clinicians continue to search for the most accurate and

feasible method of identifying functional impairments associated with a SRC both on the field and on the sideline within 10-30 minutes post injury. The SCAT5© is a tool for both on-field and sideline assessment; however, it has not incorporated a wide range of ocular assessments that can help in identifying a dimension of impairments that may assist in recognizing a SRC.

Purpose

The purpose of this study was to develop, implement and determine the general effectiveness of a novel battery of ocular tests referred to as the *Rapid Ocular Screening Test (ROST)* that can be performed efficiently on the sideline and is based on our current understanding of the physiological effects of blunt head trauma on ocular functioning.

Specific Aim

The following specific aim guided this study:

Specific Aim: Investigate the relative contribution of a novel ocular assessment strategy delivered at the time of injury and in addition to commonly accepted techniques for the assessment of SRC in adolescents with suspected head injuries.

Hypothesis: We hypothesized that the addition of ocular assessments will allow healthcare providers to identify individuals who may have suffered a SRC but are asymptomatic immediately following the injury.

Justification: Research within the past 5-10 years related to disruption of ocular functions following a sport-related concussive event demonstrate a high likelihood that if a SRC exists, ocular impairments will also exist.

Significance of the Study

Healthcare providers who assess student-athletes following blunt head trauma during an athletic event (practice or competition) have a responsibility to keep student-athletes safe from further harm; however, they also do not want to keep a student-athlete out of participation if no injury exists. Being able to assess a SRC within the first 15-30 minutes, without the benefit of a biomarker, can be very challenging. The findings of this study may improve a clinician's ability to accurately determine if a SRC exists when assessing an injured player on the sideline in order to make a better decision on behalf of the safety and well-being of the participant.

Dependent Variables (Outcome Variable)

The dependent variables for this study are (1) the score/findings on the ROST which were delivered on the sideline following a suspected SRC and (2) the scores/findings of a battery of tests delivered within 72 hours of the head injury/SRC. This battery consisted of the Immediate Post- Concussion Assessment and Cognitive Test (ImPACT®) which included both the self-report symptoms score (SRS) and reliable change indices (RCI) on the neurocognitive composites, the Balance Error Scoring System (BESS) and the King-Devick test.

Independent Variables

Independent variables of this study include: (1) administration of ROST, (2) administration of post-SRC battery, (3) age, (4) sex.

Limitations

The following characteristics limited the design of this study and set parameters on the application or interpretation of the results:

(1) The number of student-athletes who report SRCs and were evaluated on the sideline by an attending licensed athletic trainer trained in the delivery of the ROST;

(2) Student-athletes who have completed baseline testing at the start of the season; and

(3) Student-athletes who meet the inclusion criteria; and/or

(4) Student-athletes who have suffered a SRC within the timeframe for data collection.

Delimitations

In order to improve the internal reliability of the study, the following considerations were included:

(1) The principal investigator followed up with student-athletes at participating schools who had not completed baseline testing prior to the start of the fall sports season to ensure they were scheduled.

(2) The principal investigator invited additional licensed athletic trainers to assist with implementation of the ROST.

(3) Licensed athletic trainers agreeing to participate attended an inter-rater training session to ensure their understanding of the methods for delivering the ROST and demonstrate experience with the tool.

LITERATURE REVIEW

Strategies to assess sport-related concussion (SCR) in youth sport participants have evolved over the past decade and continue to incorporate new evidence and expert opinion. The most current and commonly supported algorithm for sideline SRC assessment is the SCAT5©.[19] Even though this tool includes best evidence and expert opinion as of 2015; it is sometimes lengthy to deliver and does not include a more comprehensive ocular screening may be helpful in identifying impairments and is supported by current evidence. The purpose of this study was to develop, implement and determine the general effectiveness of a novel battery of ocular tests referred to as the *Rapid Ocular Screening Test (ROST)* that can be performed efficiently on the sideline and is based on our current understanding of the physiological effects of blunt head trauma on ocular functioning. The following tables summarize current literature supporting the need for this study:

Table 1: Epidemiology and Pathophysiology of a Sport-Related Concussion

Table 2: A Summary of Sideline Sport Related Concussion Diagnostic/Detection Strategies

Table 3: Benefits of Ocular Impairment Assessment and Tools Used for Ocular Impairment Assessment

LITERATURE REVIEW

Table 1: Epidemiology and Pathophysiology of a Sport-Related Concussion

Authors	N	Population	Study Design	Purpose	Main Findings
MacFarlane et al.[4]	N/A	N/A	Narrative literature review	To systematically describe the sequential metabolic changes that occur following concussive injury, as well as identify and characterize the major concepts associated with the neurochemical cascade.	Concussive injury initiates a complex cascade of pathophysiological changes that include hyper-acute ionic flux, indiscriminant excitatory neurotransmitter release, acute hyperglycolysis and sub-acute metabolic depression.
McCrory, et al.[14]	N/A	N/A	Consensus statement	To explain the definition of a SRC.	SRC is a brain injury and is defined as a complex pathophysiological process affecting the brain, induced by biomechanical force.
Register-Mihalik et al.[11]	25 high schools	High school students from 6 sports	Cross-Sectional	To examine the influence of knowledge and attitude on SRC-reporting behaviors in a sample of high school athletes.	Only 40% of SRC events and 13% of bell-ringer recalled events in the sample were disclosed after possible concussive injury. Increased athlete knowledge of SRC topics (increase of 1 standard deviation 1⁄4 2.8 points) was associated with increased reporting prevalence of SRC and bell-ringer events occurring in practice (prevalence ratio [PR] 1⁄4 2.27, 95% confidence interval [CI] 1⁄4 1.60, 3.21) and the reporting prevalence of bell-ringer-only events overall (PR 1⁄4 1.87, 95% CI 1⁄4 1.38, 2.54).

Table 1: Epidemiology and Pathophysiology of a Sport-Related Concussion, continued

Authors	N	Population	Study Design	Purpose	Main Findings
Rivara et al.[20]	770	High school athletes from Washington State	Cohort study	To determine (1) the incidence of sports-related SRCs in high school athletes using a unique system to collect reports on SRCs, (2) the proportion of athletes with SRCs who play with concussive symptoms, and (3) the effect of the type and modality of coach education on the likelihood of athletes reporting symptoms to the coach or playing with concussive symptoms	Among the 778 athletes, the rate of SRCs was 3.6 per 1000 AEs and was identical for the 2 sports studied. The cumulative SRC incidence over the course of the season was similar in girls' soccer (11.1%) and football (10.4%). Sixty- nine percent of concussed athletes reported playing with symptoms, and 40% reported that their coach was not aware of their SRC. Most measures of coach SRC education were not associated with coach awareness of SRCs in their athletes, although the modalities of a video and quiz were associated with a lower likelihood of coach awareness.
Manasse-Cohick et al.[2]	160	High school football players	Questionnaire	To compare high school foot- ball players' knowledge and attitudes about SRC before and after attending an educational presentation specifically designed to improve knowledge and attitudes	There were no significant changes in the SRC Attitude Index. Results revealed a statistically significant difference in the athletes' scores for the SRC Knowledge Index
Bompadre et al.[21]	10	High schools in Seattle Public school system	Cross-Sectional	To determine the effect of the Lystedt law on injury and SRC documentation in the Seattle public high schools	The number of documented SRCs more than doubled after the institution of the Lystedt law, which may be attributed to heightened awareness and closer monitoring.

Table 1: Epidemiology and Pathophysiology of a Sport-Related Concussion, continued

Authors	N	Population	Study Design	Purpose	Main Findings
Doucette et al.[22]	5	Massachusetts schools	Case Study	To examine the effects of SRC policy implementation	Participants viewed the use of neurological baseline testing as an essential tool in dealing with concussed students even though it is not required by the law. Given the lack of scientific evidence supporting the reliability and validity of the available neurological tests, we do not recommend mandating the use of these tests. Participants also viewed availability of a full-time athletic trainer as essential for SRC management. While potentially one of the best ways to ensure that a student with concussive symptoms is removed from a field of play, some schools may not be able to employ a full-time athletic trainer due to lack of funding.

Table 2: A Summary of Sideline Sport-Related Concussion Diagnostic/Detection Strategies

Authors	N	Population	Study Design	Assessment Tool	Main Findings
Broglio et al.[10]	N/A	N/A	Position Statement	N/A	Once the concussion diagnosis has been made, the patient should be immediately removed from further participation for at least 24 hours. Follow-up testing, using the same protocol as the baseline examination, can aid in determining when to start the return to physical activity after the patient is cleared by a physician or designate. Lastly, although most concussions resolve in a relatively short time frame, patients who are young, who have had multiple concussions, or who have premorbid factors may require additional attention.
Broglio et al.[23]	75	Collegiate Athletes	Quasi - Experimental	ImPACT®, Self reported symptoms, postural control, neurocognitive assessment	.ImPACT® most sensitive (79%); Self reported symptoms (68%); Postural Control (61.9%); Pencil/paper cognitive function (43.5%
Choe et al.[24]	N/A	N/A	Review	Glasgow coma scale, SCAT 3, Maddock's score, BESS, KD	Maddock's and KD are fastest tests to do on sideline.
McKeag, et al.	78	High School/ College athletes	Case Control	ImPACT®, alteration in mental status, self-reported sx (Headache, nausea, dizziness),disorientation, retrograde amnesia, LOC	The presence of amnesia, not loss of consciousness, appears predictive of symptom and neurocognitive deficits following SRC in athletes

Table 2: A Summary of Sideline Sport-Related Concussion Diagnostic/Detection Strategies, continued

Authors	N	Population	Study Design	Assessment Tool	Main Findings
Galetta, et al.[25]	332 (243 youth, 89 collegiate	High school, College athletes	Prospective Study	.KD, SCAT 3, child SCAT3, SAC	Adding a vision-based performance measure to cognitive and balance testing enhances the detection capabilities of current sideline SRC assessment
Guskiewicz et al. [26]	N/A	N/A	Review	BESS, SAC, SCAT 2, GCS	An increase of 3 or more errors on BESS was 34% sensitive, and 91% specific to a SRC.
King et al. [27]	292	N/A	Systematic Review	SCAT 3, KD	SRC is hard to recognize and diagnose. Initial sideline assessment via the Sports SRC Assessment Tool 3 (SCAT3), Child-SCAT3 or King-Devick test should be undertaken to identify athletes with SRC as part of a continuum of assessment modalities and athlete management
McCrea et al. [28]	55 control 63 concussed	High school and college football players	Repeated measures, ANOVA	SAC	A decline in SAC score from baseline was 95% sensitive, and 76% specific in classifying injured and uninjured subjects

Table 2: A Summary of Sideline Sport-Related Concussion Diagnostic/Detection Strategies, continued

Authors	N	Population	Study Design	Assessment Tool	Main Findings
Meagher et al. [29]	22	N/A	Systematic Review	Months backwards test	The MBT is a simple, versatile tool that is sensitive to significant cognitive impairment. Performance can be assessed according to accuracy and speed of performance
Okonkwo et al.[30]	N/A	N/A	Expert Opinion	PCSS, Maddock's, SAC, BESS, SCAT	A variety of tools should be used to assess a SRC
Putukian, et al.[31]	N/A	N/A	Expert Opinion	GCS, SAC, BESS	SRC assessment, involving the use of symptom checklists, neuropsychological testing, and postural stability testing, are indicated for any athlete suspected of having sustained a SRC, and research has shown the utility of these when incorporated into a systematic sideline assessment.
Ventura et al.[7]	N/A	N/A	Expert Opinion	KD, VOMS, Pupillary reflex, SCAT3, ImPACT®, SAC, BESS	Tests involving the visual system can probe higher cognitive functioning and can increase our ability to detect subtle changes associated with head ImPACT®s

Table 2: A Summary of Sideline Sport-Related Concussion Diagnostic/Detection Strategies, continued

Authors	N	Population	Study Design	Assessment Tool	Main Findings
Adler et al.[32]	51	Children and adults up to age 30	Repeated measures	Finger, penlight, pencil tip, N5 letter	There was no significant differences in near point convergence between the tools
Rosenthal et al.[1]	100 Schools	High Schools	Descriptive epidemiologic	High School RIO	Overall SRC diagnosis rates increasing significantly from 0.23 to 0.51 SRC diagnosis rates increased for each of the 9 sports studied with 5 sports having statistically significant increases over this 7-year period

Table 3: Benefits of Ocular Impairment Assessment and Tools Used for Ocular Impairment Assessment

Authors	N	Population	Study Design	Assessment Tool	Main Findings
Galetta, et al.[25]	332 (243 youth, 89 collegiate)	High school, College athletes	Prospective study	KD, SCAT 3, child SCAT3, SAC	Adding a vision-based performance measure to cognitive and balance testing enhances the detection capabilities of current sideline SRC assessment
Ventura et al.[7]	N/A	N/A	Expert Opinion	KD, VOMS, Pupillary reflex, SCAT3, ImPACT®, SAC, BESS	Tests involving the visual system can probe higher cognitive functioning and can increase our ability to detect subtle changes associated with head ImPACT®
Mucha et al.[17]	66	Concussed Patients	Cross Sectional	VOMS	VOMS demonstrated internal consistency as well as sensitivity in identifying patients with a SRC. The VOMS may serve as a single component of a comprehensive approach to the assessment of a SRC

METHODOLOGY

Arrangements for Conducting the Study

The principal investigator implemented the following steps to ensure the credibility, reliability and validity of the study.

Ethical Approval: The principal investigator sought and obtained approval from the Institutional Review Board at South Dakota State University. Written parent/guardian permission and student assent was obtained prior to a child's inclusion in the study. A copy of the IRB approval is found in appendix A.

Participant Selection: Participants were recruited from a sample of student-athletes currently enrolled in an established rural youth cohort and completed baseline testing yearly prior to the start of athletic participation. Approximately 800 students participated in baseline screenings prior to the start of the 2017 athletic season and we estimated a minimum of 5% or 40 student-athletes would suffer a sport-related head injury in the fall and meet the first level of our eligibility criteria to participate. Further inclusion criteria; however, required that a licensed athletic trainer on the sideline evaluate injured adolescents at the time of injury in order to continue in the study. Unfortunately, a licensed athletic trainer was not always available to administer the tool on the sideline/at the time of the injury, and it was therefore difficult to predict the number of cases for final inclusion. Additional exclusion criteria included adolescents who lost consciousness or were referred to the emergency room before the delivery of the *Rapid Ocular Screening Test (ROST)*, student-athletes not evaluated immediately after sustaining a SRC (did not report) and/or who chose not to participate in baseline testing.

Development of the Rapid Ocular Screening Test: The investigator developed a screening tool for the purpose of this study since a comprehensive ocular screening did not exist to meet the needs of the study. Steps taken to develop the novel ocular sideline-screening tool to ensure validity of the tool and reliability of delivering the tool included: (1) development of the *Rapid Ocular Screening Test (ROST),* (2) recruiting licensed athletic trainers/research assistants, and (3) completing an inter-rater training session with the licensed athletic trainers.

Development of the Rapid Ocular Screening Test (ROST): No sport-related concussion testing prototypes included a full ocular assessment prior to this study. Therefore, we developed the *Rapid Ocular Screening Test (ROST)* using a combination of strategies including the SCAT5© symptom checklist, portions of the Vestibular/Ocular Motor Screening (VOMS) test, vertical and horizontal saccades, near point convergence, eye tracking, pupil size, and lastly vertical and horizontal nystagmus. The tool was validated against current literature and practitioner critique (Table 4). Appendix B includes a copy of the instrument.

Table 4: Validation Matrix for the *Rapid Ocular Screening Test (ROST)*

Criteria	Brogilo et al.[23]	Galetta et al.[25]	King et al.[27]	Ventura et al.[7]	Alder et al.[32]	Mucha et al.[17]	Kontos et al.[33]	McDevitt et al.[18]	Guskiewitz et al.[26]
Self-Report Symptoms Scale (SCAT5©)	X	X	X	X					
VOMS Modification				X	X	X	X	X	
Pupils Equal				X					
Tracking	X	X	X	X					

Vertical Nystagmus	X	X
Horizontal Gaze Nystagmus	X	X

Table 5 includes a summary of the justification for the inclusion of the various sections of the ROST.

Table 5: Summary of Justification for the Rapid Ocular Screening Test (ROST)

Test	Justification
SCAT5© Symptom Checklist	The SCAT5© symptom checklist is one portion of the entire SCAT5© battery of tests; however, it is recognized as an essential tool in sideline assessment. The SCAT5© was developed by medical professionals knowledgeable and skilled in assessing SRCs during an annual conference in Zurich.[19] A patient rates a series of 22 different symptoms on a scale of 0 to 6, ranging from none to severe, respectively. The SCAT5© is a widely accepted test that has been demonstrated sensitivity to SRCs, with a positive prediction value of <. 001 within the first 24 hours of a SRC.[3,34] We not only chose to incorporate this test for that reason, but also because we needed a pre-assessment score before we start the VOMS portion of our battery. A positive finding would include an increase of number of symptoms and/or an increase in symptom severity.
Modified VOMS	The Vestibular and Oculomotor Screening (VOMS) is a tool not typically used as a sideline tool, but contains components that may be helpful in a sideline evaluation. It is comprised of five smaller tests including horizontal and vertical saccades, slow and fast smooth pursuit, near point convergence, optokinetic stimulation, and dynamic visual acuity. The VOMS is a reliable test for determining oculomotor dysfunction, with an internal consistency of .97. [18,5,33] To begin, the examiner will ask the patient to rate baseline symptoms of headache, dizziness, nausea, and fogginess on a scale of 0 to 10. The examiner will then administer each of the 6 tests asking the patient to rate their symptoms after each test. Any response that caused and increase in symptom severity by 2 from baseline is abnormal, and should be considered results of a SRC. In order to keep the sideline test short in duration, we only included vertical and horizontal saccades, and near point convergence. The symptom scale will be rated from 0 to 6 to allow for the symptom checklist to be used.
Vertical and Horizontal Saccades	Vertical and horizontal saccades measure the ability to quickly move the eyes between two targets.[5, 11] To assess saccades; the examiner is seated approximately 3 feet in front of the patient. To assess vertical saccades the examiner holds his or her index finger 1.5 feet above and below the midline of the face, so the patient must gaze 30 degrees upward and 30 degrees downward. The same procedures are used with the other index finger, except the finger is placed 1.5 feet on either side of the patients head. The patient is then asked to move between the 2 targets 10 times, and then report symptom scores to the

	examiner. Patients are asked to rate their symptoms at the completion of this task. A positive finding would include an increase in symptoms by 2 or more from baseline.

Table 5: Summary of Justification for the Rapid Ocular Screening Test (ROST) (cont.)	
Test	**Justification**
Near Point Convergence (NPC)	NPC measures the patient's ability to view a near target without seeing double.[5, 11] Abnormalities in convergence have been reported in 47-64% of concussed patients.[7] NPC scores greater than 5cm were shown to increase the likelihood of identifying concussed individuals by 38%.[18] To assess NPC, the examiner is positioned in front of the patient. The patient focuses on the tip of the examiners pen, as the examiner slowly brings the pen from the patient's arm length, towards the patients nose. The patient is told to say stop once they see 2 distinct targets, or the examiner will stop once he or she sees outward deviation of the patient's eye. Once the patients says stop, the examiner measures the distance from the target to the patient's nose. The test is repeated three times. A positive finding would include a measurement of 6 or more centimeters.
Pupil size, eye tracking, vertical and horizontal nystagmus	*Pupil size* is commonly assessed in SRC testing to rule out serious conditions, such as hematomas and optic nerve damage. Pupil size is measured using a pen light, with a scale of different pupil sizes recorded on the side of the pen. A positive finding would include one pupil being larger or smaller than the other. *Eye Tracking*…Abnormalities in eye tracking have been observed in patients with a head injury.[7] Maintaining gaze on a predictive target requires high cognitive functioning, such as memory, attention, and anticipation.[5] To assess eye tracking, the examiner will stand approximately 3 feet in front of the patient. The examiner will begin with his or her finger positioned at the center of the patients face. The examiner will then move approximately 45 degrees to the left of the center of the face, then 45 degrees to the right of the patients face. During this process the examiner will be looking for smooth tracking of the patient's eyes. A positive finding would include the patient not being able smoothly follow a target. *Nystagmus* is defined as a visual condition in which the eyes make repetitive, uncontrolled movements.[35] Spontaneous nystagmus can be seen in association with a SRC.[7] To assess ***vertical nystagmus***, the examiner will stand approximately 3 feet in front of the patient. The examiner will begin with his or her finger at the center of the patients face. Next the examiner will raise his or her finger up the midline of the face, until the patient's eyes have reached their maximal superior position. The examiner will hold this position for approximately 5 seconds, while looking for nystagmus. The examiner will then repeat this process, but while the patient's eyes are at his or her maximal inferior position. ***Horizontal nystagmus*** will be assessed with the same protocol address above, but this time nystagmus will be assessed with the patient's eyes in the maximal abducted position, on both the left and right side. A positive finding would include the eyes "bouncing" from side to side, or up and down.

Recruitment of Athletic Trainers and Inter Rater Training Session: Three licensed athletic trainers in addition to the principal investigator participated in the delivery of the sideline SRC protocol, which included a standard evaluation and the ROST for the

detection of a sport-related concussion, and usual accepted care for management of the sport-related concussion. We selected these athletic trainers since they provided services to seven of the school districts enrolled in the rural youth cohort. In order to improve inter-rater reliability, we administered a training session to all athletic trainers and research assistants assisting with the delivery of this study. During this training session, clinicians were educated on proper techniques and scoring to deliver the ROST.

Standard Evaluation and Usual Care: As the ROST is currently not a validated tool for clinical practice; we determined a priori that the attending licensed athletic trainer would use their preferred sideline evaluation as the primary evaluation tool (standard evaluation). Standard evaluation referred to the standard evaluation process an athletic trainer would use to assess for the presence of a concussion. Common techniques among all 4 athletic trainers were observable traumatic mechanism of injury, identification of key symptoms and symptoms severity score, orientation screening (Maddock's score), SCAT5® cognitive screening and cranial nerve assessment. A concussion was suspected if the adolescent suffered an observable mechanism of trauma and positive findings in any 1 or multiple areas of the standard evaluation. Usual care referred to the common management practice following the suspicion of a concussion. Usual care for our participating athletic trainers included removal of the participant from the activity, placing the injured athlete in a safe place, completing any further testing, and providing instruction to the athlete and their parent/guardian regarding rest and recovery principles necessary to aid in recovery over the next 72 hours.

Narrative of the Episode of Care

Presenting Concern: During the timeframe of this study (8/1/2017/-10/31/2017), 32 student-athletes were evaluated for a suspected sport-related concussion among all participating licensed athletic trainers; however, only 3 participants met the inclusion criteria. The primary reason for exclusion was the participant not being evaluated on the sideline by a licensed athletic trainer. The remaining 29 participants were evaluated by a licensed athletic trainer during an office evaluation up to 3-5 days after the original incident. On-field or sideline assessment was completed by a coach or parent.

The 3 student-athletes who met the inclusion criteria for this study and are described in this episode of care. Each suffered an observable blow to the head (mechanism for SRC) and at minimum, presented with primary symptoms concurrent with a concussion, including headache, nausea, dizziness, feeling foggy, and/or visual problems. They did not present with immediate concerns for more serious head injury such as hematomas or skull fractures (as denoted by "Red Flags" in the SCAT5©). Attending athletic trainers then continued with the remainder of the standard evaluation and the ROST.

Relevant Demographic Data/Clinical Findings Pre-Injury: Two males and 1 female were included in this study (average age of 15.7 years old). Two injuries occurred while playing football and 1 during soccer. All were during a competition rather than practice. Each participant completed a valid baseline test prior to the start of the competitive season. A review of their history as described in ImPACT® revealed no participants reported modifiers for head injury, including previous history of SRCs, reported treatment for headaches or migraines, reported medications, or treatment for ADD/ADHD.

Protocol and Novel Ocular Screening/Assessment: The licensed athletic trainers used a multi-step process to detect and confirm the likelihood of a sport-related concussion. This process started with inviting student-athletes to participate in a baseline testing session in order to collect pre-injury/healthy state data pertaining to their individual cognitive and neurological health. Collecting baseline data has become a recommendation in the serial assessment of concussion in order to individualize care. If a student-athlete does not suffer a concussion, the data remains dormant. However, if they do sustain a concussion, post-concussion data collected using similar measures can then be compared back to their baseline data in order to make an individualized assessment of their condition. Our baseline testing process included self-report symptoms and neurocognitive indices scores using computerized Immediate Post-Concussion Assessment and Cognitive Test (ImPACT®), King-Devick Test (KD) times and errors, and the Balance Error Scoring system (BESS) scores. Table 6 includes a description of these outcome measures.

Table 6: Description of Baseline and Post-Concussion Testing Tools

Test	Description
ImPACT®	ImPACT® is a computerized test designed to provide objective information regarding a patient's cognitive function. The program tests patients on visual and verbal memory, visual motor speed, reaction time, and impulse control. ImPACT® allows for baseline testing to be done before an athletic season, then the patient will take the test again after suspicion of a SRC and the provider will compare the 2 test results. ImPACT® is used by over 90% of NCAA schools, and is considered the cornerstone of SRC assessment.[36] within the first 72 hours of a suspected SRC, ImPACT® has been proven to be 62.5- 83% sensitive to a SRC.[12]
Balance Error Scoring System (BESS)	The BESS is a test commonly used to assess static balance changes that may occur related to a head injury.[37] This test requires the athlete to perform 3 stances lasting 20 seconds each with their eyes closed: the double leg stance (feet together), single leg stance (standing on their non dominant foot), and tandem gait stance (non dominant foot behind dominate foot). A maximum of 10 errors can be made in each stance.[30] The athlete will then complete the same 3 tests on an unstable surface, such as a foam pad. Errors include: hands lifted off the iliac crest, eye opening, a step, stumble or fall, hip abduction greater than 30 degrees, lifting forefoot or heel, or out of testing position for more than 5 seconds. The number of errors is then recorded and used as a

	baseline. After sustaining a head injury the test is repeated. A greater number of errors could be associated with a SRC, as SRCs affect our postural stability.
King-Devick Test	The KD test is a simple sideline test that was designed with parents and coaches in mind.[38-40] The KD test is a screening of the visual system and is based on the measurement of the speed of rapid number naming. To perform this test, the student-athlete reads the numbers on three separate cards, which increase in difficulty, as fast as they can without making any errors. The student-athlete is timed during this exercise, and the results are compared to baseline. An increase in time and/or errors could be the results of a SRC. The ability to perform these tasks requires the coordination of multiple cortical and subcortical pathways of the brain, which are sometimes impaired after a SRC.[30] The KD test was designed to be delivered in less than 2 minutes, making it a desired sideline test.

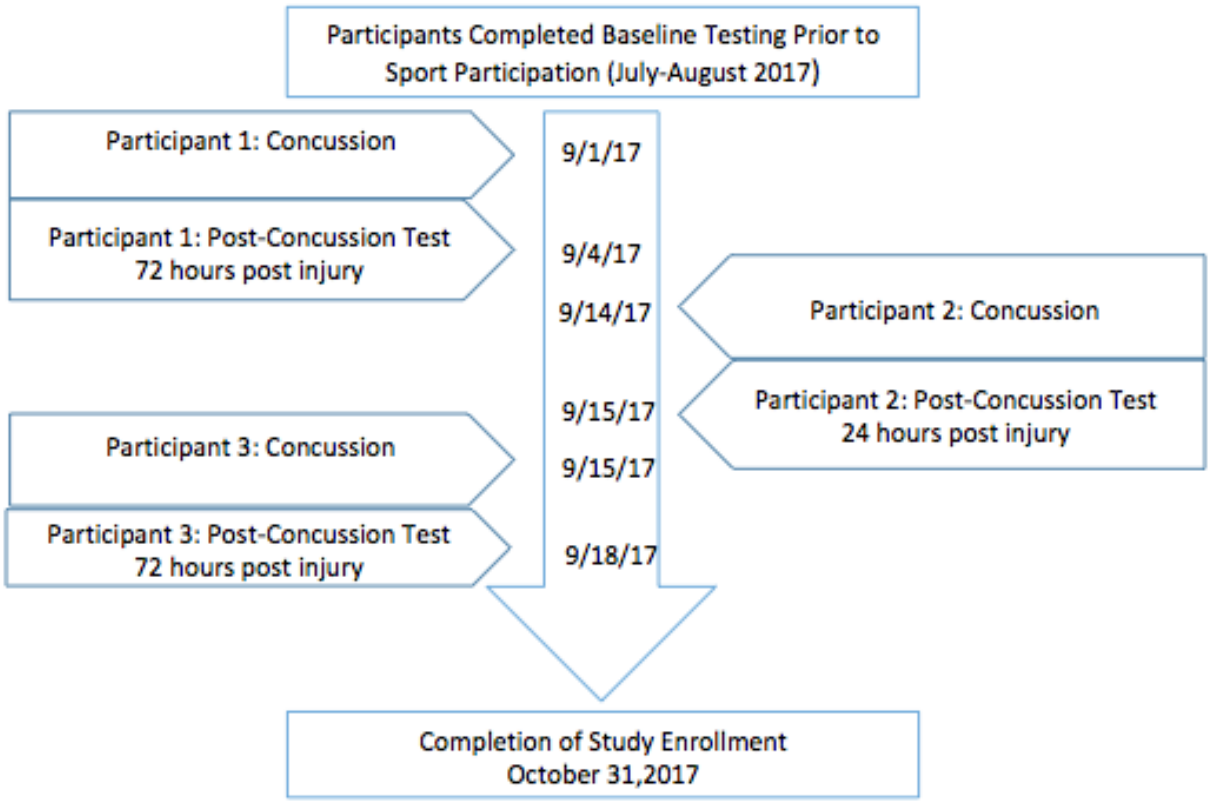
Secondly, if a student-athlete sustained a head injury, the licensed athletic trainer immediately removed the student-athlete from participation and completed an evaluation. A concussion was suspected if the adolescent suffered an observable mechanism of trauma and positive findings in any one or multiple areas of the standard evaluation. If the provider determined the student-athlete met the criteria for suspicion of a SRC as per their standard evaluation strategy, their continued evaluation included the ROST. If a SRC was suspected following standard evaluation strategy and/or administration of the ROST, the student-athlete was removed from activity and placed in a safe environment. Parents and the student-athlete were provided information regarding the suspected diagnosis and appropriate care guidelines. Parents and student-athletes were also informed of a follow-up appointment within 72 hours following the injury.

Finally, participants who were withheld from participation completed a follow-up evaluation with their athletic trainer within 72 hours after the initial injury. Again, this is common practice in the serial assessment of concussion as functional impairments may take several days to fully present and confirm the diagnosis of a concussion. The process is typically used to confirm the diagnosis of a sport-related concussion rather than any one single test. The tests completed during this assessment were similar to the baseline testing session (computerized Immediate Post-Concussion Assessment and Cognitive

Test (ImPACT®), King-Devick Test (KD) times and errors, and the Balance Error Scoring system (BESS) scores). A sport-related concussion was confirmed if any of the criteria, either individually or in combination, was met: (1) an increase in the number of symptoms or increase in symptom severity score as compared to the baseline report, (2) a reliable change indices (RCI) in one of the four neurocognitive indices in ImPACT® (verbal memory, visual memory, visual motor speed, reaction time), (3) increased time and/or errors on the KD test as compared to their baseline, or (4) a increase in their BESS composite score as compared to baseline.

Figure 1 includes a clinical timeline for each of the student-athletes completing the process.

Figure 1: Clinical Timeline for Student-Athletes Completing Testing



Differential Diagnosis: Although a majority of traumatic brain injury in athletics results in a concussion, differential diagnosis included subdural hematoma, epidural hematoma, skull fracture. If a student-athlete demonstrated any of the following "red flags" after suffering trauma to the head, they were immediately referred to an emergency room for further evaluation and testing: neck pain or tenderness, double vision, weakness or tingling/burning in the arms or legs, severe or increasing headache, seizure or convulsion, loss of consciousness, deteriorating conscious state, vomiting, and/or increasingly restless, agitated or combative.[3]

Clinical Findings at Time of Injury and 24-72 hours Post-Injury: Three participants who met our inclusion criteria were reviewed in this case study (2 males, 1 female). A summary of their findings through the serial assessment are included in Table 7.

At the time of injury: All 3 athletes received a remarkable traumatic injury to the head and were further evaluated by the attending licensed athletic trainers according to their standard evaluation. On the sideline, each presented with symptoms, disorientation and impairments on the cognitive screening. The ROST demonstrated positive findings in number of symptoms, symptom severity and an increase in symptoms during horizontal saccades for all participants. All 3 participants reported headache and dizziness as the primary symptoms. Two participants demonstrated increased symptoms during vertical saccades and 1 participant demonstrated impairment with smooth pursuit. Two out of 3 individuals had at least 1 near point convergence measure greater than 5 centimeters; however, when looking at the average of the 3 measurements only 1 person had a mean

over 5 centimeters. None of the participants showed impairments with pupillary reflex, vertical eye tracking, vertical nystagmus or nystagmus with maximum deviation.

Intervention at time of injury: Athletic trainers withheld all 3 participants from further activity due to suspected sport-related concussion. After removal, student-athletes dressed to go home and both the student-athlete and their parents/guardians were provided instructions on the usual care strategy of rest and scheduled for post-SRC assessments within the next 72 hours. All 3 participants completed a follow-up post-SRC test within 72 hours post-injury as requested to confirm the presence of a SRC.

Post-concussion test results in 24-72 hour window: This testing window is clinically valuable for several reasons. First, this timeframe helps to confirm the diagnosis of the injury itself. Any change from baseline findings can verify the functional presence of a sport-related concussion (i.e. increase in number of symptoms, increase in symptom severity, a reliable change indices in cognition, slower times/more errors for the KD, and a higher score on the BESS composite). Secondly, the pathophysiology of a sport-related concussion often progresses over the course of several days before healing begins. Therefore, an individual may not present will a full set of impairments until this time point. Quantifying their impairments at this time helps to determine severity. Finally, impairments identified at this time may inform the treatment plan, i.e. accommodations for school, work and activities of daily living. For the purpose of our case report, we were interested in examining the post-concussion results at this time frame to help establish the existence of a sport-related concussion, and therefore determine the additive value of the ocular assessment (ROST) to the standard sideline evaluation.

Two participants presented for post-concussion testing at 72 hours, and 1 student presented at 24 hours. Each participant presented with at least 1 domain of impairment (out of 8 domains documented) indicating the presence or confirmation of a sport-related concussion in each of the participants. In each of these 3 participants, at least 1 ocular movement area was disrupted at the time of injury. We noted 2 additional observations across the serial assessment process. First, the 2 students presenting at 72 hours had a marked decrease in the number of impairments as compared to the participant who presented at 24 hours. Secondly, the student presenting with the highest number of symptoms and symptoms severity at the time of injury, as well as increased symptoms with both vertical and horizontal saccades, also recorded the most impairments at the time of post-concussion testing in the symptomatic window.

Table 7: Positive Findings During Serial Assessment of Sport-Related Concussion			
Measure	**CASE 1 (72 hrs. post)**	**CASE 2 (24 hrs post)**	**CASE 3 (72 hrs. post)**
Sideline - Standard			
SCAT5 Symptom Checklist	X	X	X
SCAT5 Orientation (Maddock's)	X	X	X
SCAT5 Cognitive Screening	X	X	X
Cranial nerve assessment	X		X
Sideline - ROST			
# Symptoms (0-22)	2	17	14
Symptom Score (0-132)	3	46	32
Pupillary Reflex			
Vertical Eye Tracking			
Vertical Nystagmus			
Lack of Smooth Pursuit			Abnormal to the right
Nystagmus at Maximum Deviation			
Horizontal Saccades	Increase Sx	Increase Sx	Increase Sx
Vertical Saccades		Increase Sx	Increase Sx
Near Point Convergence			Abnormal
≤ 72 hrs. Post-Concussion Test			
# Symptoms (0-22)	0	11	0
Symptom Score (0-132)	0	26	0
RCI – Verbal Memory		RCI	
RCI – Visual Memory		RCI	
RCI – Visual Motor Speed		RCI	
RCI – Reaction Time			
BESS	+4 errors	+6 errors	
KD Test		4.37 sec. slower	3.09 sec. slower

*Only positive findings are reported in this table.

DISCUSSION

It is considered best practice to use multiple means of evaluation for a sideline sport-related concussion assessment. Common tools used in the evaluation of a suspected concussion include self-report symptom inventories, cognition and balance. In recent years, multiple studies have suggested the use of some sort of ocular assessment in addition to these common tools to further aid in the diagnosis of a SRC.[7,17,18,26,32,33] Currently, if a provider would like to add an ocular screening to their sideline assessment, two choices exist: assessing horizontal and smooth pursuits as per the SCAT5© and the King-Devick Test to measure saccadic rhythm. The primary limitation of these two tools is the lack of ability to assess a wider range of ocular function in one protocol. The purpose of this study, therefore was to develop, implement, and determine the general effectiveness of a novel battery of ocular tests referred to as the *Rapid Ocular Screening Test (ROST)* that can be performed efficiently on the sideline and is based on our current understanding of the physiological effects of blunt head trauma on ocular functioning. A sideline test including multiple ocular assessment techniques had not been developed before this study.

On the sideline of an athletic event (practice or competition), a healthcare provider evaluating a child suspected of a head injury is simply trying to determine if a concussion exists or not, and if a concussion is present, remove the child from participation. This logic may sound straightforward; however, convincing a participant, coach or parent that enough evidence exists to detect a concussion is sometimes challenging, especially if findings are minimal (i.e. a mild headache). Although symptoms are key in determining the presence of concussion, symptoms do not always

present within the first 10 minutes and sometimes student-athletes are not always honest in reporting symptoms. Additional objective testing can increase the likelihood of detecting a sport-related concussion early in the pathophysiological cascade and therefore strengthening the decision to withhold a young participant.

After analyzing the data, the results of this study suggest that symptomology is still the best way to identify concussed individuals. Our results showed that 100% (3/3) of participants described symptoms of dizziness and headache following a blow to the head during the initial evaluation within the first 15 minutes. Two of the 3 participants also demonstrated impairments in orientation and cognition. Results from this study also hint that minor ocular changes may be identified by measuring smooth pursuit, report of symptoms following horizontal saccades, report of symptoms using vertical saccades and measuring near point convergence (NPC). Our findings support research by Ventura, Mucha and McDevitt that adding NPC may aid in the diagnosis of a SRC.[7,17,18] Pupillary reflex, vertical eye tracking, vertical nystagmus, and nystagmus at maximum deviation as part of the ROST did not prove to be valuable in recognizing subtle oculomotor changes after a suspected head injury. None of the participants presented with ocular impairments alone, therefore using the ocular assessment without other tests would not be advisable.

Healthcare providers who assess student-athletes following blunt head trauma during an athletic event have a responsibility to keep student-athletes safe from further harm; however, they also do not want to keep a student-athlete out of participation if no injury exists. Being able to assess a sport-related concussion within the first 15-30 minutes, without the benefit of a biomarker, can be very challenging. The findings of this study demonstrate the addition of an ocular screening may improve a clinician's ability to

accurately determine if a SRC exists when assessing an injured player on the sideline in order to make a better decision on behalf of the safety and well being of the participant.

Two other observations were noted secondarily as part of this study. First, it is clear that head injuries and sport-related concussion are occurring in an adolescent athletic environment, not only as supported by national epidemiological statistics, but as demonstrated in the timeframe of this study. During the period of this study (approximately 4 months), 32 participants received a follow-up post-concussion visit by 1 of our participating athletic trainers; however, only 3 of the student-athletes were evaluated on the sideline by an athletic trainer. The remaining 29 student-athletes did not have access to a qualified medical provider on the sideline of their athletic event to evaluate the injury, leaving the evaluation and decision to remove or continue participation up to a coach or parent. Secondly, all 3 student-athletes who were evaluated on the sideline by a licensed athletic trainer, determined to have a concussion, removed from participation and followed a plan of usual care, showed marked improvement in the 24-72 hour window of post-concussion testing. Although this sample was small, this study is consistent with the importance of early reporting, removal and consistent care in order to limit long-term effects of the head injury.

A major limitation of this study was the number of participants that met the inclusion criteria. We accurately predicted the number of concussions that might occur within the study timeframe (32); however, only 3 participants had access to an athletic trainer to complete the sideline evaluation. A larger number of participants would be needed to better determine the efficacy of the *Rapid Ocular Screening Test (ROST).* The ROST attempted to include a variety of ocular assessments and was designed to be

delivered with minimal equipment by a trained clinician. Although the sample size was small, it shows promise that these techniques can be completed efficiently and accurately.

After completion of this study, there are a few changes we would make in regards to the ROST. First, we would change the terminology surrounding smooth pursuit. Removing “lack of smooth pursuit” would make the test easier to understand and interpret. In the symptom evaluation portion of the test, we would remove the symptom “trouble falling asleep” as it is not appropriate for a sideline assessment. Lastly, we would explain the measurements for NPC better, stating that the 3 scores should be averaged for better accuracy.

CONCLUSION

Sport-related concussions occurring in an adolescent athletic population can be challenging for a provider to recognize within the first 15-20 minutes, especially in the dynamic environment of a sideline. Until clinicians can use “biomarkers” to diagnosis a sport-related concussion, a multimodal approach should be utilized. Our findings suggest the addition symptom evaluation with saccades and near point convergence (NPC) may aid in the recognition of a sport-related concussion during a sideline assessment. Our findings also reiterate the importance of a thorough symptom examination.

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APPENDIX A

Office of Research Assurance
and Sponsored Programs

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Dianne.Nagy@sdstate.edu

To: Payton Monson, Department of Health & Nutritional Sciences

Date: July 25, 2017

Project Title: Pilot Study: Does the Addition of an Ocular Screening to a Standard Sideline Assessment Aid in the Detection of a Concussion in High School Athletes?

Approval #: IRB-1707010-EXP

The committee approved your project using expedited procedures as described in 45 CFR 46.110. The activity was deemed to be no greater than minimal risk, and the following expedited categories from 63 FR 60364-60367 were found to be applicable to your activity:

(5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for nonresearch purposes (such as medical treatment or diagnosis).

One-year approval of your project will be dated starting 8/01/17. If you require additional time to complete your project, please submit a request for extension before 7/31/18. Protocol changes must be approved by the Committee prior to implementation. Forms may be found on the Human Subjects web page. If there are any unanticipated problems involving risks to subjects or others, please contact the SDSU Research Compliance Coordinator. Please inform the committee when your project is complete.

If I can be of any further assistance, don't hesitate to let me know.

Sincerely,

Dianne Nagy
Acting IRB Coordinator

APPENDIX B

Rapid Ocular Screening Test
Scoring Sheet

1. Pupillary Reflex and Nystagamus

Directions: Assess the patient's ***pupil size,*** if pupils are unequal (response is no above) refer to ER immediately.

Test the patient's ***vertical eye tracking*** by having them follow your finger looking up, then down.

Check for ***vertical nystagmus*** by having the patient follow your finger to maximal superior eye position. Hold this position for 5 seconds then look for nystagmus. Repeat this procedure for maximal inferior eye position.

	Yes	No
Equal Pupils		
Vertical Eye Tracking		
Vertical Nystagmus		

2. Smooth Pursuit and Nystagmus

Directions: Asses smooth pursuit by having the patient follow your finger to the patients left side. Repeat towards the right Next assess nystagmus by having the patient follow your finger to their left. Hold for 5 seconds at maximal eye abduction and look for nystagmus Repeat towards the right.

Lack of Smooth Pursuit	Left (Yes/No)	Right (Yes/No)
Nystagmus at maximum deviation	Left (Yes/No)	Right (Yes/No)

3. Self-Report Symptoms Score:

Directions: Ask the patient symptoms questions above on how they feel right now. After completing all symptom questions, add up how many symptoms had a score of more than 0 (Maximum of 22). Then add the total score of all symptoms (Maximum of 132)

Total Number of Symptom: _____/22
Symptom Severity Score: ____ /132

Headache	0	1	2	3	4	5	6
Pressure in head	0	1	2	3	4	5	6
Neck pain	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like in a fog	0	1	2	3	4	5	6
Don't feel right	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or anxious	0	1	2	3	4	5	6

4. Modified VOMS

Directions: Fill in the baseline symptoms of headache, dizziness, nausea, and fogginess reported from the symptom check list above in the table below.

Horizontal saccades: stand approximately 3 feet in front of the patient. Hold your index fingers about shoulder width apart and ask the patient to move his or her eyes between your fingertips 10 times without moving their head. After this is complete, ask the patient about symptoms listed above(Headache, Dizziness, Nausea, Fogginess) on a 0-6 scale (0= no symptoms, 6=severe symptoms).

Vertical saccades: Complete vertical saccades similar to horizontal saccades except with the examiners fingers positioned vertically approximately 1.5 feet above and below the midline of the patient. After the test the patient will again rate symptoms 0-6.

Near point convergence: Having the patient follow your finger towards his or her nose. Instruct the patient to say "stop" once her or she reports seeing double of your finger. Hold this position, and then use a centimeter ruler to measure from the tip of the patient's nose to where your finger is stopped. Repeat this test 3 times.

Symptoms on a 0-6 point scale

Vestibular/ Oculomotor	**Headache**	**Dizziness**	**Nausea**	**Fogginess**	**Comments**
Baseline symptoms					
Saccades (Horizontal)					
Saccades (Vertical)					
Near Point Convergence **(Centimeters)**					**Measure 1____** **Measure 2____** **Measure 3____**

(Pre test scores are obtained from the symptom evaluation above.)
(Scores ≥6cm for NPC are considered abnormal)
(Any score increase of 2 or more from pre test is considered abnormal)