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A TEST PANEL TO ASSESS AND DOCUMENT AN ABSENCE OF CONCUSSIVE SIGNS FOR SPORTS-RELATED CONCUSSION

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ABSTRACT

As sports-related concussions gain notoriety, legislation has also increased, placing greater liability on athletic trainers, who are typically the first to assess mild traumatic brain injury (mTBI). This has led to an increase in assessments for documenting an absence of or evidence of an mTBI. Although, their validation and standardization have been called into scrutiny.

The purpose of this report is to develop and validate a neurologic test that provides objective evidence useful for documenting an absence of suspicious injury. In this retrospective cohort study, 26 athletes from the University of Cincinnati who incurred a suspicious concussive impact were evaluated using this assessment battery.

Of the 26 athletes, 7 were found to have a suspicious injury and referred to a specialist for further work-up. All 7 were eventually diagnosed with a concussion. Nineteen were found to have an absence of suspicious injury, none of which developed delayed concussive symptoms.

Key Words: *Concussion, Neurology, Suspicion, Documentation, Traumatic Brain Injury.*

Key Points

1. The Absence of Suspicion Test (AOST) methods are a battery of neurological assessments that may be used by Athletic trainers to evaluate and document an absence of suspicious injury.
2. The data collected from using the AOST may help providers when making decisions to refer an athlete for further neurological testing.
3. The AOST may derive useful data to help guide clinical sports-related concussion management decisions.

Concussions are reported by the American Medical Society for Sports Medicine as a serious health concern among healthcare professionals, athletic organizations, athletes, and the public-at-large.[1] Sports-related concussion (SRC) is generally considered to be a subset of mild traumatic brain injury (mTBI).[2,3] mTBI remains a complicated clinical diagnosis due to highly variable symptom presentation involving multiple neurologic systems. A variety of neurological dysfunctions can be present (i.e., ocular, vestibular, cognitive, sleep, hormone imbalances, etc).[4] The Center for Disease Control and Prevention estimates around 3.8 million TBIs occur in the USA annually.[5]

SRC has been regularly in the popular press with celebrity athletes being allegedly impacted from a history of SRC,[6-8] as well as lawsuits alleging brain injury from SRC.[9–11] The health concerns and litigation has led to increasing concern regarding liability for athletic organizations and the implementation of concussion legislation across all 50 of the United States.[12] Existing concussion legislation generally involves the following areas: (1) concussion education for nonmedical personnel such as coaches, parents/guardians, and athletes; (2) removal from play at the time of suspected injury without eligibility for same-day return-to-play; and (3) evaluation by a healthcare provider trained in TBI to diagnose an mTBI or to clear an athlete to be eligible to continue playing.[13,14]

This paper focuses on the third step, the clinical evaluation after a suspected SRC. We feel that the clinician who is assessing an athlete following a suspected SRC, for example, the day after a pull from play event, needs an objective system that will help direct care if needed and document absence of suspicion of concussive signs.[15] We also believe that such an exam panel should be neurologic based, easy to perform, objective, and quantitative.

We present the methods and data concerning the use of an absence of suspicion test (AOST) that can be used by athletic trainers and similarly trained clinicians to assess after an athlete has presented with a suspected SRC. The test panel can be used to direct the next steps concerning neurologic management as well as document brain health and allowing resumption of sport participation. It is ideally suited to document the absence of suspicion the day after an athlete has been pulled from play with a suspected mTBI as is required by many state and local regulations.

METHODS

This retrospective cohort study was reviewed and approved by the University of Cincinnati Institutional Review Board, study #2013-1534. The care or management was not changed for patients examined in this study. All personal and/or medical information has been removed. Included in this study were 11 female and 15 male division-1 collegiate athletes between the ages of 18 and 22. The athletes were a part of a variety of sports teams including football, women's and men's soccer, women's volleyball, women's basketball, marching band, cheerleading, and dance. We col-lected information on the AOST for 26 consecutive athletes who were referred to the college SRC team. All 26 athletes were referred by athletic trainers for the evaluation of suspected SRC.

The AOST Panel

The individual assessments of the proposed AOST tool included: (1) Near point of convergence,[16] (2) Brock string for accommodation – convergence and suppression,[17–19] (3) Maddox rod for horizontal and vertical phorias,[20] (4) Hart chart for saccadic eye movement,[17–19] (5) Near/far accommodation using Hart charts of different font sizes,[17–19] (6) closed-eye turns, for balance using a modified Rhomberg test,[21] and (7) Pupil response.[22] These methods and additional quantitative data for the individual assessments are described in the cited literature.[16–22] Data for each test was collected on the AOST data collection tool shown in Figure 1.

Statistical Analysis

We evaluated the results through descriptive sta tistics and report them as means, standard deviations, and confidence intervals. Confidence intervals of 95% were chosen as a means by which practitioners could assess if their athletes were within a normal population.

RESULTS

Of the total 26 athletes, 19 athletes (73.1%) were found to have an absence of suspicion concerning SRC and were cleared to return to their sport. Seven athletes (26.9%) were found to have a suspicious

FIG. 1 Data collection tool for AOST.

NAME: _____			DATE: _____	
SIGNATURE FOR CONSENT: _____				
PARENTAL SIGNATURE (if under 18 y.o.): _____				
TESTS:	**RESULTS:**		**TESTER INITIALS:**	**COMMENTS:**
Ocular Motor Assessments				
Reading Saccades - OU Close (sec)	_____ seconds			
Near/Far - OU Dist. (# per min)	_____ in 1 min			
Suppression Assessment				
Brock String (inches)	_____ inch(es)			
Maddox Rod @ 20 feet	Only 1 eye required			
Vertical Phoria	OD: _____	OS: _____		
Horizontal Phoria	OD: _____	OS: _____		
Vestibular Assessment				
Closed Eye Turn	R: _____°	L: _____°		
Other Assessments				
Near Point of Convergence (inches)	_____ inch(es)			
PERRLA w/Consensual Reflex (circle)	OD: Constrict YES / NO Consensual YES / NO	OS: Constrict YES / NO Consensual YES / NO		

TABLE 1 AOST Individual Test Descriptive Statistics

	Average:	STD:	CI, 95% (±):
NPC[a] (cm)	1.26	1.66	0.789
PERRLA w/ consensual reflex[b]	1.00	0.00	-
Reading saccades (seconds)	55.6	16.7	7.51
Near/Far (# called per minute)	30.3	6.80	3.70
Brock string (cm)	-0.660	2.26	0.886
Closed-eye turns - right (°)	360	11.7	4.60
Closed-eye turns - left (°)	358	13.0	5.09
Maddox rod - vert. eye alignment (cm)[c]	0.00	0.00	-
Maddox rod - hor. eye alignment (cm)[c]	-0.103	1.65	0.783
AOST outcome: suspiciond	0.269	0.452	0.174

[a]Near point of convergence. [b]1 = normal reflex, 0 = abnormal reflex. [c]Maddox rod values are measured from the centimeters off normal or "ortho" eye alignment position (parallel to ground), 0 = ortho positioning, + = esophoric alignment, - = exophoric alignment. [d]Statistics of AOST exams resulting in a suspicious injury determined and indicating referral to undergo full neurological assessment; 1= suspicion, 0 = absence of suspicion.

exam resulting in a full neuro assessment. All 26.9% were eventually diagnosed with SRC. None of the 19 athletes who were cleared using the AOST tool were reported to have developed or experienced prolonged concussion-like symptoms.

Table 1 reports the averages, standard deviations, and confidence intervals (95%) of the individual assessments which make up the AOST. Within the AOST, the Near/Far test elicited concerning symptoms 57.1% of the time to indicate a suspected mTBI, having the greatest sensitivity of the individual tests. Also, clinical observations along with the AOST results accounted for or participated in 85.7% of the observations of an SRC referral for a full neuro exam

(Table 2). Table 2 lists the common clinical notes that were observed when there was a suspicion of an mTBI and referral for neuro exam.

DISCUSSION

The purpose of this paper is to present the testing methodologies used at the University of Cincinnati to document the absence of suspicion for SRC. To our knowledge, this proposed 'absence of suspicion' exam is the first to demonstrate a series of non-computerized assessments designed to evaluate neurological functions that are commonly observed in individuals who are suspected to have incurred an SRC. The utility of this AOST tool is that it can be performed by trained athletic trainers as part of compliant SRC management and the test panel can be used to guide clinical management.[16–22] In the current -litigious environment, it is critical to document objective testing to safely return an athlete to play.[9–12] The AOST results are objective and quantitative neurologic methods useful to make clinical decisions such as clear to play or aid in directing clinical SRC management.[15]

Our results demonstrated that 72% of the AOST tested athletes had no evidence of an SRC. It is reported throughout the scientific literature that SRC symptoms may not present for several days.[1,3,5–8] In these cases, the AOST was typically performed 24 to 48 hours post-incident. Of the 73.1% (n=19) determined to have an absence of suspicion, all returned to normal sporting activities and none reported the development of delayed post-concussive like symptoms. Moreover, 26.9% of athletes (n=7) tested were found to have a suspicious test during the AOST and were referred for neurologic exams. This was documented and those athletes were referred to UC's Independent Neurology Consultant for additional neurological evaluation. All 26.9% of those athletes (n=7) were eventually diagnosed with an SRC determined through a full neurological exam and then entered into the SRC management pathway.

The clinical observations noted during the AOST are also an important factor in making an SRC referral to a neuro specialist.[26,27] In Table 2 we illustrate that the notes section of the AOST had good concordance (85.7%) with SRC referral and diagnosis of a concussion. These clinical notes are consistent with good clinical practice to take and record notes concerning diagnostic testing and management of the injured athlete. For example, with the Closed-Eye Turns balance assessment, we report five cases where the turn was normal in degrees turned, but deficiencies were noted including wobble, complaints of 'spinning', and or continued perception of rotation (dizziness). The Near/Far assessment was the most sensitive of the testing battery, with 57.1% of athletes to have incurred a suspicious injury (n=7) showing difficulty accommodating and elicited concerning symptoms common with concussion diagnoses.

The AOST is designed to document and guide SRC related management shortly after a suspected concussive event; to document the absence of mTBI or recommend a full neurological assessment be performed. We believe that the AOST has utility for athletic trainers who want and/or need objective clinical documentation to return a player to play. Many of the states in the USA require documentation of an absence of SRC post pull from play event.[9–12] The AOST could fulfill that test matrix and clinical documentation requirement concerning clearing an

TABLE 2 Common Clinical Notes

Percentage with complaints	Common clinical notes
57.1%	Difficulty accommodating during Near/Far assessment
42.9%	Uncomfortable with NPC evaluation
42.9%	Photophobic symptoms with PERRLA
28.6%	Symptomatic with closed-eye turns
28.6%	Neck pain & stiffness

Percentage of common clinical notes found when symptoms were elicited from AOST examination on the 7 athletes determined to have a suspicion of concussive injury.

athlete and be compliant with most SRC protocols. It is important to realize that the AOST is distinct from a sideline or return to baseline assessment. The test results aid in communication with team physicians and SRC specialists. As the AOST battery is small in physical size and can easily fit within any regular travel bag or backpack, it may also be a useful tool for athletic trainers traveling with teams as well as managing SRCs. Thus, an athletic trainer traveling with a team without access to a neuro specialist or a qualified team physician, they can use the AOST to care for their athlete post suspected SRC. The AOST can be used in conjunction with other tests such as ImPACT, BESS and or SCAT.[23-25] An experienced clinician can make their own decisions as to what methods to use when managing SRC and use the AOST to aid in documenting the SRC pathway.[26,27]

It is beyond the scope of this paper to make diagnostic claims regarding SRC, as the AOST was not designed to be a diagnostic panel or a baseline. While baseline data of the AOST tests can be helpful, several of these tests have population norms that can be applied to assessing the absence of suspected SRC.[28,29]

The AOST tool is designed to be quick, quantitative, and easy to perform. The cadre of tests is somewhat visually oriented but still multi-faceted in the functions tested. Including complementary tests for a full AOST can be used by athletic trainers based on tests that they feel comfortable with. Tests that could be partnered with our AOST panel include but are not limited to; ImPACT, BESS, SCAT, NIH Memory Exam, Mini Mental Status Exam, Montreal Mental Status Exam, NIH Stroke Scale, CNS vital signs and others.

Normal performance parameters will depend upon the athletic population and the subtle methodological differences of the clinical practitioners. Table 1 presents a reasonable range for the quantitative results of the AOST exams. Plus, the athletes studied herein were all post suspicious events with SRC concern, so Table 1 does not report true "norms". Therefore we strongly recommend that should the athletic trainer decide to use any or all parts of the AOST that the tests are practiced and the trainer develop his/her norms and have good clinical experience with the tests to make the decisions to best and safely serve their athletes; complimenting Table 1.

Also, in Table 1 we report the data observed from AOST, and several of the tests had different "n" numbers. This is because the current study is a retrospective chart analysis. The tests were performed as part of clinical practice. Several times, when clinical suspicion of an SRC was made the tests are often discontinued to avoid symptom exacerbation and to refer the patient to a neuro specialist and/or change the AOST exam to a neuro exam to better serve the patient.

The emphasis of this report is to provide a neurological testing series that can be performed by an athletic trainer, or similarly trained healthcare professional and used to document that an absence of suspicion for SRC has occurred. Those trained in SRC diagnostics can choose to use these tests as and when needed to further support clinical decisions with these objective data.

We suggest two main opportunities for the use of the AOST for athletic trainers. The first opportunity is after an athlete is pulled from play after a suspected SRC event, say during a game or practice. The athletic trainer pulls the athlete due to suspicion but then needs to evaluate the athlete later. When a follow-up exam is performed the AOST can be used to document the absence of suspicion or to guide SRC care. The second opportunity is with an athletic trainer traveling with a team in the absence of a team physician or neuro specialist. The AOST can be performed to document a safe return to play or the decision to continue to play. Similarly, in this example, the AOST results can be conveyed to a team physician as a means of communicating the neurologic status of the athlete.

CONCLUSION

In conclusion, we believe the AOST can be used by athletic trainers to document cleared to play as part of an SRC protocol and aid in compliance with many state laws. It can also be used as a means for guiding clinical decisions as well as a means for communicating with other clinicians when managing suspected SRC. We do not propose that the SRC be used exclusively as a diagnostic tool, but rather for guiding in making clinical decisions for athletes with a suspected SRC.

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CONFLICT OF INTERESTS

Jonathan Vincent declares that he is the founder of Inneuractive™, a Limited Liability Company that trains and educates athletes, coaches, athletic trainers, and other interested healthcare practitioners in neuro-visual training methodologies for performance enhancement and may commercialize the Absence of Suspicion Test (AoST). Jon Divine, Aaron Keuhn-Himmler, Robert Mangine, Kimberly Hasselfeld, and Joseph Clark declare that they do not have any conflicts of interest.

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