CONCUSSION EVALUATION AND MANAGEMENT IN THE ACUTE AND CHRONIC PHASES: COGNITIVE EVALUATION AND TREATMENT

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Background
Neuropsychologists have been at the forefront of concussion evaluation and management and played a primary role in establishment of the baseline model of concussion evaluation and management. In the 1980s, Jeffrey Barth, Ph.D., developed the Sports as a Laboratory Assessment Model (SLAM) to study the effects of concussion in collegiate football players. A brief paper-and-pencil neuropsychological battery was utilized to conducted pre-season baseline evaluations and serial post-injury assessments. This provided an opportunity to assess and document post-injury changes in cognitive functioning and the course of recovery cognitive in healthy, motivated individuals. This proved to be a useful model. In the 1990s, Mark Lovell, Ph.D., and Ruben Echemendia, Ph.D., utilized brief paper-and-pencil test batteries with athlete populations. There was demand for greater efficiency and availability, which led to the development computerized cognitive test batteries (e.g., ImPACT, ANAM, CogState CCAT, others). Use of baseline and post-injury computerized neurocognitive tests (with or without additional testing) became widespread in sports in the 2000s. Testing was often completed in group settings and was conducted by non-neuropsychologists with varying degrees of training in standardized test administration and interpretation. Guidelines were established and computerized neuropsychological testing became a key component of concussion management and return to play decisions. Many concussion programs continue to use abbreviated paper-and-pencil neuropsychological test batteries as well.

Acute Assessment & Intervention
Sideline assessment of concussion is being discussed by Amaal Starling, MD.

Cognitive testing in the setting of acute concussion is typically brief and ideally utilizes measures that have alternate forms, given the frequent need for serial assessments. In athlete populations, particularly at the high school level and above, baseline testing may be available. Baseline/pre-participation assessments in athlete populations commonly include the Standardized Assessment of Concussion (SAC), which is a component of the Sport Concussion Assessment Test (SCAT-3; McCrory et al, 2013). Computerized neuropsychological tests (i.e., Cogstate CCAT, ImPACT, ANAM) are widely used. Brief paper-and-pencil neuropsychological test batteries have been developed (e.g., Barr, 2003; Echemendia et. Al., 2001). When baseline assessments are available, these same metrics should be repeated post-injury for comparison. Unfortunately, many of these measures are either not available or are understudied in youth (e.g., pre-high school) populations. Newly available data from our center on the appropriateness and reliability of the SAC in youth athletes of various ages will be introduced. Factors contributing to the optimal timing of cognitive assessments, when they should be repeated, and who should interpret them will be discussed.

In non-athlete populations, the initial neuropsychological assessment is also typically brief. Assessment batteries commonly used in athlete populations can be useful in non-sport setting, but may require modification or supplementation depending on the age of the individual, chronicity of the injury, purpose of the assessment (e.g., return to work/school, driving, rehabilitation recommendations). Assessment of injury perceptions as well as prior and current psychological functioning should be included and can be helpful in identifying individuals at increased risk of developing a persistent post-concussion syndrome (Whittaker et al, 2007; Snell et al, 2013). Early neuropsychology involvement is important to assist with return to school/work plans, providing reassurance and setting appropriate expectations for recovery, and early identification and treatment of negative psychological reactions.

Cognitive deficits post sport-related concussion in high school and collegiate players are most apparent immediately and in the first 2-3 days post-injury (McCrea et al, 2013, 2015). Common domains of acute cognitive deficits include processing speed and reaction time, attention, and memory. The vast majority of athletes at this level with first concussion will experience full clinical recovery over the course of 1-2 weeks, with return to baseline levels on commonly used measures of symptoms, cognition, and balance. Prolonged recovery beyond

this time period is associated with acute indicators of more severe injury, including loss of consciousness, anterograde or retrograde amnesia, and more severe initial report of symptoms (McCrea et al, 2013). Cognitive functioning on commonly used screening measures is typically normal several weeks post-injury, even in athletes who report persistent symptoms (McCrea et al, 2013). There is some evidence that younger athletes may be more susceptible to injury and prolonged recovery (Zuckerman et al, 2012; Field et al, 2013).

There are several factors that may contribute to a longer course of recovery, including prior concussion, time between repeat concussions, history of learning disability or attention deficit hyperactivity disorder, history of migraine, non-sport related concussion, age, psychiatric history, external forces (e.g., secondary gain), situational factors (e.g., pain, stress), and biological factors (e.g., gender). While psychiatric factors and potential for secondary gain are often cited as potential reasons for prolonged recovery in non-sport related concussion, there are a number of other mechanisms that may contribute as well. See Rabinowitz et al (2014) of an excellent review of concussion science and sport and non-sport etiologies of concussion. Again, early neuropsychological involvement can assist in identifying and intervening with individuals at increased risk of prolonged recovery.

Assessment and Intervention in the Chronic Stages

While the majority of concussed individuals will experience full recovery, some will experience a prolonged or complicated recovery. For individuals with persistent cognitive symptoms for more than 3 months post injury and/or significant risk factors (e.g., multiple concussions, significant exposure to concussive or subconcussive hits, learning disability, other neurologic disorders); traditional comprehensive neuropsychological evaluation may be necessary. These evaluations involve a thorough history; including details on the course of recovery and surrounding events, identification of psychological and other risk factors for prolonged recovery, interventions tried thus far, potential sources of secondary gain, and details of persistent symptoms. There will be a standardized assessment of a variety of cognitive processes including various aspects of attention, learning and memory, language, visuospatial skills, and executive systems functioning; as well as psychological functioning. Measures of performance and symptom validity are typically included. Neuropsychological evaluation is helpful for differential diagnosis; identifying areas of objective cognitive deficit, if any; identifying personal or psychological factors that may contribute to the presentation; and identifying treatment strategies that are likely to be of benefit.

Psychological interventions can be useful in both the acute and chronic stages to prevent and/or treat persistent post-concussion syndrome and related disorders (Mittenberg et al, 1996; Sayegh et al, 2010; Snell et al, 2013; Silverberg et al, 2013). Models exist that may allow us to predict and therefore provide early intervention to those at risk of developing a persistent post-concussion syndrome. Education and cognitive behavioral approaches have been the most studied, but other techniques hold promise as well (Sayegh, et al, 2010).

Cognitive rehabilitation is appropriate for individuals with cognitive deficits that persist beyond the initial weeks post-concussion. Cognitive rehabilitation includes methods that facilitate the remediation of and/or compensation for areas of neuropsychological compromise post-concussion. Treatment is often provided by neuropsychologists, speech therapists, or occupational therapists. Extensive reviews of the cognitive rehabilitation literature have been conducted and empirically validated techniques have been summarized and manualized (i.e., Cicerone et al, 2005, 2011; Helnick et al, 2010; Haskins et al, 2012). Recent advances in cognitive rehabilitation and computerized versus in-person approaches will be briefly discussed.

Recommended Readings

Bauer, R.M., Iverson, G.L., Cernich, A.N., Binder, L.M., Ruff, R.M., & Naugle, R.I. (2012). Computerized neuropsychological assessment devices: Joint position paper of the American Academy of Clinical Neuropsychology and the National Academy of Neuropsychology. Archives of *Clinical Neuropsychology, 27*:362-373.

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Whittaker, R., Kemp, S., & House, A. (2007). Illness perceptions and outcome in mild head injury: a longitudinal study. *Journal of Neurology, Neurosurgery and Psychiatry, 78*:644-646.

Zuckerman, S.L., Lee, Y.M., Odom, M.J., Solomon, G.S., Forbes, J.A., & Sills, A.K. (2012). Recovery from sports-related concussion: Days to return to neurocognitive baseline in adolescents versus young adults. *Surgical Neurology International, 3*:130.