The ANAM Lacks Utility as a Diagnostic or Screening Tool for Concussion More Than 10 Days Following Injury

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ABSTRACT Congress has mandated that the Department of Defense perform screening for concussion, or mild traumatic brain injury, on all service members redeploying from Iraq and Afghanistan. However, the retrospective diagnosis of concussion is complicated by the subjective nature of the complaints, overlap of symptoms with other conditions, and the normally rapid recovery of neurocognitive function following a concussive event. One diagnostic and screening test in current use by the Department of Defense is the Automated Neuropsychological Assessment Metrics (ANAM). A team of researchers deployed to Iraq between January and April 2009 to test the validity of the ANAM for the diagnosis of concussion in the combat environment. Performance by concussed participants on all six ANAM subtests was compared with that of controls. The ANAM appears to have no utility as an individual diagnostic or population screening tool for the detection of neurocognitive dysfunction from a single, uncomplicated concussion when administered 10 or more days following injury. Further studies are required to determine the modalities providing optimal sensitivity and specificity for use as diagnostic or screening tests beyond the first 72-hour acute postinjury period.

BACKGROUND

Mild traumatic brain injury, hereafter referred to as a concussion, although certainly not unique to the theater of operations, has been described as the “signature wound” of the current conflicts in Iraq and Afghanistan. As many as 13 to 22% of deployed soldiers report sustaining a concussion during their most recent deployment. Most of these injured service members can be expected to completely recover over the course of several days to several weeks. However, a substantial number will continue to report symptoms such as poor concentration, dizziness, and headaches for a prolonged period of time following the injury. These postconcussive symptoms have significant overlap with those of other clinical conditions commonly occurring following deployment such as post-traumatic stress disorder and depression, making diagnosis of concussion based on subjective symptoms problematic. Further complicating the retrospective diagnosis of concussion is the rapid recovery of neurocognitive function limiting the utility of neurocognitive testing as a post-deployment screening tool for unrecognized or unreported concussion. The ability to accurately identify and diagnose neurocognitive dysfunction secondary to concussion and postconcussive syndrome is critical not only to provide adequate protection, treatment, and rehabilitation to injured service members with these conditions, but also to ensure that symptoms resulting from other syndromes are not misclassified as postconcussive in nature.

Both the Departments of Defense and Veterans Affairs have great interest in developing and validating diagnostic and population-based screening modalities for the presence of concussive or postconcussive effects. Modalities are needed to identify concussion-induced dysfunction in the immediate postconcussive setting, during the recovery phase (days to weeks following a concussion), and among service persons who may have sustained a concussion weeks to months previously. To this end, Congress mandated evaluation of all service persons returning from Operation Iraqi Freedom and Operation Enduring Freedom for the residual effects of a concussive injury during their deployment. The best mechanism to accomplish this screening remains controversial.

Much attention has been given to the use of neurocognitive tests as both diagnostic and screening tools. There is a strong body of evidence that several neurocognitive test batteries demonstrate validity in the first few days following concussion. Particularly, promising is the use of a simple reaction time (SRT) measure. Currently, the Automated Neuropsychological Assessment Metrics (ANAM) is the most commonly used neurocognitive test battery in the theater of operations. The version in current use, specifically, is ANAM4-TBI-MIL. It is the military’s intent for all deploying service persons to receive predeployment baseline ANAM testing, the results of which can be compared to postinjury testing results. What remains unclear at this time

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is the validity and utility of using the ANAM after the first few days following injury, either as a diagnostic tool in individual patients or as a population postdeployment screening tool. The limited evidence to date indicates that the ANAM lacks utility as a population concussion screening tool for redeploying service persons. Little information is available on the validity and utility of this modality in the subacute period, several days to weeks following injury. This article reports the results of follow-up ANAM testing in a group of concussed Soldiers in Iraq versus comparable control Soldiers 5 or more days following concussion.

METHODS

Study Design

The study team deployed to Iraq from January to April 2009. Neurocognitive functioning of U.S. Army Soldiers presenting for medical care within 72 hours of a concussion event was assessed by the ANAM with results compared to those of comparable controls. Follow-up ANAM testing was then performed 10 days after initial testing ± 5 days. The large range of acceptable follow-up times was required to account for nonavailability of subjects because of military duty requirements in a combat environment. Participants were enrolled at Victory Base Complex, Joint Base Balad, and Mosul. This study was approved by the Institutional Review Board of Brooke Army Medical Center. All participants provided written informed consent before enrollment. Funding was provided by the U.S. Army Medical Research Acquisition Activity.

Participants

Concussed participants included all U.S. Army Soldiers from 18 to 50 years old presenting to an outpatient medical facility within 72 hours of a concussion per Department of Defense criteria regardless of whether the concussion was combat related. Eligible participants also had to be free of cognition altering medication or severe psychiatric diagnosis requiring ongoing therapy, not report a pain level greater than 7 on a scale of 1 to 10, and give consent. Individuals with any prior severe TBI, a moderate TBI within the previous 3 years, or any concussion within the previous 90 days were excluded. To minimize fatigue effects, participants had to have a night’s rest before testing. Two non-concussed control groups were enrolled: Soldiers presenting for care for minor traumatic injuries not involving the head and noninjured volunteers from U.S. Army combat units stationed at the same locations. The same excluding factors were applied to control groups as to concussions. The non-concussed control groups were combined to increase analytical power; the justification for this is presented elsewhere.

Questionnaire and Neurocognitive Testing

At enrollment, participants were administered a questionnaire with items assessing demographics, physical health, mental health, sleep, and other service-related factors. Neurocognitive testing at enrollment included the Military Acute Concussion Evaluation, the ANAM, a battery of traditional neurocognitive tests, and the Test of Memory Malingering as a test of effort. To minimize time required of the participants, only the ANAM was repeated at the follow-up visit.

The ANAM is an automated neurocognitive testing modality that includes six subtests: SRT, procedural reaction time (PRT), code substitution (CDS), code substitution delayed (CDD), mathematical processing (MTH), and matching to sample (MSP). The ANAM is administered on a laptop computer with the respondent using a mouse to register their responses. Throughput scores, reflecting composite speed and accuracy were analyzed and reported as T-scores. When available, predeployment baseline results were obtained from the Army ANAM Program Office.

Data Analysis

Statistical analysis was performed using Stata v11.1 (Stata, College Station, Texas). Proportions were compared using Fisher’s exact test and continuous data with the Mann–Whitney U test as the data were not normally distributed and the sample size was too small to invoke the central limit theorem. No adjustment was made for multiple comparisons. A p-value of <0.05 is considered as statistically significant.

RESULTS

Demographics

Initially, 71 concussed and 166 non-concussed participants were enrolled. Two concussed participants were excluded after demonstrating poor effort. Of the 235 remaining participants enrolled, 22 concussed and 58 non-concussed subjects were lost-to-follow-up because of relocation. Therefore, this analysis includes 155 participants, 47 concussed and 108 non-concussed on whom follow-up data are available. At the time of the study, predeployment ANAM testing had not been fully implemented for all units deployed to Iraq, therefore predeployment baseline ANAM testing results were available on only 26 concussed and 34 non-concussed participants.

Demographic, health, and service-related factors are presented in Table I. Compared to non-concussed participants, concussed participants were more likely to have been enrolled at Joint Base Balad or Mosul; have some college education; be Hispanic; be noncommissioned officers who report pain, headaches, blackouts, confusion, or flashbacks; report mental health less than 4 on a scale of 1 to 5 (1 being poor, 5 being excellent); report a greater than 2-hour loss in average nightly sleep; have been in Iraq less than 6 months; been exposed to an blast; and had previous concussion(s). Concussions were less likely to have been enrolled at Baghdad; have a college degree; be black; be a commissioned officer; or diagnosed with a learning disability or attention-deficit hyperactivity disorder. There was no statistically significant difference between concussed and non-concussed participants based on age, gender, marital status, English as a second language.
self-reported physical health, mental health counseling or medications, average nightly sleep, length of service, or number of combat tours.

To address concerns of follow-up bias, ANAM scores from initial enrollment of those who were available for follow-up were compared with those who were lost-to-follow-up. There were no statistically significant differences in scores on any ANAM subtest between participants available for follow-up and lost-to-follow-up, in aggregate or when stratified by concussion status.

Baseline, initial enrollment, and follow-up ANAM scores are presented in Table II. Although there were significant differences in almost all ANAM subtests at the time of initial enrollment (<72 hours after injury), there were no statistically significant differences in scores at follow-up examination, except for CDS. CDS median scores were lower in...
concussed participants than in controls at both baseline and follow-up. This difference was not statistically significant when analysis was limited to those tested 10 or more days after injury.

Median changes from baseline scores at initial enrollment and at follow-up are presented in Table III. Again, there were significant differences in changes from baseline scores for almost all ANAM subtests when concussed are compared to non-concussed participants. At follow-up, none of the ANAM subtests showed statistically significant differences between concussed and non-concussed participants.

**DISCUSSION**

A new finding of this study is how rapidly all components of the ANAM normalize following a concussive injury in the combat setting, within 5 to 10 days. This finding is highly consistent with the adult sports medicine literature on recovery of cognitive function and postconcussive symptoms during the first 10 days following injury.17–19 The finding that the ANAM, particularly SRT, demonstrates utility in detection of neurocognitive dysfunction within 72 hours of a concussive event is consistent with previously reported data.10–12 Results of the current study clearly demonstrate the ANAM’s lack of utility as a diagnostic or screening test beyond the first 10 days following a single, uncomplicated concussion. Repeat administration of the ANAM may be indicated to monitor an individual concussed patient’s neurocognitive recovery, if baseline scores are available.

There are limitations of this study, the most prominent of which is the small sample size of participants on whom predeployment baseline testing was available for comparison. However, the sample size used to examine median postinjury scores was adequate to detect significant differences but failed to do so. This study also addressed concerns of follow-up bias by demonstrating no differences in initial enrollment ANAM performance between those available for follow-up and those lost to follow-up. It should also be noted that the sample was restricted to soldiers with a history of a single recent concussion, and results cannot be generalized to...
those with a history of multiple concussions occurring in close temporal proximity.

The initial signs and symptoms of concussion may be subtle and particularly difficult to diagnose and manage in the austere combat environment, particularly if soldiers are reluctant to report symptoms to complete their mission. As a result, concerns have been raised that concussions incurred in combat may go unrecognized and untreated, and several methodologies have been developed for postdeployment screening. The current study adds to the body of literature indicating that neurocognitive testing, and in particular the ANAM, does not have a role as a screening instrument for detection of concussion by approximately 10 days postinjury. Rather, computerized neurocognitive testing is a validated clinical tool available to assist military providers in detection and management of concussion during the acute phase. Early diagnosis and proper management of concussion are critical to successful outcomes in wounded service personnel. Current Department of Defense efforts to foster prompt identification of concussion in theater should mitigate the need to screen for undetected concussions in the future.

CONCLUSION
The ANAM appears to have no utility as an individual diagnostic or population screening tool for the detection of neurocognitive dysfunction from a potential single, uncomplicated concussion when administered 10 or more days following injury. Alternative strategies relying on questionnaires focused on medical history are more valuable for “screening” purposes. Other modalities for screening, to include biomarkers and neuroimaging techniques, must be explored. A thorough evaluation by a medical provider, including a detailed history and physical examination, must be included in any “diagnostic” assessment of potential concussion or postconcussive syndrome. Further studies are required to determine the modalities providing optimal sensitivity and specificity for their use as diagnostic or screening tests beyond the acute postinjury period.

REFERENCES