# CHARACTERISTICS OF EYE-TRACKING METRICS OBTAINED USING A PORTABLE DEVICE FOR ASSESSING RETURN TO DUTY CLEARANCE AFTER CONCUSSION


Kenneth L. Cameron, PhD, MPH, ATC, FNATA

Director of Orthopaedic and Sports Medicine Research

John A. Feagin Jr. Sports Medicine Fellowship

Keller Army Hospital

United States Military Academy

West Point, New York

# CO-AUTHORS & COLLABORATORS


**Jess Yeager[1], Michael J. Aderman[2], Steven R. Malvasi[2], Katelyn M Ward-Kantanas[2], Sadie Buboltz-Dubs[3], Darryl J. Mayeux[1], Christina L. Master[4]**

[1]Oculogica, Inc., New Richmond, WI.

[2]John A. Feagin Sports Medicine Fellowship, Keller Army Hospital, United States Military Academy, West Point, NY.

[3]University of Wisconsin - Green Bay, Green-Bay, WI.

[4]Children's Hospital of Philadelphia Center for Injury Research and Prevention/University of Pennsylvania Perelman School of Medicine, Philadelphia, PA.

# DISCLOSURE

**The views expressed herein are those of the author(s) and do not necessarily reflect the official policy of the Department of the Army, Defense Health Agency, Department of War, or the US Government**

# DISCLOSURE

Neither I, Kenneth Cameron, nor any family member(s) have any relevant financial relationships to be discussed, directly or indirectly, referred to, or illustrated with or without recognition within this presentation.

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# BACKGROUND

# BACKGROUND

- **Determining when an individual is concussed or cleared for unrestricted return to activity after concussion is a critical decision, heavily dependent on self-reported symptoms**
- **Under-reporting of concussion symptoms is common in collegiate athletics and military settings, with studies indicating rates of up to 50% within these groups**
- **Objective eye-tracking metrics have been demonstrated to distinguish concussed from healthy individuals**

Bookbinder HA, 2020; Escolas SM, 2020; Beidler E, 2021; Meehan WP, 2013; Kerr ZY, 2016; Master CL, 2016, 2025

# PURPOSE

To evaluate the sensitivity and specificity of a novel eye-tracking device within 72 hours of concussion, at the initiation of a graded return to activity protocol (GRTA), and at the time of unrestricted return to activity/duty (URTA) clearance in military service academy cadets

# METHODS

CASES

UNINJURED


# METHODS

- **Participants**
  - Cadets entering the United States Military Academy in 2022-2024
- **Baseline Assessments**
- **Follow-up Assessments**
  - Within 72 hours of injury, initiation of a GRTA protocol, and at clearance for unrestricted return to activity/duty
  - Symptom severity (SCAT 6)
  - Eye tracking assessment

# METHODS

- **Eye Tracking Assessment**
  - 167 FPS infrared eye-tracking camera
  - Eye movement metrics included measures of saccadic, pursuit, pupillary function
  - Collected while participants viewed a 90-second video
  - Generates a composite score

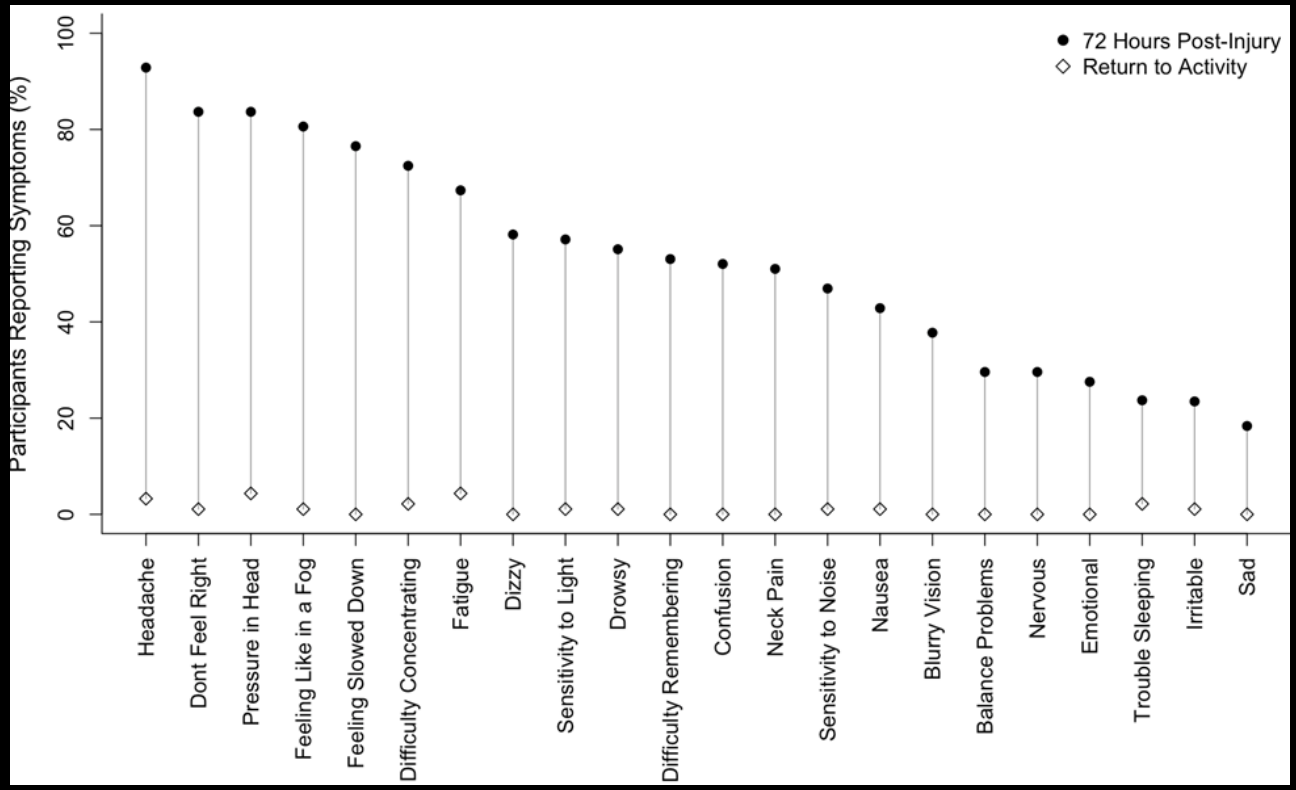
- **Data Analysis**
  - Prospective cohort divided into model development and validation sets
  - 98 concussed participants
  - 998 uninjured control participants

# RESULTS

- **Observed 98 concussions during follow-up**
  - Age: 19.5 ±1.2 (Range 18-23)
  - Sex: 63 Male (64%), 35 Female (36%)
- **Median follow-up time**
  - Injury to initial assessment: 1d (IQR 1-2d)
  - Initial to initiation of GRTA protocol: 8d (IQR 5-13d)
  - Initiation of GRTA protocol to URTA/D: 8d (IQR 6-15d)
  - Initial to URTA/D: 17d (IQR 12-26d)

# RESULTS

- **SCAT Symptom Severity Score**
  - With 72 hours: 27.5 ±16.6
  - Initiation of GRTA protocol: 2.7 ±3.4
  - URTA: 0.3 ±1.3
- **SCAT Symptom Number**
  - With 72 hours: 11.6 ±4.7
  - Initiation of GRTA protocol: 2.1 ±2.6
  - URTA: 0.2 ±0.7

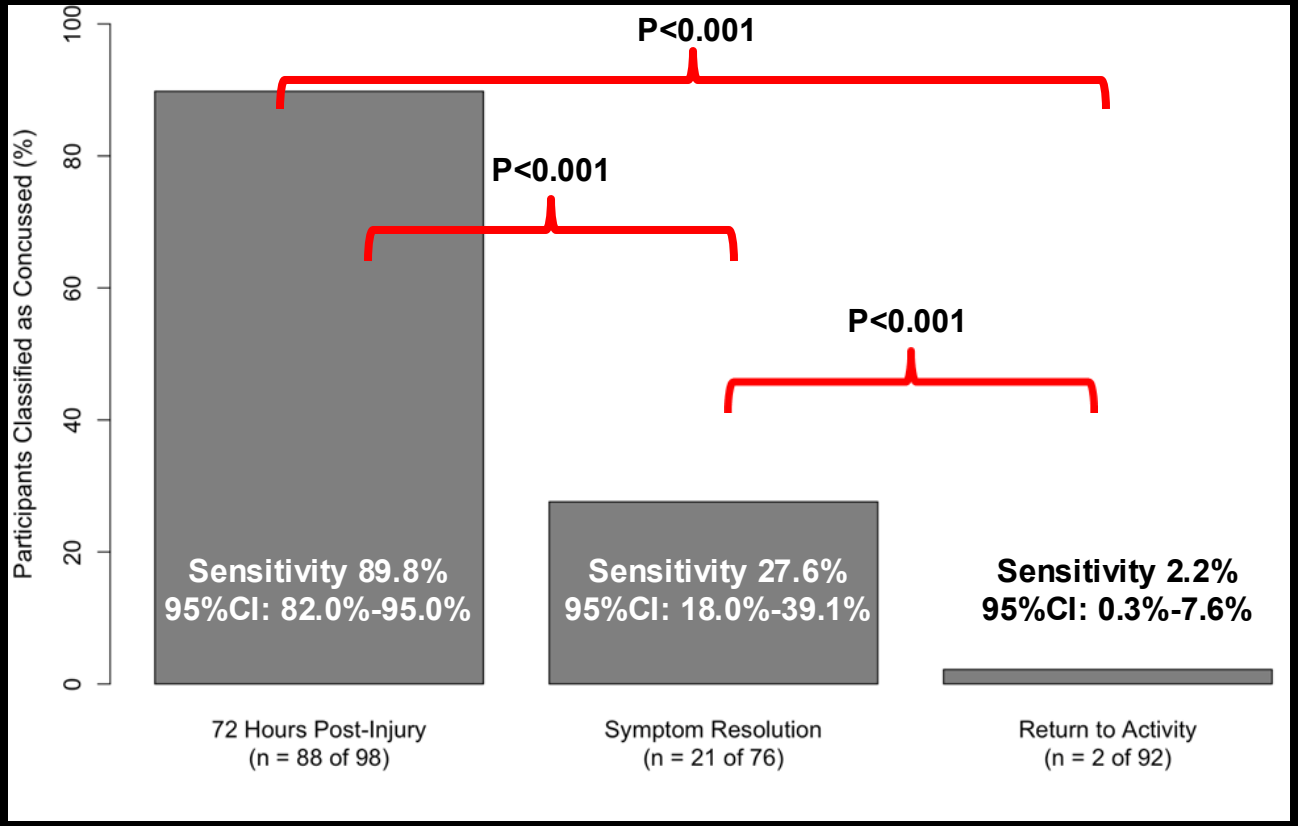


# RESULTS

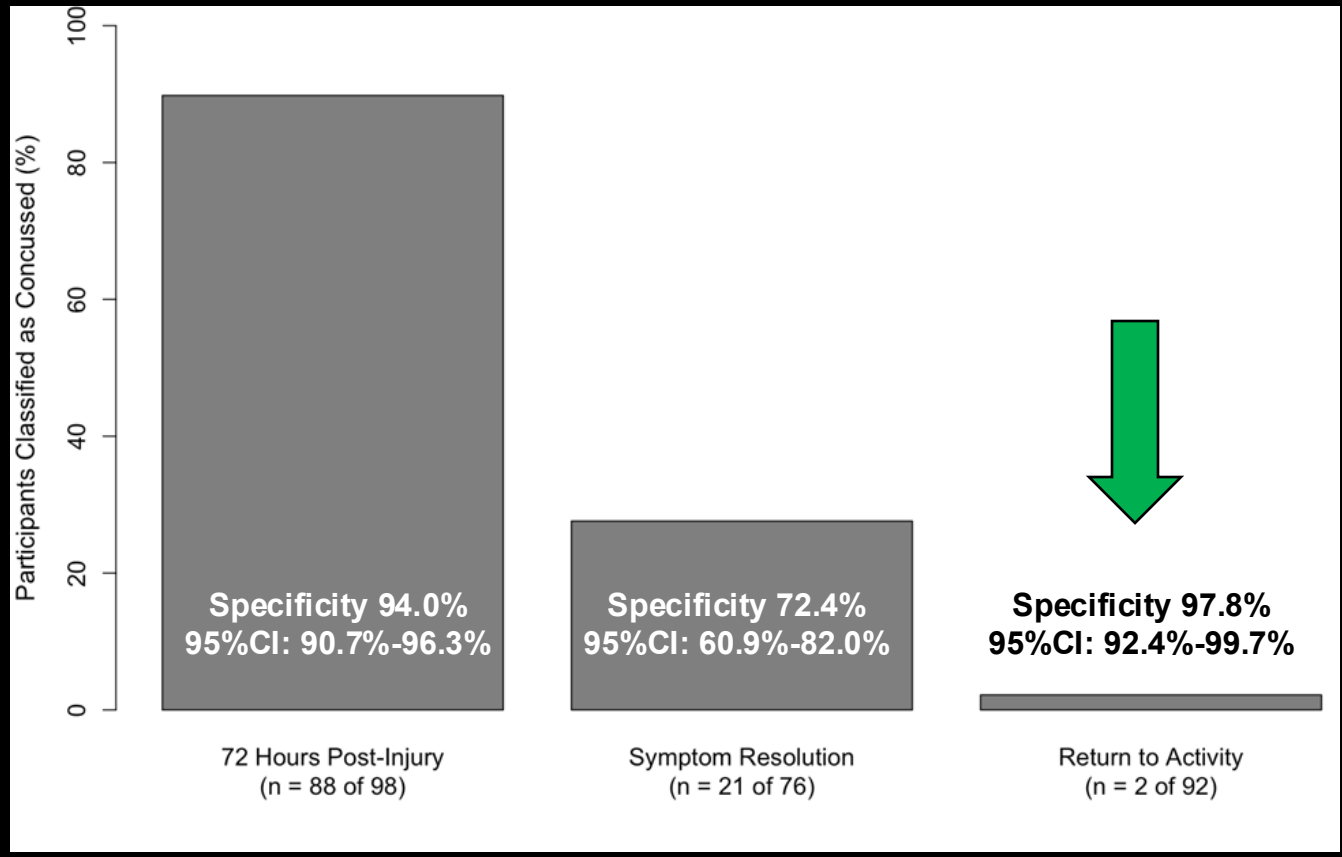
- **Composite Eye Tracking (SNAP) Score**
  - With 72 hours: 6.2 ±3.0
  - Initiation of GRTA protocol: 4.6 ±2.6
  - URTA: 5.0 ±3.0

| Eye Metric Description | AUC | Sensitivity | Specificity |
|---|---|---|---|
| The minimum variance of travel distances between frames of all segments | 63% | 70% | 53% |
| Median of saccade speed | 62% | 56% | 63% |
| The variance of travel distances between frames along the left segment | 61% | 50% | 70% |
| Mean of distance traveled along the actual path of all saccades (not straight-line distance) | 61% | 68% | 50% |
| The average duration (ms) of pupil dilation events | 60% | 51% | 69% |
| Mean of the saccade peak velocities | 60% | 49% | 70% |
| Median of horizontal travel distance of all saccades | 60% | 57% | 62% |
| Mean of vertical travel distances of all saccades | 60% | 67% | 50% |
| The total distance traveled by the eye movements | 59% | 35% | 82% |
| Variance of the amplitude of microsaccades in degrees of visual angle | 59% | 41% | 76% |
| The sum of the magnitudes of the ten frequency bands between 6 and 83 fps for Y | 59% | 21% | 92% |
| The maximum variance of travel distances between frames of all segments | 59% | 41% | 75% |
| Pct05 of the distance between saccade endpoint and the following fixation | 58% | 37% | 81% |
| The variance of the average Y position along the bottom side of the visual path recording | 55% | 42% | 72% |

# RESULTS


P<0.001
P<0.001
P<0.001
Participants Classified as Concussed (%)
0
20
40
60
80
100
Sensitivity 89.8%
95%CI: 82.0%-95.0%
Sensitivity 27.6%
95%CI: 18.0%-39.1%
Sensitivity 2.2%
95%CI: 0.3%-7.6%
72 Hours Post-Injury
(n = 88 of 98)
Symptom Resolution
(n = 21 of 76)
Return to Activity
(n = 2 of 92)

# RESULTS


Participants Classified as Concussed (%)
0
20
40
60
80
100
Specificity 94.0%
95%CI: 90.7%-96.3%
Specificity 72.4%
95%CI: 60.9%-82.0%
Specificity 97.8%
95%CI: 92.4%-99.7%
72 Hours Post-Injury
(n = 88 of 98)
Symptom Resolution
(n = 21 of 76)
Return to Activity
(n = 2 of 92)

# DISCUSSION

Forbes

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**“The device carries an FDA indication as an aid to diagnosis, not a standalone diagnostic, and is optimally deployed as an adjunct to structured clinical assessment.”**

# DISCUSSION

- Implications for clinical care
- Symptom burden is still driving most of the predictive model with objective eye tracking providing additional supportive data to determine injury and recovery
- Results may not be applicable to children and adolescents or older adults

# CONCLUSIONS

- A portable eye-tracking device, in combination with self-reported symptoms, provides objective data that is highly sensitive and specific to concussion injury
- The device may also have utility in monitoring recovery and making unrestricted return to activity and duty decisions
- Additional research is needed to optimize decision support at the initiation of the GRTA protocol and the time of URTA or Duty clearance
- Validation in heterogeneous populations is also needed

# THANK YOU