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Gender and age predict outcomes of cognitive, balance and vision testing in a multidisciplinary concussion center

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ABSTRACT

Objective: This study examined components of the Sports Concussion Assessment Tool, 3rd Edition (SCAT3) and a vision-based test of rapid number naming (King–Devick [K-D]) to evaluate sports and non-sports concussion patients in an outpatient, multidisciplinary concussion center. While the Symptom Evaluation, Standardized Assessment of Concussion (SAC), modified Balance Error Scoring System (BESS), and K-D are used typically for sideline assessment, their use in an outpatient clinical setting following concussion has not been widely investigated.

Methods: K-D, BESS, SAC, and SCAT3 Symptom Evaluation scores were analyzed for 206 patients who received concussion care at the Concussion Center at NYU Langone Medical Center. Patient age, gender, referral data, mechanism of injury, time between concussive event and first concussion center appointment, and the first specialty service to evaluate each patient were also analyzed.

Results: In this cohort, Symptom Evaluation scores showed a higher severity and a greater number of symptoms to be associated with older age ($r = 0.31$, $P = 0.002$), female gender ($P = 0.002$, t-test), and longer time between the concussion event and first appointment at the concussion center ($r = 0.34$, $P = 0.008$). Performance measures of K-D and BESS also showed associations of worse scores with increasing patient age ($r = 0.32$–0.54, $P \leq 0.001$), but were similar among males and females and across the spectrum of duration since the concussion event. Patients with greater Symptom Severity Scores also had the greatest numbers of referrals to specialty services in the concussion center ($r = 0.33$, $P = 0.0008$). Worse Immediate Memory scores on SAC testing correlated with slower K-D times, potentially implicating the dorsolateral prefrontal cortex as a commonly involved brain structure.

Conclusion: This study demonstrates a novel use of sideline concussion assessment tools for evaluation in the outpatient setting, and implicates age and gender as predictors of outcomes for these tests.

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1. Introduction

Many research studies on concussion have focused on sideline testing for sports-related injuries and have investigated assessment tools such as the Sports Concussion Assessment Tool, 3rd Edition (SCAT3). Visual assessments of rapid number naming, including the King–Devick (K-D) test, have also been extensively studied. While these tools are useful on the sideline [1–6], their administration in the outpatient clinical setting following a concussive event or mild traumatic brain injury (TBI) has not been widely investigated. Using these tools at an outpatient, urban-based, multidisciplinary concussion center, patients were examined across the age spectrum who suffered concussions by a wide variety of sports- and non-sports-related mechanisms.

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Three sections of the SCAT3: the SCAT3 Symptom Evaluation, the Standardized Assessment of Concussion (SAC, a brief cognitive test), and the modified Balance Error Scoring System (BESS) were utilized in the current study. A vision-based test of rapid number naming, the K-D test, was also administered. Rapid number naming tasks require saccadic (fast to a target) and other eye movements, and may be impaired following concussion [7–9].

The purpose of this study was to examine characteristics of patients from a recently established multidisciplinary concussion center. The profile of scores from performance measures of K-D, SAC and BESS were determined in the outpatient clinical setting. Given the sports and non-sports model of care at a multidisciplinary concussion center, this study presents a unique opportunity to measure characteristics of the SCAT3 Symptom Evaluation, SAC, BESS and K-D test in a heterogeneous cohort of patients.

2. Subjects and methods

Patients 6 years of age or older that had received care for a diagnosis of concussion at the Concussion Center at NYU Langone Medical Center were invited to participate in data collection for the NYU Concussion Center Registry. The Institutional Review Board (IRB) at the NYU School of Medicine approved all study protocols. Informed consent and/or age-appropriate assent were obtained from each participant.

The diagnosis of concussion was established at the time of all initial patient visits using the standard definition of witnessed or reported impulse blow to the head or body followed by any neurological symptom(s). Judgments about whether a concussion occurred were made for each patient by physician experts; this was applicable at the initial evaluation and at the time of data capture for these analyses.

Data that related directly to concussion diagnoses were obtained from patient electronic medical records. This information included the patient's age at the time of concussion, gender, the time that elapsed between the concussion event and the first appointment with the Concussion Center, and specialty of the first physician seen at the Concussion Center. Also captured were the sub-specialty services to which patients were referred (such as vestibular rehabilitation), the total number of referrals given, and mechanism of concussive injury (sports- vs. non-sports-related and nature of injury itself). Scores for the K-D, BESS, SAC, and Symptom Evaluation (including symptom severity score and total number of symptoms) were also recorded. Descriptions of each of these tests are outlined below.

2.1. King–Devick (K-D) test

The K-D test is based on the speed of rapid number naming and requires saccadic (fast to a target) and other eye movements [2–4,6]. The test involves reading aloud a series of single-digit numbers on three test cards. Standardized instructions are used; participants are asked to read the numbers from left to right as quickly as possible without making errors. K-D is scored by adding the times in seconds required to read each card; the sum of the three card times is the summary time score. Total K-D test times for college students during preseason baseline testing are generally close to 40 s [2,6]. As such, the K-D test requires less than 2 min to administer for most patients.

2.2. SCAT3 Symptom Evaluation

The Symptom Evaluation, a component of SCAT3, is comprised of 22 symptoms, each of which is rated on a 0–6 scale (0 indicates absence of a symptom; 6 is most severe). A symptom is counted towards the total number of symptoms if it has a non-zero score. The total number of symptoms thus has a maximum of 22. The symptom severity score is the sum of the individual scores for each of the symptoms; this scale has a maximum score of 132.

2.3. Standardized Assessment of Concussion (SAC)

Also a component of SCAT3, the SAC is a brief cognitive battery that captures domains of Orientation (score 0–5), Immediate Memory (score 0–15), Concentration (score 0–5), and Delayed Recall (score 0–5). The maximum total score for the SAC is 30. Unlike the K-D, Symptom Evaluation and BESS, lower scores indicate worse performance for the SAC.

2.4. Modified Balance Error Scoring System (BESS)

To perform the modified BESS, patients are asked to stand with their hands on their hips and their eyes closed for 20 s. Three stances are examined, including feet together, non-dominant foot only, and tandem (heel-to-toe) stance. Any time the patient moves from the stance or opens his or her eyes, an error is recorded by the examiner. There are a maximum of 10 errors per 20-s period of stance, with a total maximum of 30 errors.

2.5. Statistical analyses

Statistical analyses were performed using Stata 13.1 software. Pearson linear correlations and linear regression models were used to assess the relation between test scores and patient characteristics as continuous variables. Differences in each variable by gender were assessed using two-sample t-tests or Wilcoxon rank-sum tests.

3. Results

3.1. Patient characteristics and patterns of multidisciplinary referral

Characteristics of the study cohort are summarized in Table 1. The mean age of the cohort was 35 ± 16 years, with a range of 10–77 years. Among 206 patients with concussion, 80 sustained a concussion during sports participation; the remaining 126 developed concussion following a motor vehicle accident, fall, assault, or other type of trauma. Patients with sports-related injuries were younger (25 ± 14 years, range 10–65) than those with non-sports injuries (41 ± 14 years, range 14–77). The most common initial points of contact with the multidisciplinary concussion center were through the Departments of Rehabilitation Medicine (40%), Neurology (38%), and Orthopaedics/Sports Medicine (20%) (Fig. 1A). The most common specialties patients were referred to neuropsychology (45%), physical therapy (31%), vestibular rehabilitation (25%), and vision rehabilitation/occupational therapy (19%) (Fig. 1B).

Table 1
Characteristics of the study cohort (n = 206).

Age at appointment	35 ± 16 years (range 10–77)
Mechanism of injury	n (%)
Sports	80 (39%)
Non-sports	126 (61%)
MVA	42 (33%)
Falls	38 (30%)
Assaults	7 (6%)
Other Trauma	39 (31%)
Test Performance Scores	Mean ± SD (range)
Symptom Severity Score (n = 102, higher scores worse, maximum 132)	41 ± 30 (0–120)
Total Symptom Score (n = 106, higher scores worse, maximum 22)	14 ± 7 (0–22)
King–Devick (K-D) Total Time Score, s (n = 103, higher scores worse)	55.6 ± 21.6 s (29.4–140.5)
Standardized Assessment of Concussion (SAC) Total Score (n = 103, lower scores worse, maximum 30)	27 ± 3 (18–30)

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