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Changes in pupils after asymptomatic high-acceleration head impacts indicate changes in brain function

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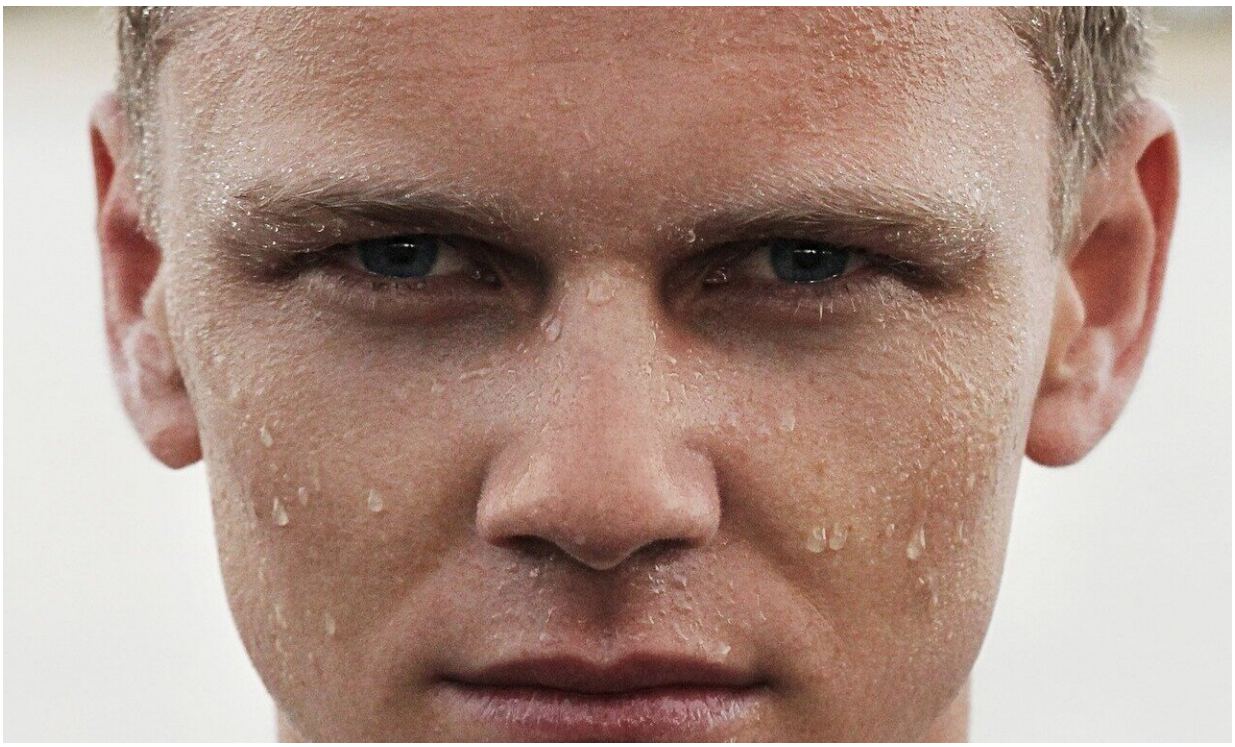

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Researchers from the University of Michigan found significant pupillary changes in high-school football athletes after they had sustained a high-acceleration head impact. The changes were detected using a

noninvasive, hand-held, quantitative pupillometry device, which potentially could be used in a nonclinical setting for a quick assessment of possible brain injury. Detailed findings on this subject are found in the article, "Pupillary changes after clinically asymptomatic high-acceleration head impacts in high school football athletes," by Jacob R. Joseph, M.D., and colleagues, published today in the *Journal of Neurosurgery*.

Background

During American football practices and games, athletes are regularly subjected to head impacts of varying intensities—hits that may or may not produce the clinical signs and symptoms of a concussion.

Previous studies have found associations between high-acceleration head impacts and neuronal and axonal injury, even in the absence of symptoms and diagnosis of concussion. These studies have relied on the results of invasive tests, such as biomarker analysis and advanced neuroimaging, which are expensive, time-consuming, and not always readily available.

The authors of this study looked at the potential of quantitative pupillometry (QP) as an objective, fast, and noninvasive method to assess the neurological effects of high-acceleration head impacts when no symptoms are apparent. QP provides objective, quantifiable data on changes in pupil size and reactivity to light. Such changes can reflect changes in brain function.

Present Study

Thirteen high-school football players completed the entire study. Sensors were placed in these athletes' football helmets to measure and record the

frequency and intensity of head impacts during all practices and games in a football season. Data on all head impacts were collected for each athlete. The focus of this study was on high-acceleration head impact, which was defined as an impact that simultaneously exceeds 95-gravity linear acceleration and 3760-radian/second^2 rotational acceleration.

QP was performed to measure each athlete's pupil size and reactivity to light (in all, eight parameters of the pupil) at various time points throughout the playing season and to compare these measurements with normative data. The authors state that testing only took two minutes per session, and in each instance the ambient lighting was similar. Testing was performed 1) before the playing season began; 2) at the middle of the season, following a game; 3) after the season had ended; and 4) in athletes who sustained a high-acceleration head impact, following the practice session or game in which the impact occurred.

At the time of pupillometry testing, the athletes also underwent neurocognitive testing to determine whether the impacts produced concussive injuries. This was performed using the Sport Concussion Assessment Tool, 5th Edition. The authors focused on evaluations of symptoms, cognitive screening, balance assessment, and delayed recall.

Seven athletes experienced high-acceleration head impacts without a related concussion diagnosis during the playing season, six of them before the midseason evaluation. In a comparison of QP measurements obtained following high-acceleration head impacts with those obtained at the midseason evaluation (control), the authors found significant decreases in three of the eight QP parameters, specifically pupil dilation velocity, percent change in pupil diameter, and maximum pupil constriction velocity.

In a comparison of QP measurements across the playing season (measurements obtained at the preseason [baseline], midseason, and end-

of-season evaluations), the authors found significant changes in two QP parameters, namely average pupil constriction velocity and maximum pupil constriction velocity.

The authors found no significant changes in neurocognitive test values when they compared values obtained following a high-acceleration head impact with values obtained at the midseason evaluation. They also found no significant changes when they compared neurocognitive test values across the playing season.

The results of this study show that measurable changes in pupillary parameters occurred following asymptomatic (non-concussion-related) high-acceleration head impacts. The authors state these results suggest that "nonconcussive [high-acceleration head impacts] may affect intrinsic brain reflex pathways and may reflect biological injuries that previously were found using more invasive methods" such as biomarker analysis and advanced neuroimaging.

QP may prove to be an inexpensive, rapid, objective, noninvasive method of determining brain injury following sports-related head impacts.

The authors point out that the sample of athletes evaluated in this study is small and the study is preliminary. The authors stress the importance of conducting a larger study to confirm their findings.

When asked about the study, Dr. Joseph said, "In this study, we found more evidence that extremely severe head impacts seem to have an effect on these high school athletes. We had previously found that these severe hits (high-acceleration head impacts) caused increases in traumatic brain injury biomarkers, and now we are seeing changes in the pupil's response to light, all despite the athlete being completely asymptomatic otherwise. This suggests that high-acceleration head

impacts may be the most important aspect of football and other contact sports to reduce in frequency and eventually eliminate from the game."

More information: Joseph JR, Swallow JS, Willsey K, Almeida AA, Lorincz MT, Fraumann RK, Oppenlander ME, Szerlip NJ, Broglio SP. Pupillary changes after clinically asymptomatic high-acceleration head impacts in high school football athletes. *Journal of Neurosurgery*, published online, ahead of print, November 26, 2019; DOI: 10.3171/2019.7.JNS191272

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