Oculomotor, Vestibular and Reaction Time Outcomes in IndyCar Drivers compared to University Athletes at start of season and after an mTBI event

Terry R. Trammell, M.D.1; Stephen E. Olvey, M.D.2; Geoffrey L. Billows, M.D.3; Mikhail Y. Szczupak, M.D.2
Michael E. Hoffer, M.D.2; Dr. Naomi Deakin4; James Buskirk, M.S.2; Carey Balaban, PhD3; Alex Kiderman, PhD6
1Trammell Consulting LLC; 2University of Miami, Miller School of Medicine; 3Indianapolis Motor Speedway, INDYCAR Series; 4University of Cambridge, UK; 5University of Pittsburgh, Pittsburgh, PA; 6Neuro Kinetics, Inc., Pittsburgh, PA

BACKGROUND

Previous studies demonstrate that mTBI patients present a diverse profile of Oculomotor, Vestibular, and Reaction Time (OVRT) deficits and that measures of these deficits can identify non-mTBI groups with over 90% sensitivity and specificity in multi-variable categorization models[1]. OVRT assessments can be achieved using a multi-modal test battery completed with a portable, head-mounted video-nystagmography (VNG) system[2, 3, 4].

The incidence of concussion has dropped significantly in IndyCar; 42 drivers sustained concussions between 1996 – 2005 (4.6 concussions/year) versus 5 drivers with concussions between 2006 – 2012 (0.83 concussions/year). During this time INDYCAR cockpit safety innovations have included: improved energy management “head surround”; mandatory use of frontal head restraint (Head and Neck Support, HANS); installation of the SAFER Barrier at all INDYCAR oval track race venues and helmet advances.

METHODS

An eight minute OVRT test battery was administered using a head mounted display with two integrated, high-speed 100 Hz infrared eye-tracking cameras, (I-PASON™ Neuro Kinetics Inc., Fig.1), operating VEST™ and I-Portal® software (Neuro Kinetics Inc.) for test administration and analysis. See Table 1.

Study sites
- IndyCar drivers (ID): INDYCAR – LLC, Indianapolis 2017/2018
- University Athletes (UA): University of Miami, Miller School of Medicine, Miami, FL
- University of Pittsburgh, Pittsburgh, PA; University of Cambridge, UK

Statistical Analysis

All variables were assessed for normality of distribution using SPSS Version 21 (IBM); descriptive statistics and results were reported based on raw, as collected, measurements (variables). A general linear model was created, running multivariate regression analyses.

Data collection I-PASON™ capability

Eye tracking:
- Horizontal/vertical/torsional eye position, pupil area
- Sampling rate: 100 frames per second (100 Hz)
- Spatial resolution: <0.01 degrees
- Range: ±30 degrees horizontal, ±20 degrees vertical, ±10 degrees torsional

Stimulus Presentation:
- Field of View (degrees): 60° diagonal
- Display Resolution: 1920 x 1080
- 3-D display functionality

RESULTS

Pre-season OVRT assessment

A total of 202 participants were tested; n = 158 University athletes and n = 44 IndyCar drivers. Baseline (pre-season) OVRT results are summarized in Table 2. There were no differences found in smooth pursuit (horizontal and vertical), subjective visual vertical, predictive saccade, and auditory reaction time between the two groups (UA, ID).

The UA and ID athletes performed differently on:
- Optokinetic test at 60 degrees/second
  - Gain substantially lower (ID vs UA, p<0.001, Fig. 6)
  - Gain asymmetry higher (ID vs UA, p<0.001)
- Velocity (fast) slower (ID vs UA, p<0.001, Fig.7)
- Anti-saccade:
  - Pro-saccade error less (UA vs ID, p<0.001)
  - Saccade and Reaction time:
    - Accuracy (final) higher (UA vs ID, p=0.002, Fig.8)
    - Latency 20% faster (ID vs UA, p<0.001, Fig.9)

Table 2: baseline/pre-season OVRT assessments in ID vs UA

RESULTS – cont.

Case 1 – previous concussion

43 Y.O. male ID with history of mTBI event

OVRT assessment results:
- Leftward gain = 0.35; Rightward gain = 0.58
  (5th percentile of controls = 0.78)
- % saccadic intrusion = 54.5%
  (5th percentile of controls = 0.45)

Case 2 – accident with normalized SCAT

42 Y.O. male ID, impact suspicious for mTBI. The patient was tested within 24 hours of the accident, at which time all self-report symptoms had resolved. He passed the Sports Concussion Assessment Tool (SCAT) and Balance Error Scoring System (BESS).

OVRT assessment results:
- Abnormal SVV response

Case 3 – serial testing post-concussion

25 Y.O. male, motorsport accident 1 week prior to Session 1 test. Session 2 repeated 1 month later, prior to competition. Based on clinical findings and OVRT assessment, not cleared to drive.

CONCLUSIONS

> For sever of the OVRT tests, IndyCar drivers performed similarly to University Athletes and neither group differed significantly from historical controls.
> For three OVRT tests, comparison of IndyCar Drivers to University Athletes revealed statistical differences:
  - Optokinetic responses (OKN): IndyCar drivers appear to be able to suppress optokinetic responses during VR-based tests.
  - Anti-saccade task errors: both groups are within normal limits.
  - Saccade and Reaction Time: IndyCar drivers have a shorter button press reaction time and lower saccadic accuracy; likely a speed-accuracy trade-off.

> These results suggest that separate norms are needed for some tests in certain professional sports.
> The three mTBI cases indicate changes in OVRT assessments after motorsport accidents in the acute and chronic stages. This requires further investigation.

REFERENCES

2. Hoffer M. et al., The use of saccadometer, vestibular and reaction time test to assess mild traumatic brain injury (mTBI) over time, Published: 12 April 2017, Laryngoscope Investigative Otorhinolaryngology

DISCLOSURE

Dr. Terry R. Trammell is a Contractor/Consultant to INDYCAR LLC; Alexander Kiderman is Chief Technology Officer for, and shareholder of, Neuro Kinetics, Inc.